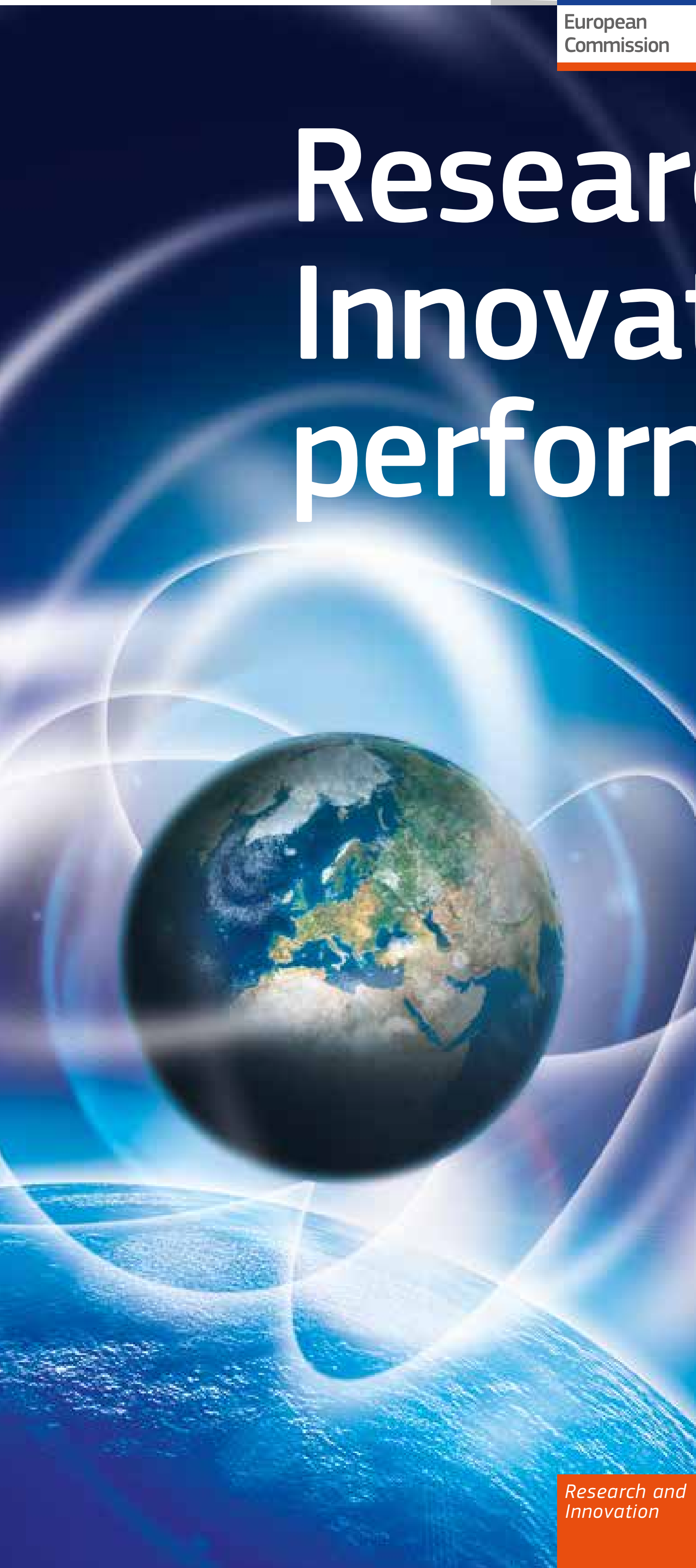
European Commission

Research and Innovation performance in the EU

Innovation Union progress at country level

2014



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This 2014 edition of the report was prepared under the guidance of Román Arjona Gracia, Chief Economist and Head of Unit for Analysis and monitoring of national research policies and coordinated by Diana Senczyszyn. The statistics were collected and analysed by Dermot Lally and Cristina Moise. Valuable analytical assessment was provided by Patrick Brenier, Stéphane Vankalck and Richard Deiss.

The individual chapters were written by (in alphabetical order): Andrew Bianco, Patrick Brenier, Fotini Chiou, Rosella Cravetto, Richard Deiss, Tania Friederichs, Diana Ivanova-Van Beers, Pia Laurila, Carmen Marcus, Antoine Masson, Patrick McCutcheon, Cristina Moise, Ana Nieto Nuez, Diana Ognyanova, Eugenija Puciute, Steve Rogers, Raquel Saiz, Diana Senczyszyn, Johan Stierna, Telemachos Telemachou, Sylviane Troger and Stéphane Vankalck.

The structure of the report is similar to that of the 2011 and 2013 editions. The previous editions of the report as well as the Innovation Union Competitiveness report can be found on the Europa website (http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=keydocs).

The report made use of the data available from the Eurostat database up until 16 May 2014.

Foreword

Four years ago, in June 2010, Europe's leaders endorsed the Europe 2020 growth strategy, our roadmap to get the EU's economy back on track. Building an Innovation Union became one of the flagship initiatives of this strategy, given the wide consensus that research and innovation (R&I) are the way for Europe to restore long-term sustainable growth.

Europe now has the largest internal market in the world, an educated workforce, and many of the world's leading innovative companies. And we are among the world's top performers in excellent science and innovative products, in the same league as our international competitors such as the United States, Japan and South Korea.

We are also ahead in key science and technology fields such as health, food, renewable energies and environmental technologies, and over recent years, Europe's ecosystem for innovation has improved markedly. However, the economic impact of our R&I investments and reforms ultimately depends on the capacity of our economies to become even more knowledge-oriented and innovation-driven.

Within the European Semester, Europe's framework for economic policy coordination, Member States were asked to give priority to growth-enhancing expenditure, notably on R&I, in line with the concept of growth-friendly fiscal consolidation. Reforms to modernise the national R&I systems have also continued to gain increasing importance. The recent Commission Communication 'Research and Innovation as sources of renewed growth', COM(2014) 339 final, which the Vice-President for Economic and Financial Affairs and I prepared, emphasises that to get the most value for every euro invested and to allow Europe to capture upcoming growth opportunities, investments in R&I must go hand in hand with an improvement in their quality. This requires a step change in identifying, designing and implementing far-reaching priority reforms at strategy, programme and institutional level.

As the heads of state and government concluded in June 2014, four years after the launch of the Europe 2020 strategy, we need to "invest and prepare our economies for the future". The success of the Innovation Union depends not only on the greater efficiency of public policies but also on putting in place and fully exploiting the right framework conditions to stimulate Europe's companies to innovate. The 2014 'State of the Innovation Union' report highlights the progress we have made in this respect.
However, further efforts are needed to deepen the Single Market, facilitate and diversify access to finance, strengthen the innovation capacity of the public sector, create resilient jobs in knowledge-intensive activities, develop a human resource base equipped with innovation skills, foster frontier research, address the external dimension of R&I policy, and embed science and innovation more strongly in society.

The analysis presented in the 2014 edition of the report 'Research and Innovation performance in the EU. Innovation Union progress at country level' has been designed to support Member States and selected non–EU countries in identifying and addressing the main R&I challenges, which include the need to improve the quality of research and its economic and societal impact as well as the framework conditions for innovation in the business sector.

Looking at the facts and figures in the report, we can see that while public R&I funding and the overall quality of the science and innovation base increased in some countries throughout the crisis, investments and structural reforms are still needed in others to avoid unwanted delays in their transformation into knowledge-based economies. Measuring country performance in relation to the new Innovation Output Indicator, developed to assess to what extent the ideas stemming from innovative sectors are capable of reaching the market and making Europe more competitive, completes the analysis in each country profile.

If we get it right, Europe will become the leading destination for ground-breaking science and innovation, where ideas will flourish and companies will develop and market the next generation of products and services, while tackling the needs and aspirations of European citizens.

One of the strengths of this report is that it looks at the overall picture of the performance of individual countries in R&I, allowing for transparent comparisons thanks to a straightforward analytical structure for each country. It is with pleasure that we release the third edition of this report, which has already established itself among the useful analytical tools for monitoring R&I systems and assessing their performance in Europe.

Máire Geoghegan-Quinn

European Commissioner for Research, Innovation and Science

Introduction

The country profiles in this publication aim to provide an operational tool for stakeholders and policy-makers to support the framing of research and innovation (R&I) policies and to facilitate the monitoring of performance, on the basis of a holistic economic and indicator-based analysis.

In an effort to better understand the driving forces in the major R&D-intensive countries and the reasons behind differences in the performance of various national R&I systems, in addition to the EU-28, country profiles of five non-EU countries were selected to complete the analysis. They reveal the various 'bottlenecks' and different types of 'systems' that have resulted in a diversified but marked R&I landscape.

First published in June 2011 as part of the Innovation Union Competitiveness Report[1], the country profiles provided a concise and comparative overview of R&I trends and developments in individual countries. The second edition, published in March 2013[2], together with the 2013 Innovation Union Scoreboard[3], and the State of the Innovation Union 2012 report[4], expanded on the content of the first edition, placing particular emphasis on thematic and sector-based analyses.

This year's 'Research and Innovation performance in the EU. Innovation Union progress at country level-2014', which covers the whole R&I cycle, tackles both investments in R&I and reforms within the national science, technology and innovation systems. It highlights areas of scientific and technological strengths at the national level, presents developments linked to newly enacted R&I strategies, examines how the upgrading of manufacturing industries is progressing, and addresses the overall link between R&I and progress towards the goals set by the Europe 2020 strategy.

In addition, the 2014 analysis presents a number of novelties, among which is an analysis of the factors underlying each country's performance, using the Commission's new Innovation Output Indicator[5], and its focus on the science and technology specialisation patterns based on the thematic priorities of the EU's Seventh Framework Programme for Research and Innovation.

The performance of individual countries is benchmarked against both the EU average and a group of other European countries with similar knowledge and industrial structures. The benchmarking employs the same methodology as that used in 2011[6], to ensure comparability over time. The analysis presented in the report draws on the assessments carried out within the 2014 European Semester and reflected in the 2014 Country-specific recommendations[7]and the supporting Commission Staff Working Documents assessing the National Reform Programmes.

The country profiles in this report do not constitute a policy statement by the Commission. They aim to provide an objective economic and indicator-based analysis carried out by the Commission services[8]. In order to ensure cross-country learning and comparability, Eurostat and OECD data have been exploited, and have been complemented with data from some other sources where required[3].

The first part of this introduction presents an overview of the key European R&I challenges identified at country-level and grouped around three blocks: (1) lack of quality of the science base; (2) feeble contribution of the science base to the economy and society; and (3) inadequate framework conditions for business R&D and innovation. The second part focuses on two novelties featured in this year's analysis at country level: science and technology co-specialisation and the new Innovation Output Indicator, comparing EU performance with that of its international competitors.

1 http://ec.europa.eu/research/innovation-union/index_en.cfm?section=competitiveness-report&year=2011

2 http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2012/innovation_union_progress_at_country_level_2013.pdf#view=fit&pagemode=none

3 http://ec.europa.eu/enterprise/policies/innovation/files/ius-2013_en.pdf

4 http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=home&section=state-of-the-innovation-union&year=2012

5 http://ec.europa.eu/research/press/2013/pdf/indicator_of_innovation_output.pdf

6 See Methodological annex at the end of this document.

7 http://ec.europa.eu/europe2020/pdf/csr2014/eccom2014_en.pdf

8 The statistical data and evidence on policy reforms has been validated by the responsible administrations in each Member State and non-EU country.

I. The key research and innovation challenges at country level

Research and innovation are at the heart of the Europe 2020 strategy, the EU's ten-year growth and jobs strategy launched in 2010. Europe 2020 stresses that the knowledge economy is at the basis of Europe's future competitiveness. As the strategy relies to a large extent on structural reforms at the country level, the Commission introduced the European Semester mechanism to facilitate the governance of economic policy by undertaking a comprehensive monitoring of Member States' reform efforts and economic and structural policies, including R&I policy, and to provide recommendations for the following year.

While the country profiles in this report are not part of the European Semester mechanism, they are an essential component of the Commission's analytical efforts to monitor national R&I systems and assess their performance. The information and analysis gathered in these country profiles have been designed to support Member States in identifying and addressing the main challenges and bottlenecks impeding R&I's full contribution to smart, sustainable and inclusive growth. The role of the European Semester is to assess whether the policies either in place or planned constitute an appropriate policy response to these challenges in the specific context of each Member State.

The key R&I policy challenges at Member State level, which can be identified based on the country profiles, can be grouped as follows:

1) Quality of the science base

A lack of quality in the science base can be due to one or several of the following factors:

a) **Insufficient funding of the public research system.** Investment in public R&D are key in generating the knowledge and talent needed by innovative firms and leverages business investment in research and innovation, crucial elements to fulfil the ambitions of the Europe 2020 strategy. The Commission's 2014 Annual Growth Survey[9] calls on Member States to protect and, where possible, promote public support to R&D in the context of a growth-friendly fiscal consolidation strategy.

   The country profiles show that during the first period of the crisis, from 2008 to 2010, many Member States protected their R&D budgets and some even increased their expenditure on R&D. In some Member States the funding of the public research system continued to increase after 2010, even from an already high level of public R&D intensity[10] in some cases, such as Denmark and Germany. Thanks in particular to the significant mobilisation of European Structural Funds, several Central and Eastern European countries (in particular Slovakia, Estonia and the Czech Republic) also display strong growth rates in public R&D intensity since 2007[11].

   Conversely, budget cuts in public R&D in recent years in other Member States which already had a public R&D intensity well below the EU average – such as Bulgaria, Romania, Croatia and Hungary – risk delaying considerably the transformation of these countries into knowledge-based economies.

b) **Inefficiencies and lack of reforms within the public research system.** In a number of Member States, critical structural reforms are still required to increase the efficiency, effectiveness and excellence of the public research system. The Commission Communication on a 'Reinforced European Research Area Partnership for Excellence and Growth', adopted in July 2012, sets a common agenda defining the reforms required in national research systems to complete the European Research Area (ERA). These include, for example, fair, open and transparent recruitment to academic positions and the allocation of research funding on a competitive basis.

   In the Commission's Annual Growth Survey 2014, the modernisation of national research systems in line with the objectives of the European Research Area is set as one of three priorities for promoting growth and competitiveness, which has been reflected in the recommendations and analyses of the 2014 European Semester.

   Moreover, the recently adopted Commission Communication 'Research and innovation as sources of renewed growth'[12] explores how the potential of research and innovation as drivers of renewed growth can be maximised by raising the quality of investments. To this end, it focuses on three priority axes for reform: improving the quality of strategy development and of the policy-making process; improving the quality of programmes, and focusing of resources and funding mechanisms; and optimising the quality of those public institutions performing R&I.

9 At the start of each European Semester (November), the Commission adopts the Annual Growth Survey which reviews the progress achieved during the past year and sets out priorities for action for the coming 12 months at both EU and national levels (without being country specific).

10 'Public R&D intensity' is the expenditure on R&D performed in the public research system (higher education institutions and other public research organisations) as a % of GDP.

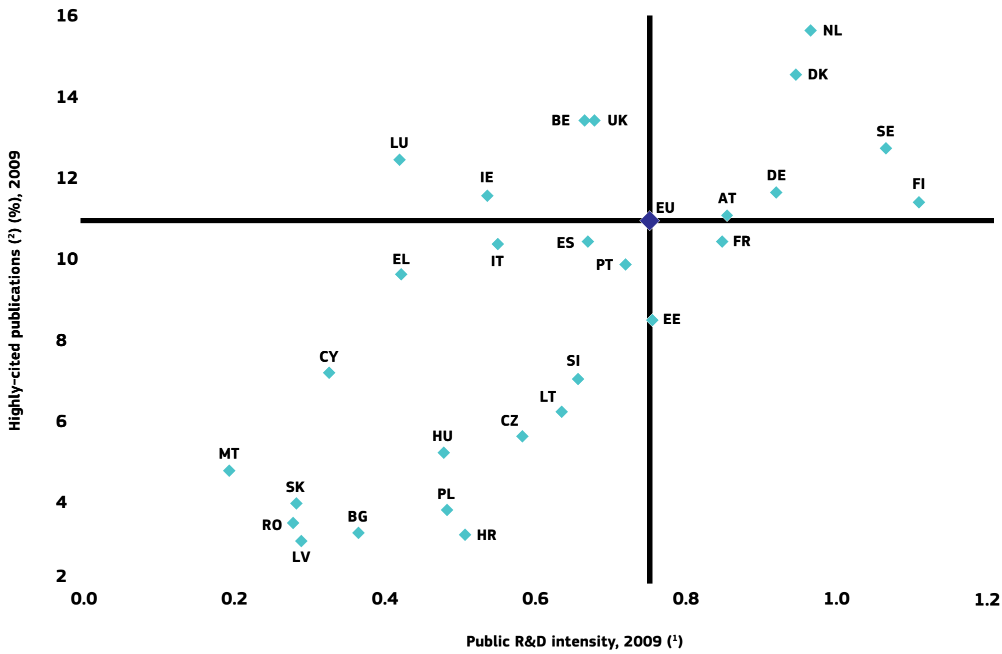
11 As a result, in Estonia and the Czech Republic, public R&D intensity is now higher than, for example, in Spain or Italy (even higher than the EU average).

12 COM (2014) 339 final

The country profiles analyse in particular the quality of Member States' knowledge base through two indicators: an indicator of the science output based on the percentage of highly cited scientific publications[13] among all national publications[14], and a composite indicator which combines this indicator with others, notably the country's capacity to host grants from the European Research Council.

All these metrics point to the persistence of a clear 'East-West' science divide in Europe, with a weaker science base in all Central and Eastern European countries (as well as Cyprus and Malta) compared to the other Member States. This is complemented by a 'North-South' differential, as Greece, Portugal, Spain and Italy, with performances just below the EU average, hold an intermediate position between Central and Eastern European countries and Northern/Western Europe. Based on the indicator on highly cited scientific publications, Latvia, Croatia, Bulgaria and Romania appear to be the Member States with the weakest science base, while the Netherlands and Denmark, followed by the UK, Belgium and Sweden, are the Member States with the strongest science base (see figure 1 below)[15].

Figure 1 **Highly-cited publications** (scientific publications within the 10 % most cited scientific publications worldwide, as % of country's total scientific publications) **versus public R&D intensity** (government plus higher education exp. on R&D as % of GDP)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, Innovation Union Scoreboard
Notes: (1) EL: 2007.
(2) Fractional counting method.

2) Contribution of the science base to the economy and society

While for some Member States the urgency is to increase the overall quality of their science base, others need to find ways to harness their strengths in order to create economic wealth and address societal challenges. The Commission's Annual Growth Survey 2014 highlights two critical points in this respect: the need to address the growing skills mismatches that are affecting the knowledge-intensive sectors, in particular, and the

13 Publications which are among the 10 % most cited worldwide. The number of citations a scientific publication receives indicates the value which the scientific community ascribes to this publication for subsequent scientific developments.

14 A country with an average scientific performance is expected to have 10 % of its publications among the top 10 % most cited worldwide.

15 As it is necessary to analyse the citations within a window of several years after the publication date, the most recent data concern publications produced in 2009.produced in 2009.

relevance of fostering public-private cooperation. Both issues have been examined in the context of the 2014 European Semester.

A weak science base contribution to the economy and society can be due to:

- **The inadequacy of public research capacities vis-à-vis the needs** of the economy and society: by identifying scientific and technological specialisations consistent with each region's potential to develop competitive economic activities (and focusing resources on them), a smart specialisation strategy is critical for fostering public-private cooperation, ensuring a leverage effect on private investments and thereby maximising the economic impact of public research funding;

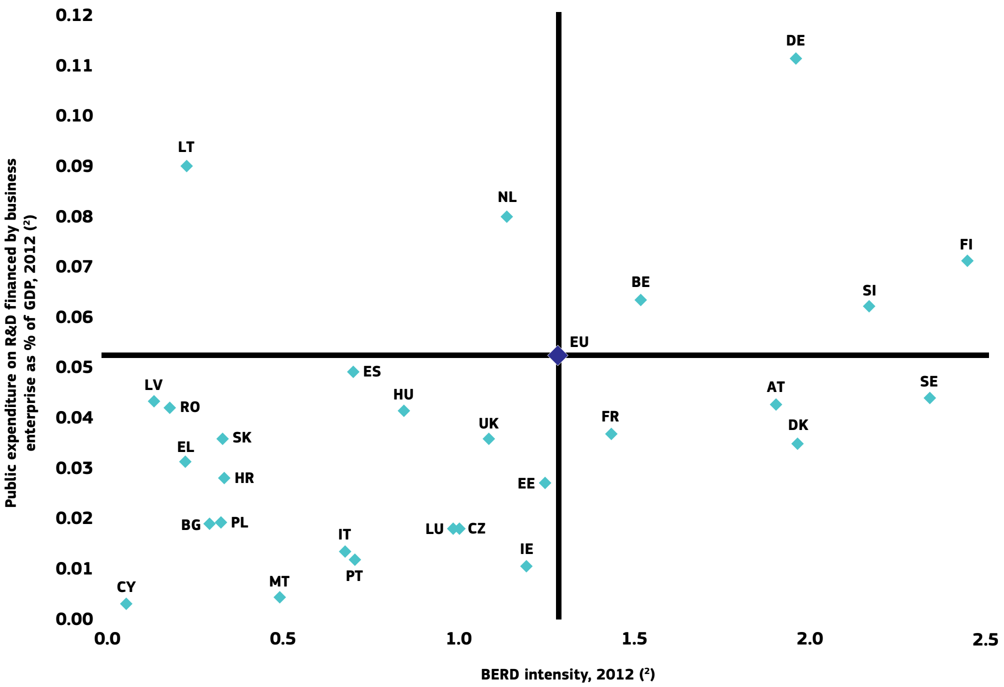
- And/or the **lack of mobilisation of the capacities**: the public support system needs to be designed in such a way that public research capacities are mobilised to efficiently address the needs of both society and the economy, with appropriate incentives for public researchers.

The Walloon '*pôles de compétitivité*' policy or the German comprehensive innovation-oriented strategy ('The High-Tech Strategy for Germany') are examples of policies to support the mobilisation of public research capacities around business needs. Such approaches channel significant funding into research agendas defined with industry.

In the country profiles, a new approach has been developed to try to assess the appropriateness of public research capacities vis-à-vis the needs of the economy. This analysis of science base specialisation (based on publications) and of technological specialisation (based on patents, reflecting mainly business R&D activities) using a common nomenclature allows for the detection of mismatches between the two (see section II below).

Another indicator displayed in the country profiles concerns the volume of research which is performed in the public research system but funded by business (see figure 2)[16]. While this is only one form of public-private cooperation, it is a particularly relevant one.

Figure 2 **Public expenditure on R&D** (government expenditure on R&D plus higher education expenditure on R&D) **financed by business enterprise as % of GDP (¹) versus BERD intensity** (business enterprise expenditure on R&D as % of GDP)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (¹) Public expenditure on R&D financed by business enterprise does not include financing from abroad.
(²) BE, BG, DE, ES, FR, IT, CY, NL, AT, PT, SE, EU: 2011.

16 The figure allows the analysis of the level of business R&D intensity to be taken into account: if a country does not have much business R&D, then the opportunity to have public-private cooperation is obviously very limited.

Looking at the countries with a low performance level on this indicator, it is not surprising to find Member States with an overall relatively low-quality science base. However, there are also Member States with an average or even excellent science base which clearly do not perform well on this indicator, in line with the overall quality of their science base: Portugal, Estonia, Luxembourg, Italy, Ireland (Member States with an average quality science base), as well as, for instance, Denmark (despite its scientific excellence).

For example, Luxembourg's country profile tries to analyse why, despite the good level of scientific excellence reached, the rapid build-up of public research capacities over the last three decades (from a situation where, 30 years ago, the public research system was actually first developed) has only triggered a limited volume of public-private cooperation and has not permitted a decline in business R&D investments to be avoided.

3) Framework conditions for business R&D and innovation

Most Member States remain a long way from their national R&D targets under Europe 2020, mainly reflecting a deficit in business R&D expenditure. Besides an adequate science base, other conditions must be met to enable business R&D and innovation to flourish. In this respect, the key bottlenecks and policy challenges are:

a) **Inefficiencies in public incentives to stimulate business R&D** (for example, grants, R&D tax incentives, measures to facilitate access to private funding). While a key aim of public R&D funding and indirect support measures is to give the business sector incentives to engage in more R&D activities and to attract R&D foreign direct investments, policy failures may result. They could be linked, for instance, to the fact that an impact evaluation was not carried out, the existing policy mix of a given country was not adequately considered when setting up the policy measure, the substitution or crowding-out effects were not explored, or that cost-effectiveness and unwanted cross-border effects were not addressed when defining the measure. In such cases, complexity and a lack of systemic impact on business R&D might materialise.

b) **Lack of demand-side measures and poor match between supply- and demand-side measures:** public efforts to support knowledge supply will fail to leverage private R&D investments if they are not matched with demand-side measures fostering the development of markets for innovation, avoiding their fragmentation and reducing the risks for private investors (for example, product market regulation, innovative and pre-commercial procurement), as part of an integrated and comprehensive policy approach.

c) **Bottlenecks that restrict the growth of firms in innovative sectors**, leading to a slow rate of renewal of the economic fabric. Economic studies have shown that a surprisingly small number of fast-growing innovative firms starting up in any given year are responsible for the majority of jobs created 10 years down the line. However, to date, only a few Member States have adopted a truly systemic approach to identifying the obstacles that need to be overcome to create a business environment in which innovative firms are more likely to grow.

Even for those Member States with the most advanced R&I systems, efforts related to these challenges are crucial to ensure efficient reforms. For instance, in countries like Finland and Belgium, there is a lack of renewal of the economic fabric, as shown notably by the number of employees in fast-growing firms as a share of the total number of employees, which is lower than the EU average. In Belgium, although in recent years well-designed policies have enabled business R&D intensity to increase, R&D remains too concentrated in a limited number of large multinationals. While Finland is the Member State with the highest business R&D intensity, this has been declining since 2009: crucially, the country would benefit from fostering the emergence of a new generation of fast-growing innovative firms.

Included with the country profiles is a chapter displaying and analysing Member States' results on the Innovation Output Indicator, which was adopted by the European Commission in 2013 (see section III of this introduction).

II. S&T specialisations: the EU and its Member States display less consistency than their main trading partners

In 2009, the European Commission's Research and Innovation DG launched a series of studies aimed at developing a system capable of the sustainable monitoring of knowledge and R&D flow from research to technology and to the market, given the increasing focus on measuring the impact of research activities on the economy[17].

In order to better allow for the analysis of knowledge transfer from science to technology in a given field, a common denominator was needed for the various classifications of science and technology fields. Given that Framework Programmes represent a core business of DG Research and Innovation, it was natural to choose the thematic priorities of the Seventh Framework Programme as the common denominator. The science and technology classifications were matched with FP7 thematic priorities thereby offering the possibility of further analysis of co-developments of science and technologies at the EU and national level.

A message emerging from the analysis and comparison of R&I performance at national level is that efforts are still needed in many countries to ensure a better match between scientific output and industry needs. The analysis presented in this report is based on a comparison between each country's scientific specialisation (in terms of publications) and technological specialisations (in terms of patent applications). The comparison is done using a *sui generis* reclassification of scientific fields and technology domains based on the EU's Seventh Framework Programme (FP7) thematic areas.

Overall results show a lack of consistency in Europe between the specialisation patterns of the public science base and the business innovation system. In other words, the majority of countries display scientific specialisations in areas which differ substantially from the technology domains in which their industry is most active. There are only few countries where scientific and technological specialisations can be considered as matching, namely Sweden, the UK and Israel.

A comparison between the EU as a whole and the US, Japan and China confirms the impression that S&T specialisations in Europe lack consistency:

- To a certain extent, scientific and technological specialisations in the EU only coincide in three areas (automobiles; construction and construction technologies; and food, agriculture and fisheries), as compared to five areas in the US (aeronautics and space; health; security; nanosciences and nanotechnologies; and biotechnology), four areas in Japan (materials; nanosciences and nanotechnologies; automobiles; and energy) and five areas in China (other transport technologies; energy; ICT; security; and construction and construction technologies).

- A strong mismatch between scientific and technological specialisations in the EU is observed in five areas (health; ICT; energy; other transport technologies; and aeronautics and space), compared to none in the US, only one in Japan (environment) and four areas in China (new production technologies; materials; aeronautics and space; and nanosciences and nanotechnologies).

A more detailed analysis reveals the nature of these S&T mismatches in the EU:

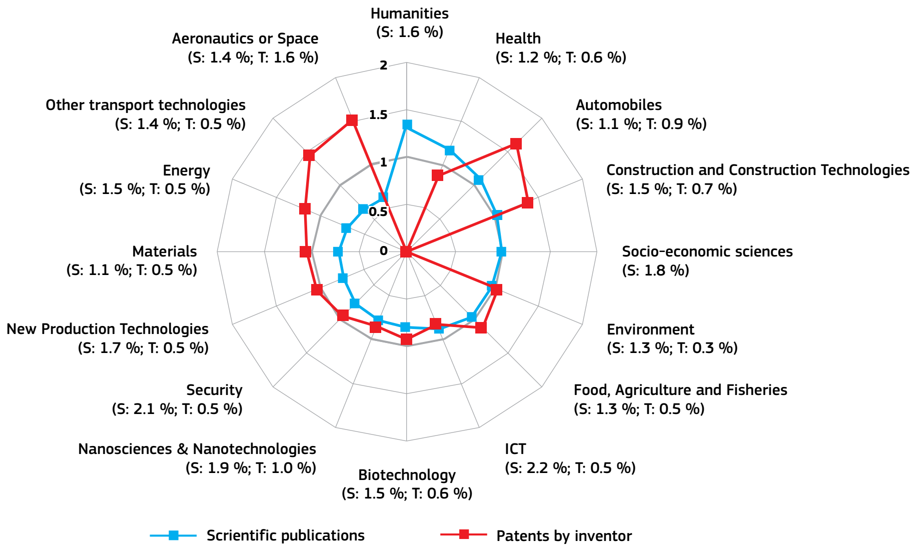
- In the areas of heath and ICT, there is a relatively strong scientific specialisation (coupled with citation rates which are slightly above average) but a weak technological specialisation. This situation compares unfavourably to the US and China where health and ICT, respectively, are areas of strong S&T co-specialisation. Consideration should be given in the EU to better articulating supply- and demand-side policies in these areas and improving the exploitation of research results.

- In the areas of energy, other transport technologies, and aeronautics and space, there is a strong technological specialisation but a very weak scientific specialisation. However, it is interesting to note that these three areas have the highest citation rates among all the scientific fields, which could indicate that it would be more efficient to increase the number of researchers and the amount of funding in these areas. Thus, consideration could be given to better prioritising these areas when allocating research funding.

Finally, it is noteworthy that all four areas of S&T mismatch in China correspond to areas where the scientific specialisation is very strong and the technological specialisation very weak, which indicates the orientation of the country's scientific efforts and its ambition to achieve better positions in the related technologies.

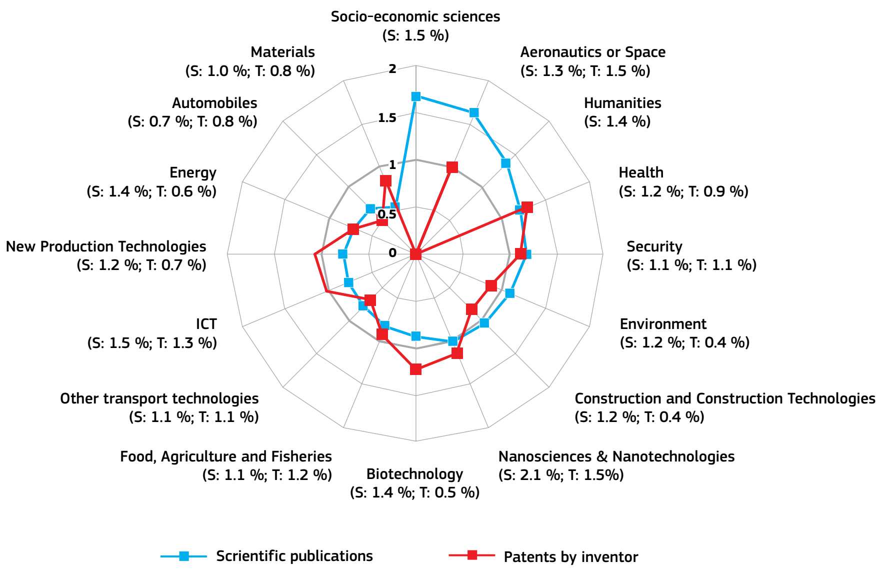
[17] For a more developed analysis see the Innovation Union Competitiveness paper, issue 2013/4 on the Europa website (http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=other-studies).

Figure 3 **EU (1) – S&T National Specialisation in FP7 thematic priorities, 2000–2010**
in brackets: growth rate in number of publications (4) (S) and in number of patents (5) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) EU: Croatia is not included.
(2) Values over 1 show specialisation, under 1 lack of specialisation.
(3) The Revealed Technology Advantage is calculated based on the data corresponding to the number of patent applications by country of inventors. For the thematic priorities with less than 5 patent applications over 2000–2010, the Revealed Technological Advantage (RTA) is not taken into account. Patent applications in "Aeronautics or Space" refers only to "Aeronautics" data.
(4) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(5) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Figure 4 **United States – S&T National Specialisation in FP7 thematic priorities, 2000–2010**
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
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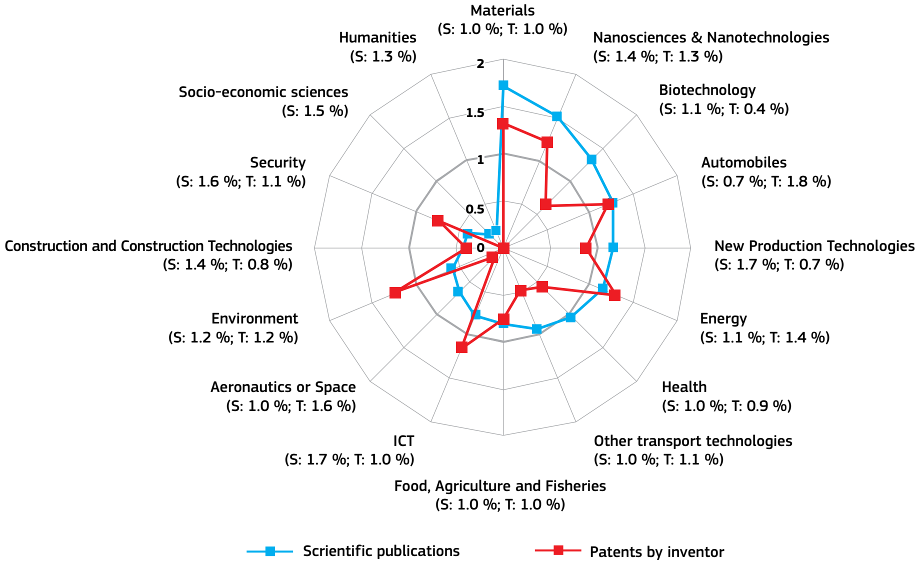
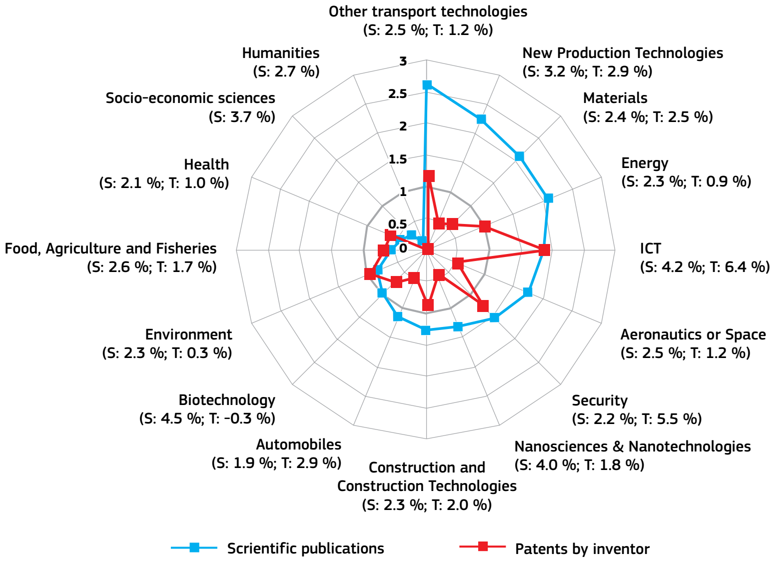
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Figure 5 **Japan – S&T National Specialisation in FP7 thematic priorities, 2000–2010**
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data corresponding to the number of patent applications by country of inventors. For the thematic priorities with less than 5 patent applications over 2000–2010, the Revealed Technological Advantage (RTA) is not taken into account. Patent applications in "Aeronautics or Space" refers only to "Aeronautics" data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Figure 6 **China – S&T National Specialisation in FP7 thematic priorities, 2000–2010**
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data corresponding to the number of patent applications by country of inventors. For the thematic priorities with less than 5 patent applications over 2000–2010, the Revealed Technological Advantage (RTA) is not taken into account. Patent applications in "Aeronautics or Space" refers only to "Aeronautics" data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

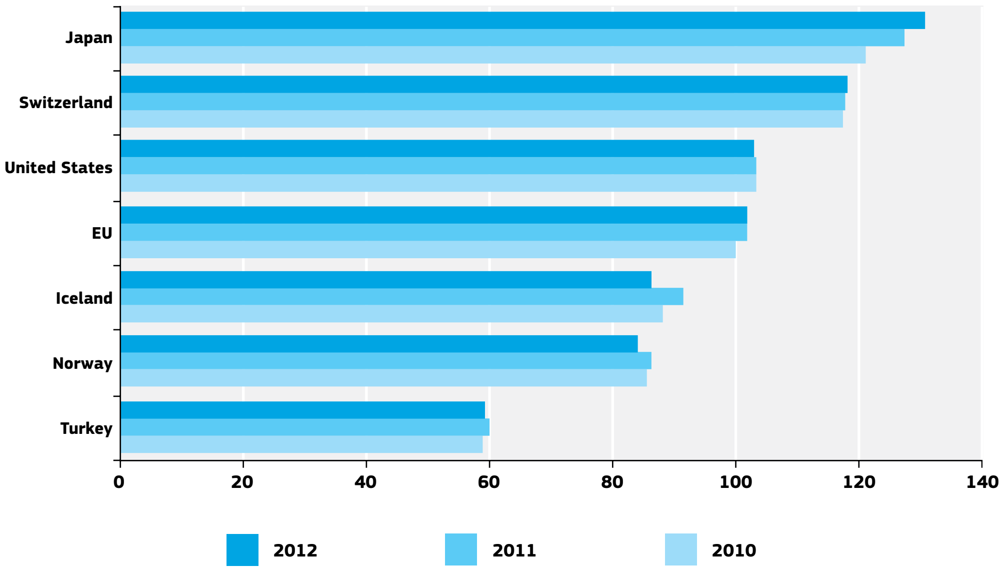
III. Innovation output: EU performance is improving slightly

The Innovation Output Indicator was developed by the Commission at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive.

The proposed new indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises[18]. It complements the R&D intensity indicator (3 % target of the Europe 2020 strategy) by focusing on innovation output. It will support policy-makers in establishing new or reinforced actions to remove bottlenecks preventing innovators from translating ideas into successful goods and services.

According to the Innovation Output Indicator, as a whole the EU performs relatively well. Despite the fact that Switzerland and Japan have a clear lead in performance, the EU is almost level with the United States.

Figure 7 Innovation Output Indicator

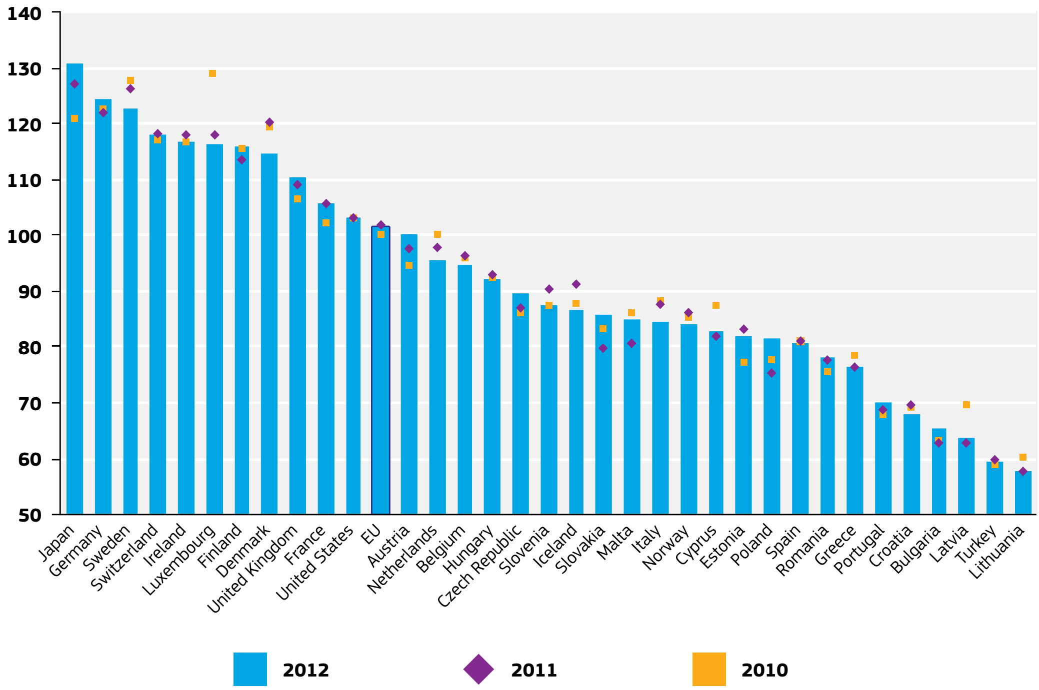


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Note: EU performance in 2010 corresponds to 100 (EU in 2010=100).

Although there was a slight improvement in performance in the EU as a whole over the period 2010-2012, it stagnated in the same period in Switzerland and the US, but moved further ahead in Japan. As a result, the EU's performance gap narrowed with Switzerland and the US, but increased with Japan. However, the observation period is still relatively short and these trends need to be confirmed.

18 Measured by a composite indicator covering the following components: PCT patent applications per billion GDP; employment in knowledge-intensive activities in business industries as a % of total employment; share of medium-/high-tech products in total goods exports, and knowledge-intensive service exports as a % of total service exports; and scores reflecting the average innovativeness of fast-growing firms.

Figure 8 **Innovation Output Indicator**



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Note: EU performance in 2010 corresponds to 100 (EU in 2010=100).

The top performers in the EU are the countries with a high R&D intensity: Germany and Sweden. They owe their high ranking to several or all of the following factors: an economy with a high share of knowledge-intensive sectors, fast-growing innovative firms, high levels of patenting, and competitive exports. Despite having a lower R&D intensity, Ireland and Luxembourg are also among the best performers, due in particular to their highly educated workforce (over half with tertiary attainment) and a high level of employment in both knowledge-intensive activities and knowledge-intensive service exports. Finland and Denmark come next in the EU ranking – they are both strong in R&D intensity, patents and knowledge-intensive activities. The EU's three lowest performers are Bulgaria, Latvia and Lithuania, countries with a very low R&D intensity. All three also perform at a very low level in patenting, in the knowledge orientation of the economy, and in corresponding exports. These three countries have not been successful in improving their performance since 2010.

The synthesis table below presents an overview of R&I performance in Member States and selected non-EU countries. The first column shows the latest R&D intensity of each country as well as its growth over the last decade. This input can be related to two new composite indicators on science and technology excellence and on structural change towards a more knowledge-intensive economy[19]. The European and country-specific performance in the Innovation Output Indicator is presented in a separate column. Finally, the last column, based on a recognised methodology used by the OECD, provides important insights on each country's competitiveness dynamic. In order to interpret it, parallel information on the trends in absolute values of exports is made available in each country profile.

[19] For an overview of these composite indicators, see the Methodological annex at the end of this document.

Overview of R&I performance in Member States and non-EU countries

	Country	R&D intensity (1) 2012		Excellence in S&T 2012		Innovation output indicator (3) 2012	Knowledge-intensity of economy 2012		HT&MT contribution to trade balance (2) 2012	
		value	growth rate (1)	value	growth rate (2007–2012)		value	growth rate (2007–2012)	value	growth rate (2)
EU	**European Union**	2.07 %	+2.4 %	47.8	+2.9 %	101.6	51.2	+1.0 %	4.2 %	+4.8 %
AT	**Austria**	2.84 %	+2.5 %	51.9	+3.6 %	100.1	45.3	+1.7 %	3.5 %	+10.0 %
BE	**Belgium**	2.24 %	+3.4 %	61.1	+3.2 %	94.8	60.8	+0.7 %	2.3 %	+7.0 %
BG	**Bulgaria**	0.64 %	+7.1 %	24.5	+0.3 %	65.3	33.5	+2.8 %	-5.2 %	n.a.
HR	**Croatia**	0.75 %	-1.3 %	18.9	+9.6 %	68.1	n.a	n.a.	1.0 %	+44.8 %
CY	**Cyprus**	0.46 %	+0.9 %	28.1	+1.4 %	82.8	40.7	+0.3 %	2.4 %	+31.9 %
CZ	**Czech Republic**	1.88 %	+6.6 %	26.1	+0.7 %	89.7	41.4	+1.6 %	3.8 %	+1.5 %
DK	**Denmark**	2.98 %	+3.0 %	81.1	+4.4 %	114.6	56.2	+2.0 %	-3.3 %	n.a.
EE	**Estonia**	2.18 %	+15.1 %	29.4	+13.4 %	81.7	49.5	+2.7 %	-2.9 %	n.a.
FI	**Finland**	3.55 %	+0.5 %	69.9	+5.1 %	115.7	55.8	+0.4 %	1.2 %	-5.7 %
FR	**France**	2.29 %	+1.0 %	49.5	+3.4 %	105.6	58.1	+0.5 %	5.2 %	+2.2 %
DE	**Germany**	2.98 %	+3.3 %	59.0	+2.2 %	124.2	47.1	+1.0 %	9.2 %	+1.7 %
EL	**Greece**	0.69 %	+0.6 %	27.2	-1.9 %	76.3	31.6	+0.8 %	-5.4 %	n.a.
HU	**Hungary**	1.30 %	+5.7 %	31.5	+2.4 %	92.0	54.4	+2.3 %	5.6 %	+4.5 %
IE	**Ireland**	1.72 %	+6.1 %	60.9	+14.6 %	116.5	68.2	+3.5 %	2.0 %	+11.6 %
IT	**Italy**	1.27 %	+1.5 %	36.5	-0.5 %	84.3	37.2	+0.9 %	4.8 %	+2.5 %
LV	**Latvia**	0.66 %	+2.0 %	19.9	+6.5 %	63.8	37.6	+3.5 %	-4.9 %	n.a.
LT	**Lithuania**	0.90 %	+2.2 %	14.1	+1.2 %	57.9	32.7	+1.7 %	-0.8 %	n.a.
LU	**Luxembourg**	1.46 %	-1.6 %	23.5	+1.6 %	116.4	68.1	+1.5 %	-4.4 %	n.a.
MT	**Malta**	0.84 %	+8.1 %	23.3	+5.6 %	84.8	55.3	+2.1 %	3.4 %	-18.4 %
NL	**Netherlands**	2.16 %	+0.9 %	79.7	+2.9 %	95.5	61.0	+0.1 %	0.9 %	+24.0 %
PL	**Poland**	0.90 %	+9.7 %	20.0	+9.8 %	81.4	34.8	+1.5 %	0.6 %	+14.7 %
PT	**Portugal**	1.50 %	-0.1 %	27.3	+3.7 %	70.1	42.6	+2.3 %	-0.3 %	n.a.
RO	**Romania**	0.49 %	-4.2 %	13.2	+2.3 %	78.0	27.5	+3.5 %	0.4 %	-14.2 %
SK	**Slovakia**	0.82 %	+12.3 %	25.2	+8.5 %	85.7	32.0	+0.6 %	3.9 %	+12.2 %
SI	**Slovenia**	2.80 %	+12.7 %	28.8	+9.9 %	87.4	50.3	+3.7 %	6.5 %	+9.4 %
ES	**Spain**	1.30 %	+0.5 %	33.2	+0.4 %	80.8	38.0	+2.1 %	3.3 %	+15.9 %
SE	**Sweden**	3.41 %	-0.2 %	87.9	+5.5 %	122.4	65.3	+2.0 %	1.8 %	+0.5 %
UK	**United Kingdom**	1.72 %	-0.3 %	63.5	+5.2 %	110.3	60.7	+0.6 %	4.2 %	+9.2 %
IS	**Iceland**	2.40 %	-2.8 %	38.7	+8.8 %	86.4	n.a	n.a.	-15.0 %	n.a.
IL	**Israel**	4.20 %	-2.5 %	64.5	-2.1 %	n.a.	n.a	n.a.	5.9 %	+8.7 %
NO	**Norway**	1.65 %	+0.7 %	67.6	+15.7 %	83.9	40.0	+2.4 %	-17.4 %	n.a.
CH	**Switzerland**	2.87 %	+0.5 %	97.7	+2.6 %	117.8	73.4	+0.8 %	8.1 %	+1.3 %
TR	**Turkey**	0.86 %	+4.4 %	17.6	+6.7 %	59.2	19.5	+5.3 %	-3.1 %	n.a.

Source: DG Research and Innovation – Unit for Analysis and monitoring of national research policies (2014)

Notes: (1) R&D intensity data refers to 2012 or latest year available (CH: 2008; IS, TR: 2011). The average annual growth rate refers to the period 2007–2012 or latest data available (IS, TR: 2007–2011; NL, RO: 2007–2010; PT: 2008–2012; SI: 2008–2010; FR: 2010–2012; CH: 2004–2008; EL: 2001–2007).

(2) HT&MT contribution to trade balance values refer to 2012 or latest year available (IT: 2011). The average annual growth rate refers to the period 2007–2012 or latest data available (IT: 2007–2011; HR, IE, PL, IL: 2008–2012; RO: 2009–2012). For countries with negative values of the HT&MT products contribution to the trade balance, in the period 2000–2010, the average annual growth rate cannot be provided.

(3) EU performance in 2010 corresponds to 100.

Austria

The challenge of further enhancing the innovation base of a knowledge-intensive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Austria. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance			
R&D intensity		***Excellence in S&T***[1]	
2012: **2.84 %**	(EU: 2.07 %; US: 2.79 %)	2012: **51.9**	(EU: 47.8; US: 58.1)
2007-2012: **+2.5 %**	(EU: +2.4 %; US: +1.2 %)	2007-2012: **+3.6 %**	(EU: +2.94 %; US: -0.24)
Innovation Output Indicator		***Knowledge-intensity of the economy***[2]	
2012: **100.1**	(EU: 101.6)	2012: **45.3**	(EU: 51.2; US: 59.9)
		2007-2012: **+1.7 %**	(EU: +1.01 %; US: +0.54 %)
Areas of marked S&T specialisations:		***HT + MT contribution to the trade balance***	
Energy, construction, environment, automobiles,		2012: **3.5 %**	(EU: 4.23 %; US: 1.02 %)
and other transport technologies		2007-2012: **+10.0 %**	(EU: +4.8 %; US: -32.3 %)

Austria has expanded its research and innovation system over the last decade with investments in R&I growing more quickly than the EU average. These efforts have been translated into a high and growing level of excellence in science and technology and clear strengths in key technologies for energy, environment and transport. The Austrian economy is characterised by specialised niche players, which require constant innovation, in particular technological innovation, in order to remain leaders in their market segment. Hence, the level of innovation in Austrian firms is relatively high. Overall, according to several indicators on trade, company innovations and patent revenues from abroad, the Austrian economy is – partly for structural reasons – less knowledge-intensive than many other EU Member States. However, the indexes on structural change and trade balance both point towards an upgrading of knowledge intensity linked to an increase in competitiveness.

Nevertheless, the efforts to boost research must be maintained, given the specialisation of the Austrian economy in a limited number of knowledge-intensive sectors where international competition is strong. These include, for example, transport technology, biotechnology and the energy sector. The economic crisis had less impact on Austria than in other Member States and its unemployment rate is currently the lowest in the EU. To maintain its competitiveness and hence its favourable economic position, the country depends on an ongoing high rate of innovation.

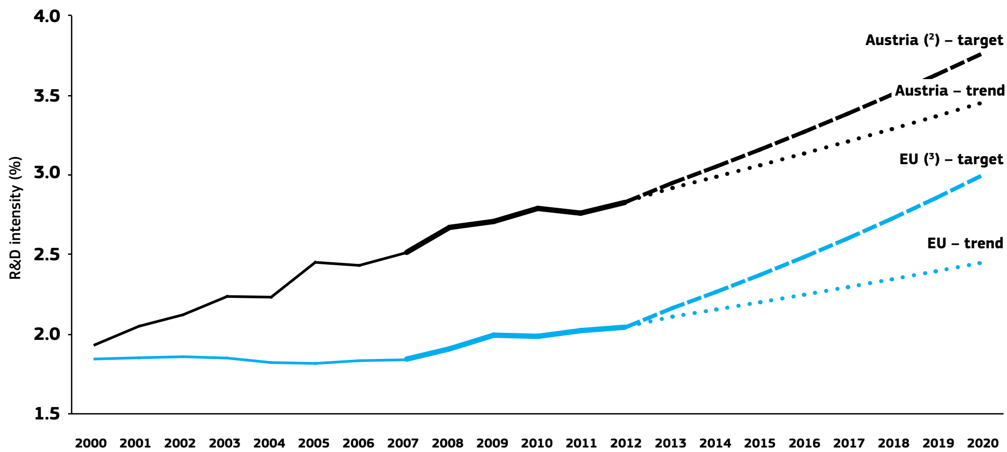
Austria's R&I policies are addressing these challenges by means of educational reform, improved governance of the R&D sector, establishing new research centres of excellence, setting up a more effective system of public research funding and, more generally, by promoting a further increase in the already high level of public and private investment in R&D.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

Investing in knowledge

Austria – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) AT: The projection is based on a tentative R&D intensity target of 3.76 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.

Austria has set a national R&D intensity target of 3.76 %, one percentage point above its performance in 2011 and the third highest national target among EU Member States. In the past decade, R&D intensity in Austria has progressed faster than the EU average – reaching 2.84 % in 2012. The trends during 2007-2012 imply that Austrian R&D intensity will progress further, but that additional efforts are required to achieve the ambitious national R&D intensity target.

Public spending on R&D as a % of GDP in Austria has shown a clear upward trend since 2002; it also increased both during and after the recession of 2009, despite budgetary constraints. In addition, business R&D as a % of GDP has expanded strongly during the last decade and is now among the highest in Europe. However, in recent years, progress in private spending has decelerated, with the share of GDP stagnating and a decline in absolute spending in real terms during the 2009 recession. From 2010, growth picked up in business R&D, with nominal growth surpassing 5 % in 2012.

Austrian R&I are also benefitting from support from the EU budget via co-funding for private and public R&D investment as well as other innovation, training and entrepreneurial activities.

A key instrument in recent years has been the Seventh Framework Programme for Research (FP7). At 22.5 %, Austrian applicants' success rate in FP7 is close to the EU average success rate of 22 %. Until mid-2013, over 3300 Austrian participants had been partners in an FP7 project, with a total EU financial contribution of EUR 1100 million.

Furthermore, Structural Funds are an important source of funding for R&I activities. For the European Regional Development Fund (ERDF) programme period 2007-2013, nearly EUR 360 million of the EUR 1200 million have been allocated from the EU budget to activities related to research, development and innovation in Austrian regions (RTDI)[1], whilst EUR 530 million has been spent on innovation in a broad sense (including entrepreneurship, innovative ICT, and human capital).

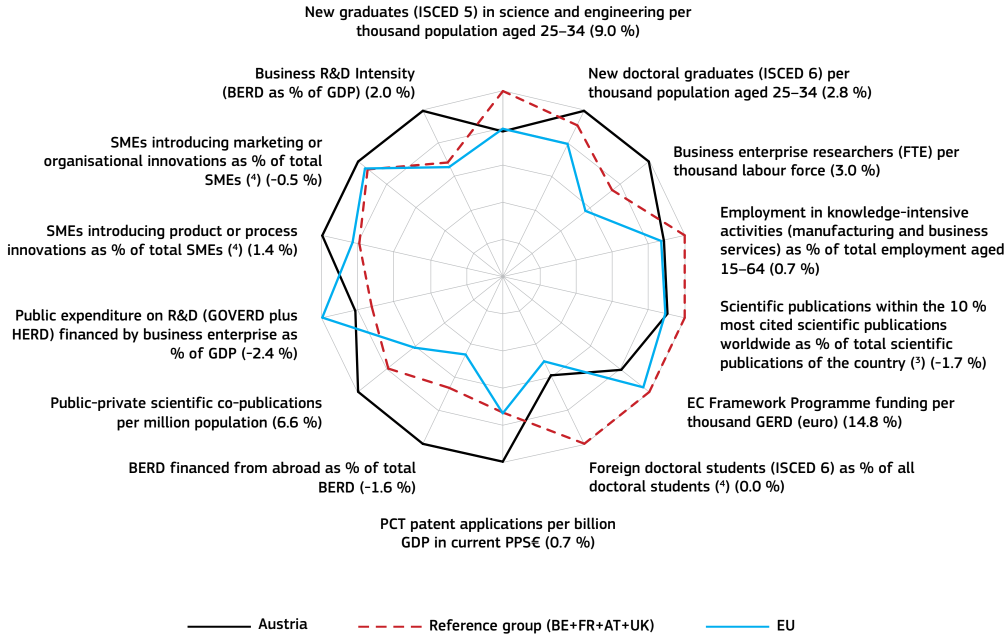
[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Austrian R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to 2012 (or the latest year) are given in brackets.

Austria, 2012 (1)

In brackets: average annual growth for Austria, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The graph shows that the Austrian R&I system is balanced and performing well in all areas: human resources, scientific production, technology development and innovation. In general, progress has also been good. However, there are some warning signs from falling marketing or organisational innovation in SMEs and declining shares in R&D investments by foreign firms. There has also been a decline in the share of foreign doctoral students, in public expenditure on R&D financed by business enterprises, and in the number of scientific publications within the 10 % most often cited.

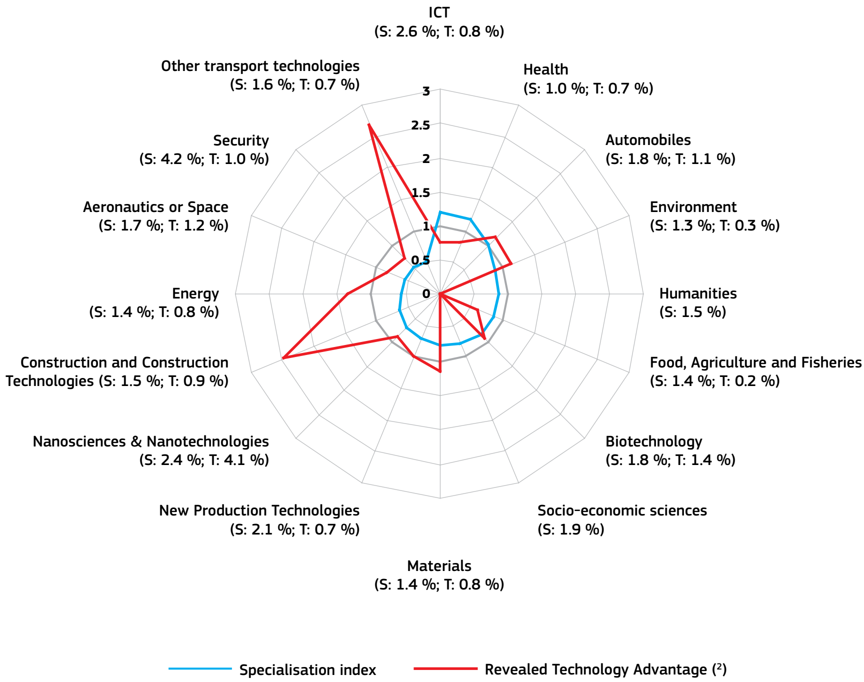
In the field of human resources for R&I, Austria is performing either at or above EU average and has made good progress since 2000. Traditionally, tertiary attainment has been low in Austria, with many graduates classified as post-secondary, non-tertiary (ISCED 4), although a relatively high share of Austrian students study science and technology subjects and an above-average proportion of them graduate at doctoral level.

Despite a strong inflow of foreign students, notably from Germany, Austria still has a lower share of foreign doctoral students than comparable countries – and the share has actually declined since 2007. Highly skilled graduates are quite well integrated into the Austrian economy, as evidenced by the relatively high number of business enterprise researchers and, linked to that, the country's good performance in the field of patent applications. Austria does not significantly outperform the EU average in high-quality scientific publications, nor in its success in international competitions for EU Framework Programme funding for R&D. The share of Austrian universities is high among those performing well in major international rankings, although they are not well represented at the very top of such rankings. In the past, Austria has improved public-private cooperation considerably, both in scientific production and in contract research by business enterprises working with public research organisations, and it now performs above the EU average in this field. It also performs well as regards innovation in SMEs.

Austria's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Austria shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Austria – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)

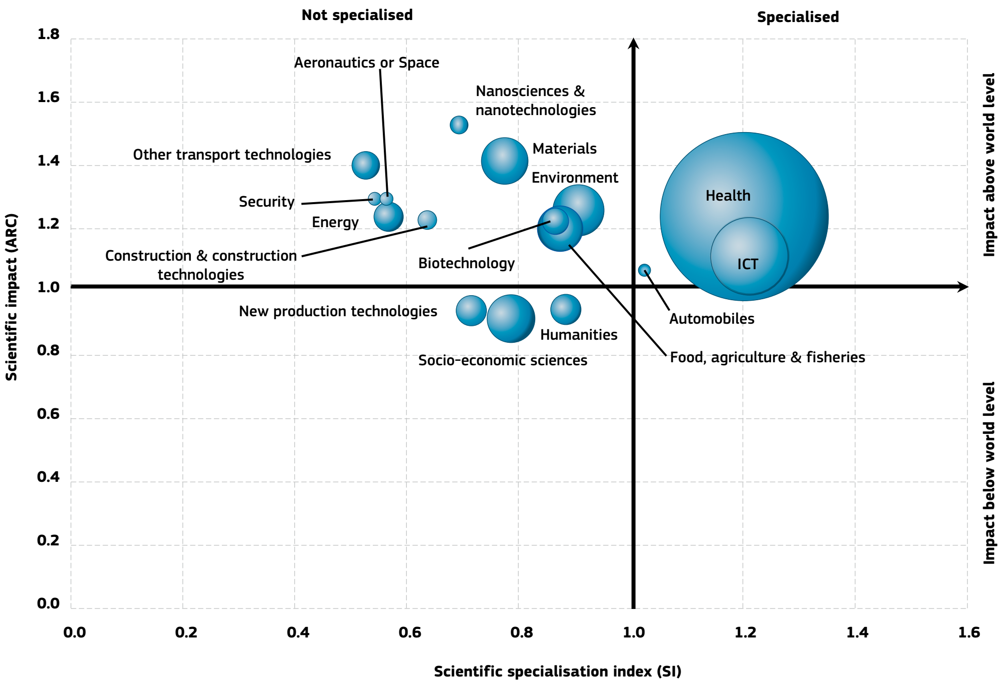


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

As illustrated in the graph above, there is a notable difference in performance between scientific production (publications) and technological production (patents) in Austria. As regards publications, Austria only shows specialisation in the fields of ICT, and health. There is a lack of specialisation in the other areas, notably in other transport technologies, energy and construction. With reference to patents (technological output), Austria has obvious strengths in other transport technologies and construction, and performs above the EU average in automobiles, environment and materials. There is a certain imbalance between those specialisations measured by citations and patents. Hence, Austria could profit more from its higher education system to better underpin its technological output.

The graph below illustrates the positional analysis of Austrian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Austria – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

Austria shows a high specialisation in health, and ICT publications, and some specialisation in automobiles. In all these areas, the scientific impact is above the global average. As regards the other areas, apart from humanities and socio-economic sciences (where the impact tends to be affected by a language bias) as well as new production technologies, the scientific impact is above the world level, despite a low specialisation index.

Policies and reforms for research and innovation

Austria is formulating R&D policies from a relatively favourable position in terms of overall R&D intensity. While research is among the priority areas in public spending, the share of private-sector expenditure on R&D in the total R&D expenditure fell from 71 % in 2007 to 69 % in 2012, thus putting at risk the achievement of the ambitious Europe 2020 R&D intensity target of 3.76 %. Among the factors attributed to the low growth in private spending in 2009-2011 are the economic crisis and a lack of venture capital (VC). However, the government has taken steps to stimulate additional private-sector spending on R&D and recently private spending growth has improved. In 2011, on the initiative of the Austrian Ministry for Transport, Innovation and Technology (bmvit), 22 of Austria's larger companies, representing more than one-fifth of the country's business enterprise research spending, have committed to increasing R&D spending by 20 % by 2015. This target had already been reached by 2013 (with a 24 % growth in spending).

The Austrian RTDI Strategy 'Becoming an innovation leader', which was published in 2011, puts forward many initiatives to improve the performance of the R&I system. These include initiatives to strengthen links to the education system, to increase the share of tertiary graduates, to promote high-quality research infrastructure and fundamental research, and to use public procurement to promote innovation.

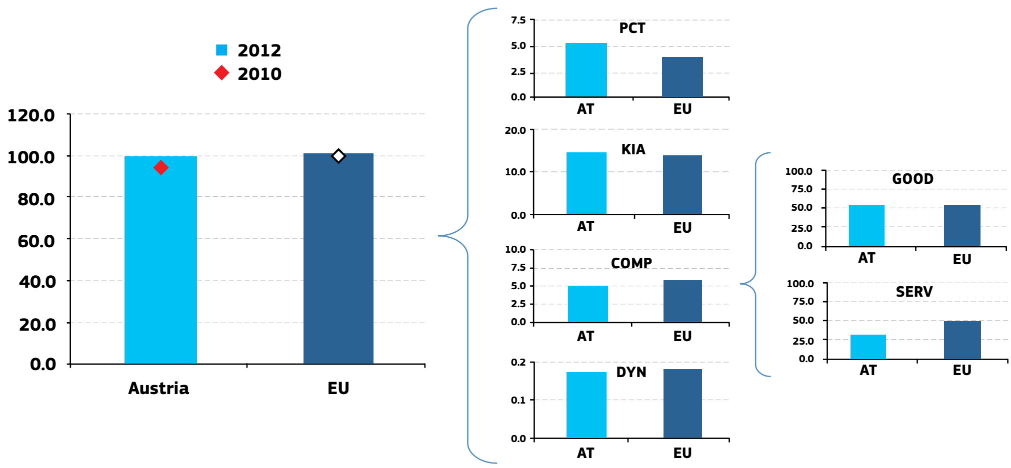
The Austrian government has set up a task force to implement the RTDI strategy. A key measure to stimulate private investment concerns the simplification of the tax regime for R&D activities to a single tax credit raised from 8 % to 10 %. In addition, the cap on the amount which can be subcontracted while remaining eligible for tax credit has risen from EUR 0.1 million to EUR 1 million. These measures, which are budget neutral, are expected to encourage subcontracting to research centres and universities. On the other hand, this approach favours established activities over the breakthrough research needed for an economy like Austria's. In July 2013' the public procurement law was updated and innovation was added as a secondary criterion.

As regards the sustainability of economic activities, which plays an important role in the public's acceptance of innovation and which in itself can also be a source of innovation, since 2012 the National Energy Strategy has aimed at increasing efficiency, energy security and the share of renewables. Funding is available for the greening of industries and an action plan was set up in October 2010 for Green Public Procurement. In 2011, a strategy paper was prepared to promote electrical mobility, and in 2012, a resource-efficiency action plan (REAP) was adopted. A Smart Grids Strategy is currently under preparation.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Austria's position regarding the indicator's different components:

Austria – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Austria is an average performer in the Innovation Output Indicator. However, its performance is improving as a result of mixed performance as regards the indicator's components.

The country performs relatively well on patents but only on or below average in the other areas. Austria's performance is relatively low in knowledge-intensive services exports. As regards employment in high-growth enterprises in innovative sectors, it performs near the EU average, although it is falling behind.

Austria's relatively good performance in patents is explained by its above-average share of industries (automobile, other transport equipment, biotechnology, ICT) which are patent-intensive thanks to the quality of the R&I system. The automobile/transport equipment industry and machinery also contribute to an above-average share of medium/high-tech exports.

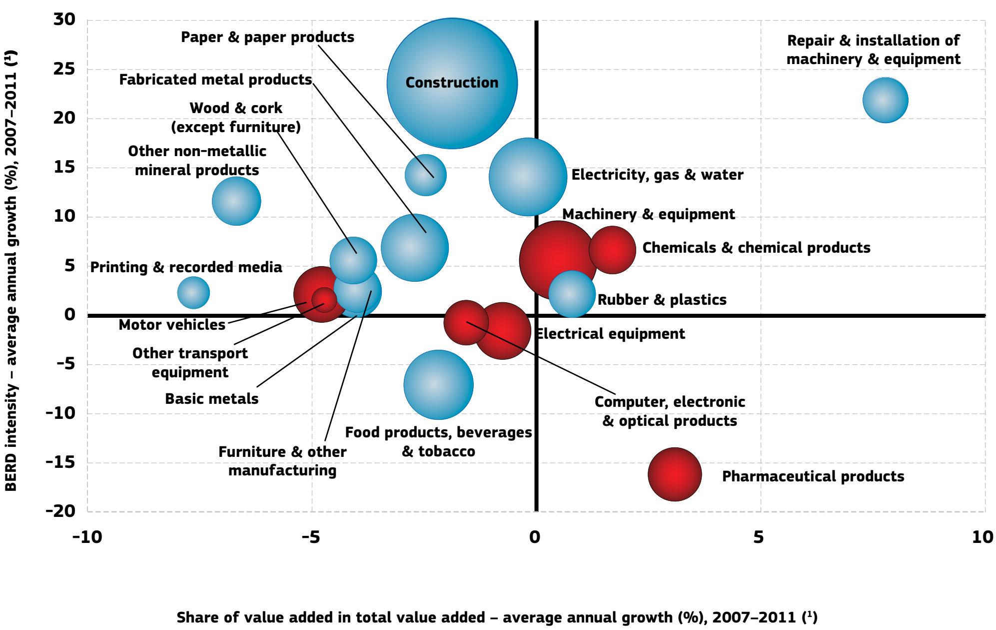
Tourism is an important economic sector in Austria, which is a leading winter tourism destination. It contributes to both a low share of employment in knowledge-intensive activities and, together with the export of services such as road and rail transport, which are not classified as knowledge-intensive, to a low share of knowledge-intensive services exports, as Austria has no particular strongholds in other knowledge-intensive service export areas to compensate for this specialisation pattern.

Expenditure on R&D is high by European standards, although Austria may not be exploiting and maintaining its innovative potential sufficiently. One reason for this is an underdeveloped venture capital market (in 2012, VC represented 0.04 % of GDP in Austria compared to the EU average of 0.29 %). It suffers from an unfavourable legal framework and from structural and other problems related to its VC market (e.g. small size and limited differentiation, general reluctance to invest in early stages, uncertainty concerning the treatment of non-incorporated companies as VC funds, etc.). In addition, the education system is facing the challenge of providing the basic skills required for innovation and competitiveness, while the low tertiary attainment rate and the general demographic development might lead to a scarcity of skilled people in the long term.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline of manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented in the graph). The red sectors are high-tech or medium-high-tech sectors.

Austria – Share of value added versus BERD intensity: average annual growth, 2007–2011 (1)



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Food products; beverages and tobacco products': 2009–2011.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

Austria is one of the EU countries with a high contribution of manufacturing industry to total value added (around 19 % compared to the EU average of 16 %). But, as in most other EU countries, the manufacturing sector's share of value added tends to decline over time. This is reflected in the general development towards a service-oriented economy, despite the fact that Austria's manufacturing industry has clearly increased its knowledge-intensity in many high- and medium-high-tech sectors as well as in most medium-low and low-tech sectors (with the notable exception of pharmaceutical products).

As in many other European countries, construction is one of the largest sectors in the economy. This sector's share of the economy has declined since the economic crisis, while its research intensity has improved significantly. In general, research intensity in Austria has increased more in low-tech sectors than in high-tech and medium-high-tech ones, although coming from a lower baseline. On the other hand, the chemicals and chemical products sector, as well as the machinery and equipment sector have seen a rise in research intensity and a parallel rise in economic importance, while the pharmaceutical sector has increased its share of the economy despite a significant decline in research intensity.

Key indicators for Austria

AUSTRIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	1.42	2.02	1.97	1.92	2.03	2.10	2.30	2.16	2.20	2.8	*1.81*	8
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	505	:	:	:	:	:	506	0.1 (3)	495 (4)	7 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	:	*1.72*	1.72	1.77	*1.85*	1.84	*1.91*	1.90	*1.95*	*2.0*	1.31	6
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	*0.74*	0.72	0.73	*0.81*	0.85	*0.88*	0.85	*0.87*	*3.6*	*0.74*	7
Venture capital as % of GDP	0.08	0.06	0.06	0.14	0.08	0.05	0.04	0.04	0.04	-23.7	0.29 (5)	17 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	43.4	:	:	:	:	51.9	3.6	47.8	9
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	10.7	10.8	11.5	11.0	11.1	:	:	:	-1.7	11.0	10
International scientific co-publications per million population	:	770	795	907	985	1035	1111	1206	1248	6.6	343	7
Public–private scientific co-publications per million population	:	:	:	67	70	77	84	86	:	6.6	53	6
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	3.8	5.0	5.3	5.2	4.6	5.2	5.3	:	:	0.7	3.9	6
License and patent revenues from abroad as % of GDP	:	0.13	0.16	0.20	0.22	0.19	0.18	0.17	0.20	0.1	0.59	15
Community trademark (CTM) applications per million population	93	168	222	235	240	268	303	315	343	7.9	152	4
Community design (CD) applications per million population	:	38	43	50	46	49	49	53	55	2.0	29	4
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	13.6	:	11.2	:	11.9	:	:	2.9	14.4	16
Knowledge-intensive services exports as % total service exports	:	21.8	22.7	24.0	22.8	23.1	22.3	23.8	:	-0.2	45.3	22
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-1.83	1.59	2.41	2.20	2.69	2.29	2.59	3.18	3.55	-	4.23 (6)	9
Growth of total factor productivity (total economy): 2007 = 100	93	96	98	100	100	96	97	98	98	-2 (7)	97	10
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	41.6	:	:	:	:	45.3	1.7	51.2	15
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	13.8	14.2	14.4	14.0	14.2	0.7	13.9	13
SMEs introducing product or process innovations as % of SMEs	:	:	47.8	:	39.6	:	40.7	:	:	1.4	33.8	9
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.47	0.44	0.48	0.60	0.63	0.69	:	:	:	6.9	0.44	5
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.55	0.65	0.78	0.79	0.64	0.67	:	:	:	-7.6	0.53	7
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	71.4	71.7	73.2	74.4	75.1	74.7	74.9	75.2	75.6	0.3	68.4	4
R&D intensity (GERD as % of GDP)	*1.93*	*2.46*	2.44	2.51	*2.67*	2.71	*2.80*	2.77	*2.84*	*2.5*	*2.07*	5
Greenhouse gas emissions: 1990 = 100	104	120	117	113	113	104	110	108	:	-6 (8)	83	23 (9)
Share of renewable energy in gross final energy consumption (%)	:	23.8	25.3	27.2	28.3	30.2	30.6	30.9	:	3.2	13.0	4
Share of population aged 30–34 who have successfully completed tertiary education (%)	:	20.5	21.2	21.1	22.2	23.5	23.5	23.8	26.3	4.5	35.7	22
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	10.2	9.1	9.8	10.7	10.1	8.7	8.3	8.3	7.6	-6.6	12.7	8 (9)
Share of population at risk of poverty or social exclusion (%)	:	16.8	17.8	16.7	18.6	17.0	16.6	16.9	18.5 (10)	0.3	24.8	6 (9)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(9) The values for this indicator were ranked from lowest to highest.
(10) Break in series between 2012 and the previous years. Average annual growth refers to 2007–2011.
(11) Values in italics are estimated or provisional.

Belgium

The challenge of fostering innovation-based competitiveness

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Belgium. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance			
R&D intensity		***Excellence in S&T***[1]	
2012: **2.24 %**	(EU: 2.07 %; US: 2.79 %)	2012: **61.1**	(EU: 47.8; US: 58.1)
2007-2012: **+3.4 %**	(EU: +2.4 %; US: 1.2 %)	2007-2012: **+3.2 %**	(EU: +2.9 %; US: -0.2)
Innovation Output Indicator		***Knowledge-intensity of the economy***[2]	
2012: **94.8**	(EU: 101.6)	2012: **60.8**	(EU: 51.2; US: 59.9)
		2007-2012: **+0.7 %**	(EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations:		***HT + MT contribution to the trade balance***	
Biotechnology, food and agriculture		2012: **2.3 %**	(EU: 4.23 %; US: 1.02 %)
		2007-2012: **+7.0 %**	(EU: +4.8 %; US: -32.3 %)

Belgium has a very high-quality research system, as reflected by its high score on the S&T excellence index. It has been able to exploit this strength to its economic advantage in several sectors, thanks in particular to a relatively good matching of the specialisations of its science base with its economy. Businesses have many opportunities to cooperate with universities and public research organisations and, since 2005, have significantly increased their R&D investment in Belgium. In the same period, the contribution of high-tech and medium-tech (HT & MT) products to the trade balance has also increased. A particularly good performance is clearly visible in the bio-pharmaceutical sector, where high scientific quality, business investment, product innovation and trade performance reinforce each other. But beyond the key role of this sector, a more generalised knowledge intensification within the economy and, to some extent, a broadening of the innovation base seem to have developed in recent years in Belgium, although this is still too limited.

In order to better translate the strengths of its research and innovation system into general economic performance, Belgium needs to accelerate the renewal of its economic fabric: it needs more firms able to grow in innovative and knowledge-intensive sectors. The country's weaknesses in terms of entrepreneurship and company dynamics are slowing this necessary renewal. One specific issue to be watched is the shortage of skilled professionals, notably in sciences and engineering, which could become a major barrier to further improving the Belgian economy's innovation performance.

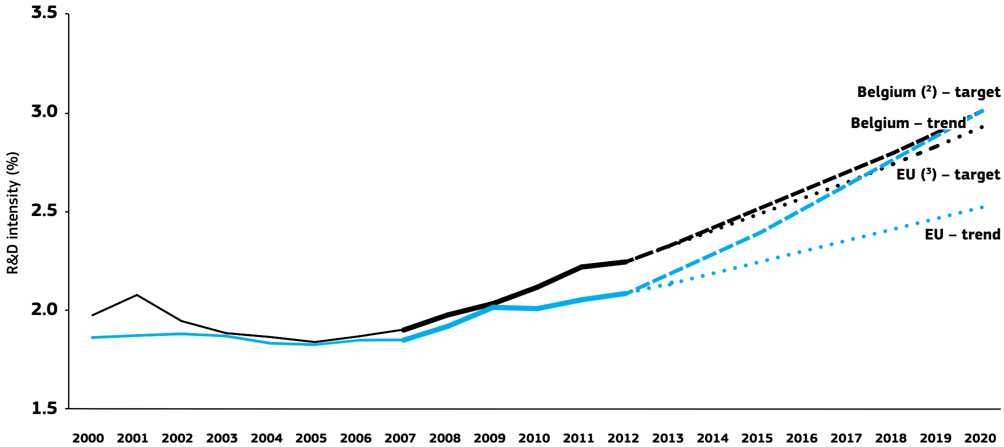
There is a consensus in Belgium about the critical importance of fostering the innovation-based competiveness of Belgian businesses. This has been reflected by all political entities in the development of sophisticated and comprehensive policy mixes at national and regional levels and in significant budgetary efforts in favour of R&D. At federal level, tax incentives for R&D are an important tool. In the Walloon Region, the focus has been on supporting a limited number of competitiveness poles (a cluster approach). In the Flemish Region, the willingness to address some specific societal challenges through innovation is a main driver of research and innovation policy. In the Brussels Capital Region, the updated innovation strategy includes a 'smart specialisation' approach.

[1] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

[2] Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Investing in knowledge

Belgium – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) BE: The projection is based on a tentative R&D intensity target of 3.0% for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.

Belgium seems broadly on track to reach its R&D intensity target of 3 % for 2020. R&D intensity has increased continuously since 2005, thanks to growth in both public (from 0.56 % in 2005 to 0.7 % in 2012) and business R&D (from 1.24 % to 1.52 %) intensities.

With reference to the breakdown of business R&D expenditure (BERD) by product fields, the increase in Belgian business R&D intensity since 2005 has been driven by the very strong growth of R&D expenditure related to pharmaceuticals (accounting for 31 % of BERD in 2011 vs. 25 % in 2005) and to services (21 % of BERD in 2011 vs. 17 % in 2005, with telecommunication services and computer-related services each accounting for 5 % of BERD). On the contrary, there was a very rapid decrease in R&D expenditure in the manufacturing sector 'Computer, electronic and optical products', reducing its share in BERD from 17 % in 2005 to 8 % in 2011. As regards chemicals and chemical products (excluding pharmaceuticals), the reduction in share from 13 % in 2005 to 10 % in 2011 corresponds to similar volumes of expenditure in 2005 and 2011 in real terms; although there was actually a trend reversal in 2007: a decrease until 2007, then an increase from 2007.

Belgium has been very successful in the Seventh Framework Programme (FP7). Almost 5600 Belgian participants have been partners in a FP7 project (success rate of 27 %), well above the EU average of 22 %), with a total EC financial contribution of EUR 1.75 billion. Structural Funds are another important source of funding for research and innovation activities. Of the EUR 2 billion of Structural Funds allocated to Belgium over the 2007-2013 programming period, around EUR 88 million (14 % of the total) relate to RTDI[1].

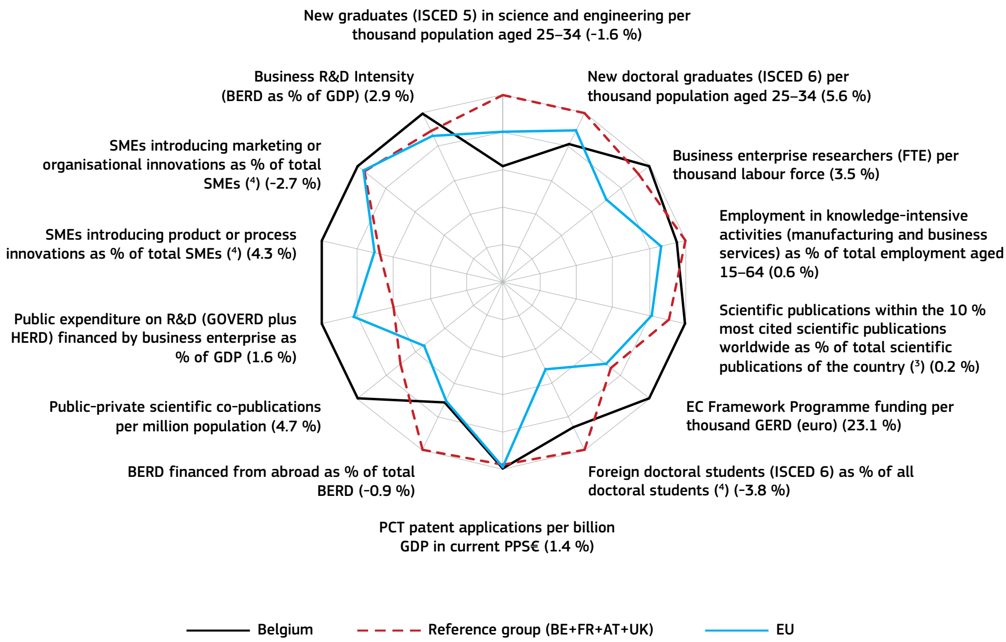
3 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Belgium's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Belgium, 2012 (1)

In brackets: average annual growth for Belgium, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The overall shape of the graph highlights the strong performance of the Belgian research and innovation system. Belgium scores higher than the EU average for the vast majority of the indicators. In particular, it has a high-quality public research and higher education system, characterised by a strong international openness. The quality of the Belgian research system is evidenced by the high share of its scientific publications within the top 10 % most-cited scientific publications worldwide[2], the country's strong position in the context of the EU R&D Framework Programmes, as well as its attractiveness for foreign doctoral students. Its international openness is further highlighted by the highest 'Collaboration Index'[3] of all the EU Member States (1.33). Belgium also performs well above the EU average for the two indicators on cooperation between public research institutions and firms (co-publications and business funding of public R&D), confirming the quality of the public scientific and technological base and highlighting its relevance for businesses.

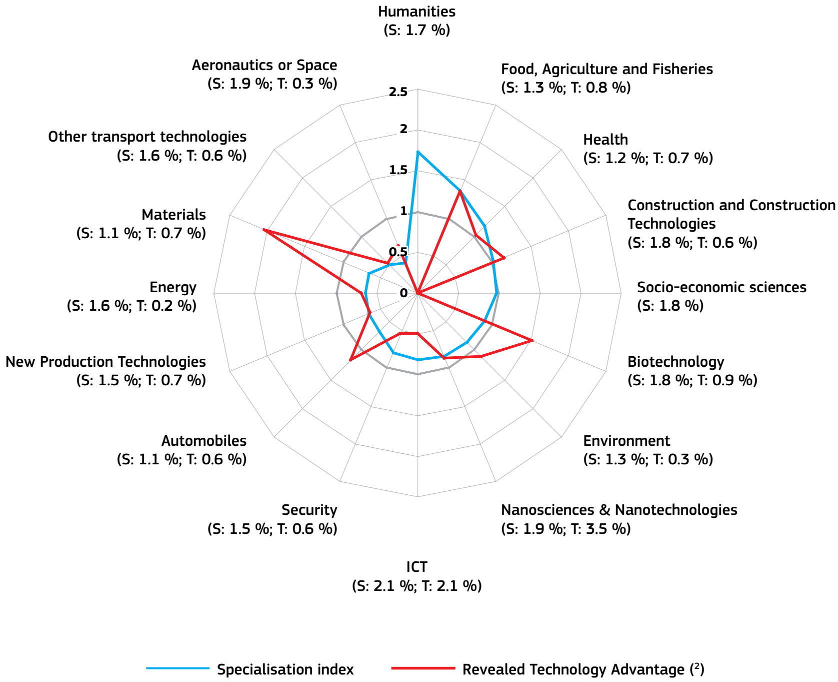
As shown on the graph, a weak point in the Belgian research system is the share of science and engineering graduates in the 25-34 years age group which is lower than the EU average: this raises the question of whether in future Belgium will be able to ensure the availability of a pool of highly skilled human resources necessary to keep an innovation-based economy up to speed.

4 13.4 %, well above the EU average of 10.9 % – this is the third best EU performance.
5 Index calculated by Science-Metrix, based on the number of co-publications while taking into account the size of national scientific output.

Belgium's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Belgium shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Belgium – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



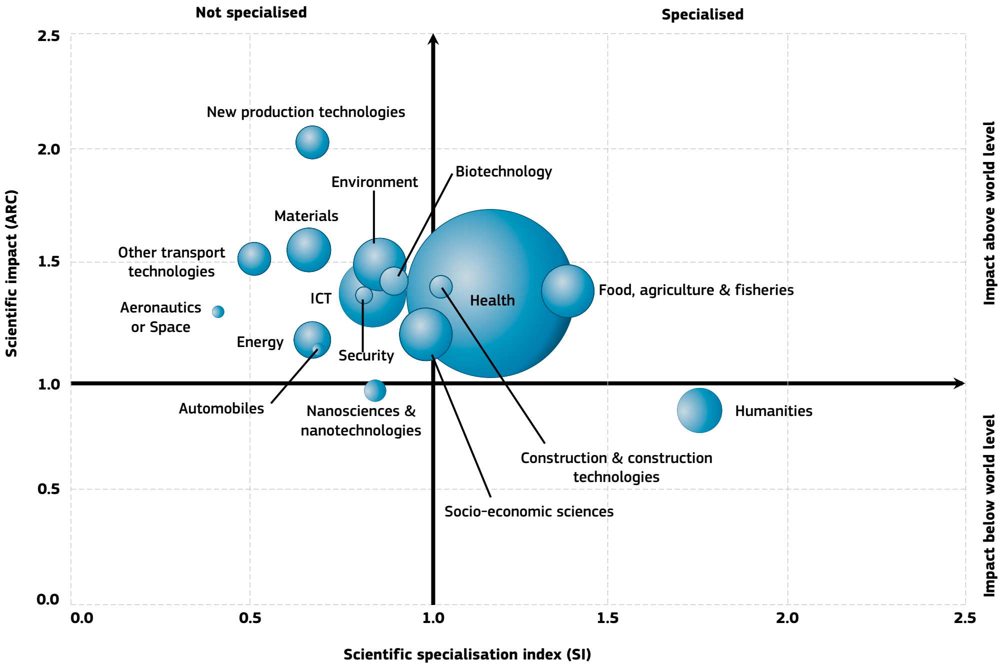
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

The graph above shows Belgium's strong technological specialisations (as measured by the number of patents) in materials, biotechnology[4] and food, agriculture and fisheries, as well as less prominent specialisations in construction, automobiles, environment and health. While in most of these areas the graph indicates a co-specialisation of the science base, based on the number of publications, revealing clear synergies between scientific activities and technological innovativeness, a striking exception is materials and, to a lesser extent, automobiles, where the volumes of scientific production are relatively limited.

The graph below illustrates the positional analysis of Belgian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

[6] Based on patenting activities, Belgium is in fact the most specialised EU Member State in materials and the second most specialised (after Denmark) in biotechnology.

Belgium – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The graph above shows that the excellence of the Belgian science base as measured through citations is consistent across nearly all fields – only two areas have an ARC[5] below 1: nanosciences and nanotechnologies and humanities.

A joint reading of the two graphs above indicates that in many areas the very high quality of the science base supports technological innovativeness: this is the case in materials, biotech, construction, food, agriculture and fisheries, and the environment. However, this appears less so in new production technologies, where there is a very high ARC in the absence of any specialisation: it might be interesting to reflect on how to best exploit this scientific strength.

Materials-related sciences present a particular situation which deserves to be highlighted. The spider graph shows a very strong technological specialisation which is not matched by a corresponding science-base specialisation. The bubble graph indicates that scientific production in materials has a high scientific impact: taking into account both its excellence and its high relevance for the Belgian industry, it might be interesting to consider 'thickening' the science base in materials by increasing its volume of funding and activities.

Policies and reforms for research and innovation

In Belgium, policies and funding for research and innovation are mainly in the hands of the regions and communities, although the federal authorities still play an important role in some specific areas (e.g. space) as well as through tax instruments. The country's broad consensus on the critical importance of further fostering the innovation-based competitiveness of businesses is reflected in the development of sophisticated and comprehensive policy mixes by each Belgian region.

[7] The ARC (Average of Relative Citations) is an indicator of the scientific impact of papers produced by a given entity relative to the world average (i.e. the expected number of citations).

The **Flanders Region** STI policy includes a "challenge-driven innovation policy" with six thematic "innovation hubs" for addressing societal challenges. In 2013, various efforts were made to target a broadening of the Flemish innovation base, notably with the launch of the SPRINT projects for companies with low R&D intensities and the new 'VIS-trajectories' for innovation followers. Extra budgets were allocated for the SOFI fund which aims to set up spin-off companies from research results from universities and public research organisations (PROs). Thanks to the reinforced orientation towards small and medium-sized enterprises by the IWT (the Flemish agency for innovation through science and technology), 40 % of its innovation support now goes to SMEs. The campaign 'ik innoveer' (I innovate) was launched to increase the innovation capacity of Flemish SMEs. Other demand-driven initiatives include (new) living laboratories for social innovation or construction renovation, as well as some pilot projects on innovative procurement. The 'New industrial policy' developed since 2011 and supported by the TINA fund[6] will lead to a more cluster-driven policy. A key instrument for such a targeted cluster policy will be the development of strategic roadmaps for each spearhead cluster. Flanders is also continuing its policy of developing public research organisations able to provide high-quality service to businesses, with the establishment of a similar organisation in the field of advanced manufacturing. In addition, the STEM action plan aims to attract more students in scientific and technological fields.

Since the launch of the first Walloon 'Marshall Plan' in 2004, the **Walloon Region** has adopted a strategic approach to its economic redeployment which integrates R&I as a key tool and focuses on supporting a limited number of "competitiveness poles" (a cluster approach). In the context of the on-going version of the Plan (Marshall Plan 2.Vert of 2009), the most recent developments relating to the competitiveness poles have been the launch of trans-sectorial innovation platforms and new tools specifically targeted at SMEs, with a particular focus on their integration in international value chains. The competitiveness poles approach is further strengthened in the new Marshall Plan 2022, which also integrates educational aspects as well as several actions targeting entrepreneurship. The implementation of both the Research Strategy 2011-2015, with a particular focus on SMEs (transfer of knowledge, collaboration with research centres, green fund for young innovative enterprises, etc.) and the 'Creative Wallonia' Plan have been pursued. New approaches have been developed under this Plan, such as in the field of support to market take-up for new products and services (technologically based or otherwise), creativity and innovation awareness and training, support for start-ups, and promotion of the creative economy.

The **Brussels Capital Region** is continuing the implementation of its innovation strategy which was updated in 2012 and includes a 'smart specialisation' approach. In 2013, Brussels managed EUR 40 million in RDI funding for enterprises and universities within the region, and EUR 8.2 million of which was devoted to setting up the strategic platform programme ICT4 Health. This strategic platform programme concept, in which collaborative university projects are designed to meet the needs of industry and the public authorities, will continue to be pursued. In 2014, two other strategic platform programmes – Data Security and Smart City and Mobility – will also be set up.

While budgetary efforts by all federated entities to support R&D led to an increase of GBAORD (government budget appropriations for research and development) of 23 % in real terms between 2005 and 2008, Belgian's GBAORD has stagnated since then (-4.5 % in real terms between 2008 and 2012). However, this has to be seen in the context of the development of powerful R&D tax incentives[7] with, at federal level in particular, a payroll tax exemption for researchers (which was increased to 80 % as of 1 July 2013) and a tax deduction amounting to 80 % of patent income. This has led to a situation where revenues foregone due to R&D tax incentives now represent around double the amount of direct public funding of business R&D. Taking into account both forms of support, public support for business R&D in Belgium represents a higher share of GDP (0.27 %) than in most other EU Member States. The way in which the public funding of research is organised by the various authorities funding research contributes to the very high efficiency, openness and quality of the Belgian research system. About half of the public funding is allocated through project-based competition (representing one of the highest rates in the EU) and Belgium is also committed to many transnationally coordinated funding systems[8].

8 An investment fund with EUR 200 million at its disposal to help reform the Flemish economy through innovation.

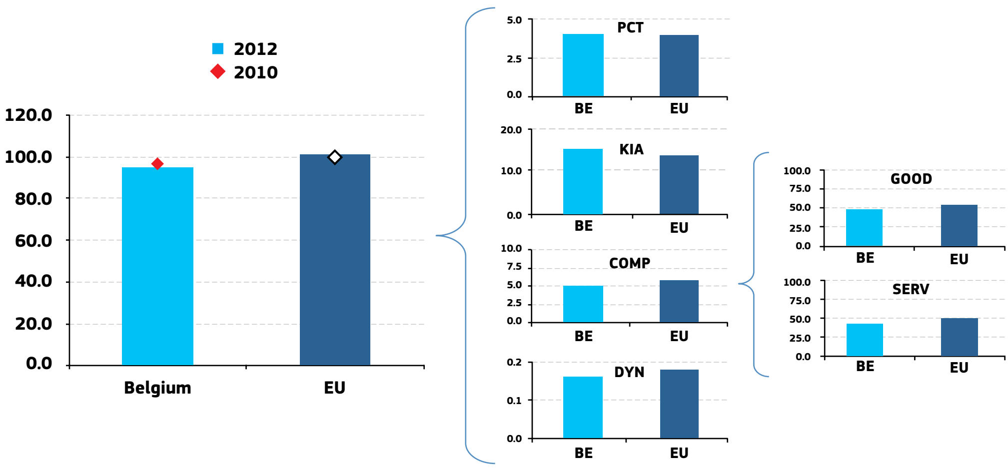
9 Foregone tax revenues due to such incentives are not included in GBAORD.

10 In particular, through participation in Europe-wide actions such as ESA, Article 185 initiatives, Joint Technology Initiatives with national funding, ERA-NET joint calls and projects from the ESFRI roadmap.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Belgium's position regarding the indicator's different components:

Belgium – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Belgium is a medium performer in the innovation indicator. While its scores on most components are close to the EU average, it is performing markedly better with respect to employment in knowledge-intensive activities.

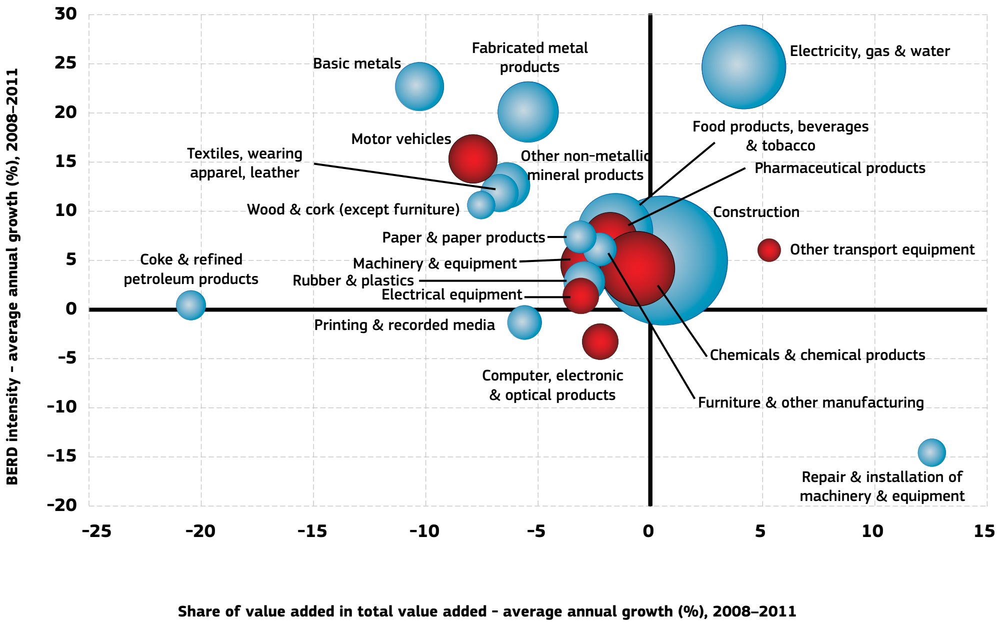
Its composite score is dragged down by its share of MHT exports and the share of knowledge-intensive services in services exports, which are both below the EU average. The latter is explained in particular by the high volume of exports in some logistics-, transport- and trade-related services, which are linked to its geographical intermediation role and which are classified as non-knowledge intensive. As the country's low scores for this indicator reflect some specificities of its economic structure which are unrelated to any underperformance, Belgium's situation in terms of innovation output is more positive than the impression given by the indicator.

Belgium also scores relatively poorly on the DYN component (fast-growing innovative enterprises), since a comparatively high share of its fast-growing companies is in sectors with low innovativeness scores, such as construction and transport. The country needs more fast-growing firms in innovative sectors to accelerate the renewal of its economic fabric and to speed up the transition towards a more knowledge-intensive and innovation-driven economy.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries for the period 2008-2011. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects a decrease in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Belgium – Share of value added versus BERD intensity: average annual growth, 2008–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: (1) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The graph shows that, throughout the crisis, the de-industrialisation trend continued in Belgium with the shares in total value added in nearly all manufacturing sectors decreasing between 2008 and 2011: this evolution is similar to that observed at the EU level as a whole. One striking exception, however, is the 'Other transport equipment' sector showing very good strong growth dynamics in value added coupled with even stronger growth in R&D expenditure (concentrated in aeronautics). The graph also shows that the high-tech and medium-high-tech sectors (in red) have remained more resilient in Belgium throughout these crisis years than the other manufacturing sectors. The 'Motor vehicles' sector appears to be an exception, being the only 'red' sector with an annual decrease in value added of more than 5 %.

The very rapid increase of R&D intensities shown on the graph in several sectors should be interpreted with caution as they concern sectors where the absolute levels of R&D expenditure are actually quite low[9]. Nevertheless, the graph does show that R&D intensities have grown in most sectors: beyond the key role of the pharmaceutical sector indicated on page 2 above, a fairly generalised knowledge intensification of the economy and, to some extent, a broadening of the innovation base seem to have developed in recent years in Belgium, although this remains too limited. In 2011, 43 % of the BERD was still concentrated in large firms (of more than 1000 employees) as against 46 % in 2002. Reducing administrative barriers and overall complexity of incentive schemes need to be part of the policy efforts to broaden the innovation base towards SMEs.

[11] This is also the case for the 'Motor vehicles' sector where the level of R&D expenditure in Belgium is very low, far off the level in the countries of origin of the car-manufacturing companies.

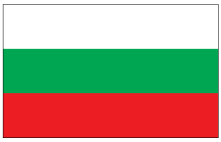
Key indicators for Belgium

BELGIUM	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.79	1.16	1.25	1.25	1.37	1.38	1.53	1.52	1.65	5.6	*1.81*	15
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	520	:	:	515	:	:	515	-0.2 (3)	495 (4)	5 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	1.42	1.24	1.29	1.32	1.34	1.34	1.41	1.52	*1.52*	*2.9*	1.31	7
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.52	0.56	0.55	0.55	0.61	0.66	0.67	0.67	*0.70*	*4.8*	*0.74*	10
Venture capital as % of GDP	0.22	0.06	0.29	0.31	0.18	0.29	0.13	0.16	0.14	-15.2	0.29 (5)	13 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	52.3	:	:	:	:	61.1	3.2	47.8	6
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	12.8	13.0	13.3	13.5	13.4	:	:	:	0.2	11.0	3
International scientific co-publications per million population	:	887	914	1004	1079	1146	1208	1299	1313	5.5	343	6
Public–private scientific co-publications per million population	:	:	:	81	85	88	90	97	:	4.7	53	5
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	3.3	3.6	3.7	3.8	3.5	3.8	3.9	:	:	1.4	3.9	8
License and patent revenues from abroad as % of GDP	:	0.36	0.39	0.36	0.30	0.53	0.53	0.50	0.55	8.6	0.59	8
Community trademark (CTM) applications per million population	77	95	105	124	128	161	170	164	156	4.7	152	14
Community design (CD) applications per million population	:	28	27	31	28	31	33	33	30	-0.3	29	9
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	13.6	:	9.5	:	12.4	:	:	14.1	14.4	14
Knowledge-intensive services exports as % total service exports	:	41.9	42.7	37.6	40.1	41.7	41.9	42.3	:	3.0	45.3	9
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	0.80	1.06	1.81	1.61	1.69	1.17	1.46	2.37	2.27	-	4.23 (6)	13
Growth of total factor productivity (total economy): 2007 = 100	96	98	99	100	99	96	97	98	97	-3 (7)	97	13
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	58.6	:	:	:	:	60.8	0.7	51.2	5
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	14.9	14.4	14.6	14.9	15.2	0.6	13.9	11
SMEs introducing product or process innovations as % of SMEs	:	:	45.4	:	44.0	:	47.8	:	:	4.3	33.8	2
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.28	0.23	0.24	0.29	0.33	0.32	:	:	:	5.4	0.44	8
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.76	0.88	0.69	0.59	0.51	0.61	:	:	:	1.8	0.53	8
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	65.8	66.5	66.5	67.7	68.0	67.1	67.6	67.3	67.2	-0.1	68.4	16
R&D intensity (GERD as % of GDP)	1.97	1.83	1.86	1.89	1.97	2.03	2.10	2.21	*2.24*	*3.4*	*2.07*	8
Greenhouse gas emissions: 1990 = 100	103	100	97	94	96	88	93	85	:	-9 (8)	83	12 (9)
Share of renewable energy in gross final energy consumption (%)	:	*2.3*	*2.6*	*2.9*	*3.2*	*4.4*	*4.9*	*4.1*	:	*9.0*	13.0	25
Share of population aged 30–34 who have successfully completed tertiary education (%)	35.2	39.1	41.4	41.5	42.9	42.0	44.4	42.6	43.9	1.1	35.7	8
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	13.8	12.9	12.6	12.1	12.0	11.1	11.9	12.3	12.0	-0.2	12.7	21 (9)
Share of population at risk of poverty or social exclusion (%)	:	22.6	21.5	21.6	20.8	20.2	20.8	21.0	*21.6*	*0.0*	24.8	12 (9)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(9) The values for this indicator were ranked from lowest to highest.
(10) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Restore competitiveness […] by promoting innovation through streamlined incentive schemes and reduced administrative barriers."



Bulgaria

Seizing the economic growth potential of innovation – policy coordination and strategic planning

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Bulgaria. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.64 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+7.1 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **24.5** (EU: 47.8; US: 58.1) 2007-2012: **+0.3 %** (EU: +2.9 %; US: -0.2)
Innovation output indicator 2012: **65.3** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **33.5** (EU: 51.2; US: 59.9) 2007-2012: **+2.8 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisation: Food and agriculture, biotechnology, energy, construction, environment, and ICT	***HT + MT contribution to the trade balance*** 2012: **-5.2 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

R&D intensity in Bulgaria increased from 0.45 % in 2007 to 0.64 % in 2012, which is still far below the national Europe 2020 target of 1.5 % and the EU average of 2.07 % in 2012. While public R&D intensity fell to 0.24 % in 2012 (the lowest value in the EU), business R&D intensity rose to 0.39 %. The knowledge-intensity of the economy increased slightly between 2007 and 2012. Starting from a very low level, the economy has been catching up in terms of high- and medium-high-technology sectors. The level of excellence in science and technology has slightly improved, but at a much slower rate than the EU average. Bulgaria is the lowest performer in the Innovation Union Scoreboard 2014 and the third lowest EU performer in the innovation output indicator.

Bulgaria's research and innovation systems face serious challenges. Inefficiencies and fragmentation in the allocation of funds for R&I, coupled with insufficient and falling public funding, impede any build-up of R&I capacities in Bulgaria. Low salary levels and outdated research infrastructures fail to retain young and qualified domestic researchers and to attract foreign ones, leading to a continuous brain drain and an ageing R&D staff. In February 2014, the government launched a public consultation in order to update the 'National strategy for development of research 2020' and the Rules of Procedure of the National Science Fund. Furthermore, it announced its intention to put in place a system of regular international evaluation of the scientific activity at public research organisations. A Strategy on Higher Education to better align education outcomes to labour-market needs was published for public consultation in 2013. However, Bulgaria still lacks a national strategy integrating education, science and innovation aspects and focusing on well-defined priorities.

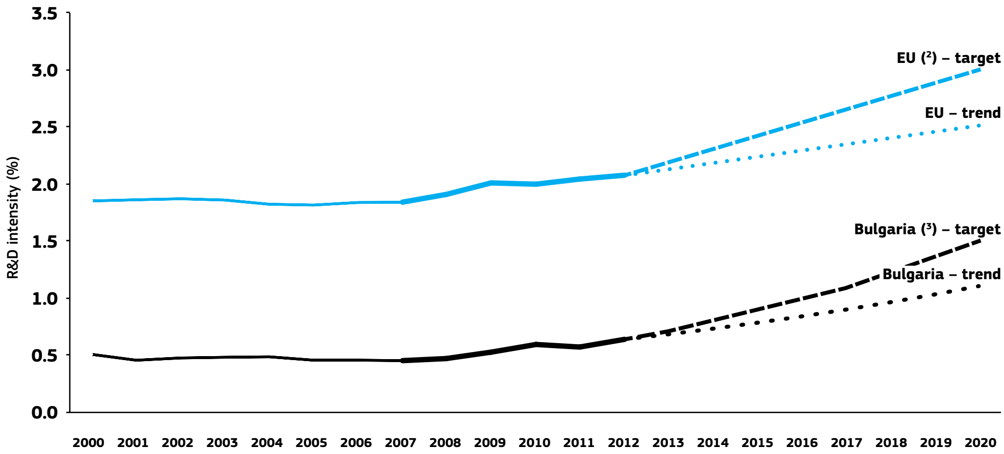
Commercialisation of research is another major weakness within Bulgaria's research system. There are only very limited frameworks for supporting collaboration between public research establishments, universities and the private sector. Sharing and support systems are insufficiently developed to facilitate knowledge transfer and the creation of university spin-offs and to attract (venture) capital and business angels. Public policies are not fostering enough long-term sustainable partnerships among innovation actors.

[1] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

[2] Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Investing in knowledge

Bulgaria – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) BG: The projection is based on a tentative R&D intensity target of 1.5 % for 2020.

In June 2010, the Bulgarian government adopted a national R&D investment target of 1.5 % of GDP by 2020. R&D intensity increased from 0.45 % in 2007 to 0.64 % in 2012. A further strong increase is required if Bulgaria is to reach its 2020 R&D intensity target. The public sector has historically been the main research funder and performer, but a strong decline can be observed over the last decade: in 2000, it provided 71.1 % of total R&D funding, in 2007 57.7 % and in 2011 only 39 %.

Public R&D expenditure in 2012 was the lowest in the EU. It decreased from 0.40 % of GDP in 2000 to 0.31 % in 2007. In 2009, it increased to 0.37 % but, due to the effects of the economic crisis, it fell sharply to 0.24 % in 2012, which is the lowest value among EU Member States. Total GBAORD shows a similar pattern: it decreased from 0.42 % of GDP (201.98 million in PPS at 2005 prices) in 2000 to 0.26 % (186.06 million) in 2007. In 2009, it increased to 0.34 % (243.55 million) then fell sharply to 0.26 % (189.67 million) in 2012. In 2013, the National Science Fund did not distribute funds because of suspicions of irregularities, which impacted negatively on the sustainability of the public research system.

Business R&D expenditure increased slowly from 0.11 % of GDP in 2000 to 0.14 % in 2007 then surged to 0.39 % in 2012, mainly because of investments by foreign pharmaceutical companies in clinical trials, but also due to technical accounting modifications. In nominal terms, business expenditure on R&D increased from EUR 43.5 million in 2007 to EUR 153.4 million in 2012, surpassing total public expenditure on R&D, which amounted to EUR 96.5 million in 2012.

The share of R&D financed from abroad, which ranged from 5-8 % for the 2000-2009 period, increased to 43.9 % in 2011. Structural Funds are an important source of funding for research and innovation activities. However, of the EUR 6.7 billion of Structural Funds allocated to Bulgaria over the 2007-2013 programming period, only EUR 293 million (4.4 % of the total, which is the lowest share in the EU) relate to RTDI[1].

The level of Bulgarian participation in EU Framework Programmes is low. Both the applicant success rate of 16.4 % and the EC financial contribution success rate of 10.5 % are much lower than the EU averages (21.9 % and 19.7 % respectively). As of October 2013, Bulgaria received a total of EUR 95.1 million in FP7 funding.

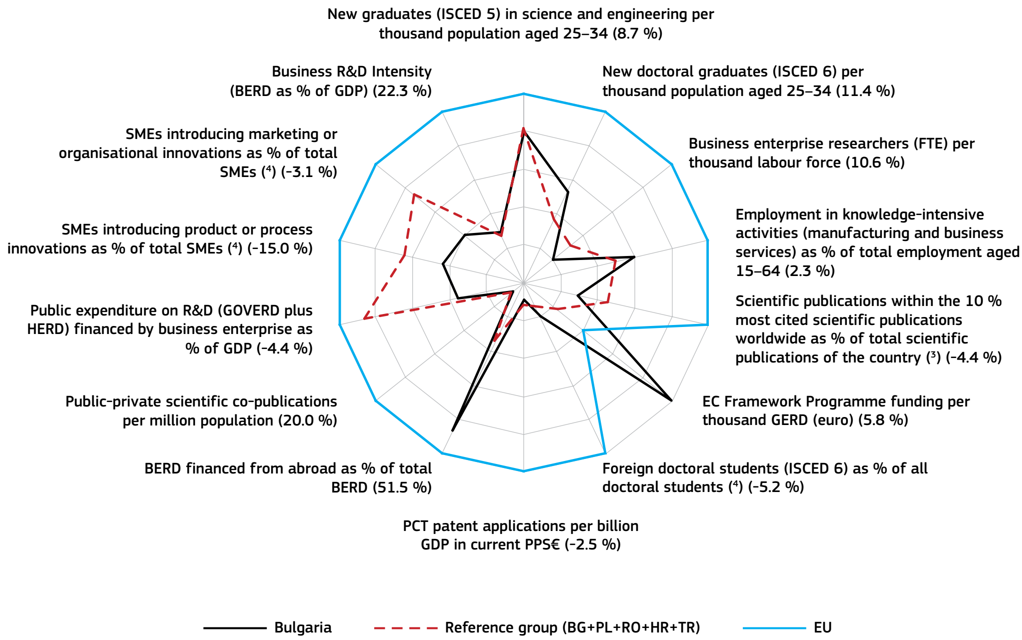
3 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Bulgaria's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Bulgaria, 2012 (1)

In brackets: average annual growth for Bulgaria, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

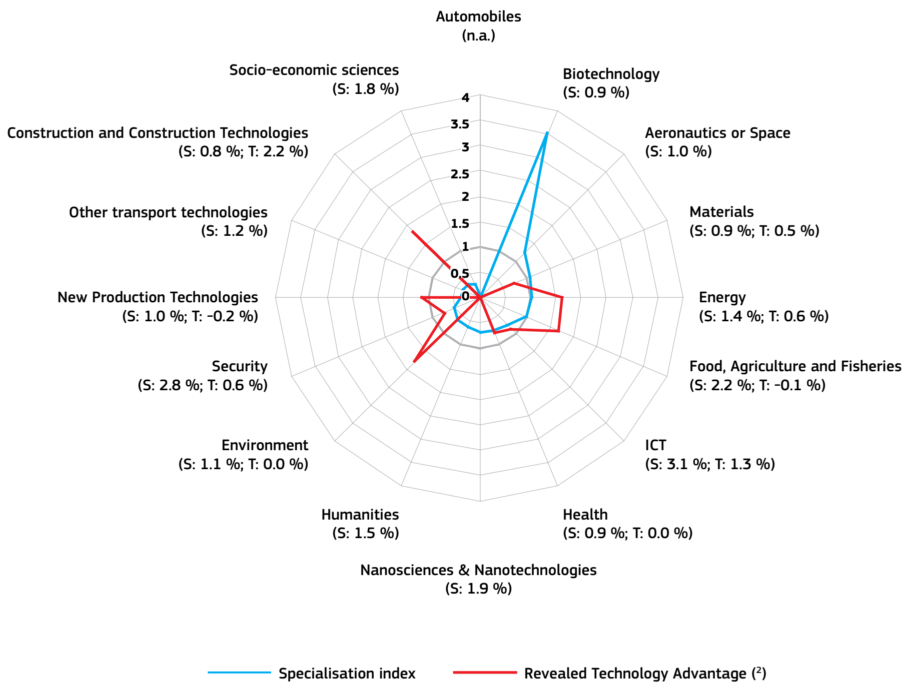
As the graph above shows, Bulgaria's R&I system is underperforming, with most indicators significantly lower than the EU average, except for EU Framework Programme funding and foreign business expenditure on R&D. In addition to these two indicators, compared to the reference group of countries, Bulgaria performs relatively well on employment in knowledge-intensive activities, new doctoral graduates and foreign doctoral students. With regard to new graduates in science and engineering, the country's performance is close to the reference group average. Of particular concern, and below the average level of the reference group, are: the low and falling level of public expenditure on R&D financed by business enterprise; the low and declining share of small and medium-sized enterprises (SMEs) introducing product or process innovations, as well as marketing or organisational innovations; the low and declining share of scientific publications within the 10 % most-cited scientific publications worldwide; and the small number of business enterprise researchers. As regards business R&D intensity (average annual growth of 22.3 %), public-private scientific co-publications (average annual growth of 20 %) and PCT patent applications, Bulgaria scores close to the average reference group level which is well below the EU average. Overall, as in most post-communist countries, patenting activity in Bulgaria is very low. While PCT patent applications show a declining trend, licence and patent revenues from abroad as a percentage of GDP increased between 2007 and 2012.

One positive development in Bulgaria is the fact that, as in the reference group, the share of graduates in science and engineering is slowly catching up with EU average levels. However, Bulgaria has been experiencing massive outflows of highly skilled people, including researchers. In the WEF Global Competitiveness Report 2013-2014, it ranks among the countries with the lowest capacity to retain (142nd out of 148) and to attract (144th) talent.

Bulgaria's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme (FP) thematic priorities, where Bulgaria shows potential in science and technology areas in a European context. Both the specialisation index (SI) and the revealed technological advantage (RTA) measure the country's scientific and technological capacity compared to that at the world level. For each specialisation field it provides information on growth rate in the number of publications and patents.

Bulgaria – S&T National Specialisation ([1]) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications ([3]) (S) and in number of patents ([4]) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: ([1]) Values over 1 show specialisation; values under 1 show a lack of specialisation.
([2]) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
([3]) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
([4]) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

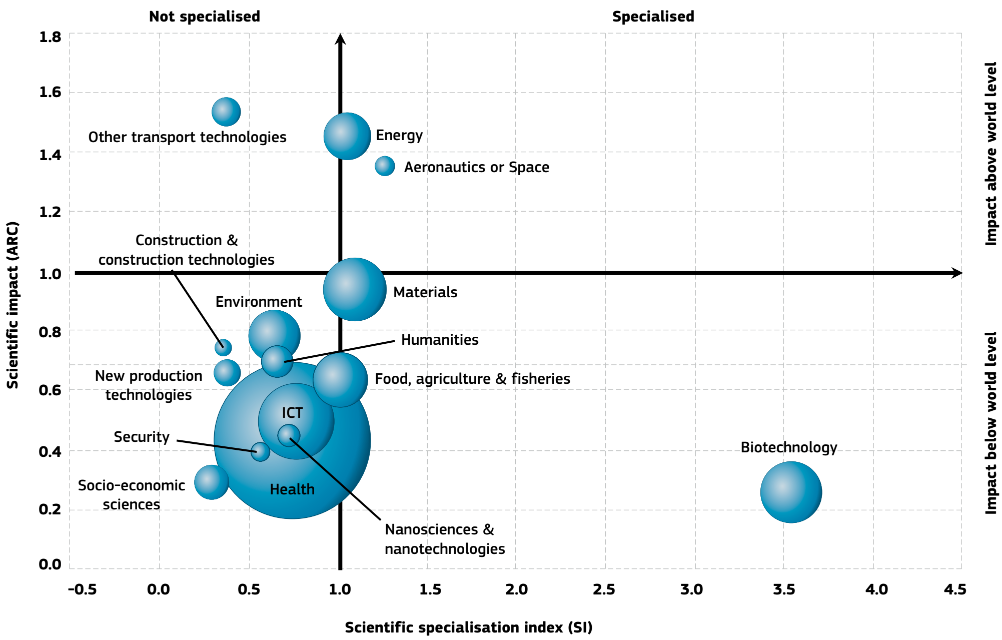
According to the RTA definition and the FP thematic classification, Bulgaria demonstrates RTA in construction and construction technologies; environment (highest participation rate of national researchers/companies in FP7); new production technologies; food, agriculture and fisheries; energy; and ICT, with only the last three having some scientific specialisation, close to or slightly below the world level. Although not visible on the graph, relative growth in patents can be observed in the field of automobiles. It should be noted that certain fields, such as textiles, which play an important role in Bulgaria, are not directly related to any FP thematic priority.

A strong scientific specialisation in Bulgaria can be found in biotechnology, which is a research priority in the National strategy for development of research 2020, but without a corresponding RTA. Aeronautics is another area where Bulgaria shows scientific specialisation but no RTA. Hence, a greater concentration of scarce resources and a better alignment of research priorities and RTA could improve the country's innovation performance. Scientific performance can be strengthened in the fields with RTA and positive growth, such as construction and construction technologies, with a view to improving knowledge transfer and economic impact of a given industry. Sectors where there is a co-specialisation in both science and technology are good candidates to start the smart specialisation process.

Based on an analysis of scientific strengths and patenting activity, as well as exports, employment generation and FDI, the World Bank input for Bulgaria's Research and Innovation Strategy for Smart Specialisation identifies five economic sectors as having a potential for growth: food processing, machine building and electrical equipment, pharmaceuticals, ICT, and cultural and creative industries. The identified sectors encounter both sector-specific and cross-cutting obstacles to realising their innovation potential. Addressing these problems is expected to impact on a number of industries, with a multiplying effect on economic growth.

The graph below illustrates the positional analysis of Bulgarian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Bulgaria – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The graph shows that only a few sectors (transport, energy, aeronautics) demonstrate some scientific impact, with either no corresponding or only limited scientific specialisation. The graph also shows that the sector ranking highest on the science specialisation index – biotechnology – is lacking scientific impact above the world level. Similarly, sectors identified in the Smart Specialisation Strategy, such as food, ICT, and health, do not demonstrate scientific impact above the world level. Publications in the area of materials demonstrate scientific specialisation and scientific impact close to that at world level. Overall, scientific performance in Bulgaria is low, as reflected in a number of indicators. For example, in 2009, only 3.2 % of all scientific publications in the country featured in the 10 % most-cited scientific publications worldwide, the third lowest value in the EU. On the composite indicator of research excellence, Bulgaria ranks 21st in the EU, a trend which is improving slightly.

Bulgarian researchers cooperate with researchers from 144 countries worldwide. Cooperation with academics in Germany is most intensive. The scientific fields of mutual interest are: physics and astronomy, chemistry, materials sciences, biochemistry, genetics and molecular biology, and medicine. Among the top 10 countries of origin of research partners (as measured by the number of co-publications) are also the USA, France, Italy, United Kingdom, Russia, Spain, Belgium, Poland and Switzerland.

Policies and reforms for research and innovation

The latest policy developments in the area of R&I are reflected in the drafts of the operational programmes (OP) 'Science and Education for Smart Growth 2014-2020' and 'Innovation and Competitiveness' and in the 'Innovation Strategy for Smart Specialisation'. All those programmes aim to promote research and innovation in the country, but they do not address the problem of fragmentation in Bulgarian R&I administrations, policies and performers. The cooperation between the two national funding instruments (the Innovation Fund and the Science Fund) remains inefficient. The previously envisaged National Innovation Board, which was expected to coordinate the funding priorities of the two funds, has not been established. The Law on Innovation announced in the National Reform Programme 2013 has not been adopted. A Strategy on Higher Education to better align education outcomes to labour-market needs was published for public consultation in November 2013. Following its expected finalisation by March 2014, it must be sent to the National Assembly for approval. However, Bulgaria still lacks a national strategy integrating education, science and innovation aspects and focusing on well-defined priorities.

The public research funding system faces significant inefficiencies. Incentives for research excellence and internationalisation are lacking and the part of public funding which is allocated competitively, transparently and based on merit is low. Due to suspicions of irregularities, the National Science Fund did not distribute funds in 2013, which had negative consequences for the sustainability of the public research system. In February 2014, the government launched a public consultation in order to update the National strategy for development of research 2020 and the Rules of Procedure of the National Science Fund. Furthermore, it also announced its intention to put in place a system of regular international evaluation of scientific activity within public research organisations.

Currently, performance-based funding of public research organisations and individual researchers is underdeveloped. The ranking of universities (launched in 2010) provides the government with a tool for performance-based allocations, but the share of funds allocated according to this ranking is comparatively small and does not prioritise R&I. Publishing and patenting activities vary significantly across the comparatively high number of 51 public universities in Bulgaria. For example, only eight universities registered patents between 2001 and 2012, and only 17 have published articles and scientific reports in the Scopus database. Notwithstanding the existence of a National Roadmap for Research Infrastructure, which is currently under revision, specific R&I cross-border or regional programmes and support schemes have been limited to date, as have plans for involvement in any ESFRI projects.

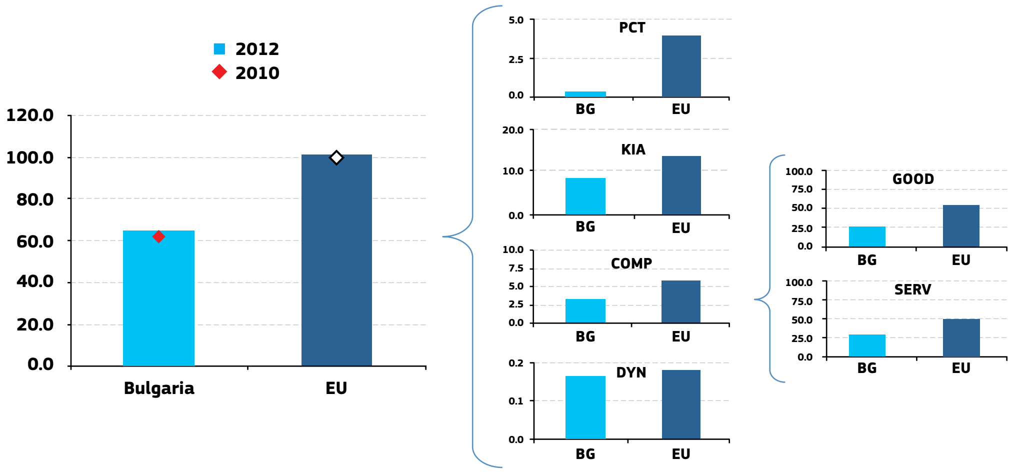
With regard to the 2013 Country Specific Recommendations on R&I, progress in Bulgaria has been very limited. There are only very few frameworks for supporting collaboration between research establishments, universities and the private sector. Research and innovation collaborative platforms, such as technology transfer offices, technology parks and clusters, remain underdeveloped. There are currently only a few technology transfer centres, most of which have been created with Structural Funds support. The first science and technology park in Sofia, co-financed by the European Regional Development Fund, would benefit from stronger political support to grow into a core R&I hub. Sharing and support systems are insufficiently developed to facilitate knowledge transfer and the creation of university spin-offs and to attract (venture) capital and business angels. Public policies are not fostering enough long-term sustainable partnerships between innovation actors.

Bulgarian legislation on intellectual property is in line with EU directives, but it has failed to spur indigenous innovative activity due to problems with enforcement and the capacity of the judiciary. According to the World Economic Forum Global Competitiveness Report 2013-2014, Bulgaria scores very poorly in terms of intellectual property protection (104th out of 148) and university-industry collaboration in R&D (117th). In order to promote private investment in R&I, the state should further develop and implement instruments such as start-up funding schemes, support for clusters, and technology centres for the commercialisation of patents, while financial engineering instruments, guarantees and venture capital should be further enhanced.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Bulgaria's position regarding the indicator's different components:

Bulgaria – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Bulgaria is the third lowest EU performer in the innovation output indicator[2]. In the period 2010-2012, the country's performance has improved slightly. Bulgaria's performance is particularly low on PCT patent applications. There are several explanations for this: first, it is linked to the country's economic structure, with a specialisation in less-knowledge-intensive sectors, the lack of large Bulgarian multinational manufacturing companies and the division of work within international companies, which have production facilities in Bulgaria but tend to do research and patenting in the headquarter country. Secondly, commercialisation of research in Bulgaria is underdeveloped, and patent literacy and patenting activity in Bulgarian universities is extremely low. Furthermore, some Bulgarian inventors prefer to maintain their secrecy as a method of preserving their intellectual assets, due to a lack of confidence in the official intellectual property protection system. In addition, it is common practice that innovative products developed by Bulgarian researchers are ordered by foreign multinational companies, and then patented and commercialised in a foreign market.

The reason for the relatively low performance in employment in knowledge-intensive activities is the importance of employment in wholesale and retail trade (16 % of total employment), agriculture, forestry and fishery (6.7 %) and accommodation, food and beverage service activities (5.1 %) in the Bulgarian economy. Bulgaria's manufacturing industry is oriented towards low-tech goods.

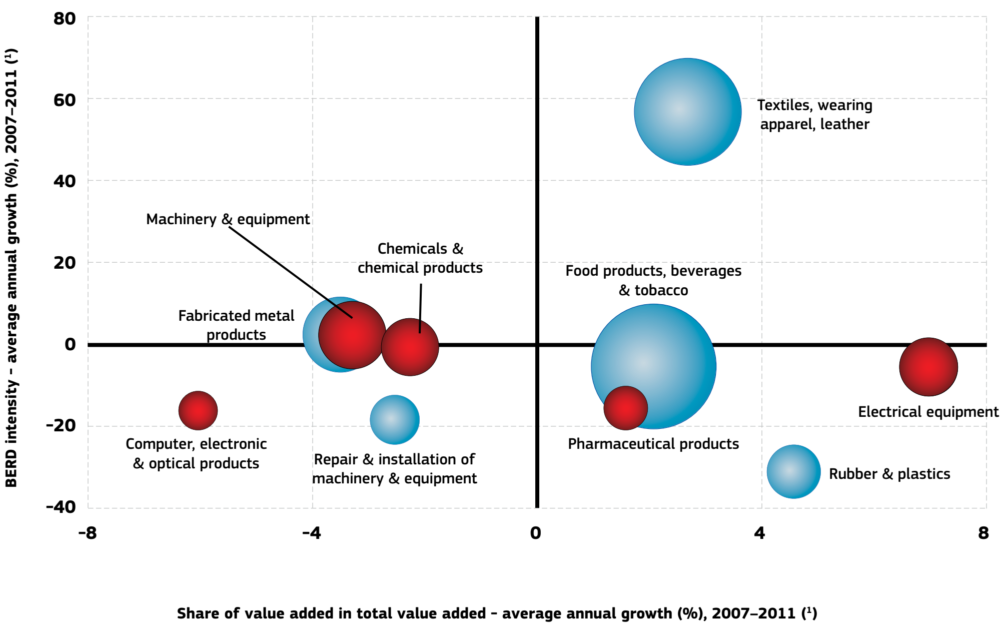
4 As regards other IPR-related innovation outputs, such as Community trademarks and designs, Bulgaria performs near the EU average, if measured per unit of GDP, and at about half the EU level, if measured on a per-capita basis.

This explains the low performance as regards the share of medium/high-tech goods in total goods exports. A relatively strong tourism and road transport sector (both not classified as knowledge intensive) partly explains the low share of knowledge-intensive service exports. Bulgaria is performing near the EU-average as regards the innovativeness of high-growth enterprises. A strong contribution from the information and communication (software) sector compensates somewhat for the high share of low-tech manufacturing in fast-growing enterprises.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period 2007-2011. The general trend to the left-hand side reflects a decrease in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Bulgaria – Share of value added versus BERD intensity: average annual growth, 2007–2011 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Electrical equipment', 'Textiles, wearing apparel, leather and related products': 2008–2010; 'Rubber and plastic products': 2009–2011.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

Bulgaria, together with Romania, Turkey, Croatia and Poland, is classified as a low knowledge-capacity system with a specialisation in low knowledge-intensive sectors[5]. Its economic specialisation has been based on low costs and a cheap labour force. The share of industry (except construction) in Bulgaria (25.2 % in 2013) is higher than the EU average (19 %). The graph above demonstrates the large relative weights of two sectors – food products, beverages, tobacco; and textiles, wearing apparel, and leather – as well as their growing share of value added in total value added. Whereas two high-tech (HT) and medium-high-tech (MT) sectors, namely electrical equipment and pharmaceutical products, demonstrate an increase in their shares of value added in total value added (although their weights remain relatively small), three HT

[5] Source: Innovation Union Competitiveness report 2013.

and MT sectors demonstrate a decrease in value added: computer, electronic and optical products; machinery and equipment; and chemicals and chemical products. All HT and MT sectors could benefit from an increase in BERD intensity, which either stagnated or declined between 2007 and 2011. The recent increase in BERD in the pharmaceutical sector is not reflected in the graph. Only one sector, namely textiles, wearing apparel and leather, demonstrates an increase in value added and BERD intensity, simultaneously.

Overall, there are only minor positive trends in the evolution of Bulgaria's economic structure and capacity to address societal challenges, such as health or environment-related challenges. The composite indicator on structural change reflects this by showing a minor improvement over time. While some improvements can be seen regarding patent applications in health-related technologies and employment in knowledge-intensive activities, the share of SMEs introducing product or process innovation has decreased considerably.

Key indicators for Bulgaria

BULGARIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.35	0.46	0.51	0.56	0.55	0.59	0.57	0.62	0.97	11.4	*1.81*	22
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	413	:	:	428	:	:	439	25.3 (3)	495 (4)	26 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.11	0.10	0.12	0.14	0.15	0.16	0.30	0.30	*0.39*	*22.3*	1.31	20
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.40	0.35	0.34	0.31	0.32	0.37	0.29	0.26	*0.24*	*-4.7*	*0.74*	28
Venture capital as % of GDP	:	:	:	0.13	0.04	0.02	0.01	0.03	0.16	5.2	0.29 (5)	9 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	24.2	:	:	:	:	24.5	0.3	47.8	21
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	4.1	4.8	3.5	2.5	3.2	:	:	:	-4.4	11.0	26
International scientific co-publications per million population	:	177	180	213	205	226	217	213	213	0.0	343	26
Public–private scientific co-publications per million population	:	:	:	2.0	2.7	3.6	3.5	4.1	:	20.0	53	27
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.5	0.5	0.5	0.4	0.3	0.4	0.4	:	:	-2.5	3.9	26
License and patent revenues from abroad as % of GDP	0.03	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.04	12.0	0.59	22
Community trademark (CTM) applications per million population	0.7	7	9	33	35	36	49	58	69	16.3	152	21
Community design (CD) applications per million population	:	0	1	6	5	7	7	8	14	20.1	29	21
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	10.3	:	14.2	:	7.6	:	:	-27.0	14.4	24
Knowledge-intensive services exports as % total service exports	:	15.0	16.7	20.5	22.5	21.9	25.2	25.5	:	5.6	45.3	21
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-8.42	-9.89	-9.31	-7.83	-7.43	-5.99	-4.84	-4.78	-5.23	-	4.23 (6)	27
Growth of total factor productivity (total economy): 2007 = 100	85	98	99	100	100	92	93	94	95	-5 (7)	97	18
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	29.1	:	:	:	:	33.5	2.8	51.2	24
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	8.2	8.6	8.6	8.7 (8)	8.3	2.3	13.9	27
SMEs introducing product or process innovations as % of SMEs	:	:	17.8	:	20.7	:	15.0	:	:	-15.0	33.8	24
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.02	0.05	0.02	0.00	0.04	0.04	:	:	:	-4.5 (9)	0.44	23
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.02	0.06	0.06	0.02	0.04	0.03	:	:	:	24.4	0.53	25
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	55.3	61.9	65.1	68.4	70.7	68.8	65.4	62.9 (10)	63.0	-1.5	68.4	23
R&D intensity (GERD as % of GDP)	0.51	0.46	0.46	0.45	0.47	0.53	0.60	0.57	*0.64*	*7.1*	*2.07*	26
Greenhouse gas emissions: 1990 = 100	54	58	59	63	61	53	55	60	:	-2 (11)	83	5 (12)
Share of renewable energy in gross final energy consumption (%)	:	9.2	9.4	9.0	9.5	11.7	13.7	13.8	:	11.3	13.0	13
Share of population aged 30–34 who have successfully completed tertiary education (%)	19.5	24.9	25.3	26.0	27.1	27.9	27.7	27.3	26.9	0.7	35.7	21
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	20.4	17.3	14.9	14.8	14.7	13.9	11.8	12.5	-3.5	12.7	22 (12)
Share of population at risk of poverty or social exclusion (%)	:	:	61.3	60.7	44.8 (13)	46.2	49.2	49.1	49.3	2.4	24.8	28 (12)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) Break in series between 2011 and the previous years. Average annual growth refers to 2008–2010.
(9) Average annual growth refers to 2008–2009.
(10) Break in series between 2011 and the previous years. Average annual growth refers to 2007–2010.
(11) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(12) The values for this indicator were ranked from lowest to highest.
(13) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2011.
(14) Values in italics are estimated or provisional.

Croatia

The challenge of structural change for a more knowledge-intensive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Croatia. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.75 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **-1.3 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **18.9** (EU: 47.8; US: 58.1) 2007-2012: **+9.6 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **68.1** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **n.a.** (EU: 51.2; US: 59.9) 2007-2012: **n.a.** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Food, agriculture and fisheries, transport, construction, and humanities	***HT + MT contribution to the trade balance*** 2012: **1.0 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+44.8 %** (EU: +4.8 %; US: -32.3 %)

Croatia is still building up its research and innovation (R&I) system. Although starting from a low level, its science and technology excellence improved between 2007 and 2012, coinciding with the accession negotiations to join the European Union. Since 2009, following the global economic and financial crisis in 2008, which affected Croatia substantially, the level of investment in R&D fell from almost 1 % to 0.75 % of its GDP and has stagnated at that level since 2010. This level of investment is well below the EU average of 2.07 %.

According to the Innovation Union Scoreboard of 2014, Croatia is a moderate innovator ranked ninth in the 13 Member States in that group. This means that its innovation performance is below the EU average with relative performance rates of between 50 % and 90 % of the EU average for the different indicators. In addition, Croatia's total innovation performance decreased from 60 % in 2011 to 55 % in 2013.

Since 2000, Croatia has been engaged in restructuring its science (and education) system with the aim of creating a knowledge-based society and strengthening the country's research capacity as a lever for economic development. In particular, as Croatia approached its accession to the EU (1 July 2013) measures were taken to reform its R&I system in line with the objectives and priorities of the European Research Area and to contribute to the Innovation Union (Europe 2020 flagship initiative). However, the country has been very slow in adopting and implementing the envisaged reforms. In addition, the administrative capacity to monitor and implement the envisaged policies on R&I is insufficient and there is room for improvement regarding the collection of data, in particular of the investments made by the private sector in research.

[1] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

[2] Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Since 2010, the level of investment in R&D in Croatia has stagnated. Business R&D intensity is very low, amounting to 0.34 % of GDP. The country's innovation performance is among the lowest in the EU (23rd), which is affecting its competitiveness. The share of small and medium-sized enterprises (SMEs) introducing product or process innovation declined between 2007 and 2012.

Particular efforts are thus needed to enhance and commercialise the results of public-sector research in cooperation with the private sector. Croatia should also improve its international competitiveness and trade by producing more technology-driven goods and services. This in turn means setting priorities, addressing the funding gap by increasing national funding, stimulating the private sector to engage in research, and supporting cooperation between the public and private sectors.

The competitiveness of public research has been partly addressed through the adoption of amendments to the Act on the Croatian Science Foundation in 2012, as well as amendments to the Act on Science and Higher Education in July 2013 which changed the financing and governance system of public research entities. Implementation began with the adoption on 6 June 2013 of the Decision on multi-annual institutional financing of research activities in public research institutes and universities 2013-2015, replacing in part project funding by performance-based institutional funding. It is too early, however, to assess the impact of this reform although the fact that funding will be based on the research institutions' performance indicators is to be welcomed.

However, the most needed reforms, aimed at creating growth and becoming more competitive through increased efforts on R&I are still to be taken – i.e. stimulating cooperation between public research organisations and the private sector that should facilitate the commercialisation of research results and the technology-transfer process. To that end, two key strategies in science, education and technology, by the Ministry of Science, Education and Sports (MSES), and the National Innovation Strategy 2013-2020, by the Ministry of Economy, were announced in 2012 but, as of June 2014, had still not been adopted. It also remains to be seen how both strategies, governed by two different ministries, will be coordinated to ensure their coherent implementation.

In addition, Croatia still has to adopt a Smart Specialisation Strategy (S3) in order to set priorities on economic activities (industrial sectors or niches therein) with existing or potential comparative advantage. A sound S3 is not only in the country's interest in concentrating efforts and creating critical mass, but is also a precondition for gaining access to the European Structural and Investment Funds (ESIFs) for R&I capacity. In turn, the use of ESIFs also requires good administrative and coordination capacity at the national level.

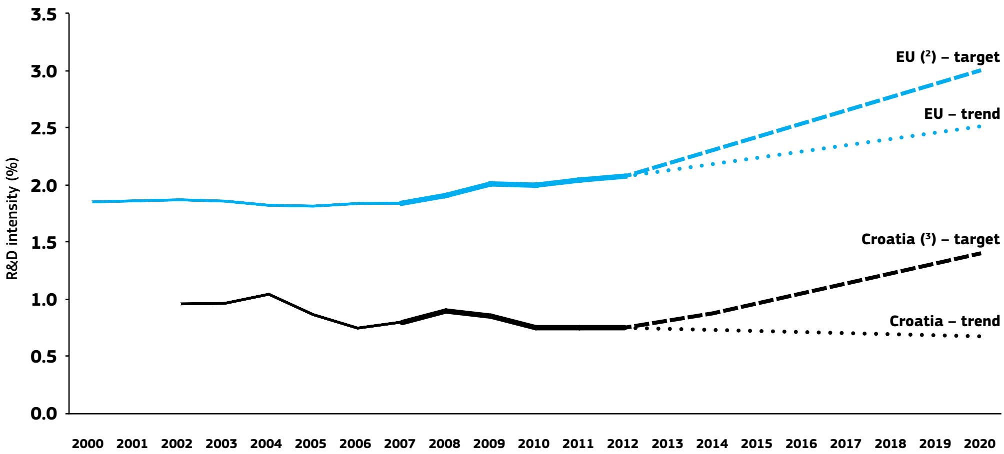
Although the new government, elected in November 2011, has started significant economic reforms and has taken initiatives to spur competitiveness and growth, Croatia is lagging behind on important issues such as protection of investment in order to stimulate private investment; decrease of regulatory burdens to do business; improvement of access to finance other than from banks; and the improvement of a skilled workforce (mismatch between curricula and labour market needs is very high).

In conclusion, the complexity of the R&I landscape in Croatia suggests that the problem is not only a funding gap caused by the economic recession but also a question of the capacity to address the necessary reforms in a comprehensive and integrated way.

Investing in knowledge

Particular efforts are needed to enhance and commercialise the results of public-sector research in cooperation with the private sector. Croatia should also aim to improve its international competitiveness and trade by producing more technology-driven goods and services. This in turn means addressing the funding gap by increasing national funding, stimulating the private sector to engage in research, and supporting cooperation between the public and private sectors.

Croatia – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) HR: The projection is based on a tentative R&D intensity target of 1.4 % for 2020.

In 2012, Croatia had an R&D intensity of 0.75 % of GDP, 0.41 % of which comes from public expenditure on R&D (HERD+GOVERD) and 0.34 % from business enterprise expenditure on R&D (BERD). The country's overall R&D intensity decreased from 0.90 % in 2008 to 0.75 % since 2010. The decrease is mainly due to an overall slowdown in the national economy during the last four years, which was affected by the global financial and economic crisis in 2008. As a result, Croatia did not meet its own target to invest 1 % of its GDP in R&D by 2010. It was also not in a position to contribute to the target set in the context of the European Semester to increase investment in R&D to 1.4 % of its GDP by 2020.

In 2012, Croatia's R&D intensity of 0.75 % was well below the EU average of 2.07 %. Moreover, it has declined at an average annual rate of 1.3 % over the period 2007-2012. In absolute terms, this means that Croatia spends about EUR 330 million a year on R&D, which is far from sufficient to carry out the reforms which Croatia should undertake to become a knowledge-based society. As recognised in the draft of Croatia's Industrial Strategy for 2014-2020, insufficient investment in R&D is another reason for the lack of industrial growth.

The share of business enterprise expenditure on R&D (BERD) is 0.34 % of GDP which is much lower than the EU average (1.3 %). Despite current fiscal constraints imposed on Croatia, the share of the MSES budget for research was set to remain stable at about 11.0 % in 2012 and to increase to 11.5 % by 2015. It should be noted, however, that more than 80 % of Croatia's public funding is allocated to salaries for personnel involved in public research. Accordingly, except through the use of the ESIFs and other sources from abroad, there is thus no real perspective of increasing Croatia's level of investment in the coming years.

Regarding EU funding, Croatia participated as an associated country in the EU's Seventh Framework Programme (FP7) until 30 June 2013 and for the last six months of FP7 as a Member State. Since 1 January 2014, the country has been eligible to participate in the new EU R&I programme Horizon 2020 as a Member State.

Croatia's level of participation in FP7 was good with a success rate of about 17 % compared to the EU (27) Member States of 20.5 %. In total, 304 proposals for funding were retained involving 385 participants from Croatia benefitting in total from about EUR 86 million. Croatia has been particularly successful under the research themes of health, ICT, and transport. In the last two years of FP7, the number of SMEs participating and being successful in FP7 has also risen, attaining a success rate of 17.5 % which is, however, still lower than the EU average success rate of 20.12 %. Croatia is a full member of the Eurostar initiative as well as of COST and EUREKA.

As a Candidate and later Accession Country, Croatia was able to deploy substantial funding (in the order of EUR 24 million) in support of its R&I capacity under the Pre-Accession Instrument (IPA) and, for the last six months of 2013, under the European Regional Development Fund. Combined with a loan from the World Bank, a dedicated institution for the promotion of R&I in SMEs was created called BICRO (Business Innovation Centre transformed in 2010 to the Business Innovation Agency of Croatia). This implemented several innovation programmes, such as the RAZUM project on soft loans; supporting patent applications; feasibility studies or matching grants to foster private-public cooperation and the technology-transfer programme; and the UKF (Unity through Knowledge Fund) project aimed at collaboration between Croatian researchers and the Croatian scientific diaspora. According to an independent evaluation study, both programmes generated positive results regarding the development of innovation, new export-oriented products and the innovation capacity of enterprises. IPA and ESIF funding also enabled the launch of the construction of a biotechnology incubation centre in Zagreb and equipping research centres and innovation in business sectors.

In preparation for the use of ESIF, an Operational Programme for Competitiveness and Cohesion is being designed which anticipates the development of a business climate and SME competitiveness as well as research, innovation and technology transfer (research-business collaboration). The necessary implementing documents and notably the S3 still have to be adopted. Thus, it is too early to say if the use of the ESIF will create growth and competitiveness by concentrating efforts on sectors and areas (specialisation) with potential, and creating the critical mass necessary to produce scientific excellence and, in turn, economic gains.

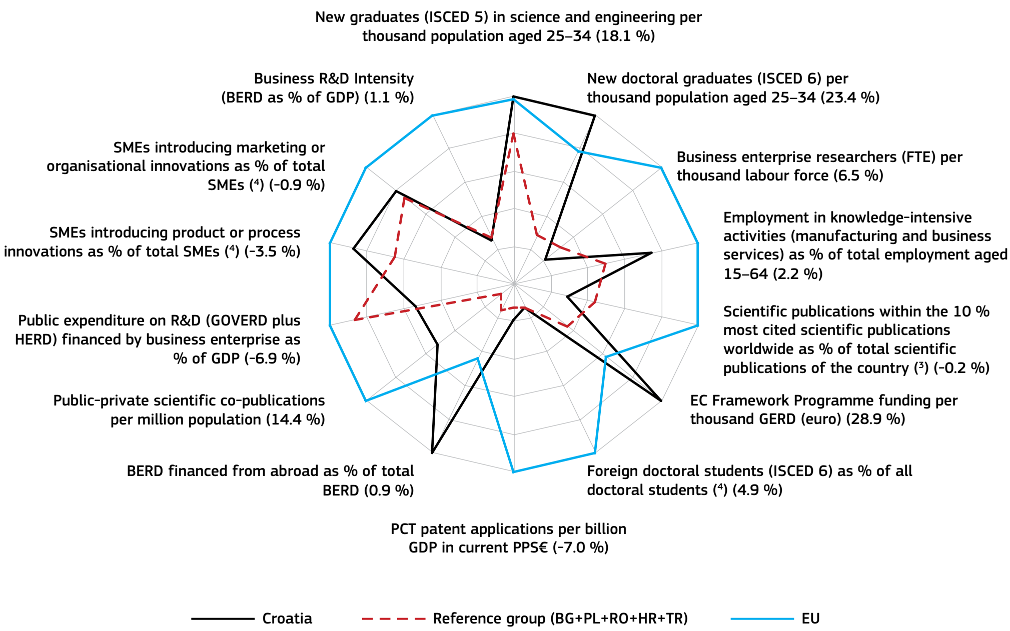
Participation in Horizon 2020 has just started. Croatia has set up the necessary administrative capacity (nomination of National Contact Points and members on Horizon 2020 programme committees). In 2013, the MSESS adopted an action plan aimed at raising the absorption capacity of Croatian entities in the Union Research Framework Programmes for 2013-2015. The ministry provides, amongst others, support for scientists in their Horizon 2020 applications and project management, rewarding the successful applicants and connecting project performance and scientific career.

An effective research and innovation system building on the European Research Area

The spider graph below provides a synthesis picture of strengths and weaknesses of the Croatian R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2007 to the latest available year are given in brackets under each indicator.

Croatia, 2012 (1)

In brackets: average annual growth for Croatia, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

As the graph above shows, Croatia is lagging behind the EU average on most key R&I indicators, except for new doctoral graduates, EC Framework Programme funding, BERD financed from abroad, and new graduates in science and engineering, where Croatia is performing above or close to the EU average.

The number of new doctoral graduates is above the EU average (2.30 per thousand population of 25-34-year-olds compared to an average of 1.81 in the EU for 2012) and grew annually between 2007 and 2012 at an impressive rate of 23.4 %. However, the share of population aged 30-34 years who have successfully completed tertiary education (23.7 %) was much lower in 2012 than the EU average of 35.7 %. Croatian scientists produce an above-average number of national and international scientific publications although the number of scientific publications among the 10% most-cited scientific publications worldwide fell slightly between 2006 and 2009 and is very low compared to the EU average (3.2 % versus 11 % for 2009). The latter suggests that Croatia should promote more quality research and scientific excellence rather than simply use the number of publications as a funding criterion.

Declines in growth are also observed in patent applications and revenues from abroad from licensing and patenting. Furthermore, public expenditure on R&D financed by business enterprise as a % of GDP has fallen, as has the share of SMEs introducing product or process innovations and those introducing marketing or organisational innovations.

The key challenge for Croatia is to stimulate business R&D intensity and the commercialisation of research through cooperation between the public and private sector, and to provide an adequate framework for technology transfer. For example, as of May 2014, no scientific centres of excellence had been established despite the fact that this was foreseen in the Science Act of 2003. The Agency for Science and Higher Education has, however, launched a public call in June 2013 and the first centre should be established before the end of the year.

Human capital building in S&T is also below the EU average and has declined in recent years compared to an increase in the EU: Croatia counts 6346 FTE (full-time employed) researchers in 2012 or 1.48 per million inhabitants compared to 3.26 per million in the EU. Most researchers (close to 80 %) are employed in the public sector and the share of business-enterprise researchers (FTE) is lower than in the reference group, which once again confirms the problem in Croatia –there is insufficient means for the private sector to generate R&I.

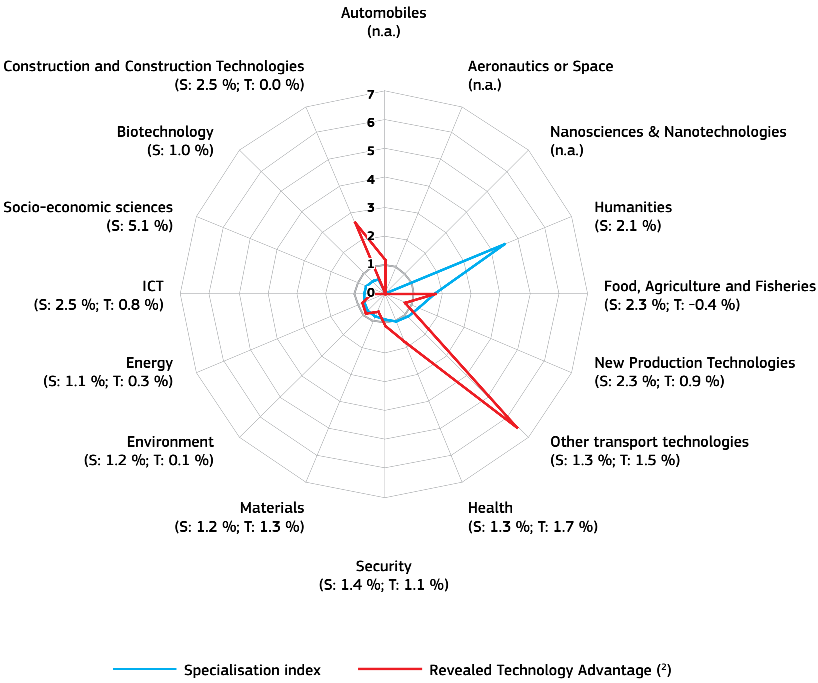
Croatia is suffering from a large out-migration of highly qualified people, including researchers. According to a recent OECD study[3], emigration of highly educated persons in Croatia is still above the average in non-OECD countries due to deteriorating economic and living conditions, and the lack of R&I infrastructure and funding. The Roadmap for the Development of Research Infrastructure adopted at the beginning of 2014 could constitute the basis for a positive change in this regard.

Croatia's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Croatia shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

[3] Connecting with Emigrants: A Global Profile for Diaspora.

Croatia – S&T National Specialisation [1] in thematic priorities, 2000–2010
in brackets: growth rate in number of publications [3] (S) and in number of patents [4] (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: [1] Values over 1 show specialisation; values under 1 show a lack of specialisation.
[2] The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
[3] The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
[4] The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

According to the RTA definition and the FP thematic classification, Croatia demonstrates RTA in construction and construction technologies, other transport technologies, and food, agriculture and fisheries, with only the last two demonstrating scientific specialisation close to or above the world level.

Strong scientific specialisation in Croatia can be found in humanities. New production technologies demonstrate scientific specialisation above the world level and RTA slightly below the world level.

Hence, a greater concentration of scarce resources and a better alignment of research priorities and RTA could improve the country's innovation performance. Scientific performance can be strengthened in the fields with RTA and positive growth, such as other transport technologies, and construction and construction technologies. The sectors where there is a co-specialisation in both science and technology are good candidates to start the smart specialisation process.

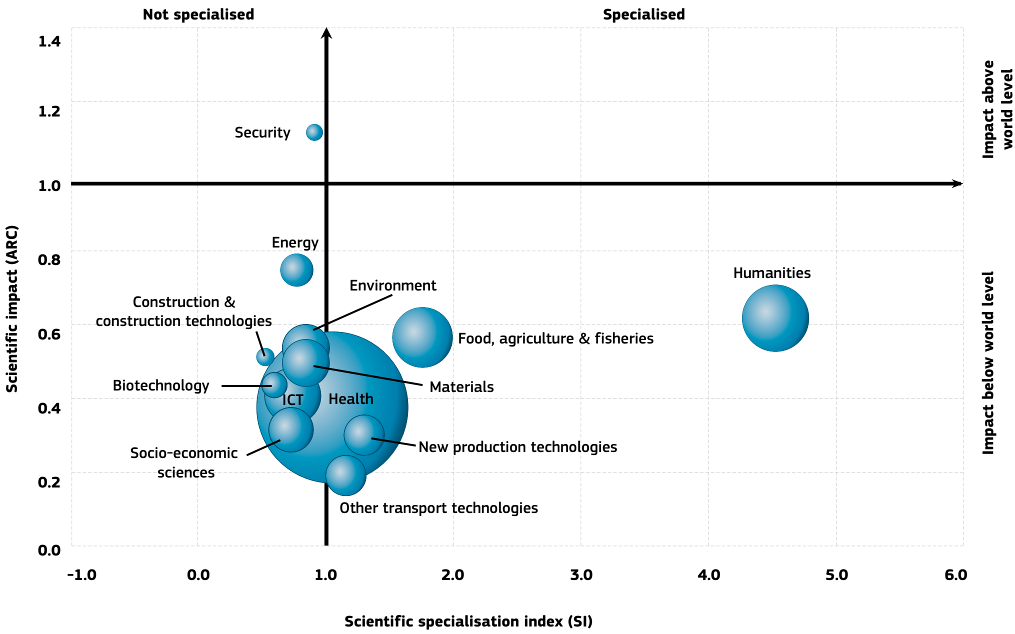
The lack of specialisation also reflects the funding policy in Croatia which does not highlight thematic areas or set national priorities but is based on a horizontal approach. One of the objectives of the announced national strategy for science is precisely to set priorities.

The areas in which Croatia performed well under FP7 reflect some scientific strengths among the public research institutions – for example, in the domain of cognitive and robotic systems and embedded systems, following a strategy adopted by the Faculty of Electrical Engineering and Computing at the University of Zagreb. Traditionally, as a country economically dependent on agriculture and tourism, Croatia has attached importance to science in the food and agricultural sector, forestry and bio-fuels, which is also reflected in the uptake of FP7 funding.

FP7 funding under the health theme, and notably on biomedical and biotechnical research, such as biomedical engineering, molecular biology, and pharmacy, is the result of concentrated efforts in that sector through a platform (grouping public universities all over the country, a private university and research units in polyclinics and hospitals) in these fields. In addition, green-field investment with IPA support has been made for the construction of a leading infrastructure – the Biosciences Technology Commercialisation and Incubation Centre (BIOCentre) in Zagreb.

The graph below illustrates the positional analysis of Croatian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publication from a science field in the country's total publications.

Croatia – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The graph shows that only one sector – security – demonstrates any scientific impact, with no corresponding scientific specialisation. The graph also shows that the sector ranking highest on the science specialisation index – humanities – is lacking scientific impact above the world level. Overall, scientific performance in Croatia is low, as is reflected in a number of indicators. For example, in 2009, only 3.2 % of all scientific publications in the country belonged to the 10 % most-cited scientific publications worldwide, the second lowest value in the EU. In the composite indicator of research excellence, Croatia ranks 26th in the EU, although the trend is improving slightly.

Policies and reforms for research and innovation

Since 2000, Croatia has been in the process of reforming the organisation of research, science and innovation in the country. In particular, since the accession negotiations on the research and science were opened then provisionally closed in October 2006, Croatia has been engaging in reforms in line with the EU actions and targets established under the EU policy for R&I (participation in EU research programmes, European Research Area, and the Innovation Union).

Despite the efforts taken, R&I capacity is still weak and requires many more actions if it is to become a real driver for economic growth and competitiveness.

Since the new government took office in 2011, several actions and strategies have been announced but only a few have been adopted. It is thus difficult to assess the reforms undertaken and whether or not the expected impact is being achieved.

The amendments to the Act on the Croatian Science Foundation and the Act on Science and Higher Education marked the beginning of a series of announced reforms. The Acts bring changes in the financing and governance system of public research activities aimed at increasing the efficiency of the R&D system. The Croatian Qualifications Framework Act, adopted in the beginning of 2013, also constitutes an important step in improving scientists' qualifications.

The first reform relates to the new model of financing scientific activities, introducing for the first time performance-based funding based on multi-annual research programmes established at the level of research institutes and universities and the level of funding based on performance indicators. Besides performance funding, funding of research projects/grants continues but is based on stricter peer-review criteria which should result in the funding of a smaller number of high-quality projects (about 800 compared to 2500 projects per year previously). In terms of governance, project funding is shifted from the MSES to the Croatian Science Foundation which will act as an independent body applying a rigid evaluation process.

Governance of research has also changed due to the fusion of several established institutions, notably the Croatian Institute of Technology which was merged with the Business Innovation Centre into the Business Innovation Agency of the Republic of Croatia (BICRO). The National Science Council has been merged with the National Council for Higher Education into the National Council for Science, Education and Technology, to which members were appointed in April 2014. Further reforms and significantly changing the rules on state aid for R&D are envisaged, aimed at providing a better fiscal framework for stimulating investment in research by the business sector.

With respect to human capital building, the MSES and the Agency for Mobility have stepped up their efforts through the adoption of a new International Fellowship Programme for Experienced Researchers in Croatia (NEWFELPRO), supported by a FP7 Co-Fund action. Croatia's EURAXESS Service Centre, launched in 2009, has been expanded since then and is now recognised as a well-performing quality centre. About 40 institutions have adhered to the declaration on principles of the charter and code on the recruitment of scientists.

On 20 December 2012, the government adopted an Action Plan on Science and Society aiming at a more systematic approach to science as a social value, promoting and rebalancing gender, and ensuring good communication on science with citizens.

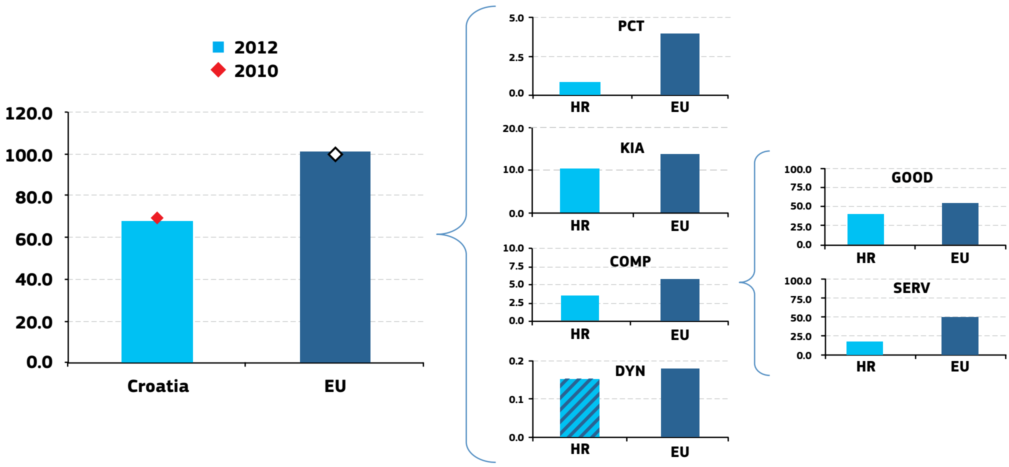
The announced Strategies for Education, Science and Technology and for Innovation are to be adopted by the summer of 2014. As both strategies propose actions to valorise the results of research efforts which, as explained above, is Croatia's major weakness, it is those improvements which should be made and implemented as a matter of priority. For example, it is well known that the research infrastructure in Croatia is outdated and that state-of-the-art equipment is lacking. In this context, in April 2014, the adoption of a Roadmap on Infrastructures according to the European Strategic Forum on Research Infrastructures (ESFRI) is to be welcomed.

Finally, the biggest change will come from the fact that since 1 July 2013 Croatia has become a Member State. This gives it full access to the Structural Funds but will also step up monitoring by the EC of the announced reforms, notably through preparation of the National Reform Programme on all policies, including R&I, to strengthen its competitiveness.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Croatia's position through subsequent components of the indicator:

Croatia – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average); estimated value.
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Croatia is a low performer in the European innovation indicator. In most components it performs below EU average (an exception is the innovativeness of fast-growing enterprises, where Croatia performs near the EU average) and furthermore its performance is stagnating.

The relatively low performance in patents is linked to the country's economic structure with a very small capital goods sector, and a lack of large manufacturing companies, which typically show high patenting activities[4]. Croatia performs near the EU average in medium-high/high-tech goods, partly as the result of its exports of ships.

Employment in knowledge-intensive activities is low. The agriculture and fisheries, and tourism sectors are still relatively important in employment terms.

Tourism has a very high share (> 70 %) in Croatian service exports. Combined with a lack of specialisation in KIS, this leads to a very low share of knowledge-intensive service exports.

[4] Performance in Community trademarks and designs per unit of GDP per capita is also relatively low.

Key indicators for Croatia

CROATIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	:	0.68	0.76	0.80	0.85	0.98	1.43	:	2.30	23.4	*1.81*	7
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	467	:	:	460	:	:	471	3.9 (3)	495 (4)	23 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	:	0.36	0.27	0.33	0.40	0.34	0.33	0.34	0.34	1.1	1.31	21
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	0.51	0.47	0.48	0.50	0.51	0.42	0.42	0.41	-3.1	*0.74*	24
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	12.0	:	:	:	:	18.9	9.6	47.8	26
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	2.8	3.0	3.2	3.2	3.2	:	:	:	-0.2	11.0	27
International scientific co-publications per million population	:	197	211	235	253	309	338	405	428	12.7	343	20
Public–private scientific co-publications per million population	:	:	:	16	18	23	27	27	:	14.4	53	17
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	1.3	1.2	1.1	0.9	0.7	0.7	0.7	:	:	-7.0	3.9	17
License and patent revenues from abroad as % of GDP	0.31	0.16	0.09	0.07	0.06	0.05	0.05	0.04	0.05	-3.9	0.59	20
Community trademark (CTM) applications per million population	0.2	5	2	5	5	8	5	11	10	15.1	152	28
Community design (CD) applications per million population	:	0.7	1.1	0.7	2.3	1.8	0.9	0.5	0.7	0.0	29	28
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	13.0	:	14.4	:	10.5	:	:	-14.5	14.4	18
Knowledge-intensive services exports as % total service exports	:	14.8	14.8	16.8	16.0	14.0	15.8	17.3	:	0.7	45.3	26
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-3.06	-2.46	-2.27	-1.22	0.23	-0.44	2.12	2.98	1.03	-	4.23 (5)	17
Growth of total factor productivity (total economy): 2007 = 100	91	100	100	100	99	91	91	91	91	-9 (6)	97	24
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	40.9	:	:	:	:	39.7	-0.6	51.2	19
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	9.5	9.2	9.9	10.3	10.4	2.2	13.9	22
SMEs introducing product or process innovations as % of SMEs	:	:	28.3	:	31.5	:	29.3	:	:	-3.5	33.8	19
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.00	0.00	0.02	0.00	0.01	0.05	:	:	:	41.6	0.44	21
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.12	0.36	0.27	0.05	0.07	0.03	:	:	:	-27.7	0.53	26
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	:	60.0	60.6	62.3	62.9	61.7	58.7	57.0	55.4	-2.3	68.4	27
R&D intensity (GERD as % of GDP)	:	0.87	0.75	0.80	0.90	0.85	0.75	0.76	0.75	-1.3	*2.07*	23
Greenhouse gas emissions: 1990 = 100	83	96	97	102	98	92	90	89	:	-13 (7)	83	16 (8)
Share of renewable energy in gross final energy consumption (%)	:	14.1	13.8	12.5	12.2	13.3	14.6	15.7	:	5.9	13.0	11
Share of population aged 30–34 who have successfully completed tertiary education (%)	:	17.4	16.7	16.7	18.5	20.6	24.3	24.5	23.7	7.3	35.7	24
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	5.1	4.7	3.9	3.7	3.9	3.7	4.1	4.2	1.5	12.7	1 (8)
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	:	30.7	32.3	32.3	2.6	24.8	22 (8)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) EU is the weighted average of the values for the Member States.
(6) The value is the difference between 2012 and 2007.
(7) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(8) The values for this indicator were ranked from lowest to highest.
(9) Values in italics are estimated or provisional.

Cyprus

New opportunities for a small economy towards key areas of innovative advantage

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Cyprus. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.46 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+0.9 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **28.1** (EU: 47.8; US: 58.1) 2007-2012: **+1.4 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **82.8** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **40.7** (EU: 51.2; US: 59.9) 2007-2012: **+0.3 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: New production technologies, energy, construction, and ICT	***HT + MT contribution to the trade balance*** 2012: **2.4 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+31.9 %** (EU: +4.8 %; US: -32.3 %)

Since 2007, Cyprus has achieved a minor increase in its R&D intensity and has improved its performance on the excellence in science and technology indicator, with both the absolute figures and growth rates still remaining below the EU average. Cyprus also managed to slightly increase its performance on the knowledge-intensity indicator compared to 2007, but this value has decreased compared to 2011 and is far from the EU average. In terms of innovation output, the country is a medium-level performer ranked just below the EU average, which can be partly explained by the poor performance in technological innovation which is measured through patent applications. In terms of the economy's competitiveness, there has been a significant increase in the contribution of high- and medium-high-tech products to the trade balance with a spectacular growth rate of 31.88 % since 2007, which is much higher than the EU average.

Despite the increase in the economy's competitiveness through innovation in recent years, there are still some challenges for R&I policy-makers in Cyprus. One of the main bottlenecks in the R&I system is the small number of human resources available for research activities. This is due to the weak demand from business and industry. There is a sharp contrast between the large number of tertiary education graduates and the very small number of human resources for research. This is partially explained by a still unfavourable environment for research activities which is leading to a substantial brain drain of S&T graduates to other countries, mainly the United Kingdom and the United States. In addition, business involvement in R&I is very limited mainly due to the lack of big companies and the absence of high-tech industrial activity. The business sector is focused on services and is dominated by very small enterprises that have yet to develop an innovation culture.

The above-mentioned R&I challenges facing Cyprus could further be exacerbated following the severe economic crisis which peaked in the country in March 2013, with strict austerity measures being imposed as part of the country's economic adjustment programme. At the same time, opportunities could be created by following

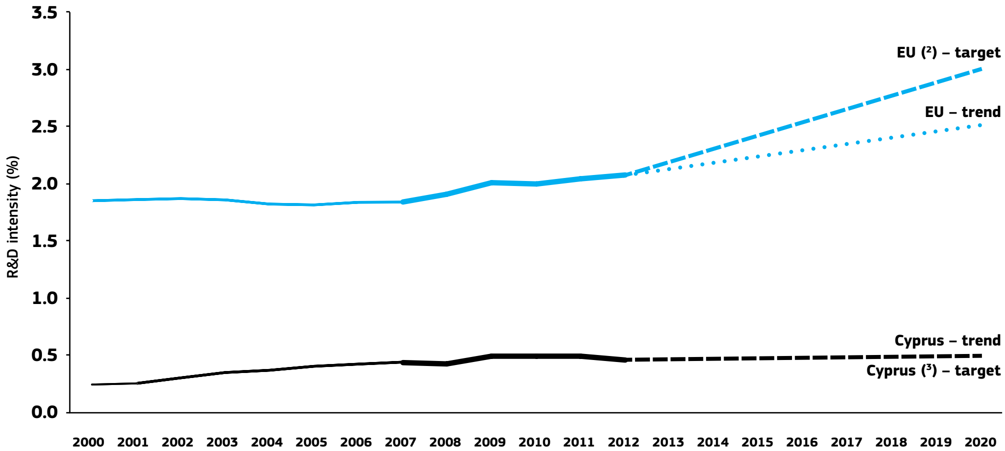
1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

the principle of smart fiscal consolidation and focusing efforts on areas where the country could have a leading edge for innovations, like the ICT sector in which Cyprus is excelling. In addition, there is potential for exploring opportunities in environmental and energy technologies, given the discovery of natural gas reserves in the periphery of the country. A greater focus on R&I in Cyprus could be further promoted by the growing importance given to this area by the government.

Investing in knowledge

Cyprus – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) CY: The projection is based on a tentative R&D intensity target of 0.5 % for 2020.

Given the latest economic developments in the country and the probable restructuring of the national R&I system, Cyprus will maintain its modest R&D intensity target of 0.5 % for 2020 as set in the context of its 2013 National Reform Programme. This restructuring is expected to take place in 2014, upon completion of the economic adjustment programme signed with the Troïka, and on the basis of the country's recent economic situation.

Despite the almost doubling of R&D intensity since 2000, a persistent stagnation can be observed in Cyprus since 2009, with R&D intensity stabilising at about 0.50 % of GDP, meeting the exact target set by the government. Furthermore, R&D intensity fell to 0.46 % in 2012, which can be attributed to the start of the financial crisis in the country which saw severe fiscal cuts in public budgets.

Low business involvement in R&I activities continues in Cyprus. In 2012, only 0.06 % of a total of 0.46 % of GERD was attributed to Business R&D expenditure (BERD), which is a very low figure compared to the rest of the EU countries. Furthermore, BERD has seen a declining trend since 2007.

Furthermore, the severe austerity measures which were applied after March 2013 and the lack of liquidity due to inadequacies in the banking system undermined the capacity of private funding for R&I activities.

EU Structural Funds are an important source of funding for R&I activities in Cyprus. Of the EUR 612 million of Structural Funds allocated to the country over the 2007-2013 programming period, around EUR 37 million (6.0 % of the total) relate to RTDI[1]. A total of EUR 108.5 million were initially allocated for R&I in the 2007-13 period, under Axis 3 of the ERDF (Knowledge Based Society and Innovation), but after a revision of the Operational Programme (OP) in 2012, EUR 21 million were

3 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

transferred to other axes due to low absorption rates, leaving a total of EUR 87.5 million for R&I. Despite the fact that the whole sum of EUR 87.5 million has been committed and paid to implementing entities (mainly through the National Framework Programme of the Research Promotion Foundation), only EUR 42.3 million has been accounted for as real expenditure spent. This is probably the result of the country's general economic situation whereby, due to severe liquidity problems and shrinking business activities, it is much more difficult for businesses and other entities to implement those projects already started.

The main source of external funding for R&I in Cyprus has been the EU's Seventh Framework Programme for Research and Technological Development (FP7). Until March 2014, 435 participants from Cyprus benefited from FP7, benefitting from a total of EUR 87.8 million, with around one-third of that funding going to Cypriot SMEs. This shows that Cyprus has a good absorption rate from the Framework Programme relative to its size – it ranks 21st in the EU-28. However, success rates in FP7 both in terms of applications and of EU financial contributions remain quite low, which indicates possible weaknesses in networking and collaboration with other European partners.

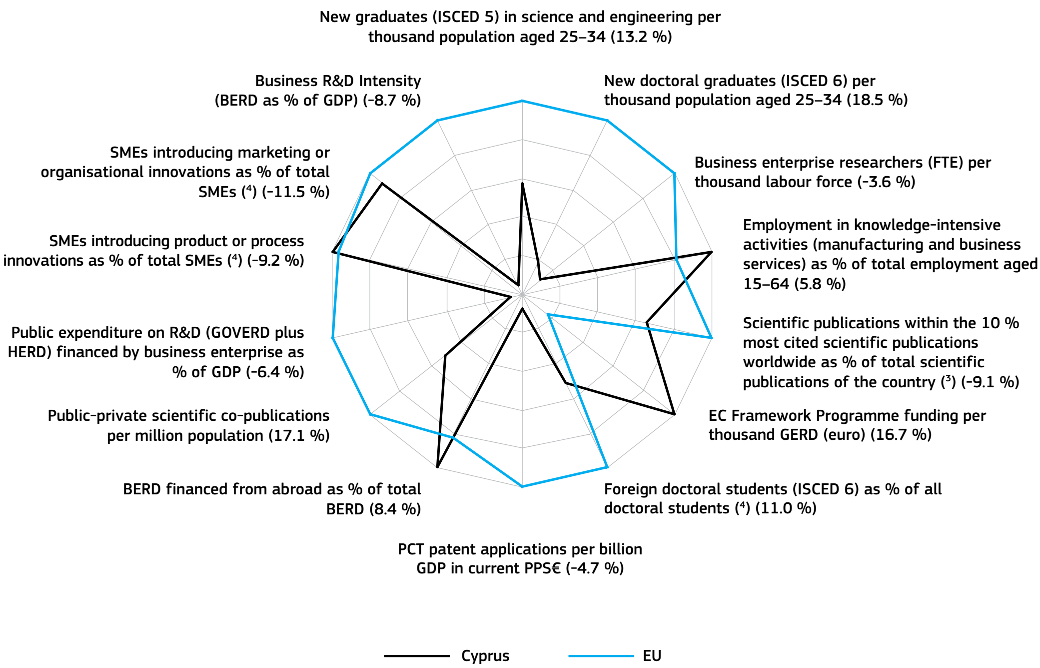
Cyprus' most active and successful participation in FP7 is in the ICT field as well as in the European Research Council and Marie-Curie actions. The most active Cypriot entities in FP7 are a few higher education institutions that absorb most of the funding. Cyprus has most FP7 collaborative links with the United Kingdom, Germany, Spain, Italy and Greece.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Cyprus' R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Cyprus, 2012 (1)

In brackets: average annual growth for Cyprus, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

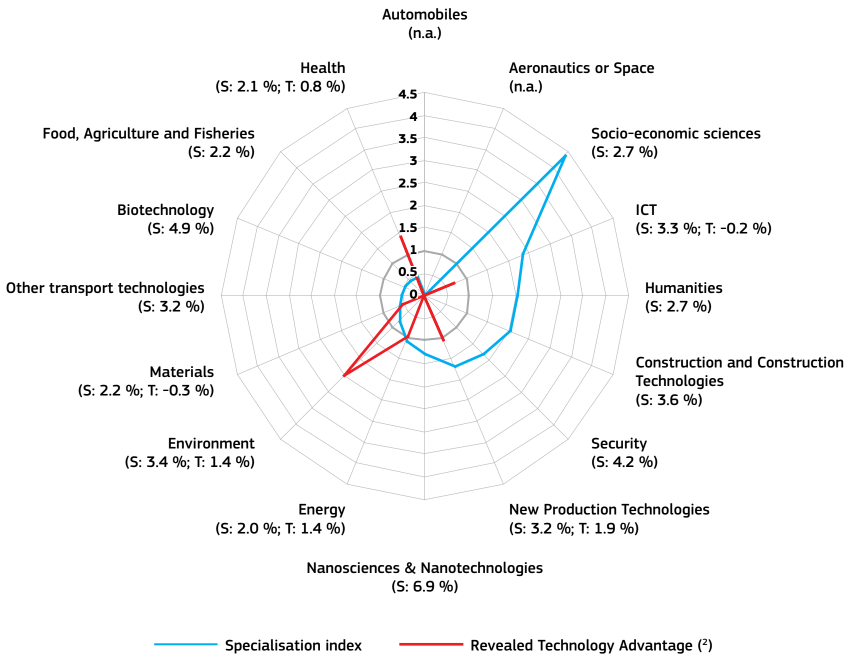
The graph above shows that R&D financing in Cyprus relies significantly more than the EU average on external funding (EU Framework Programme, private R&D funding from abroad) and in particular indicates a significant upward trend in Framework Programme funding since 2007. The graph also shows that two other indicators, employment in knowledge-intensive activities (as a percentage of total employment of age groups between 15 and 64 years) and SMEs introducing innovations (as a percentage of total SMEs) have values higher than the EU average. On the other hand, the main weaknesses in the country's R&I system occur in human resources with low levels of both business enterprise researchers and new doctoral graduates aged 25-34 years. Furthermore, Cyprus is also lagging behind regarding innovation and business investment, with the biggest gaps between Cyprus and the EU average occurring for BERD as % of GDP, public expenditure on R&D financed by business enterprise as % of GDP, and PCT patent applications per GDP. These findings underline the conclusion that significant efforts are needed domestically to promote the scientific profession and to provide appropriate incentives for business investment in R&I activities.

Research policy has a strong international dimension and is well aligned with the ERA pillars. ERA policy is seen as an opportunity to integrate the small national R&I system into the broader European market and in this context internationalisation of the research system is a high priority. The national scientific landscape does not provide space for large research infrastructures. However, due to the strong performance of its ICT and computing base, Cyprus puts particular emphasis on e-infrastructures.

Cyprus' scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where the country shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Cyprus – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



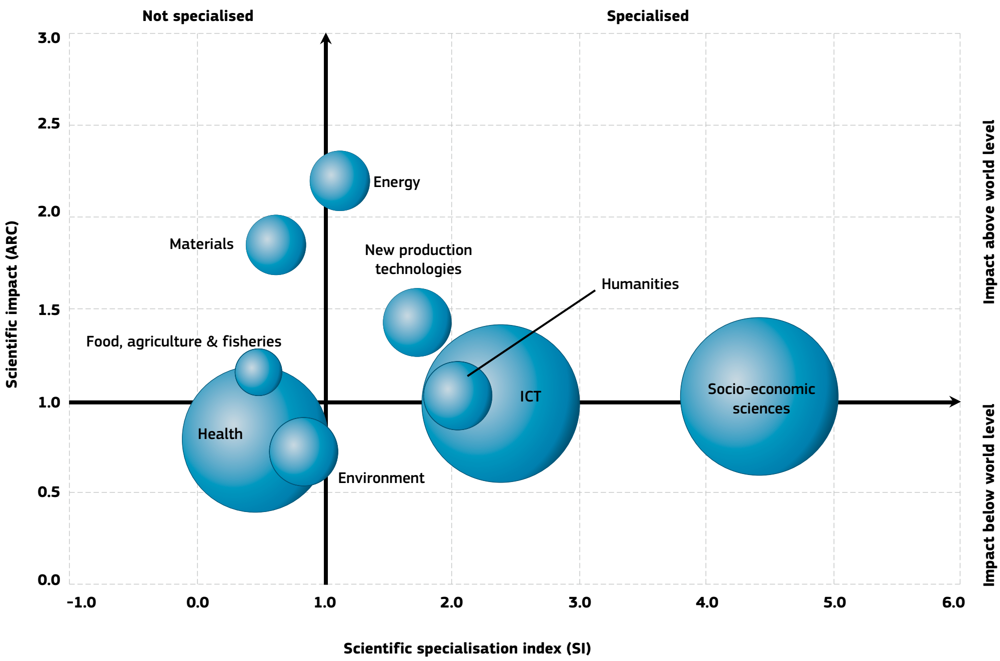
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Comparison of the scientific and technological specialisation in selected thematic priorities gives an interesting picture for Cyprus. In particular, technology production shows a strong specialisation in the environment and health sectors and, to a lesser extent, new production technologies and energy. However, when looking for co-specialisations both in the scientific and technological aspects, a match can only be seen with new production technologies and energy, with potential in the ICT sector.

In socio-economic sciences, where Cyprus has a very strong scientific specialisation, no technological advantage is revealed and, interestingly enough, in the environment sector where Cyprus appears to have the stronger technological specialisation, the scientific specialisation is weaker. The key areas identified in this graph seem to be in line with the key priority areas identified in Cyprus' national Smart Specialisation Strategy in which energy, environment and ICT have been identified as key priority areas for specialisation.

The graph below illustrates the positional analysis of Cyprus' publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publication from a science field in the country's total publications.

Cyprus – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

It can be seen that in key areas of scientific specialisation, like socio-economic sciences and ICT, the impact is similar to the world average which suggests there is some room for improvement. Furthermore, it should be highlighted that despite the relatively low levels of scientific specialisation in energy and materials, these are areas with strong potential impact, implying that Cyprus will probably benefit from concentrating efforts towards the energy technologies and materials sectors.

As the excellence in research correlates to more cooperation with researchers from other European countries and beyond, in order to increase its research excellence Cyprus would benefit from actively supporting and providing incentives for its researchers to connect to Horizon 2020 networks.

Policies and reforms for research and innovation

The R&I system in Cyprus is relatively new. It evolved mainly in the early 1990s with the establishment of the University of Cyprus in 1992 and of the Research Promotion Foundation in 1996, which aims to promote the development of scientific research, technology and innovation. In the last decade, Cyprus has achieved a significant increase in its R&D intensity, which has led to improved excellence in science and technology. However, R&D investment relies predominantly on public expenditure, with 72 % of total R&D expenditure (GERD) being financed by the government in 2012 – one of the highest percentages in the EU. BERD remains very low at about 14 % of total R&D expenditure in 2012 and has declined by a further 8.5 % since 2007.

The Cypriot economy has been in financial distress since 2011, initiated by the global economic crisis and exacerbated by the losses suffered from a restructuring of Greek state bonds, in which the local banking system had invested heavily. The debt crisis in Cyprus peaked in March 2013, when the EU-ECB-IMF Troika and the Cyprus government agreed to a Memorandum of Economic and Financial Policies, including a financial rescue package, structural reforms and a mandatory 'trimming' of bank deposits above EUR 100 000 to save the over-indebted banks and ease credit pressures on the government.

The latest economic developments in the country will undoubtedly also affect the R&I sector, in particular future government expenditure on R&D.

On the positive side, however, the new government (as of March 2013) has announced that significant effort will be put into R&I in an attempt to exit from the financial crisis. As a result, a National Committee on Research, Innovation and Technological Development (NCRITD) was set up by the Council of Ministers in September 2013, comprising distinguished experienced scientists coming from the Cypriot academic, research and business sectors, to review the national R&I system and to make relevant recommendations on its governance to the President of the Republic of Cyprus. The work of the NCRITD was completed in March 2014 and its outcomes submitted to the President. Its report proposes the creation of a new system structured on four levels (strategic, political, operational/implementation, and research stakeholders), which integrates research, innovation and entrepreneurship. The study proposes, among others, the appointment of a commissioner for research, innovation and entrepreneurship, the creation of a new DG covering these sectors under the Ministry of Finance, the establishment of an advisory committee, and the redesign of the role of the Research Promotion Foundation (RPF) to accommodate technology transfer activities. The study is currently being reviewed by the presidency.

Furthermore, the Smart Specialisation Strategy for R&I, an *ex-ante* conditionality for the use of European Structural and Investment Funds (ESIF) for R&I in Cyprus is expected to be finalised in spring 2014. The sectors identified through this process are: tourism, energy, construction, shipping, health, ICT and the environment.

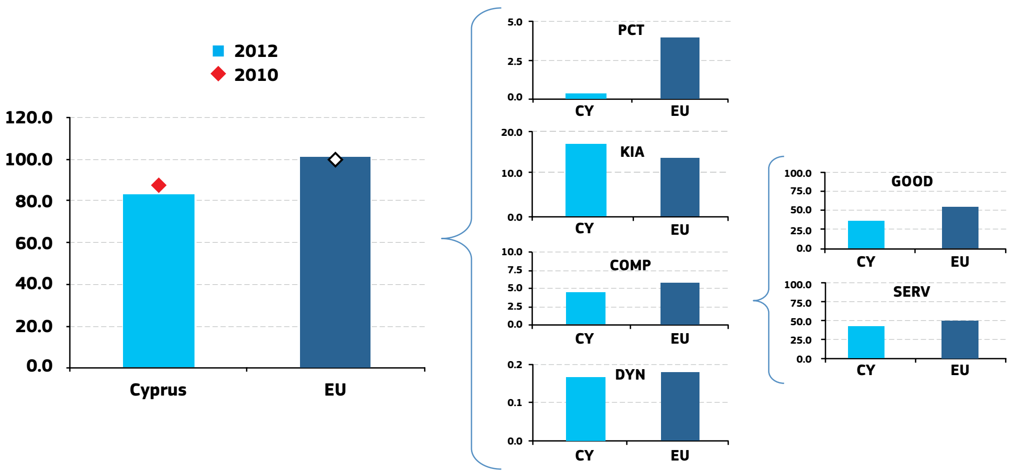
The outcome of the two above-mentioned reports is expected to prove useful for the drawing up of the National 2014-20 R&I Strategy which should be completed by the end of 2014. This strategy will be implemented mainly through programmes of the Research Promotion Foundation, which is the main funding agency for R&I in Cyprus.

Finally, due to the prevailing economic crisis in the country and the resulting liquidity constraints, the main source of public funding for the implementation of the new R&I strategy is expected to come from the ESIF for the 2014-20 period. The bulk of the funding that will be allocated for R&I from the ESIF Operational Programme for Cyprus will be spent through the DESMI 2014-20, which is the national Framework Programme for R&I designed and implemented by the RPF. In parallel, the Technology Service at the Ministry of Energy, Commerce, Industry and Tourism will implement schemes for promoting specifically business innovation.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Cyprus' position regarding the indicator's different components:

Cyprus – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Cyprus is a medium-low performer in the European innovation output indicator. This is a result of average-to-low performance in all components, except for employment in knowledge-intensive activities. Furthermore, its performance has been declining since 2010.

Low performance in patents is linked to the country's economic structure with a very small capital goods sector and a lack of large manufacturing companies, which typically show high patenting activities when headquartered in the respective country and if linked to a well-performing research system.

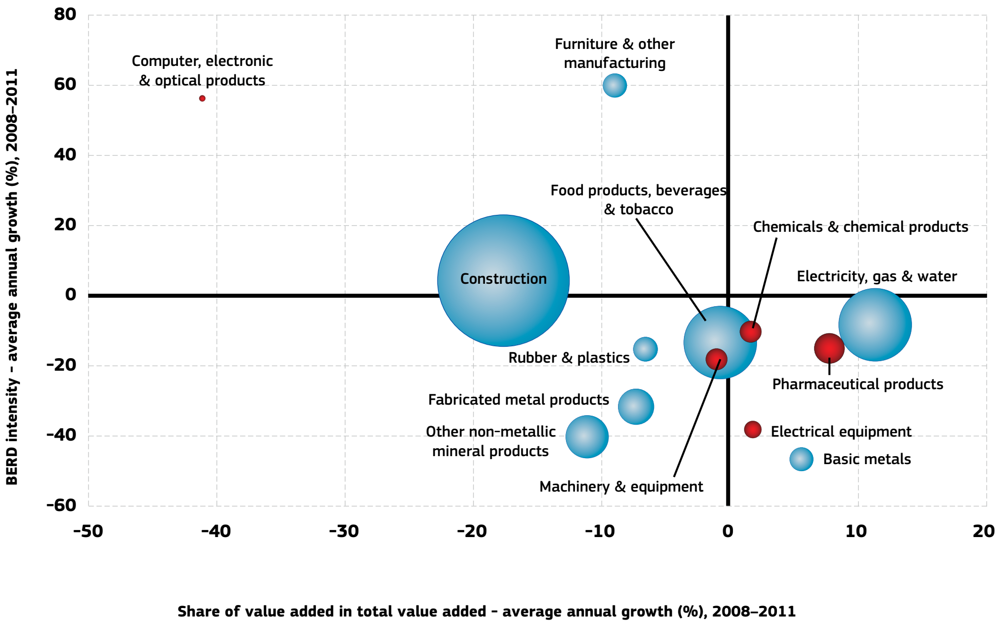
As regards trade, with its limited technology-oriented manufacturing base Cyprus has a low share of medium-high-tech and high-tech exports.

Cyprus performs below EU average as regards employment in fast-growing innovative firms as a % of total employment in fast-growing firms. This is the result of a high share of sectors with low innovation scores, including accommodation, construction and food services, among the fast-growing enterprises not compensated for by fast-growing firms in more innovative sectors.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries for the period 2008-2011. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects a decrease in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Cyprus – Share of value added versus BERD intensity: average annual growth, 2008–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: ([1]) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

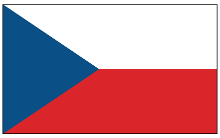
The Cypriot economy is dominated by small, family-run enterprises with limited export orientation. The country's economy is dominated by the service sector, mainly tourism, transport and finance, with manufacturing representing only around 7 %. Such characteristics do not favour R&D. SMEs which provide mainly low-value-added support services are unlikely to invest in R&I. Most firms tend to concentrate on low-value-added products and services rather than taking risks on new products or export markets.

The graph above shows that manufacturing industry in Cyprus is largely dominated by low-tech and medium-low-tech sectors (which are less research intensive) and mainly by the construction sector, followed by the electricity, gas and water sectors and the food products, beverages and tobacco sector. Structural changes towards more research-intensive economies are in general driven by high-tech and medium-high-tech manufacturing sectors. The country has four such sectors: pharmaceutical products, machinery and equipment, chemicals and chemical products, and electrical equipment.

Key indicators for Cyprus

CYPRUS	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.13	0.05	0.27	0.14	0.24	0.24	0.23	0.31	0.33	18.5	*1.81*	27
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	:	:	:	:	:	:	:	:	:	:
Business enterprise expenditure on R&D (BERD) as % of GDP	0.05	0.09	0.10	0.10	0.10	0.10	0.09	0.07	*0.06*	*-8.7*	1.31	28
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.18	0.29	0.30	0.31	0.28	0.33	0.34	0.35	*0.34*	*1.9*	*0.74*	25
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	26.3	:	:	:	:	28.1	1.4	47.8	16
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	6.8	7.7	8.7	8.7	7.2	:	:	:	-9.1	11.0	17
International scientific co-publications per million population	:	434	505	602	721	876	1005	1029	1066	12.1	343	9
Public–private scientific co-publications per million population	:	:	:	14	13	16	27	27	:	17.1	53	18
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.8	1.0	0.5	0.3	0.5	0.6	0.3	:	:	-4.7	3.9	27
License and patent revenues from abroad as % of GDP	0.00	0.09	0.09	0.10	0.05	0.05	0.04	0.01	0.01	-43.5	0.59	27
Community trademark (CTM) applications per million population	84	136	187	280	238	295	324	510	474	11.1	152	3
Community design (CD) applications per million population	:	9	12	10	3	9	15	20	17	11.1	29	18
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	12.3	:	16.1	:	14.7	:	:	-4.4	14.4	10
Knowledge-intensive services exports as % total service exports	:	33.2	35.2	41.2	47.1	47.5	48.5	42.9	:	1.0	45.3	8
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-4.71	3.79	1.78	0.60	-0.13	1.07	0.66	1.49	2.39	-	4.23 (3)	12
Growth of total factor productivity (total economy): 2007 = 100	99	98	99	100	100	96	96	95	95	-5 (4)	97	17
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	40.1	:	:	:	:	40.7	0.3	51.2	18
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	14.8	14.3 (5)	14.4	15.0	16.9	5.8	13.9	6
SMEs introducing product or process innovations as % of SMEs	:	:	37.9	:	42.2	:	34.8	:	:	-9.2	33.8	14
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.13	0.17	0.10	0.18	0.10	0.05	:	:	:	-45.9	0.44	20
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.09	0.26	0.06	0.11	0.00	0.23	:	:	:	41.0	0.53	16
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	72.3	74.4	75.8	76.8	76.5	75.3 (5)	75.0	73.4	70.2	-2.3	68.4	11
R&D intensity (GERD as % of GDP)	0.25	0.41	0.43	0.44	0.43	0.49	0.50	0.49	*0.46*	*0.9*	*2.07*	28
Greenhouse gas emissions: 1990 = 100	138	150	154	157	160	156	151	147	:	-9 (6)	83	27 (7)
Share of renewable energy in gross final energy consumption (%)	:	2.6	2.8	3.5	4.5	5.0	5.4	5.4	:	11.5	13.0	23
Share of population aged 30–34 who have successfully completed tertiary education (%)	31.1	40.8	46.1	46.2	47.1	45.0	45.3	46.2	49.9	1.6	35.7	2
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	18.5	18.2 (8)	14.9	12.5	13.7	11.7	12.7	11.3	11.4	-1.8	12.7	18 (7)
Share of population at risk of poverty or social exclusion (%)	:	25.3	25.4	25.2	23.3 (9)	23.5	24.6	24.6	27.1	3.8	24.8	18 (7)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) EU is the weighted average of the values for the Member States.
(4) The value is the difference between 2012 and 2007.
(5) Break in series between 2009 and the previous years. Average annual growth refers to 2009–2012.
(6) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(7) The values for this indicator were ranked from lowest to highest.
(8) Break in series between 2005 and the previous years.
(9) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2012.
(10) Values in italics are estimated or provisional.



Czech Republic

Improving the quality of science to accelerate the emergence of domestic innovation leaders

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in the Czech Republic. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.88 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+6.6 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **26.1** (EU: 47.8; US: 58.1) 2007-2012: **+0.7 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **89.7** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **41.4** (EU: 51.2; US: 59.9) 2007-2012: **+1.6 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Materials, environment, aeronautics, energy, and other transport technologies	***HT + MT contribution to the trade balance*** 2012: **3.8 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+1.5 %** (EU: +4.8 %; US: -32.3 %)

The Czech innovation system is characterised by sustained public funding of R&D, the training of a substantial number of new S&E graduates and doctorate holders, and the strong presence of R&D-performing foreign affiliates. Since 2007, an ambitious reform agenda has been implemented and has already achieved to a large extent the modernisation of the national innovation system. Following the adoption of the International Competitiveness Strategy for 2012-2020, the national priorities for applied R&D were revised and new supporting measures were introduced. These efforts are in line with the objective to develop innovation as the main driver of the future competitiveness of the Czech economy. However, this flurry of initiatives and efforts has yet to translate into any visible improvement in the quality of the science base output or in the number of patents produced, both of which remain very low by international standards. Despite a public R&D intensity of 0.86 %, clearly higher than the EU average, the level of scientific excellence remains markedly lower than the EU average and is not catching up. Therefore, firms are not considering universities or public research organisations as key partners for their innovation activities and there is insufficient science-business cooperation and knowledge transfer (also evidenced by the extremely low level of business co-funding of public research). The lack of strong and willing public partners is detrimental to business R&D activities and explains both the low number of intellectual property assets produced and the scarcity of domestic innovation leaders. This is compounded by the fact that Business Expenditure on R&D (BERD) is largely dominated by foreign affiliates (which perform a little over half of BERD) and is heavily subsidised by the government and from abroad (only two-thirds of BERD is funded by the national private sector). Thus, further increases in business R&D activities are likely to require the emergence and development of domestic innovation leaders actively supported by public research institutions.

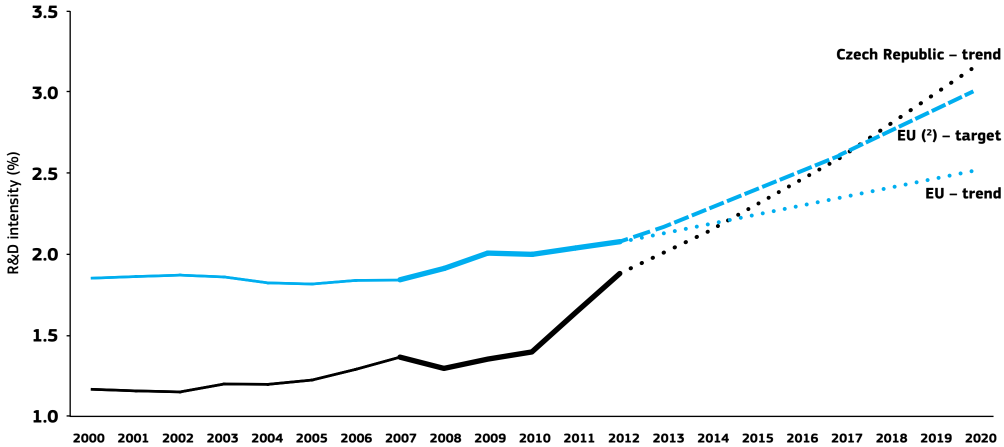
1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Despite recent structural change towards a more knowledge-intensive economy, the main challenge preventing the Czech innovation system from reaching its full potential remains the insufficient quality and attractiveness of its science base, which deters the development of domestic innovation leaders. This is linked in particular to an inadequate methodology for evaluating research performance and allocating public R&D funding to higher education and research institutions. In response to this challenge, the Czech authorities are committed to overhauling the current evaluation methodology, although changes will only start to be implemented in 2016 at the earliest.

Investing in knowledge

Czech Republic – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) CZ: An R&D intensity target for 2020 is not available.

To date, the government budget for R&D has been protected since the start of the economic crisis and has remained nominally stable during the period 2011-2014 (at slightly above EUR 1 billion).

R&D intensity rose steadily until the start of the current crisis, from 0.91 % in 1995 to 1.37 % in 2007. After a minor setback at the beginning of the crisis, the rate of growth gradually accelerated to bring R&D intensity up from 1.30 % in 2008 to 1.88 % in 2012. In 2011, the Czech Republic set a target to increase public funding of R&D to 1 % of GDP by 2020, which was reached in 2012, largely due to the sizeable share of Structural Funds allocated to R&D. Looking to the R&D activities actually performed in the public sector, public R&D intensity increased to 0.86 % in 2012, a level which is above the EU average and significantly higher than in most other EU-13 Member States. In spite of that progress, an overall R&D intensity target, encompassing both public and private R&D fields, is missing at national level.

About EUR 4.1 billion of Structural Funds were earmarked for RTDI[3] in the Czech Republic in the programming period 2007-2013 (representing 15.5 % of the total). Around 84 % of these funds had been absorbed by August 2013. Structural Funds are therefore one of the largest sources of public funding of R&D in the Czech Republic.

The relatively good performance of the Czech innovation system in terms of BERD, which reached 1.01 % of GDP in 2012, is largely due to a strong manufacturing sector (24 % of total value added in 2011) with a marked industrial specialisation in

3 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

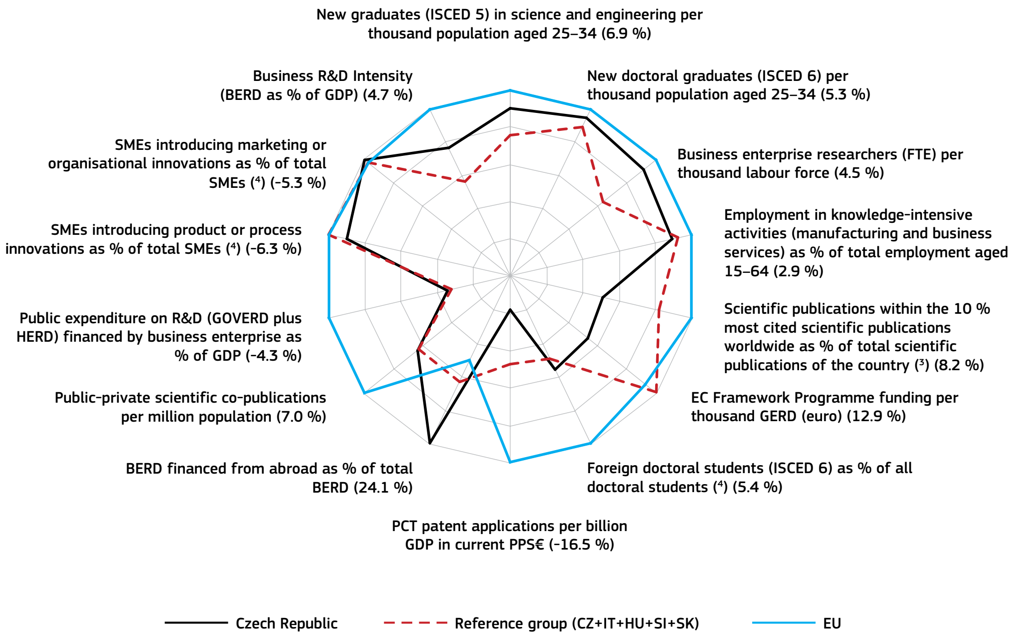
innovative sectors (such as 'motor vehicles' and 'electrical equipment') combined with increasing foreign business R&D investments ('inward BERD'). As a result, BERD is highly concentrated in a few large foreign affiliates that account for more than half of total BERD. Whereas BERD performed by domestic companies almost doubled from EUR 284 million in 1998 to EUR 487 million in 2009, inward BERD increased sixfold during the same period. This reflects the country's rising attractiveness for foreign R&D activities and highlights the dominant role played by foreign affiliates in the Czech innovation system and the need to foster the emergence of domestic innovation leaders.

An effective research and innovation system building on the European Research Area

The spider graph below provides a synthesis picture of strengths and weaknesses of the Czech research and innovation (R&I) system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2007 to the latest available year are given in brackets under each indicator.

Czech Republic, 2012 (1)

In brackets: average annual growth for Czech Republic, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The Czech innovation system displays a complex pattern of relative strengths and weaknesses affecting both its input and output. While it currently scores lower than the EU average on most S&T indicators, it has been gradually catching up with the group of innovation followers[4] and outperforms its reference group in terms of new graduates in science and engineering, new doctoral graduates, business R&D intensity, researchers employed by the business sector, and attractiveness to foreign R&D investments. The Prague region is among the EU regions with the highest share of researchers (full-time equivalent) in total employment (over 1.8 %) and is the EU leader in terms of the share of the labour force employed in an S&T sector (more than 50 %). Other relative strengths include youth with upper secondary education, international scientific co-publications, and non-R&D business innovation expenditure. The number of international

4 IU scoreboard 2014: http://ec.europa.eu/enterprise/policies/innovation/files/ius/ius-2014_en.pdf

scientific co-publications has surged over the last decade, in particular in partnerships with Germany, the United Kingdom, France, Italy and Slovakia. In addition, the success rate of Czech entities in FP7 (20.56 %) is approaching the EU average (22 %), which is evidence of enhanced scientific quality and networking within the ERA. However, Czech participants in FP7 still receive a share of the total EC funding (0.67 %) which is markedly lower than the Czech Republic's share in total EU expenditure on R&D (1.07 %).

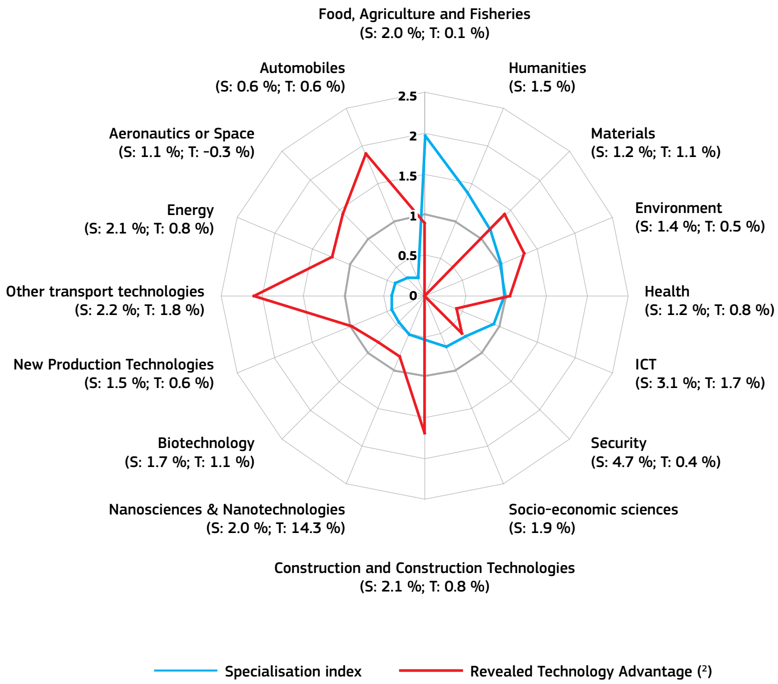
The S&T output from the Czech innovation system is critically weak in terms of high-impact scientific publications, PCT patents, and attractiveness to foreign doctoral students (other than Slovak citizens). Other marked weaknesses highlighted in the IU scoreboard are access to venture capital and licence and patent revenues from abroad. There are also relatively few co-inventions of patents, which may hint at potential weaknesses in the capacity to engage in international technological networks.

However, it is important to note that there is considerable diversity in regional innovation performances in the Czech Republic, ranging from low to medium-high[5].

The Czech Republic's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where the Czech Republic shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Czech Republic – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



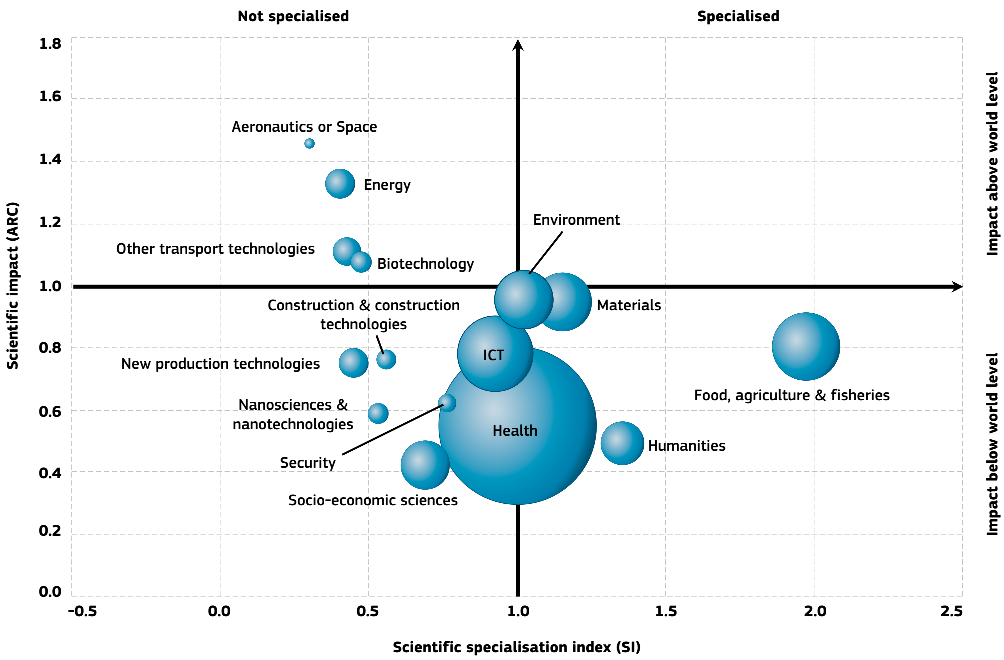
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

5 Corresponding to Severozapad and Prague, respectively.

Overall, scientific and technological specialisations are not well matched in the Czech Republic. Whereas there is a marked technological specialisation in transport (including automobiles, aeronautics and other transport technologies), construction and construction technologies, materials, energy, and environment, the Czech scientific production is strongly specialised in food, agriculture and fisheries, and in humanities. This mismatch is particularly striking regarding the automobiles and construction sectors, where the scientific production is both relatively low in quantity and scientific impact. In other areas of technological specialisation, such as aeronautics, energy, and other transport technologies, the weakness in the number of publications is partially compensated by their higher-than-average scientific impact.

The graph below illustrates the positional analysis of Czech publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publication from a science field in the country's total publications.

Czech Republic – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

In terms of scientific quality, the Czech Republic lags significantly behind the majority of Member States with, on average, only 5.6 % of publications among the 10 % most cited worldwide (EU average: 11 %). This situation varies a lot depending on the scientific field. Aeronautics and space, energy, other transport technologies and biotechnology stand out as scientific fields where the Czech Republic displays a high degree of both scientific excellence and international collaboration. However, these are not areas of specialisation in the Czech science base. Conversely, the food, agriculture and fisheries area stands out as the strongest scientific specialisation, with many publications, although, on average, it has a poor scientific impact.

The marked technological specialisation in aeronautics, energy, and other transport technologies seems to rely on a narrow but high-impact science base, which might deserve greater prioritisation. There are also areas (e.g. materials and environment) where, to some extent, the science base and technological specialisation match, and where efforts should focus on continuing to improve the quality of the scientific production. The other areas of scientific specialisation neither correspond to established technological strength nor have a strong capacity to support technological development due to the lack of scientific impact.

Policies and reforms for research and innovation

Since 2007, strong and sustained public efforts have been devoted to reforming the national research system, including building up research infrastructures, supporting innovative firms and, more recently, establishing long-term partnerships between the science base and the business sector. The National Innovation Strategy (NIS) aims to strengthen the importance of innovation as a source of competitiveness for the Czech Republic[6]. It sets out a wide range of measures to increase the effectiveness of the national R&I system, including the quality of its output and the links between the science base and the business sector. This includes amending the Investment Incentives Act to offer investors (as of July 2012) tax incentives for creating or upgrading manufacturing facilities, R&D centres and business support centres; amending the Income Tax Act so that private firms can (as of January 2014) deduct from their taxable income the cost of R&D activities contracted out; launching new programmes to stimulate cooperation between R&D institutions and industry in sectors such as transport, energy and the environment through the Technology Agency's ALFA Programme; developing a new evaluation methodology to ensure that public funding of R&D is based on excellence/quality and that support is focused on the best research teams; supporting venture capital; reforming the higher education system and improving researchers'' career prospects, especially for top scientists, in order to prevent brain drain. These efforts were largely supported through EU Structural Funds which have become one of the main sources of R&D funding in the Czech Republic.

The national RDI Policy 2009-2015, which was updated in April 2013, reviewed the progress achieved in reforming the research system and presented new measures to improve the supply of skills, knowledge transfer and business innovative capacity. Since its creation in 2009, the country's Technology Agency has grown in importance to become the main instrument for supporting applied research and science-business cooperation (notably through 'competence centres') and, together with the Science Foundation, the Academy of Sciences and the other RDI support providers, is implementing the new set of priorities for oriented RDI, adopted by the government in July 2012, which focuses on six major societal challenges: competitive knowledge economy; sustainable energy and material resources; environment for quality life; social and cultural challenges; healthy people; and secure society.

In terms of governance, the Czech innovation policy is still extremely complex and convoluted. It is defined by a set of intertwined strategic documents (International Competitiveness Strategy, National Innovation Policy, National Innovation Strategy and National Smart Specialisation Strategy and bodies); governed by three government bodies (Council for R&D and Innovation, Ministry of Education, Youth and Science, and Ministry of Industry and Trade), and implemented through a wide set of support actions, ranging from the Technology Agency's applied research programmes, R&D tax incentives, project-based funding of fundamental research by the Science Foundation, competitive-based institutional funding of universities and academic institutes, and Operational Programmes under EU Structural Funds to support R&D infrastructures and business innovation.

As part of the new government, a vice-premier in charge of research has been appointed and will chair the Council for R&D and Innovation, creating expectations that the coordination of the Czech innovation system will improve.

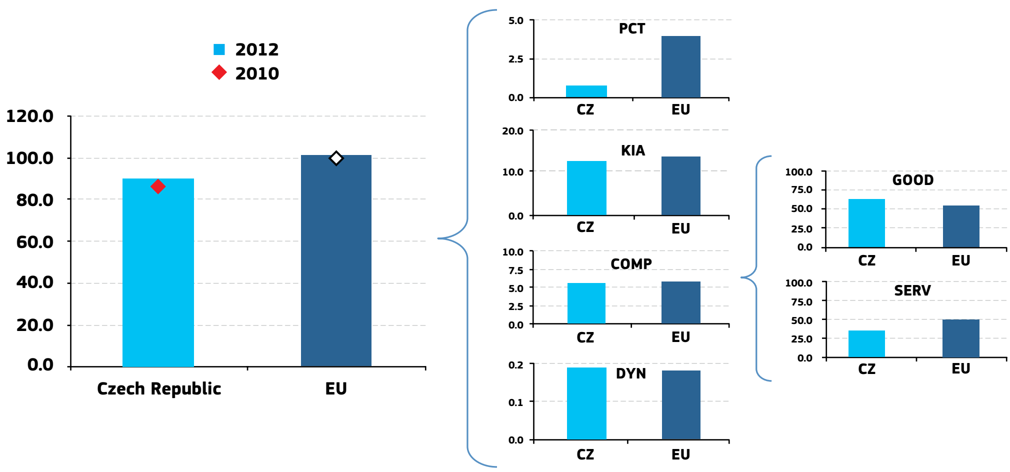
Currently, the national R&D target only covers the public funding of R&D. The lack of commitment to an overall R&D target, encompassing both public and private R&D intensity, could jeopardise the adoption (and/or endanger the rigorous implementation) of important policies and measures to incentivise private R&D investment. In light of past performance, current dynamics and the strong manufacturing sector (24 % of value added), a national target could be set at 2.5 % by 2020. There are also important delays in implementing the planned reforms, which may lead to a loss of attractiveness for both domestic and foreign R&I investors. This is particularly true for the overdue modernisation of the higher education system and the delayed development of a new methodology for evaluating research performance – two reforms required to change the attitude of academia towards the business sector with which it should start to develop stronger collaborations.

6 As part of the Czech Republic International Competitiveness Strategy for 2012-2020.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of the Czech Republic's position regarding the indicator's different components.

Czech Republic – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

The Czech Republic is a medium performer in the European innovation indicator, with an overall score slightly below average. This reflects close to average performance in all components, except the level of patenting activity which is very low.

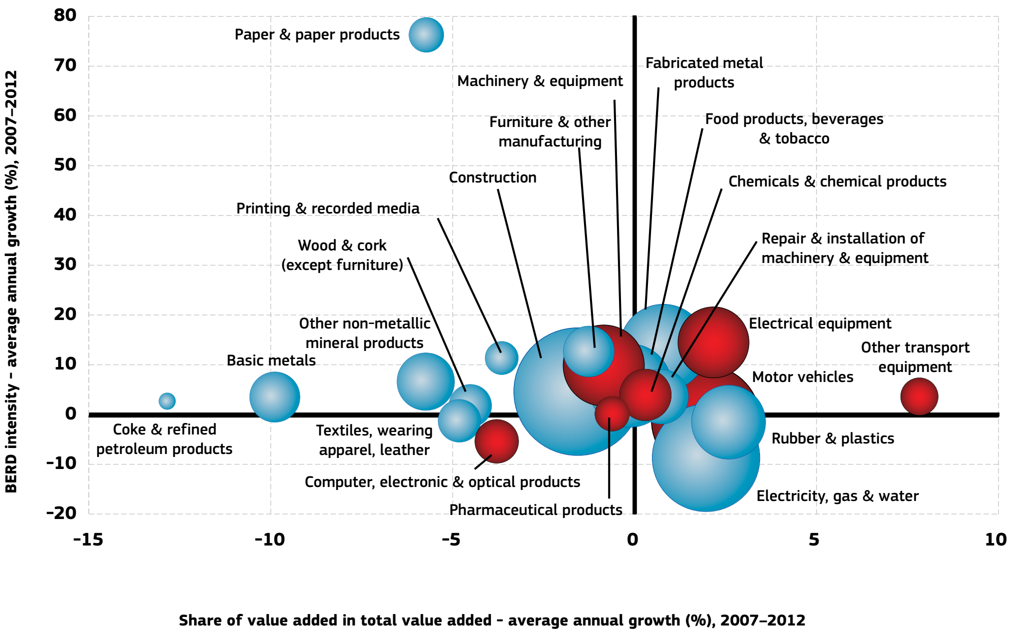
The country performs well as regards the share of medium-high/high-tech goods in total goods exports, especially as a result of road vehicle exports. Several Asian and European car manufacturers have production facilities in the Czech Republic. On the other hand, the importance of the car industry contributes to lowering the share of employment in knowledge-intensive activities. In addition, international contract manufacturers also have production facilities there, which explains the country's export surplus in electrical machinery and electronics. A third medium/high-tech sector with an export surplus is industrial machinery.

The relatively low performance in the export share of knowledge-intensive services (KIS) is partly explained by the importance of tourism which, together with business travel, represents 35 % of services exports in the Czech Republic, and which is classified as not being knowledge intensive. In addition, road and rail transport services (also non-KIS) are relatively important Czech service exports. Even compared to other Central and Eastern European countries, the Czech Republic has a very low level of patenting activity relative to GDP. A large part of the innovative economy, especially the automobile sector, is foreign owned and research and patenting is mostly done in the headquarter countries of these multinational companies[7]. The Czech Republic performs above the EU average in the innovativeness of fast-growing firms. This is due to the high share of fast-growing firms in the financial sector and in innovative parts within the manufacturing sector.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries for the period 2007-2012. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects a decrease in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents sector share (in value added) in manufacturing. The red sectors are high-tech (HT) or medium-high-tech (MHT) sectors.[8]

Czech Republic – Share of value added versus BERD intensity: average annual growth, 2007–2012



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: (1) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The graph above shows that the weights in the economy (horizontal axis) and/or the BERD intensities (vertical axis) of most manufacturing sectors in the Czech Republic have increased over the period 2007-2012. This trend concerns all the HT and MHT manufacturing sectors, with the exception of computer, electronic and optical products, and textiles, wearing apparel, leather and related products. In particular, electrical equipment, machinery & equipment, chemicals & chemical products, and other transport equipment have contributed significantly to the overall increase in BERD. For some of these sectors, this reflects the attractiveness of the country for foreign investors, with more than half of BERD being performed by foreign-owned affiliates. The share of inward BERD doubled over the period 1999-2009. Around 80 % of this inward BERD comes from EU-owned firms, half of which are German-owned companies. With shares of inward BERD of more than 80 % in total BERD, pharmaceuticals and motor vehicles are the manufacturing sectors that show the highest degree of internationalisation. The dominance of foreign affiliates in HT and MHT sectors is reflected by the fact that only two Czech-headquartered firms are amongst the EU's top 1000 R&D investing firms[8].

[7] The performance of the Czech Republic in Community designs and, to a lesser extent, trademarks is relatively better and improving fast.

[8] EU Industrial R&D Investment Scoreboard.

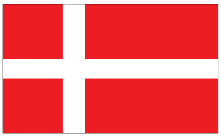
Key indicators for the Czech Republic

CZECH REPUBLIC	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.59	1.12	1.18	1.32	1.38	1.40	1.34	1.53	1.71	5.3	*1.81*	14
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	510	:	:	493	:	:	499	-10.9 (3)	495 (4)	11 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.70	0.73	0.77	0.80	0.76	0.76	0.81	0.91	*1.01*	*4.7*	1.31	13
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.46	0.49	0.51	0.56	0.53	0.58	0.58	0.72	*0.86*	*9.1*	*0.74*	8
Venture capital as % of GDP	0.19	0.02	0.01	0.05	0.03	0.04	0.02	0.12	0.01	-27.1	0.29 (5)	19 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	25.1	:	:	:	:	26.1	0.7	47.8	19
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	4.9	5.4	4.8	5.5	5.6	:	:	:	8.2	11.0	20
International scientific co-publications per million population	:	351	396	431	456	483	516	541	568	5.7	343	18
Public–private scientific co-publications per million population	:	:	:	26	28	31	33	34	:	7.0	53	13
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.6	0.7	0.8	1.0	1.0 (6)	0.9	0.7	:	:	-16.5	3.9	18
License and patent revenues from abroad as % of GDP	0.08	0.03	0.02	0.02	0.03	0.05	0.05	0.05	0.10	38.8	0.59	16
Community trademark (CTM) applications per million population	2	22	33	47	44	47	61	71	87	13.1	152	19
Community design (CD) applications per million population	:	8	14	14	13	15	19	25	27	13.4	29	14
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	14.6	:	18.7	:	15.3	:	:	-9.6	14.4	6
Knowledge-intensive services exports as % total service exports	:	31.6	29.7	29.3	30.1	29.3	27.3	29.2	:	-0.1	45.3	16
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-0.26	3.02	3.74	3.52	3.77	3.53	3.42	3.90	3.79	-	4.23 (7)	8
Growth of total factor productivity (total economy): 2007 = 100	81	93	97	100	100	96	98	99	97	-3 (8)	97	15
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	38.2	:	:	:	:	41.4	1.6	51.2	17
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	11.2	11.3	11.8	12.4 (9)	12.5	2.9	13.9	17
SMEs introducing product or process innovations as % of SMEs	:	:	32.0	:	34.9	:	30.6	:	:	-6.3	33.8	15
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.02	0.06	0.06	0.10	0.09 (10)	0.08	:	:	:	-12.1	0.44	17
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.08	0.11	0.13	0.14	0.12 (10)	0.14	:	:	:	20.1	0.53	18
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	71.0	70.7	71.2	72.0	72.4	70.9	70.4	70.9 (11)	71.5	-0.7	68.4	9
R&D intensity (GERD as % of GDP)	1.17	1.22	1.29	1.37	1.30	1.35	1.40	1.64	*1.88*	*6.6*	*2.07*	11
Greenhouse gas emissions: 1990 = 100	75	74	75	76	73	68	70	68	:	-7 (12)	83	8 (13)
Share of renewable energy in gross final energy consumption (%)	:	6.1	6.5	7.4	7.6	8.5	9.2	9.4	:	6.2	13.0	20
Share of population aged 30–34 who have successfully completed tertiary education (%)	13.7	13.0	13.1	13.3	15.4	17.5	20.4	23.7	25.6	14.0	35.7	23
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	6.2	5.1	5.2	5.6	5.4	4.9	4.9	5.5	1.1	12.7	4 (13)
Share of population at risk of poverty or social exclusion (%)	:	19.6	18.0	15.8	15.3	14.0	14.4	15.3	15.4	-0.5	24.8	2 (13)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2010.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) Break in series between 2011 and the previous years. Average annual growth refers to 2008–2010.
(10) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2009.
(11) Break in series between 2011 and the previous years. Average annual growth refers to 2007–2010.
(12) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(13) The values for this indicator were ranked from lowest to highest.
(14) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Accelerate the development and introduction of a new methodology for evaluating research and allocating funding in view of increasing the share of performance-based funding of research institutions."



Denmark

Innovation for productivity addressing societal challenges

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Denmark. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **2.98 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+3.0 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **81.1** (EU: 47.8; US: 58.1) 2007-2012: **+4.4 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **114.6** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **56.2** (EU: 51.2; US: 59.9) 2007-2012: **+2.0 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Energy, ICT, materials, nanotechnologies, new production technologies, and the environment	***HT + MT contribution to the trade balance*** 2012: **-3.3 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

Denmark has considerably expanded its research and innovation (R&I) system over the two last decades and currently has the third highest R&D intensity among EU Member States. In Denmark, the level of investment in public R&D continues to increase and reached 1.0 % of GDP in 2011 (1.01 % in 2012). Denmark is the third European country to have reached this level, after Finland and Sweden in 2009. In the EU, Danish scientific production ranks in first place in terms of percentage of highly cited publications while the Danish system for the excellence in S&T indicator is in second place. Nevertheless, this excellent research performance is not coupled with outstanding results on the innovation side, despite a favourable innovation environment for business.

Over the last decade, Denmark has experienced lower productivity growth – especially in construction and in services – than other knowledge-intensive countries, and has even seen falling levels of productivity during the economic crisis in the 2007-2010 period[3]. The Danish government identified this trend as a serious economic challenge and set up a Productivity Commission in spring 2013 to examine the reasons for this and to find answers on ways to make the Danish economy more productive and competitive.

In December 2013, the Productivity Commission issued a report on education and innovation. As regards innovation, the report puts forward the idea that the greatest potential for increasing the return on public research effort is probably in raising the quality of training. It also stresses that an important source of knowledge transfer is cooperation on R&D between universities and enterprises, and that compared with this, traditional technology transfer from universities via the sale of patents and licences is of minor importance. Hence, it recommends that knowledge and technology transfer from universities should be measured

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

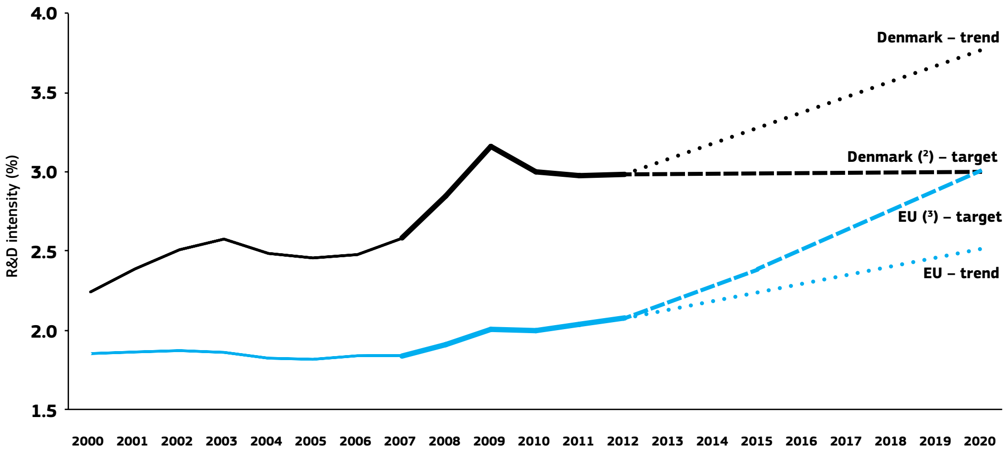
2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

3 Measured as change in GDP per person employed.

primarily by the extent of their cooperation with businesses on R&D activities. The report also recommends providing a simpler and more flexible legal framework for university knowledge transfer and giving a higher priority to the impact evaluation of programmes on the innovation system.

Investing in knowledge

Denmark – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) DK: The projection is based on a tentative R&D intensity target of 3.0 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(4) DK: There is a break in series between 2007 and the previous years.

In the context of Europe 2020, Denmark set a national R&D intensity target of 3 % for 2020. This target was achieved in 2009, but the peak in 2009 must be interpreted with caution since GDP fell by -5.7 % that year. In 2011, Denmark also reached the public R&D investment level of 1 % of GDP; it was the third In the context of Europe 2020, Denmark set a national R&D intensity target of 3 % for 2020. This target was achieved in 2009, but the peak in 2009 must be interpreted with caution since GDP fell by -5.7 % that year. In 2011, Denmark also reached the public R&D investment level of 1 % of GDP; it was the third European country to reach this level, after Finland and Sweden in 2011.

Over the last decade, business R&D intensity has increased in Denmark to reach the US level. Having reached its peak in 2009-2010, business expenditure on R&D has declined slightly since 2011 (2.01 % in 2010; 1.96 % in 2012), but remains at the third highest level in the EU. Denmark is behind Finland and Sweden for that indicator, although between 2007 and 2012 the gap with those countries narrowed: -0.23 % with Finland and -0.36 % with Sweden. The share of business enterprise expenditure on R&D financed by the government is one of the lowest in the EU (2.8 % in 2011), the same as in Finland but lower than in Sweden (5 %).

Of the EUR 510 million of Structural Funds allocated to Denmark over the 2007-2013 programming period, around EUR 159 million (31.1 % of the total) relate to RTDI[4]. Almost 2616 partners from Denmark have been participating in FP7, receiving financial contributions of over EUR 952 million from the European Commission.

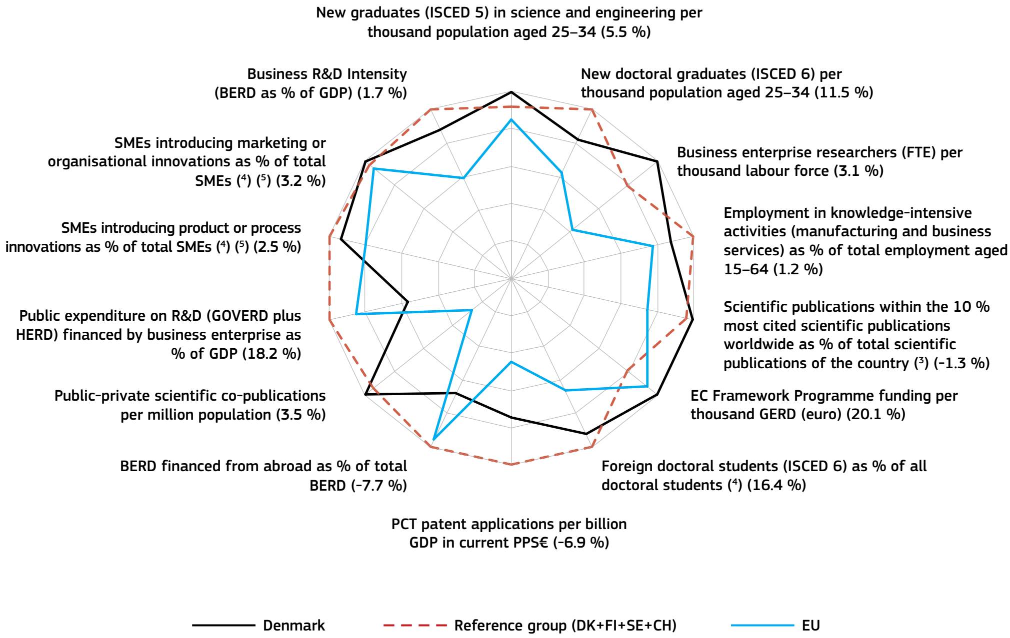
4 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Danish R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Denmark, 2012 ([1])

In brackets: average annual growth for Denmark, 2007–2012 ([2])



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: ([1]) The values refer to 2012 or to the latest available year.
([2]) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
([3]) Fractional counting method.
([4]) EU does not include EL.
([5]) CH is not included in the reference group.

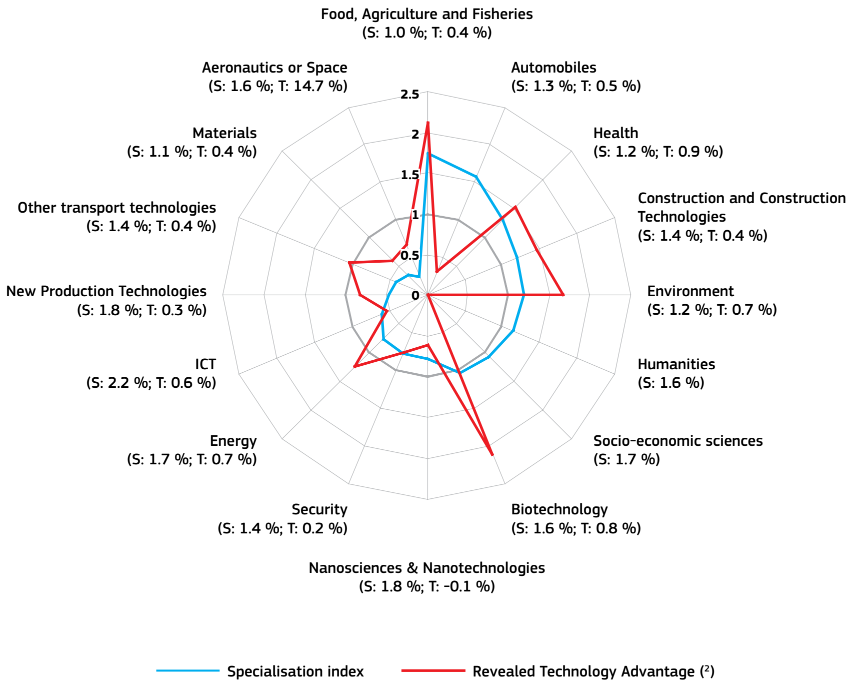
Denmark's research and innovation system, which mainly performs above the EU average, benefits from a high level of funding, highly cited scientific production and good human resources. Denmark has a high tertiary education attainment rate and performs above the EU average on new graduates in science and engineering per thousand of the population. A weaker point concerns the number of new doctoral graduates. The share of foreign doctoral students among all doctoral students is above the EU average. Denmark performs well as regards business enterprise researchers in the labour force, and the share of employment in knowledge-intensive activities is increasing. Denmark has one of the world's highest rates of highly cited publications (14.5 % of total national scientific publications in the 10 % most highly cited scientific publications in the world).

The value of two indicators suggests that the country's innovation performance could be improved: the rate of public expenditure on R&D financed by business is below the EU average, and the rate of PCT patent applications per billion GDP is decreasing and is significantly below that of the reference group.

Denmark's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Denmark shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Denmark – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



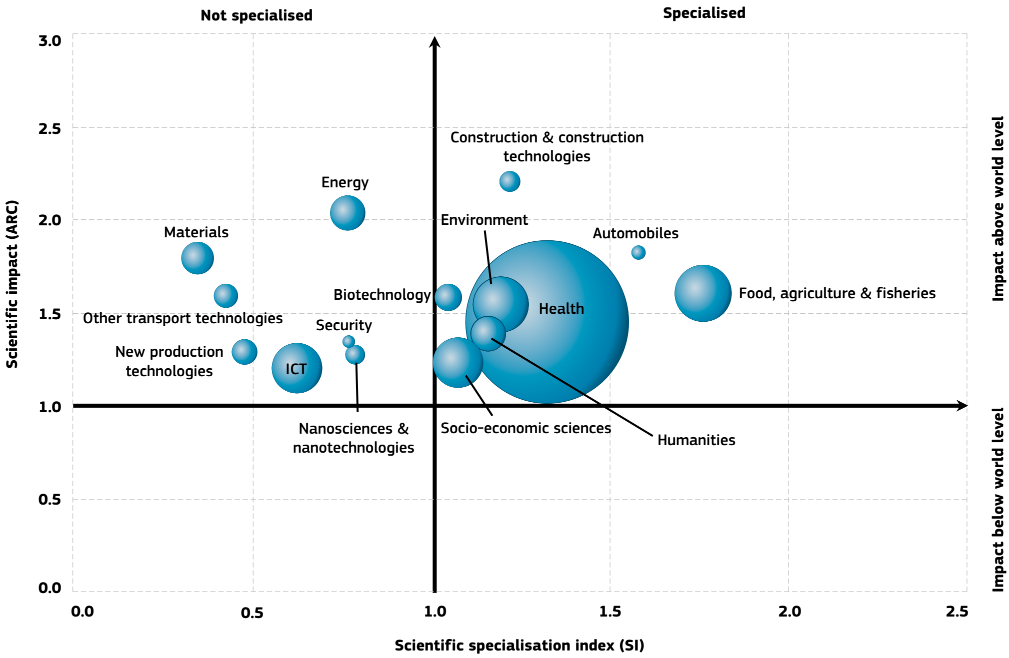
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

In scientific production, Denmark has high specialisation indexes for publications that can be related to the following areas: food, agriculture & fisheries, automobiles, construction & construction technologies, environment, and health. For publications that can be related to the areas of ICT and energy, the specialisation index is low. Unlike Sweden and Finland, the specialisation index for humanities is above average.

The revealed technology advantage is high in areas where specialisation indexes are high, except for automobiles.

The graph below illustrates the positional analysis of Denmark's publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Denmark – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The above graph shows that for all Framework Programme thematic priorities, the scientific impact of the scientific publications that can be related to them is above the world level. The impact is particularly high in the areas of energy, and construction & construction technologies. In the energy field, scientific specialisation is low but scientific impact is high, with revealed technology advantage slightly above average. This would suggest that, subject to further analysis, excellent research capacity linked to that area could be further developed.

Policies and reforms for research and innovation

In December 2012, the Danish government launched a comprehensive innovation strategy setting out three objectives:

- Increase the share of innovative enterprises so that by 2020 Denmark will be among the five OECD countries with the highest share of innovative enterprises;
- Increase private investments in R&D so that by 2020 Denmark will be among the five OECD countries with the highest business R&D expenses as a share of GDP;
- Increase the number of people with higher education in the private sector so that by 2020 Denmark will be among the five OECD countries with the highest share of highly educated employees in the private sector.

The main policy initiatives of the new innovation strategy are as follows:

- *Innovation-driven societal challenges*: revision of the structure of research and innovation councils, new market maturation fund, new basis for the prioritisation of innovation policy (INNO+), pilot innovation partnerships, strategy for participation in EU programmes, etc.
- *Knowledge translated into value:* support for professional clusters and networks, new programme for research into future production systems, new programme for students wanting to start a company, new innovation centres abroad, simplification package for public innovation schemes, critical mass for innovation incubators, more recognition and attractive career paths for researchers and educators, regional patent libraries established at university libraries, etc.

- *Education as a means of increasing innovation capacity:* more innovation competences for teachers, support initiatives for talented students, improvements in vocational education to increase innovation and entrepreneurial skills, strengthening the innovation and business-oriented competences of PhD students, innovation competitions for students in primary and secondary education, etc.

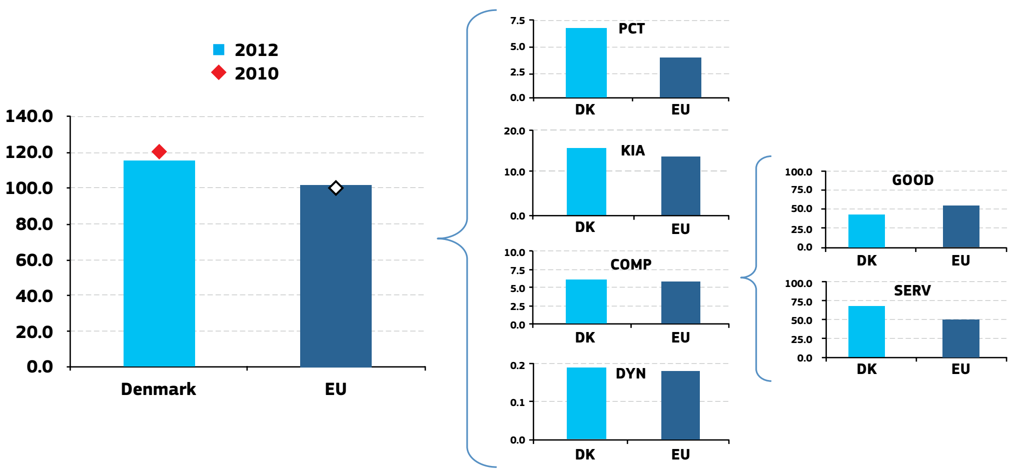
With reference to the new innovation strategy, the Danish government started a process that led to the creation of the first INNO+ catalogue presented in September 2013. Based on the involvement of a multitude of actors from the innovation system, INNO+ defines 21 concrete areas for research and innovation that are geared towards finding solutions to the grand societal challenges. The catalogue has been used to prioritise a few, particularly important initiatives in the Budget Bill for 2014. The six most prospective areas are defined as follows: innovative transport, environment and city development, innovative food production and bio-economy, innovative health solutions, innovative production, innovative digital solutions, and innovative energy solutions.

Danish STI policy has proposed a number of new initiatives outlined in the Budget Bill 2014 and centred around education. The initiatives generally aim to improve the quality of the education system. To reduce drop-out rates, new efforts are being made to provide guidance, good study environments as well as various ways of planning the instruction and teaching methods, including how to use IT as a support tool to target different learning behaviour among pupils and students. About EUR 335 million in additional funding has been set aside for these purposes. Furthermore, the government has proposed reforming the study grant scheme so as to reduce the age of graduates, and reforming the accreditation programme for higher education to reduce bureaucracy and improve quality at institutions of higher education. The Budget Bill 2014 also aims to support more students via study grants.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Denmark's position regarding the indicator's different components:

Denmark – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Denmark ranks sixth in the European innovation indicator after Germany, Sweden, Ireland, Luxembourg and Finland. This is the result of good or very good performances as regards three of the five components in the indicator. However, Denmark's performance declined between 2010 and 2012.

The country performs well as regards patents, employment in knowledge-intensive activities (partially explained by the high share of employment in the manufacturing of pharmaceuticals, computer programming, and financial services) and the export share of knowledge-intensive services.

The good performance in knowledge-intensive activities and in the share of exports in knowledge-intensive services is explained by the economic structure (the relatively large pharmaceutical industry generates a relatively large volume of patents and high-tech exports) and the importance of maritime freight transport. Denmark is home to the EU's largest container shipping company.

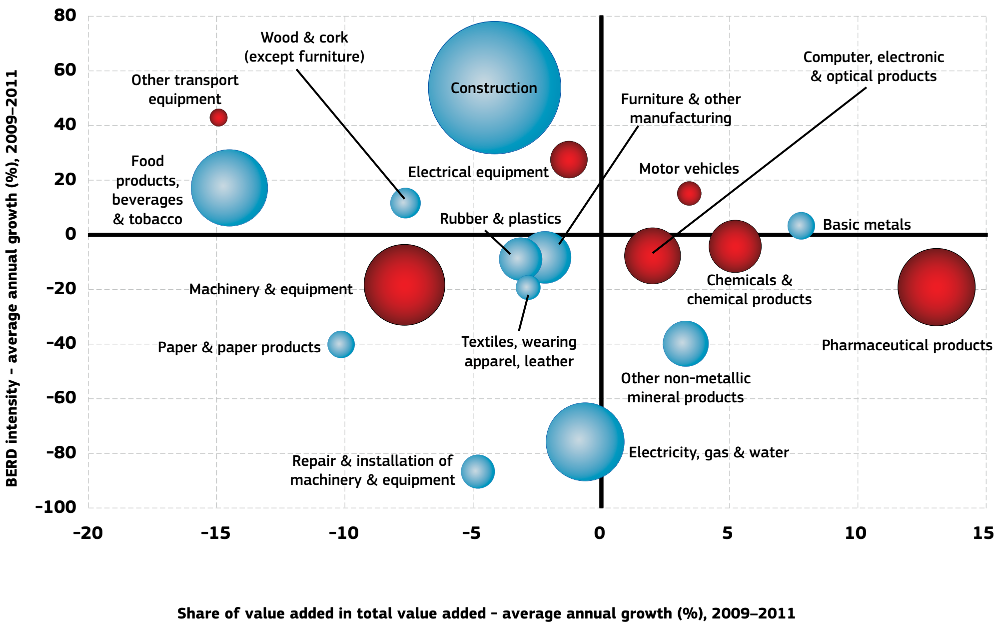
The poor performance in the contribution of high-tech and medium-high-tech goods to the trade balance is explained by the high level of exports of agricultural products (notably pork and dairy products) and, to a lesser extent, mineral fuels.

Denmark performs at the EU average as regards employment in fast-growing innovative firms as a percentage of total employment in fast-growing firms.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates with the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in all sectors presented on the graph. The red sectors are high-tech or medium-high-tech sectors.

Denmark – Share of value added versus BERD intensity: average annual growth, 2009–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: (1) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

As shown by the graph above, the share of value added of four of the seven high-tech and medium-high-tech sectors (red circles) in the Danish economy increased between 2009 and 2011, and significantly for the two first: pharmaceutical products, chemicals & chemical products, motor vehicles and computer, and electronic & optical products. On the other hand, the share of the machinery & equipment and other transport equipment sectors has decreased significantly.

The graph above shows very significant growth in BERD intensity in the construction sector. However, it should be noted that this sector's share in BERD is very low (0.1 % in 2011).

Having declined between 2005 and 2009, industry's share in GDP increased slightly between 2009 and 2011 from 17.0 % to 17.4 %. Latest data show that it declined to the historically low share of 16.8 % in 2013.

Key indicators for Denmark

DENMARK	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	1.00	1.31	1.27	1.39	1.60	1.72	2.09	2.30	2.39	11.5	*1.81*	6
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	513	:	:	503	:	:	500	-13.0 (3)	495 (4)	10 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	1.50	1.68	1.66	1.80 (5)	1.99	2.21	2.01	1.96	*1.96*	*1.7*	1.31	5
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.73	0.76	0.80	0.76 (5)	0.85	0.94	0.98	1.00	*1.01*	*5.8*	*0.74*	3
Venture capital as % of GDP	0.16	0.51	0.17	0.59	0.22	0.20	0.18	0.17	0.28	-13.6	0.29 (6)	4 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	65.4	:	:	:	:	81.1	4.4	47.8	2
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	14.5	14.4	14.9	14.7	14.5	:	:	:	-1.3	11.0	2
International scientific co-publications per million population	:	1092	1170	1280	1352	1469	1582	1725	1840	7.5	343	1
Public–private scientific co-publications per million population	:	:	:	171	166	162	180	197	:	3.5	53	1
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	6.9	7.8	7.3	8.1	7.3	7.1	6.5	:	:	-6.9	3.9	4
License and patent revenues from abroad as % of GDP	:	0.61	0.64	0.65	0.80	0.94	0.71	0.74	0.76	3.2	0.59	7
Community trademark (CTM) applications per million population	149	158	192	210	204	195	228	235	241	2.8	152	7
Community design (CD) applications per million population	:	58	68	74	73	72	66	71	75	0.2	29	2
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	7.8	:	11.4	:	15.0	:	:	14.4	14.4	7
Knowledge-intensive services exports as % total service exports	:	65.1	67.0	67.0	67.4	61.6	64.3	65.1	:	-0.7	45.3	3
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-4.13	-3.63	-4.56	-4.23	-3.52	-3.32	-3.83	-2.77	-3.34	-	4.23 (7)	24
Growth of total factor productivity (total economy): 2007 = 100	97	100	101	100	98	94	97	98	97	-3 (8)	97	12
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	51.1	:	:	:	:	56.2	2.0	51.2	8
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	14.8	15.2	15.9	15.6	15.5	1.2	13.9	8
SMEs introducing product or process innovations as % of SMEs	:	:	35.7	:	37.6	:	39.5	:	:	2.5	33.8	11
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.48	0.86	0.88	1.21	1.30	1.50	:	:	:	11.3	0.44	1
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	1.87	2.33	1.98	1.88	1.45	1.31	:	:	:	-16.6	0.53	1
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	78.0	78.0	79.4	79.0	79.7	77.5	75.8	75.7	75.4	-0.9	68.4	5
R&D intensity (GERD as % of GDP)	2.24	2.46	2.48	2.58 (5)	2.85	3.16	3.00	2.98	*2.98*	*3.0*	*2.07*	3
Greenhouse gas emissions: 1990 = 100	100	94	106	99	94	90	90	83	:	-16 (9)	83	11 (10)
Share of renewable energy in gross final energy consumption (%)	:	16.0	16.4	17.8	18.6	20.0	22.0	23.1	:	6.7	13.0	7
Share of population aged 30–34 who have successfully completed tertiary education (%)	32.1	43.1	43.0	38.1 (5)	39.2	40.7	41.2	41.2	43.0	2.4	35.7	10
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	11.7	8.7	9.1	12.9 (5)	12.5	11.3	11.0	9.6	9.1	-6.7	12.7	12 (10)
Share of population at risk of poverty or social exclusion (%)	:	17.2	16.7	16.8	16.3	17.6	18.3	18.9	19.0	2.5	24.8	7 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2007 and the previous years.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Values in italics are estimated or provisional.

Estonia

The challenge of continuing upgrading Estonian industry by research and innovation

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Estonia. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **2.18 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+15.1 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **29.4** (EU: 47.8; US: 58.1) 2007-2012: **+13.4 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **81.7** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **49.5** (EU: 51.2; US: 59.9) 2007-2012: **+2.7 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Energy, environment, food and agriculture	***HT + MT contribution to the trade balance*** 2012: **-2.9 %** (EU: 4.23 %; US: 1.02 %) 2007-2012**: **n.a.** (EU: +4.8 %; US: -32.3 %)

Broadly speaking, since the 2000s', the basic principles of developing R&D and innovation as well as policy and implementation system in Estonia have remained the same. While the policy mix has been set in the right direction, driven by steady development based on quality, excellence and competition, Estonia still has to develop an R&I system able to make a real difference to the economy at large, filling the remaining gaps. Further efforts are needed in terms of tackling the lack of highly skilled personnel that is hindering growth and investments, the low level of cross-sector cooperation (business/academia/government) that is hampering the effective translation of research and development results into innovation, and the weak internationalisation of the R&I system.

A rather significant challenge affecting the R&I system is coming from Estonia's industrial sector, mainly driven by a large volume of subcontracting in manufacturing. Therefore, any effort to upgrade the role of the country's industry in global value chains through R&I is of the utmost importance in raising overall productivity and added value. This requires developing a broad range of supply-and-demand policies. The small size of the country is reflected in its limited number of companies, and the lack of economies of scale and critical mass in many areas of research.

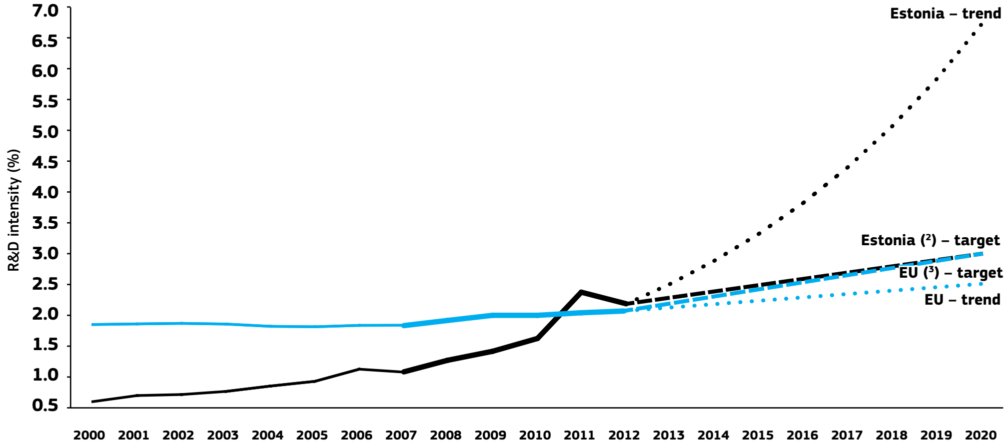
However, Estonia has been able to turn its small size into an advantage by means of specialisation. The innovation governance system has remained basically intact since 2000.The present system is uncomplicated with quite a clear division of responsibilities and a firm connection with the political leadership. The main priorities for R&D and innovation policies set down in the RDI Strategy 2007-2013 have been followed. While this strategy focused more on capacity building, the new strategic documents for 2014-2020 concentrate on obtaining social and economic results from these capacities. The effective implementation of these reforms through concrete measures, developed and defined in cooperation with all stakeholders (government, financial institutions, industry, SMEs, academia), should enable Estonia to make further progress.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Investing in knowledge

Estonia – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EE: The projection is based on a tentative R&D intensity target of 3.0 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.

Estonia had an R&D intensity of 2.18 % in 2012, slightly above EU average, which puts the country in ninth place within the EU-28 R&D intensity ranking. Despite a slight decrease from 2.37 % in 2011, the country seems well on track to reach its 3 % R&D intensity target for 2020. Business R&D intensity was at 1.25 % in 2012, only slightly below the EU average, with an overall annual growth rate of 19.7 % between 2007 and 2012. Public expenditure on R&D reached a share of 0.91 % of GDP in 2012, above the EU average, with an overall annual growth rate of 10.7 % between 2007 and 2012. The overall growth in R&D investments has been impressive, but questions remain as to whether the current trajectory is sustainable in view of the shale-oil sector's key role in an increase in business R&D expenditure and of the European Structural Funds in an increase of public R&D expenditure.

To date, the number of Estonians participating in the Seventh Framework Programme totals 489 (out of 2359 applications); in total, they have received about EUR 80.1 million. Their success rate is 15.21 % (data from E-CORDA, November 2013). Structural Funds are another important source of funding for R&I activities. Of the EUR 3.4 billion of Structural Funds allocated to Estonia over the 2007-2013 programming period, around EUR 681 million (20 % of the total) relate to RTDI[3]. The absorption rate of the funds dedicated to R&I and entrepreneurship for 2007-2013 is 85.4 %. Notwithstanding the high level of public funding of R&D, reaching the 2020 R&D intensity target will depend both on the ability to attract R&D intensive foreign direct investments and a further significant growth in business R&D. The expected leverage effect of the front-loaded EU Structural Funds for business R&D will be monitored closely.

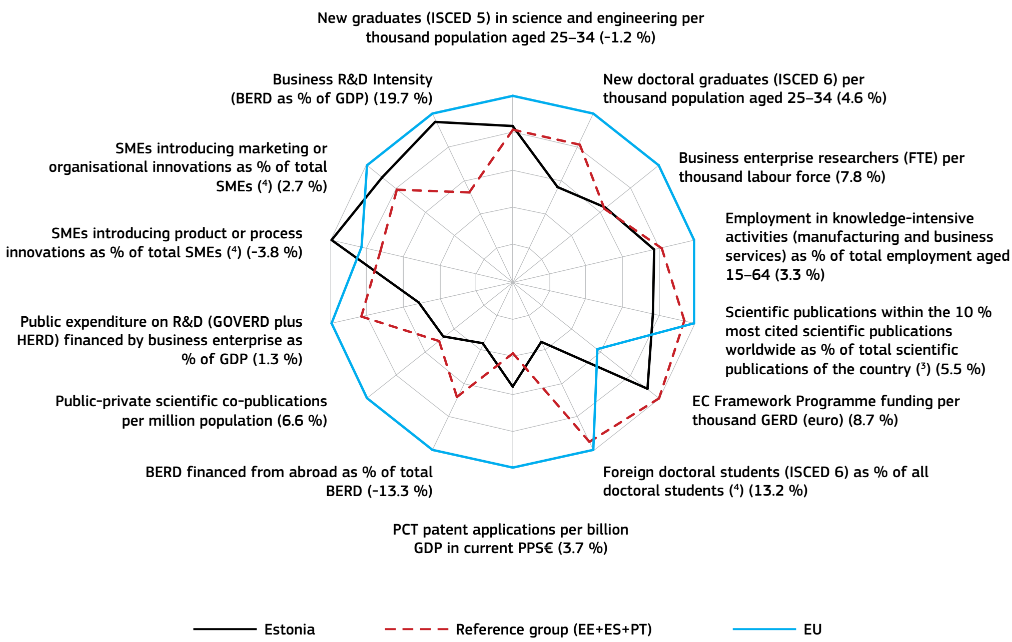
[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Estonia's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year (2012) are given in brackets.

Estonia, 2012 (1)

In brackets: average annual growth for Estonia, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

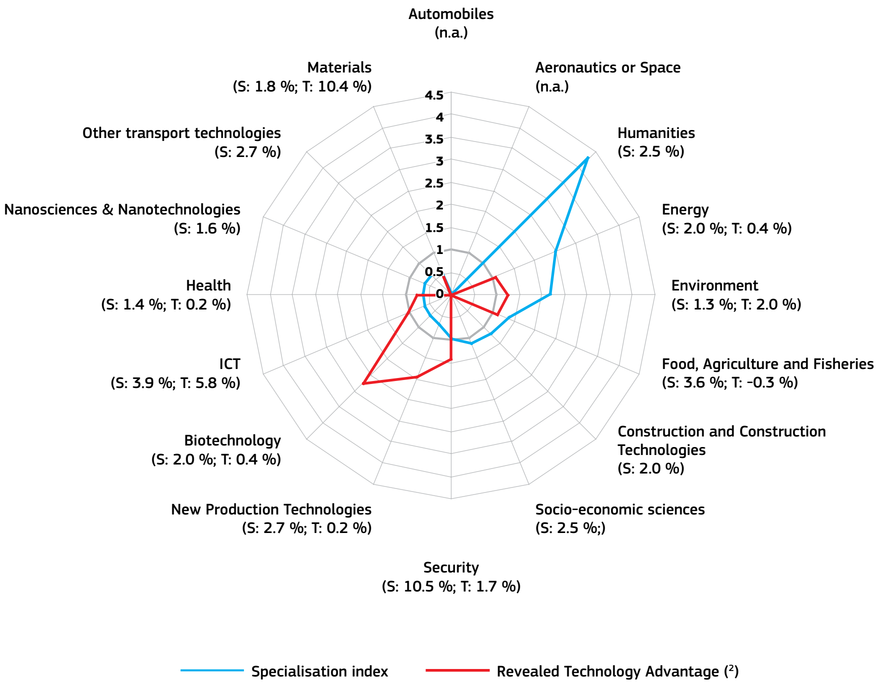
The graph above shows a performance above the EU average both in small and medium-sized enterprises (SMEs) introducing product or process innovation, and in funding from the EC Framework Programme. However, for the time being Estonia remains below the EU average in all four large dimensions of its R&I system: human resources, scientific production, technology development and innovation. In the field of human resources for R&I, Estonia is still suffering from a low number of new doctoral graduates and business enterprise researchers, although it has made good progress in the past year to catch up with its reference group. The share of foreign doctoral students remains at a low level, while BERD financed from abroad as part of total BERD has followed a negative trend, falling to 13.3 % for 2012.

While these indicators show that the measures taken by Estonia have produced some results, they also point to the need to continue enhancing the quality of the higher education system and addressing the non-absorption of highly skilled graduates in firms. Estonia has improved its scientific quality and production but still faces the challenge of increasing the excellence and internationalisation of its research institutions. It has also made some progress in its public-private cooperation performance although it still performs well below the EU average. Knowledge valorisation takes place in clusters, where SMEs, larger firms and public research organisations cooperate and compete. Business R&D intensity and PCT patent applications have increased, although they remain below the EU average.

Estonia's scientific and technological strengths

The graph below illustrates national specialisation in thematic priorities and hence Estonia's science and technology strengths. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Estonia – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
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(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

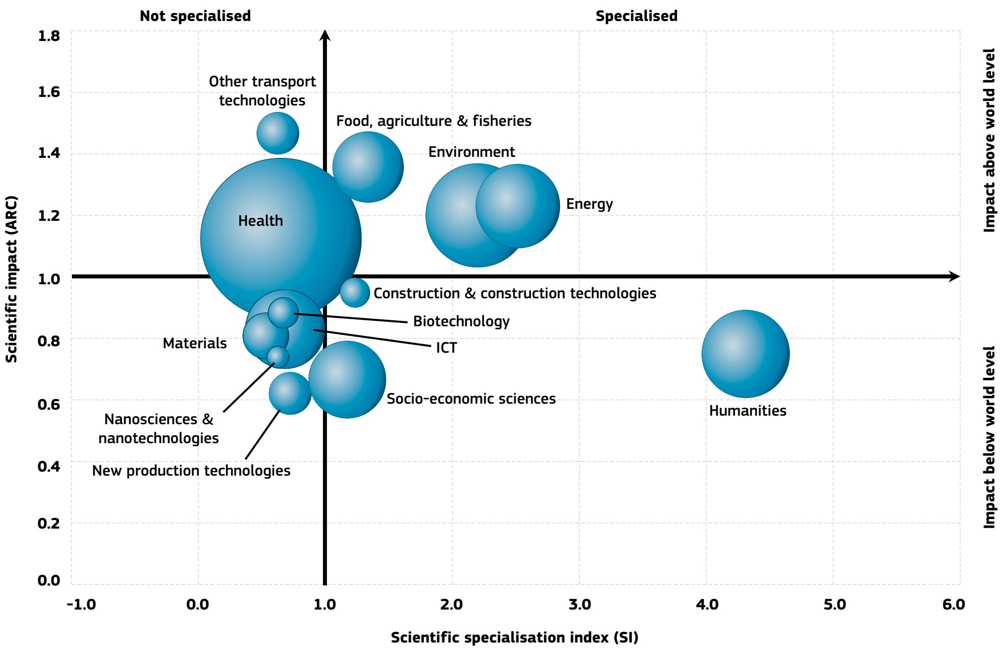
As illustrated in the graph above, there is little correlation between scientific production (publications) and technological production (patents) in Estonia. As regards publications, the country shows specialisation in the fields of humanities, energy, environment, and food, agriculture and fisheries. As regards patents (technological output), Estonia has strengths in biotechnology, new production technologies, security, and ICT.

The country has a medium-level knowledge capacity and a relatively young R&I system. Sectors with strong potential for a smart specialisation strategy are those in which it is specialised in both science and technology. Estonia's science and technology specialisation profile is built around food, agriculture and fisheries, security, energy and the environment. In other sectors, the country has no scientific or technological specialisation yet, although the overall production of publications and patents is growing significantly, indicating a possible future specialisation profile. Estonia is experiencing a very high growth rate of patents in both materials and ICT. With a focused R&I system, it has the possibility to push for economic transformation in some new knowledge-intensive fields. This may be the case for health in Estonia, an area where the country counts on excellent science and a broad participation in the Framework Programme, ensuring S&T co-creation and network building.

Estonia's main key challenges, as illustrated above, prove the special attention being given to them in the country's policy documents. Among them, the weak R&D system and poor cooperation between academia and industry sectors should be properly addressed in the implementation measures. The new RDI Strategy 2014-2020 pointed to ICT areas cross-cutting other sectors horizontally, health technologies and services, and the more efficient use of resources as sectors for country specialisation. This orientation will give the necessary push for these sectors to develop or extend their technological quality further, and to maintain their dynamism in the long term.

The graph below illustrates the positional analysis of Estonian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Estonia – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The country's areas of specialisation in environment, energy, food and agriculture also proved to be the areas making an impact above the world level. The only exception is the area of humanities which is performing less well. On the other hand, the impact made by good-quality scientific production in health and other transport technologies is slightly above the world level for the first specialisation and well above for the second one, even though Estonia has a low specialisation level in those areas.

Policies and reforms for R&I

Estonia's innovation governance system has remained basically intact with a rather clear division of responsibilities. The Research and Development Council (R&D Council) is an expert consultative body that advises the government on R&D and innovation matters – all policy documents seeking approval from the government have to pass through the R&D Council. The Ministry Education and Research (MoER) and the Ministry of Economic Affairs and Communications (MEAC) are the ministries responsible for the implementation of economic policy, and R&I policy. The cooperation between ministries is important for smart specialisation measures, several of which are relevant to many growth areas. A Smart Specialisation Steering Committee was created to encompass ministries in the respective growth areas.

The Estonian Development Fund is a promoter of innovation-oriented projects which carries out risk capital investments in start-up and growth-oriented technology companies as well as socio-economic and technology Foresight exercises. The Enterprise Estonia Foundation, responsible for managing business support, innovation and technology programmes, and the KredEx Foundation, which helps to increase the competitive strength of Estonian companies by improving the availability of financing and managing credit risks, are the two implementing agencies supporting MEAC.

The Baltic Innovation Fund (BIF) is a 'fund-of-fund' initiative launched by the EIF in 2012 in close cooperation with the governments of Lithuania, Latvia and Estonia to boost equity investments in those Baltic SMEs with high growth potential. With a focus on the Baltic States, over the next four years BIF will invest EUR 100 million into private equity and venture capital funds through a fund-of-fund process to attract additional private finance and to implement the best market standards for equity investing in businesses.

The Cluster Development Programme (2008-2013) and Competence Centre programme (2008-2013) are state-aid measures classified as aid for innovation clusters. A total of 19 cluster projects and eight competence centres have already received funding. In October 2013, the first Social Innovation Incubator (SEIKU), co-financed by Enterprise Estonia, was founded and began operations.

From the research policy perspective, the Ministry of Education and Research has two main agencies which deliver funding and support: the Archimedes Foundation is coordinating and implementing different national and international programmes and projects in the field of training, education and research (among the other activities it is also implementing agency for structural support). Since 1 March 2012, the Estonian Research Council has been responsible for distributing grants and handling grant applications as well as assessing the effectiveness of grants and the availability of research information. The Estonian Research Council acts as a national contact point for the Seventh Framework Programme/Horizon 2020 Framework Programme and is responsible for international, bi- and multinational research cooperation programmes and organisations.

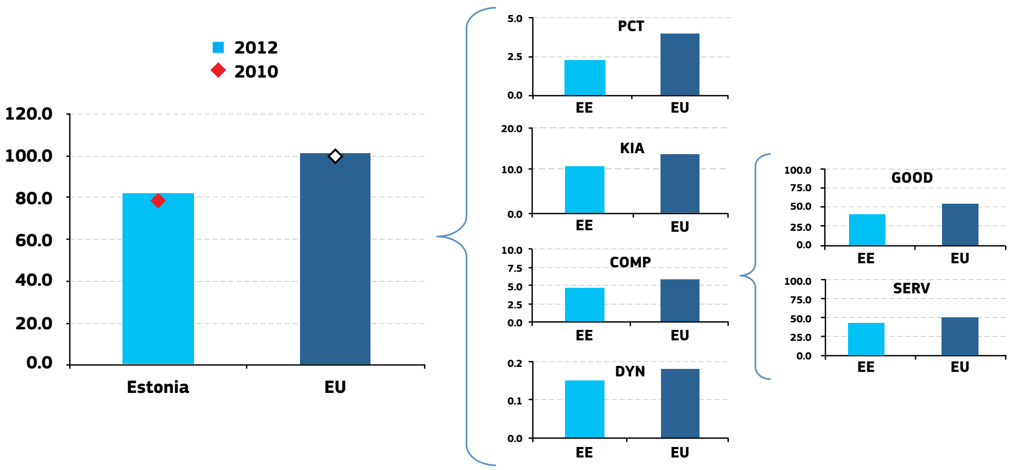
The only ministry with a sectoral RD&I Strategy (Strategy for Agricultural Research 2007-2013) and corresponding budget (EUR 10.9m) is the Ministry of Agriculture.

The Estonian approach to R&I in the new programming period is built around two strategies: the RD&I Strategy 2014-2020 'Knowledge-based Estonia', approved by *Riigikogu* (Parliament) in January 2014, and the Estonian Entrepreneurship Growth Strategy 2014–2020, adopted by the government in October 2013. The two strategies are analysing the possibility of gradually replacing current direct support actions with financial instruments, increasing the competency of the human resources – from inside the country or from abroad – enhancing national as well as international cooperation of Estonian R&D institutions and enterprises, reinforcing the framework for cooperation between the private and public sector, and developing demand-side policies for innovation solutions. However, since the implementing measures remain unclear it is difficult to assess whether or not they will meet the objectives and fill the persisting gaps, namely in the weak public-private cooperation.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Estonia's position regarding the indicator's different components.

Estonia – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Estonia is a medium-low performer in the European innovation indicator. It has no area of strong performance and scores below the EU average for most components. However, its performance has improved slightly since 2010.

Its relatively low performance in patents is linked to its economic structure, and the lack of large manufacturing companies, which typically show high patenting activities[4].

Employment in knowledge-intensive activities is relatively low because sectors classified as not knowledge intensive, such as construction, manufacturing in general, and transport, are comparatively important in Estonia.

With no road vehicle or pharmaceutical industry and a relatively large export share of mineral fuels, wood, paper and textiles, Estonia scores low as regards the share of medium-high/high-tech goods in total goods exports.

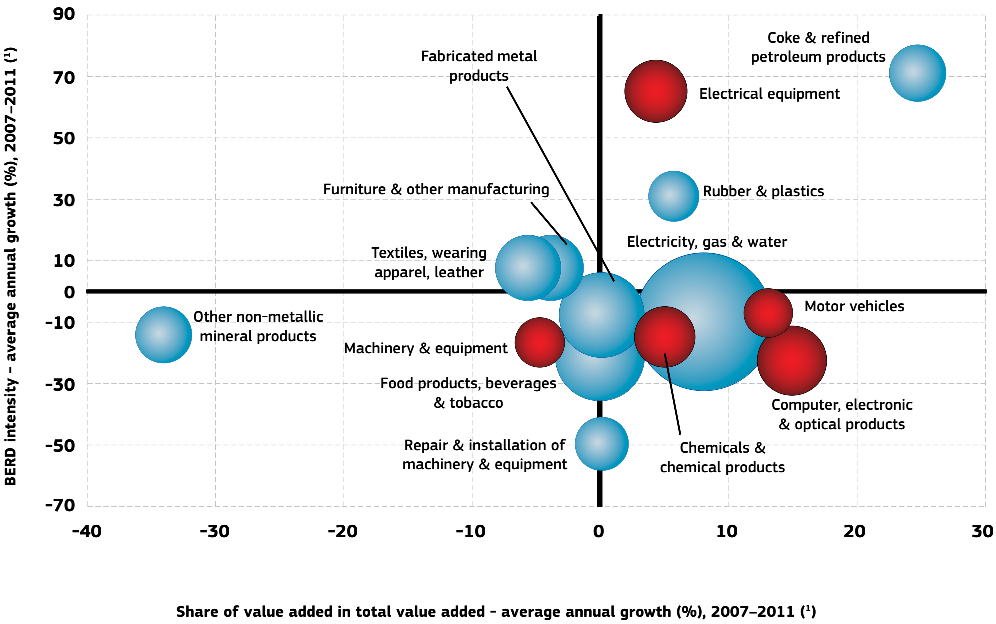
Estonia's performance is low as regards the innovativeness of fast-growing firms. This is a result of a high share of low-tech manufacturing, construction, and administrative and support activities (for example, private security companies) among the fast-growing enterprises.

4 However, a look at other IPR-related innovation outputs reveals that Estonia performs near the EU average in Community designs and above the EU average in Community trademarks.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline of manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented in the graph). The red sectors are high-tech or medium-high-tech sectors.

Estonia – Share of value added versus BERD intensity: average annual growth, 2007–2011 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Other non-metallic mineral products': 2007–2009; 'Repair and installation of machinery and equipment', 'Rubber and plastic products': 2008–2011.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

Estonia is one of the countries catching up fast in terms of manufacturing industry: in 2011, manufacturing production represented 17.3 % of total value added (compared to an EU average of 15.6 %). Estonia is improving its competitiveness and has the clear potential to join the group of higher-income countries specialising in labour-intensive industries[5]. The country's economic structure is dominated by medium- to low-tech industries combined with high- or medium-high-tech industries in a few sectors or niche segments. In terms of trade and industry specialisation, Estonia is specialised in the manufacturing of electronic products, fabricated metal products, motor vehicles, electrical equipment, and machinery and equipment. As an innovation-driven country, it faces the challenge of upgrading its industry in response to increased global competition in the lower and medium segments of the value chains.

The graph above synthesises structural change in the Estonian manufacturing sector over the period 2007-2011. It shows that economic expansion was related to both lower-tech sectors and large consumer goods and services, in particular, coke & refined petroleum products, rubber and plastics, and electricity, gas and water but also the high-tech and medium-tech items such as electrical equipment, motor vehicles, computer, electronic and optical products, chemicals and chemical products. Among those sectors, a definite increase in R&I investment has been shown in the low-tech and traditional sectors such as rubber and plastics, textiles, coke & refined petroleum products, and also in the high-tech sector of electrical equipment.

5 DG Enterprise, Industrial Performance Scoreboard, 2012.

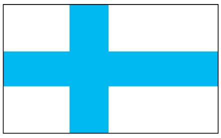
Key indicators for Estonia

ESTONIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.61	0.68	0.75	0.81	0.86	0.85	0.93	1.34	1.02	4.6	*1.81*	21
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	515	:	:	512	:	:	521	6.0 (3)	495 (4)	2 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.14	0.42	0.50	0.51	0.55	0.63	0.81	1.50	*1.25*	*19.7*	1.31	9
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.45	0.49	0.61	0.55	0.70	0.75	0.79	0.85	0.91	10.7	*0.74*	6
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	15.6	:	:	:	:	29.4	13.4	47.8	14
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	7.3	7.7	7.6	7.4	8.5	:	:	:	5.5	11.0	16
International scientific co-publications per million population	:	381	378	458	506	542	680	756	831	12.7	343	12
Public–private scientific co-publications per million population	:	:	:	19	22	26	28	25	:	6.6	53	19
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	1.2	0.6	1.5	2.0	2.0	2.4	2.2	:	:	3.7	3.9	12
License and patent revenues from abroad as % of GDP	0.03	0.04	0.04	0.05	0.11	0.13	0.11	0.10	0.09	12.4	0.59	19
Community trademark (CTM) applications per million population	3	30	43	83	65	72	119	138	178	16.4	152	11
Community design (CD) applications per million population	:	2	9	7	11	17	23	30	26	28.5	29	15
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	13.7	:	10.2	:	12.3	:	:	9.7	14.4	15
Knowledge-intensive services exports as % total service exports	:	30.3	33.2	37.5	36.9	36.8	37.3	36.4	:	-0.7	45.3	11
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.68	-4.61	-3.83	-4.18	-2.77	-1.53	-3.00	-2.70	-2.94	-	4.23 (5)	23
Growth of total factor productivity (total economy): 2007 = 100	85	97	98	100	92	83	87	90	91	-9 (6)	97	25
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	43.4	:	:	:	:	49.5	2.7	51.2	13
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	9.5	10.2	9.8	10.7	10.8	3.3	13.9	20
SMEs introducing product or process innovations as % of SMEs	:	:	45.8	:	43.9	:	40.6	:	:	-3.8	33.8	10
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.01	0.00	0.00	0.17	0.13	0.20	:	:	:	8.3	0.44	11
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.03	0.05	0.27	0.11	0.31	0.17	:	:	:	21.4	0.53	17
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	67.4	72.0	75.8	76.8	77.0	69.9	66.7	70.4	72.1	-1.3	68.4	8
R&D intensity (GERD as % of GDP)	0.60	0.93	1.13	1.08	1.28	1.41	1.62	2.37	*2.18*	*15.1*	*2.07*	9
Greenhouse gas emissions: 1990 = 100	42	46	44	52	48	40	49	52	:	0 (7)	83	4 (8)
Share of renewable energy in gross final energy consumption (%)	:	17.5	16.1	17.1	18.9	23.0	24.6	25.9	:	10.9	13.0	5
Share of population aged 30–34 who have successfully completed tertiary education (%)	30.8	30.6	32.5	33.3	34.1	35.9	40.0	40.3	39.1	3.3	35.7	14
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	15.1	13.4	13.5	14.4	14.0	13.9	11.6	10.9	10.5	-6.1	12.7	14 (8)
Share of population at risk of poverty or social exclusion (%)	:	25.9	22.0	22.0	21.8	23.4	21.7	23.1	23.4	1.2	24.8	14 (8)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) EU is the weighted average of the values for the Member States.
(6) The value is the difference between 2012 and 2007.
(7) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(8) The values for this indicator were ranked from lowest to highest.
(9) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Further intensify prioritisation and specialisation in the research and innovation systems and enhance cooperation between businesses, higher education and research institutions to contribute to international competitiveness."



Finland

Broadening the innovation base towards new growth areas

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Finland. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **3.55 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+0.5 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T*[1]** 2012: **69.9** (EU: 47.8; US: 58.1) 2007-2012: **+5.1 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **115.7** (EU: 101.6)	***Knowledge-intensity of the economy*[2]** 2012: **55.8** (EU: 51.2; US: 59.9) 2007-2012: **+0.4 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: ICT, environment, materials, energy, security, food & agriculture, and health	***HT + MT contribution to the trade balance*** 2012: **1.2 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **-5.7 %** (EU: +4.8 %; US: -32.3 %)

Finland has one of the world's highest R&D intensities. The country also performs very well in terms of scientific and technological excellence, showing a strong positive evolution. The Finnish economy is knowledge-intensive and has achieved an impressive and continuous change towards a stronger high- and medium-high-tech specialisation. The country has several hot-spot clusters in key technologies on both a European and world scale, in particular in ICT, the environment, materials, energy, security, and in food and agriculture.

However, Finland's competitive position is facing challenges and its large export businesses have suffered. Considering its high level of R&D intensity, high-tech and medium-high-tech goods make a relatively low contribution to the country's trade balance. Since the start of the economic crisis in 2008, the major decline of the important electronics (telecommunications) sector, in particular, has led to a large-scale structural change of manufacturing industries in Finland. The decline of this sector is further reflected in a decrease in business R&D expenses that were previously dominated by Nokia. Consequently, as part of the Europe 2020 strategy, the Council recommended in 2014 that Finland boosted its capacity to deliver innovative products, services and high-growth companies in a rapidly changing environment. The extent to which both the business and public sector will be capable of absorbing new innovations from the ICT sector – and, more concretely, the available highly skilled human resources – is seen as a determinant for new growth.

To address these challenges, the Finnish government has intensified the reform of the national R&I system. In addition to general efforts to enhance the efficiency and improve the internationalisation of the system, current and planned policy reforms are targeted, in particular, at increasing the number of high-growth innovative firms as the major source of future employment

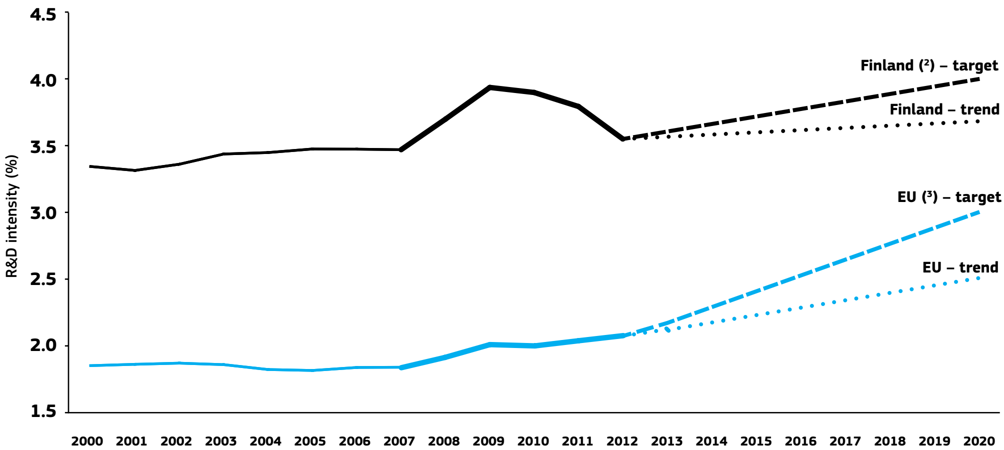
[1] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

[2] Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

and growth. The R&D tax incentive targets both limited companies and cooperatives and is applicable only to the fiscal years 2013-2014. The tax incentive for private investors into start-ups was introduced in 2013 to increase the volume of domestic venture capital market. These actions are expected to support in particular knowledge- and innovation-based young growth enterprises. The government has also recently fostered innovation and the country's transfer to a digital service economy by opening the non-sensitive databases it administers for public use.

Investing in knowledge

Finland – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) FI: The projection is based on a tentative R&D intensity target of 4.0 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.

In 2012, R&D intensity fell in Finland to 3.55 % of GDP (3.80 % of GDP in 2011). While this remains the highest value in the EU, the decreasing trend since 2009 means that Finland is not on track to reach its R&D intensity target for 2020 of 4 %. This trend is due to a fall in business R&D intensity. As to public R&D expenses, they remained around EUR 2 billion in 2012. Due to the government's budget deficit, the volume of public R&D funding is not expected to increase in the coming years.

Finland is the top performer in the EU in terms of business R&D spending, although in 2012 its share decreased to 2.44 % of GDP (2.68 % of GDP in 2011) reflecting the major restructuring of the R&D intensive electronics sector. Although many other manufacturing and services sectors have increased their R&D intensities in Finland, in 2012 business R&D investments were still highly concentrated in Nokia and a few other large firms. This has made the country's economic position more vulnerable than it may appear. In 2012, the percentage share of venture capital of GDP amounted to 0.24 % (0.20 % of GDP in 2011).

The European Structural and Investment (ESI) Funds are an important source of funding for R&I activities. Of the EUR 1.6 billion of Structural Funds allocated to Finland over the 2007-2013 programming period, EUR 468 million (29.3 % of the total) related to RTDI[3]. In general, the share of the ESI Funds allocated to R&I has increased in Finland throughout the programming periods.

[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

In the current period 2014-2020, Finland will receive almost EUR 1.3 billion from the European Structural and Investment Funds. R&D as well as improving the competitiveness of SMEs feature among the most important thematic objectives together with a cross-cutting theme that is seeking new solutions for development towards the low-carbon economy. The plan is for all three themes together to absorb more than EUR 822 million of the funding received from the European Regional Development Fund. Furthermore, it is proposed to allocate more than EUR 99 million from the ERDF to R&I-related activities supporting bio-economy developments in Finland.

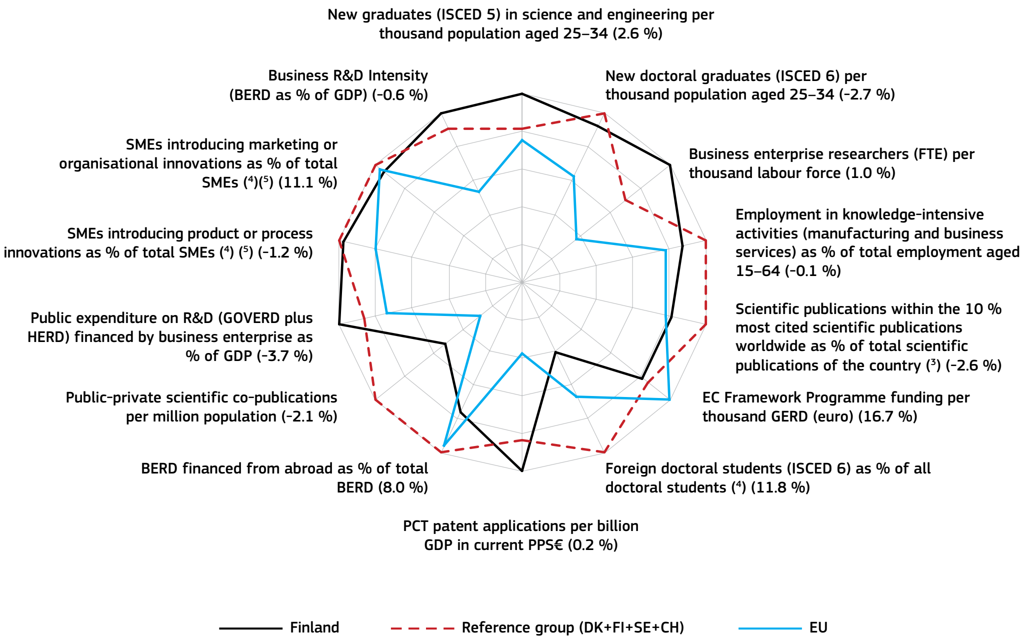
In the past, Finland has also sought to increase its participation in the Seventh Framework Programme for Research and Technological Development. By 31 March 2014, almost 2600 Finnish entities had participated in a FP7 project, with a total EU financial contribution of EUR 848 million and a success rate of 21.2 % (slightly over the EU average of 20.5 %).

An effective research and innovation system building on the European Research Area

The spider graph below illustrates the strengths and weaknesses in the Finnish R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.

Finland, 2012 (1)

In brackets: average annual growth for Finland, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.
(5) CH is not included in the reference group.

Overall, Finland has a strong innovation performance and outperforms its reference group in terms of highly skilled human resources (new graduates in science and engineering as well as business enterprise researchers), public and business investment in R&D and patent applications. However, in 2012 the share of new doctoral graduates was lower in Finland than in the reference group. The main weakness in the Finnish innovation system lies in its low level of internationalisation, affecting both the public and private sectors. It performs below the EU average on inward BERD, share of foreign doctoral students and funding from EU excellence-driven programmes.

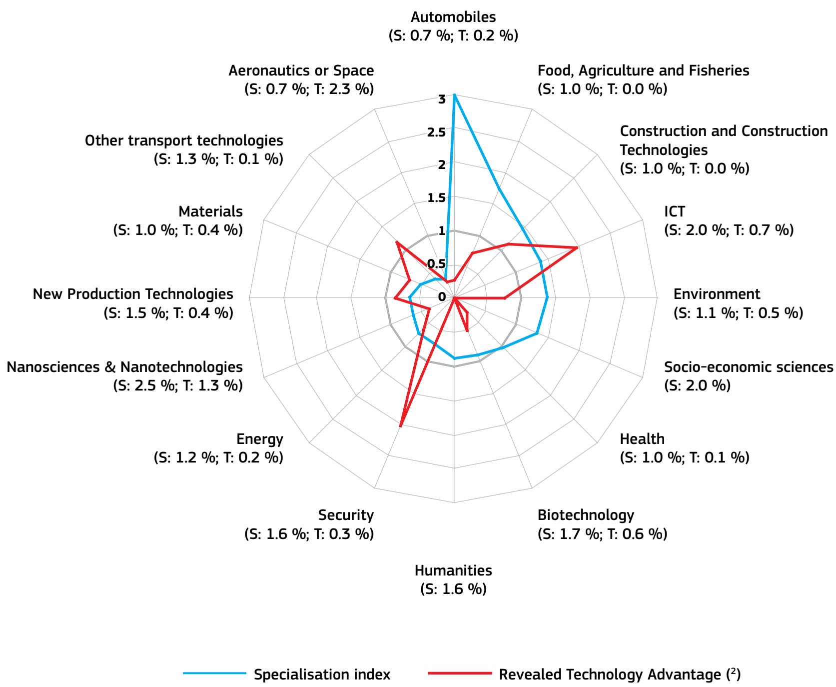
The ongoing restructuring of the ICT sector is both a challenge and an opportunity for Finnish SMEs, as much of future innovation and growth depend on them. The graph does not take this fully into account. It is expected to affect, in particular, the number of business sector researchers and business R&D intensity. In addition, the effect that the expected loss of R&D jobs in the business sector and the subsequent capacity to attract foreign researchers will have on linkages in the R&I system remains to be seen.

Finland's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Finland shows scientific and technological specialisations. Both the specialisation index (based on the number of publications) and the revealed technological advantage (based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field, it provides information on the growth rate in the number of publications and patents.

Finland – S&T National Specialisation (1) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

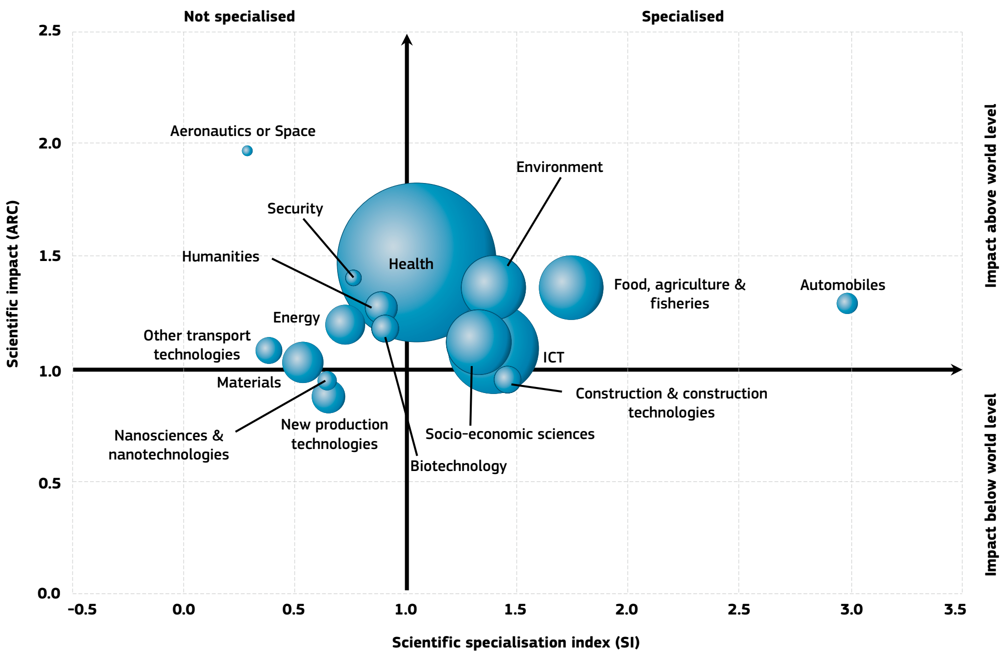
A comparison of the scientific and technological specialisations in the FP7 thematic priorities shows a mixed situation. Technology production is specialised in security, ICT, and other transport technologies.

Finland's scientific specialisation indexes show a specialisation in the scientific fields related to the FP7 thematic priorities of automobiles, food, agriculture and fisheries, construction and construction technologies, ICT, the environment and socio-economic sciences. The ICT thematic priority is where scientific and technological specialisations are best matched.

In this respect, there is room for improvement in the scientific impact related to some FP7 thematic priorities ranking high on the science specialisation index, i.e. construction and construction technologies. It is also interesting to note the above-world-level scientific impact of Finnish scientific publications related to aeronautics and space as well as to security and energy, while the specialisation indexes related to those thematic priorities are rather low.

The graph below illustrates the positional analysis of Finnish publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Finland – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

Policies and reforms for research and innovation

The Finnish R&I policy documents are prepared at the strategic level by the Research and Innovation Council which is led by the prime minister. The current 'Research and Innovation Policy Guidelines' cover the period of 2011-2015, and the government has tasked the Council to prepare new guidelines for 2014-2020. At the end of 2012, the government also published a document 'Growth through expertise, Action plan for research and innovation policy' which seeks to enhance the quality, impact and internationalisation of the Finnish R&I system. The action plan emphasises the need to increase the number of high-growth innovative firms, and anticipates that the digital service economy will provide Finland with opportunities for growth.

One of the fundamental reforms launched in Finland in 2013 concerns the reform of research institutes and research funding. It marks a major restructuring of the Finnish R&I landscape with a view to strengthening multi-disciplinary and high-level research of societal significance. National sectorial research institutes will gradually be combined into larger entities. A Strategic Research Council will be established to finance research-seeking solutions to the challenges facing Finnish society and to promote the renewal of the country's economic base and competitiveness. The funding will be assembled in stages from state research institutes' appropriation, as well as from the funding for the Academy of Finland and Tekes, with a view to making EUR 70 million available for strategic research in 2017.

As the key government objective is to fortify the growth of the Finnish economy, more public funding is now being channelled into innovation activities. The activities target, in particular, growth-oriented companies as well as new and young innovative enterprises, and include measures that help knowledge-based companies to enter international markets. For example, the government budget for 2013 included two tax incentives aimed at growth-seeking businesses. The R&D tax incentive for limited companies and cooperatives is a novelty for Finland. It allows for a deduction from corporate income taxes tied to the wage costs of R&D personnel. The tax incentive for private investors targets business angels investing equity in small and medium-sized enterprises (SMEs) providing the possibility to postpone paying capital gains taxes as long as those gains are reinvested in qualifying businesses. However, the R&D tax incentive is only applicable to fiscal years 2013-2014 and the tax incentive for private investors to 2013-2015, due to the lowering of corporate income tax rate from 24.5 % to 20 %.

As to the availability of venture capital, together with pension funds the Finnish Industry Investment will launch a new growth fund for growth-stage businesses as part of the government's long-term risk finance programme. The experiences gained from the Vigo accelerator programme have been positive and it has attracted direct foreign investment in Finnish start-ups. The government has also made non-sensitive data gathered by public authorities freely available with the aim of promoting the emergence of innovative start-ups. In the area of internationalisation, the establishment of Team Finland has streamlined services for companies, and the FiDiPro programme – the Finland Distinguished Professor Programme – continues to enhance the international dimension of the universities and research institutes.

Among the most significant structural changes in Finland in recent years has been the university reform that took effect in 2010. This made universities autonomous legal entities and developed them towards more flexibility with the aim of promoting high-level research, internationalisation and the focusing of resources. As part of the reform process, a new university funding model entered into force in 2013 that seeks to build a more efficient university system with a greater emphasis on quality and impact as well as better profiling and internationalisation. In parallel, the polytechnics reform is ongoing, and a new polytechnics funding model came into force at the beginning of 2014. In the second stage of the reform, the responsibility for polytechnics funding will be transferred from municipalities to the government, and polytechnics will be made independent legal entities. These changes will come into force from the beginning of 2015. The objective is to reinforce the role of polytechnics as increasingly independent educational institutions contributing to a renewal of the working life and competitiveness of the regions. The government is currently reviewing the funding models of both universities and polytechnics with a view to reinforcing, inter alia, the utilisation aspect of research. Furthermore, a national road map of research infrastructures was published recently.

In Finland, R&I policies have emphasised the importance of both academic entrepreneurship through start-ups and university-industry collaboration. In that respect, the main funding instruments are the Tekes programmes and the Strategic Centres for Science, Technology and innovation (SHOKs)[5]. In the last five years, SHOKs have become one of the main mechanisms of Finnish innovation policy and one of its 'flagship programmes'. These are industry-driven public-private partnerships of research actors and the private sector which aim to speed up innovations and renew industrial clusters. The government is currently introducing several improvements to the SHOK concept with the view to sharpening the focus and increasing competition for funding, renewing governance and steering, and increasing international cooperation.

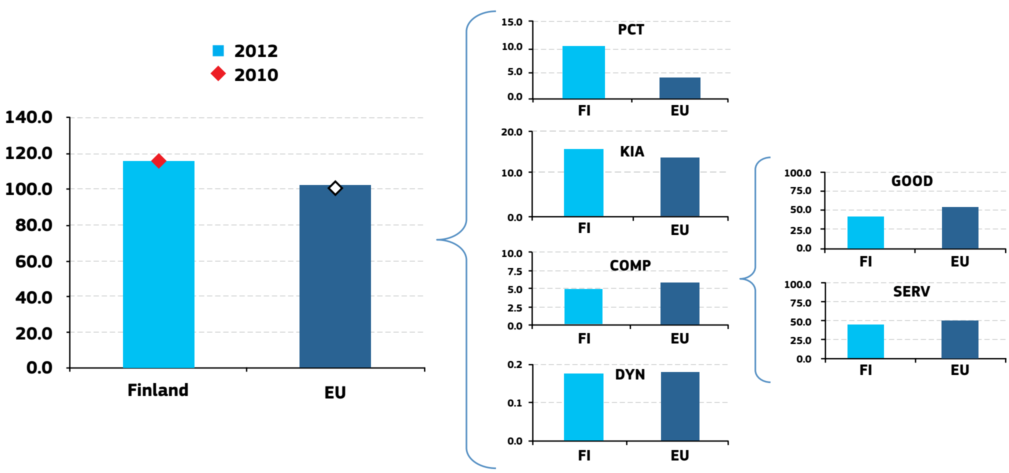
The ICT 2015 advisory board has been set up in the restructuring field of electronics with the mandate to coordinate the implementation of the ICT 2015 actions[5] aiming to re-establish Finland's technological lead in ICT. These actions include the rapid development of a common architecture for all public services; establishment of a 10-year programme on ICT-related R&I; and the launch of a funding programme for high-growth enterprises. In addition, the government's four other strategic growth targeted programmes – in the fields of clean-tech, bio-economy, health, and intangible value creation – build heavily on the increased role of ICT which is expected to be the main driver of the country's productivity growth. If successful in boosting growth in other sectors, ICT is expected to have the potential to diversify the Finnish economy.

The government has launched the 'Innovative Cities' programme that will be implemented from 2014-2017 and represents a novel innovation policy instrument for Finland. The programme embeds the ideas and approaches of a 'smart specialisation strategy for research and innovation'. In so doing, it supports urban regions in identifying and focusing on their strengths, encouraging them to select new types of specialisation areas, and intensifying cooperation between the public and private sectors. The programme seeks to create internationally attractive urban innovation hubs and platforms in Finland. In 2013, the government announced five thematic priorities for each lead city: health and well-being in the future (Oulu); bio-economy (Joensuu); sustainable energy solutions (Vaasa); smart cities and restructuring industries (Tampere) and cyber safety (Jyväskylä). The programme is managed by Tekes and the funding will be channelled from the government's budget, the cities' budgets and the European Structural and Investment Funds. The programme will also help to align the content of the Finnish national research and innovation strategy and related regional strategies.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Finland's position regarding the indicator's different components.

Finland – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

[4] Six SHOKs are in operation: Cleen Ltd (environment and energy), FIMECC Ltd (metals industry), SalWe Oy (health and well-being), Digile Oy (ICT and digital services), RYM Ltd (built environment) and Bio-economy Cluster FIBIC.

[5] The actions are outlined in the report of the 'ICT 2015 working group' set up by the government.

Finland is a very good performer in the European innovation indicator. It ranks fifth in the EU after Germany, Sweden, Ireland and Luxembourg. This is the result of a good or very good performance as regards all the components of the indicator, with the exception of the export of goods and services. The country's performance stagnated between 2010 and 2012.

Finland performs particularly well in patents (data refers to 2010), where it is the EU's top performer as a result of strong patenting in the ICT sector. The relatively low performance in the share of medium-/high-tech goods in total goods exports is explained by the importance of wood and paper exports, not sufficiently compensated for by strong exports of medium-/high-tech products.

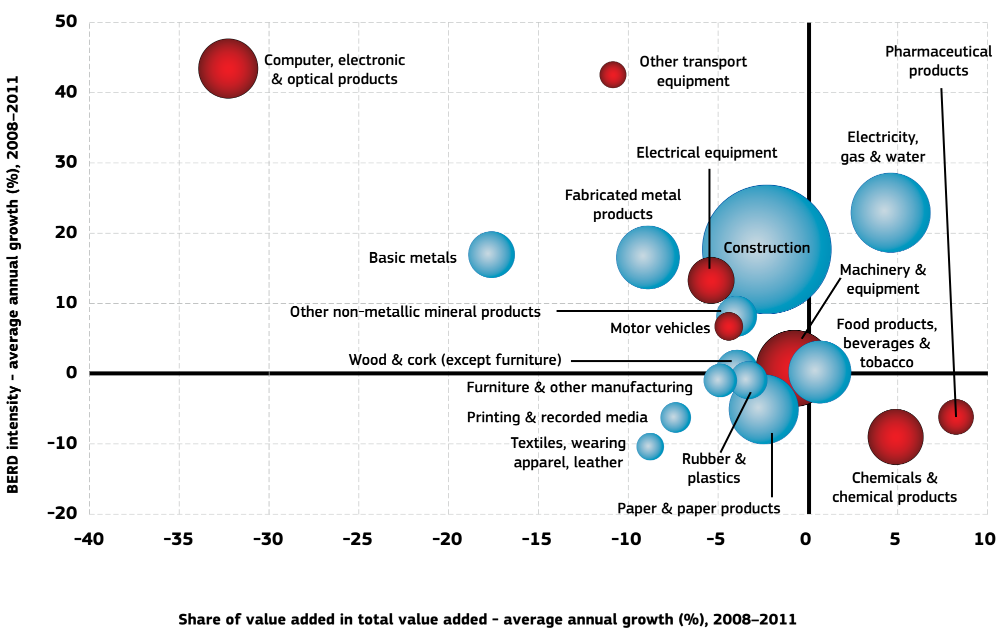
As a freight-transport transit country to and from Russia, Finland has a relatively important non-knowledge-intensive transport and merchant-related services (rail freight transport, pipeline) sector, leading to a below EU average share of knowledge-intensive services exports, despite relatively high computer services exports.

The country's performance is average in employment in fast-growing innovative firms as a % of total employment in fast-growing firms. In addition, there is a high share of computer programming, architectural and engineering companies among the fast-growing enterprises.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period 2008-2011. The general trend to the left-hand side reflects a decrease in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Finland – Share of value added versus BERD intensity: average annual growth, 2008–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: (1) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The Finnish manufacturing sector has achieved a clear upgrading of its knowledge intensity since the 1990s. Finland has evolved from having a primarily pulp and paper and machinery-driven manufacturing sector to being a producer of electronics as well as software and services. Simultaneously, the services sector, including business services, has grown significantly. However, since the start of the economic crisis in 2008, the Finnish manufacturing industries which are highly dependent on export markets have faced major difficulties. In the past five years, the country has undergone a period of major economic restructuring, and the electronics industry, in particular, has lost significant market share and employment. In effect, the 2008-2009 economic slowdown has had a more severe effect on the Finnish economy than in many other competing countries, because the recession coincided with the decline in the electronics industry.

In the period 2008-2011, the R&D intensive manufacturing sectors (red bubbles) which had contributed most to the growth of value added in the Finnish economy were pharmaceutical products and chemicals and chemical products, although business R&D intensity decreased in both sectors. The recent reorganisation of the electronics industry has resulted in a major reduction in its share of the value added to the economy, but in the period under review, the sector was still able to increase its BERD intensity substantially. Machinery and equipment continues to be an important R&D-intensive manufacturing sector in Finland. In 2008-2011, its R&D investment increased marginally while, at the same time, its share of value added fell slightly. Although the sectors of other transport equipment and electrical equipment did not make a positive contribution to the economy's added value during that period, the two sectors increased their BERD intensity, the former, in particular. Similarly, the motor vehicle sector experienced an increase in R&D investment.

As regards traditionally less R&D-intensive industries (the other bubbles), in the period of 2008-2011, the paper and paper products sector experienced reductions in both its R&D intensity and its share of value added to the economy. A renewal in R&D investment is observed in the basic metals sector – an industrial sector that is leading the mining boom mainly in the north-eastern and northern parts of Finland. The fabricated metal products sector also shows a positive upward trend in its R&D intensity. Moreover, the electricity, gas and water sector increased its R&D intensity in the same period. Finally, the country's important construction sector has also increased its R&D intensity. In that regard, it is worth emphasising that since 2007 the government has supported the renewal of traditional manufacturing sectors with a specific instrument 'Strategic Centres for Science, Technology and Innovation' that bridges innovative companies and world-class research aimed at producing globally significant breakthrough innovations.

Key indicators for Finland

FINLAND	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007-2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	2.71	3.07	2.96	3.07	2.96	2.89	2.56	2.71	2.67	-2.7	*1.81*	3
Performance in mathematics of 15-year-old students – mean score (PISA study)	:	:	548	:	:	541	:	:	519	-29.6 (3)	495 (4)	3 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	2.37	2.46	2.48	2.51	2.75	2.81	2.72	2.67	2.44	-0.6	1.31	1
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.95	0.99	0.98	0.94	0.93	1.10	1.16	1.09	1.09	2.9	*0.74*	2
Venture capital as % of GDP	0.29	0.15	0.16	0.21	0.25	0.20	0.23	0.20	0.24	2.4	0.29 (5)	6 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	54.6	:	:	:	:	69.9	5.1	47.8	4
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	11.6	11.4	12.0	11.5	11.4	:	:	:	-2.6	11.0	9
International scientific co-publications per million population	:	920	995	1101	1139	1204	1286	1356	1415	5.1	343	5
Public–private scientific co-publications per million population	:	:	:	107	107	106	102	98	:	-2.1	53	4
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	12.1	10.9	11.6	10.3	9.5	10.5	10.4	:	:	0.2	3.9	1
License and patent revenues from abroad as % of GDP	0.72	0.62	0.51	0.52	0.54	0.73	0.98	1.23	1.34	21.0	0.59	3
Community trademark (CTM) applications per million population	100	104	120	139	143	148	181	187	196	7.1	152	9
Community design (CD) applications per million population	:	37	35	36	38	43	46	44	52	7.9	29	6
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	15.7	:	15.6	:	15.3	:	:	-1.0	14.4	5
Knowledge-intensive services exports as % total service exports	:	:	:	23.8	39.7	37.7	36.4	34.9	:	10.0	45.3	12
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-0.58	1.44	1.39	1.66	3.56	2.41	2.01	1.69	1.24	-	4.23 (6)	16
Growth of total factor productivity (total economy): 2007 = 100	88	95	97	100	98	91	93	95	93	-7 (7)	97	20
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	54.8	:	:	:	:	55.8	0.4	51.2	9
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	15.5	15.2	15.1	15.3	15.5	-0.1	13.9	9
SMEs introducing product or process innovations as % of SMEs	:	:	44.7	:	41.8	:	40.9	:	:	-1.2	33.8	8
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.46	0.52	0.53	0.46	0.51	0.75	:	:	:	27.3	0.44	4
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.75	0.65	0.65	0.56	0.57	0.52	:	:	:	-3.2	0.53	10
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	71.6	73.0	73.9	74.8	75.8	73.5	73.0	73.8	74.0	-0.2	68.4	7
R&D intensity (GERD as % of GDP)	3.35	3.48	3.48	3.47	3.70	3.94	3.90	3.80	3.55	*0.5*	*2.07*	1
Greenhouse gas emissions: 1990 = 100	99	98	114	112	101	95	107	97	:	-16 (8)	83	19 (9)
Share of renewable energy in gross final energy consumption (%)	:	28.6	29.8	29.4	30.7	30.4	31.4	31.8	:	2.0	13.0	3
Share of population aged 30–34 who have successfully completed tertiary education (%)	40.3	43.7	46.2	47.3	45.7	45.9	45.7	46.0	45.8	-0.6	35.7	7
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	9.0	10.3	9.7	9.1	9.8	9.9	10.3	9.8	8.9	-0.4	12.7	11 (9)
Share of population at risk of poverty or social exclusion (%)	:	17.2	17.1	17.4	17.4	16.9	16.9	17.9	17.2	-0.2	24.8	3 (9)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(9) The values for this indicator were ranked from lowest to highest.
(10) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Continue to boost Finland's capacity to deliver innovative products, services and high-growth companies in a rapidly changing environment."

France

The challenge to revitalise industry

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in France. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on the knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **2.29 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+1.0 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **49.5** (EU: 47.8; US: 58.1) 2007-2012: **+3.4 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **105.6** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **58.1** (EU: 51.2; US: 59.9) 2007-2012: **+0.5 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Energy, ICT, materials, nanotechnologies, new production technologies, and the environment	***HT + MT contribution to the trade balance*** 2012: **5.2 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+2.2 %** (EU: +4.8 %; US: -32.3 %)

France is a major R&D country. It ranks sixth among world countries for gross domestic expenditure in R&D. It has a large science base, is well equipped with large world-class research infrastructures, and is well connected in Europe and internationally. However, France's scientific performance is average in terms of high-impact scientific work and its industrial base continues to be eroded.

The level of business R&D intensity is relatively low in France in comparison with other R&D-intensive countries. This reflects primarily the sectoral composition of the economy, where medium-high and high-tech manufacturing sectors represent a relatively modest share.

In recent years, France has substantially reformed its R&I system – new funding and evaluation agencies and mechanisms[3], *pôles de compétitivité* policy, more autonomy for universities, amplified research tax credit (CIR), innovation tax credit, *Investissements d'Avenir programme* and increased funding for the valorisation of public research results.

However, there is a limited use of evaluation and assessment tools to monitor the socio-economic impacts of research and innovation policies in France.

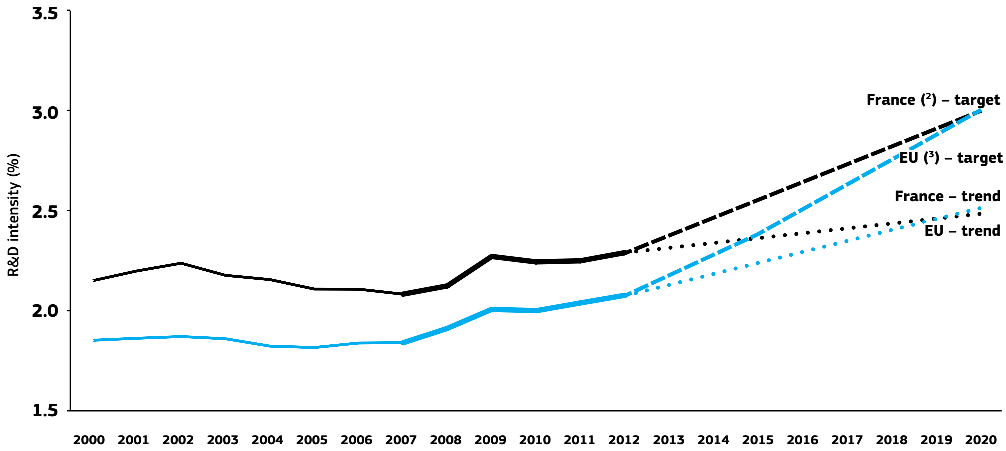
1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

3 Agence Nationale de la Recherche, BPI France, Agence d'Evaluation de la Recherche et de l'Enseignement Supérieur.

Investing in knowledge

France – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2010–2012 in the case of France.
(2) FR: The projection is based on a tentative R&D intensity target of 3.0 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(4) FR: There is a break in series between 2004 and the previous years and between 2010 and the previous years.

France has set a national R&D intensity target for 2020 of 3 %. In 2012, the country's R&D intensity was 2.29 %, with an average annual growth rate of 1.0 % over the period 2010-2012. As shown above, this trend will not allow France to reach its target by 2020.

With EUR 46.5 billion of global R&D expenses representing 17.3 % of EU total, France is a major player in the EU. It ranks second, behind Germany (EUR 79.4 billion, 29.5 % of the total) and ahead of the UK (EUR 33.3 billion, 12.4 % of the total). Having peaked in 2009-2010, public R&D intensity stabilised at 0.78 % in 2011 and 2012, at the same level as at the beginning of the 2000s and slightly over the EU average of 0.74 %.

France is one of the few countries where R&D expenditure in the business sector progressed in 2009, in spite of the economic crisis. Amplification of the R&D tax credit in 2008 may have contributed to that. Together with a decline in GDP, this progress caused a marked increase in overall business R&D intensity from 1.33 % in 2008 to 1.40 % in 2009. In 2010, 2011 and 2012, business R&D intensity further progressed to 1.48 % of GDP. The country's business R&D intensity is above the EU average (1.31 % in 2012) but below that of other knowledge-intensive countries. It should be noted that a significant part of business R&D is publicly funded (public direct and indirect funding of business R&D was 0.38 % of GDP in 2011[4], which ranks France as number 1 in the EU for this indicator). In terms of economic activities, business R&D expenditure in France is dominated by motor vehicles (15.0 % of total business R&D expenditures), aircraft and spacecraft (10.6 %) and pharmaceuticals (10.3 %)[5].

The 2013 EU Industrial R&D Investment Scoreboard has registered 124 French companies among the top 1000 EU R&D investors worldwide (252 in the UK and 224 in Germany). In 2012, their R&D expenses worldwide increased by 2.3 %, whereas the total growth in R&D expenses for the sample is 6.0 % (11.6 % for Germany, 0.5 % for the UK). Among the 2000 top world business R&D investors in 2012, the worldwide R&D expenses of French companies represented 5.2 % of the total R&D expenses of the top 2000 world R&D investors (10.5 %, 4.2 % and 35.1 % for Germany, the UK and the USA, respectively).

France's industrial base has been continuously eroded for more than a decade. The country's share of industry in the total value added fell from 17.8 % in 2000 to 12.5 % in 2012. France is now ranked 16th among the 18 euro-area countries, behind the UK (14.6 %), Italy (18.4 %), Finland (19.1 %) and Germany (25.8 %).

4 Cf. Maximising the benefits of R&D tax incentives for innovation, OECD, 2013.

5 2012. Data from the French Ministère de l'Enseignement supériEUR et de la Recherche.

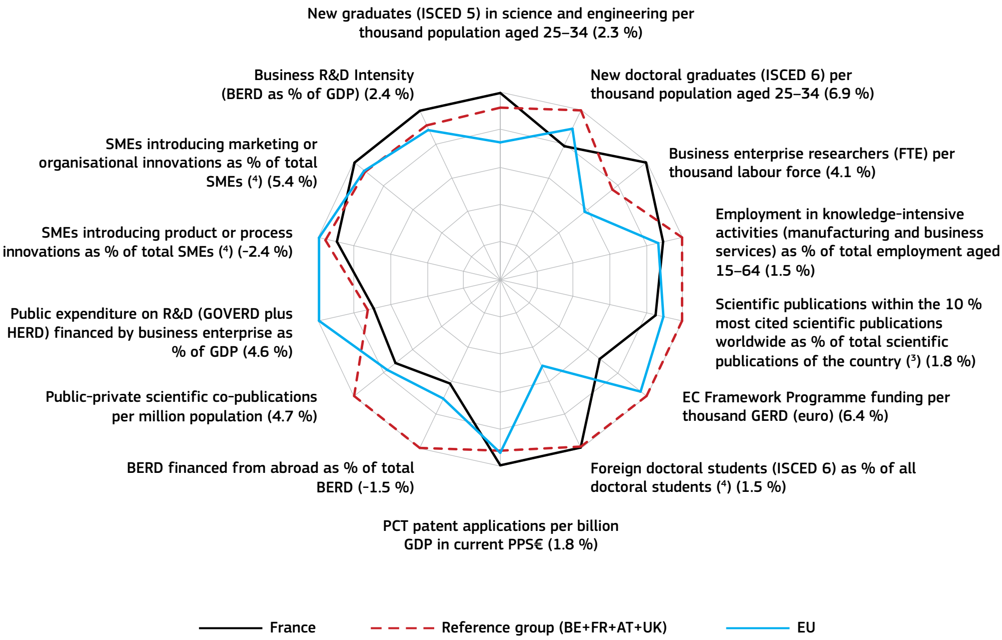
Of the EUR 13.4 billion of Structural Funds allocated to France over the 2007-2013 programming period, around EUR 2.2 billion (16.4 % of the total) related to RTDI[6]. Almost 11 700 partners from France are participating in FP7, receiving a financial contribution from the EC of nearly EUR 4.5 billion.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of France's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology development and innovation. Average annual growth rates from 2007 to the latest available year (2012) are given in brackets.

France, 2012 (¹)

In brackets: average annual growth for France, 2007–2012 (²)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (¹) The values refer to 2012 or to the latest available year.
(²) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(³) Fractional counting method.
(⁴) EU does not include EL.

The graph shows that France rates well for many skills-related indicators: new graduates in science and engineering, business enterprise researchers (in spite of an eroding industrial base), and foreign doctoral students. With a rate of 4.2 % for PCT patent applications per billion GDP, France is slightly above the EU average (3.9 %), well behind Germany (7.5 %) and Sweden (13.3 %), but ahead of the UK (3.3 %). The country's performance is average for employment in knowledge-intensive activities and for new doctoral graduates, and slightly below average for highly cited scientific publications and for new doctorates. It is significantly under the average for BERD financed by abroad, as is Germany, but in France foreign-owned companies

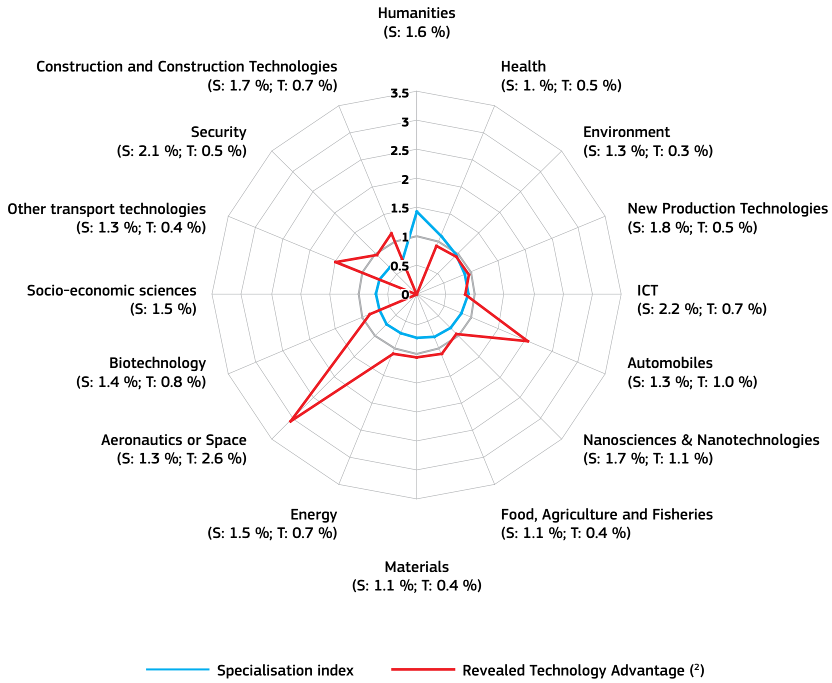
6 TDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

perform 20 % of BERD[7]. France is also significantly below average for public expenditure on R&D financed by businesses. Public-private research relationships take place rather in the form of collaborative research (where research is done by all collaborating parties and costs are shared among participants), which is highly state subsidised[8], than in the form of contract research (where businesses finance public research without performing research themselves).

France's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where France shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

France – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

7 2010. Data from the French Ministère de l'Enseignement supérieur et de la Recherche.

8 In 2011, public-private collaborative research represented a significant part of all R&D expenditure in France (about 10 %) with a public co-funding rate of around 75 % (Government Report: Mission sur les Dispositifs de Soutien à la Recherche Partenariale, 2013).

The methods are as follows:

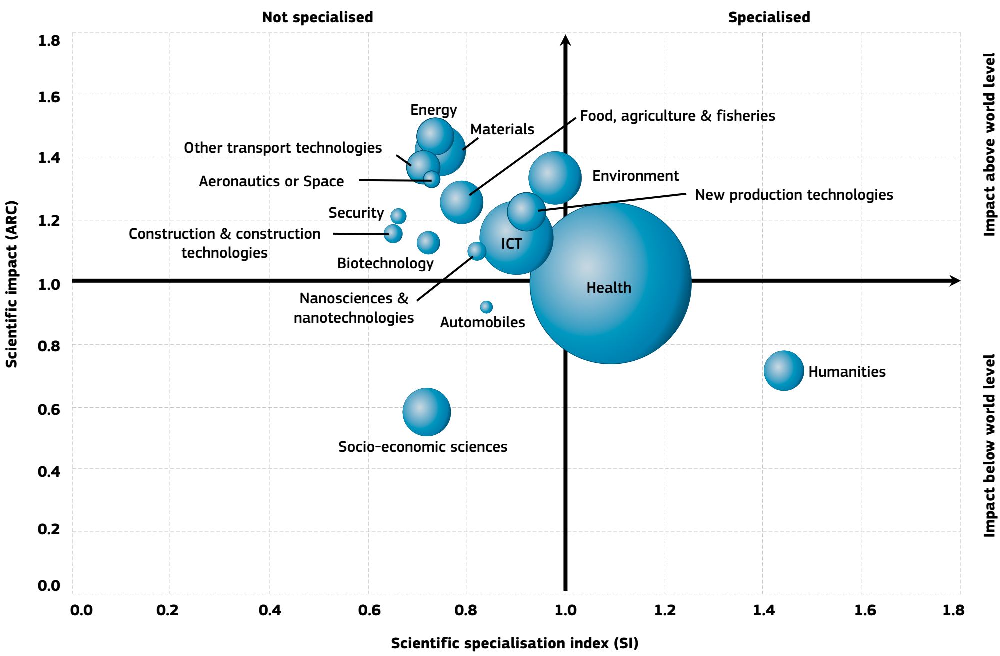
- *Specialisation index*[9]: The scientific journals indexed in Scopus have been classified according to a three-tier taxonomy of six scientific domains, 22 fields and 176 subfields, each journal being assigned to a subfield. Then, through expert judgment supported by relevant statistics, the most relevant scientific fields and subfields were identified for each of the 16 FP7 thematic priorities. The number of publications in Scopus for the FP7 thematic priorities corresponds to about 70 % of the total number in Scopus. In particular, the publications in the journals assigned to the scientific fields of mathematics & statistics and physics & astronomy are not assigned to any of the FP7 thematic priorities. The specialisation indexes refer to world publications in Scopus.

- *Revealed technology advantage*[10]: For the FP7 thematic priorities (except socio-economic sciences and humanities), search keys have been developed. The delineation of search keys used existing technological classifications as a starting point. Based on content analysis of the different thematic priorities, the existing classifications have been refined and adapted. The latter step benefited from input provided by EC experts involved in the thematic priority initiatives and programmes. Some technology fields in existing classifications are not related directly to FP7 categories.

In scientific production, France has high specialisation indexes for publications that can be related to humanities and health. The revealed technology advantage is high in following sectors: automobiles, aeronautics or space, and other transport technologies.

The graph below illustrates the positional analysis of French publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publication from a science field in the country's total publications.

France – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The above graph shows that for most of the Framework Programme thematic priorities, the scientific impact of the scientific publications related to them is above the world level. The impact is particularly high for the energy, materials, and other transport technologies sectors.

[9] http://ec.europa.eu/research/innovation-union/pdf/scientific-production-profiles.pdf#view=fit&pagemode=none

[10] http://ec.europa.eu/research/innovation-union/pdf/technological-specialization-of-countries.pdf#view=fit&pagemode=none

Policies and reforms for research and innovation

A new law on research and higher education was promulgated in July 2013. Preparation of the law started with a large consultation process among the interested parties, which resulted in a report used as the key input for the law. The ongoing reformation modifies some components of the system's organisation and deals with knowledge transfer.

Organisation of the system is meant to change as regards the following five aspects:

- *Strategy*: A new National Strategy for Research will replace the present National Research Strategy for Research and Innovation. Together with the National Strategy for Higher Education, the government will present them to the parliament every five years.

- *'Site policy' and higher education institution groupings*: PRES (Higher education and research institutions clusters, which used to stand for *Pôles de Recherche et d'Enseignement Supérieur)* have been replaced by Communities of Universities and Institutions (*CUE, Communautés d'Universités et d'Etablissements*) which comprise a board of directors, an academic council and board members. A single contract per site is to be signed with the Minister of Higher Education and Research. Current PRES have a year to change status.

- *Roles of regions*: The law transfers both the mission and the budget to regions to develop and disseminate scientific, technical and industrial culture, especially among young audiences. The regions will also define "a regional plan for higher education, research and innovation, which determines the principles and priorities of its activities"; the regions' initiatives shall fit into "the context of national strategies".

- *University governance*: One new initiative is the acceptance of 'externals' as voters for the election of the university's president. In addition, an Academic Council is established, reuniting the Scientific Council and the Board of Studies and University Life, and is given a decisive role. The Academic Council is responsible for the allocation of resources, the adoption of rules for examinations and for the evaluation of teaching, laboratory operation or examination of individual issues relating to recruitment, placement, and teachers and researchers' careers. Board composition is rebalanced in favour of students, technicians and support functions. Parity is set for the elections.

- *High Council of the Evaluation of Research and Higher Education:* The Agency for the Evaluation of Research and Higher Education is replaced by the High Council of the Evaluation of Research and Higher Education, which is an independent administrative authority.

As regards PhDs, and knowledge transfer:

- *PhDs*: The law requires that 'A Class' competitions for civil servants are adjusted to allow for the participation of PhDs. A new opportunity is also given to PhD holders to access the National School of Administration (ENA), provided that they have at least three years of professional experience, and to access ENA internal competition provided that PhD holders are funded through a "doctoral contract". In the private sector, negotiations for the recognition of the PhD in sectoral collective agreements should be completed by 1 January 2016.

- *Knowledge transfer*: The transfer of research results for the service of society is added to the mission of public higher education. The law provides that preferably inventions from public research should be commercialised through SMEs and intermediate-size enterprises, in the EU.

Enhancing research and innovation was confirmed as a priority with the following recent measures announced since 2012:

- 15 measures to increase the dynamism of knowledge transfer from public research (November 2012): better monitoring, training, simplification of regulatory framework, and a new research centre for innovation economy;

- New innovation tax credit for SMEs (December 2012): EUR 160 million tax debt expected in 2014, which will add to the EUR 5.8 billion expected for the R&D tax credit;

- Shift of the *poles de compétitivité* policy to more support for economic opportunities and job creation (January 2013);

- An additional EUR 12 billion allocated to the Investment for the Future Programme (July 2013);

- Build-up of 34 sectorial industrial plans (*plans industriels de reconquête*) led by industry managers, with a strong focus on innovation in sectors where France has competitive assets, partially relying on EUR 4 billion of funding from the Investment for the Future Programme budget (September 2013);

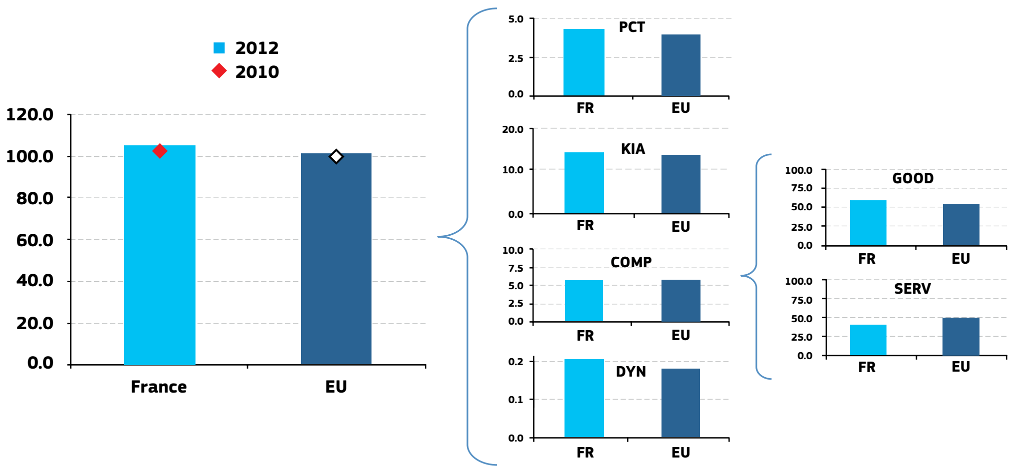
- An innovation contest in seven fields, open to all types of enterprises with EUR 300 million of funding from the Investment for the Future Programme (October 2013).

- A New Deal for Innovation plan, with 40 measures to "promote innovation for all", to be implemented by ministries and public agencies (November 2013): new R&D programmes within the existing budgets, measures to foster innovative public procurement, a programme to foster entrepreneurship in secondary school, new public late-stage VC fund, a new commission for the evaluation of innovation policies, a new "mediator for innovation", new inter-ministerial commission for coordination of innovation and knowledge-transfer policies.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of France's position regarding the indicator's different components:

France – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

France ranks eighth in the European innovation indicator. It has particular strengths in the share of medium-high and high-tech goods in total goods exports and in the innovativeness of fast-growing innovative firms. Performance stagnated in the period 2010-2012.

Industries contributing most to the high share of medium-high and high-tech exports in France are other transport equipment (aeroplanes and trains), medicinal & pharmaceutical products, essential oils & resinoids & perfume materials, and power generating machinery & equipment.

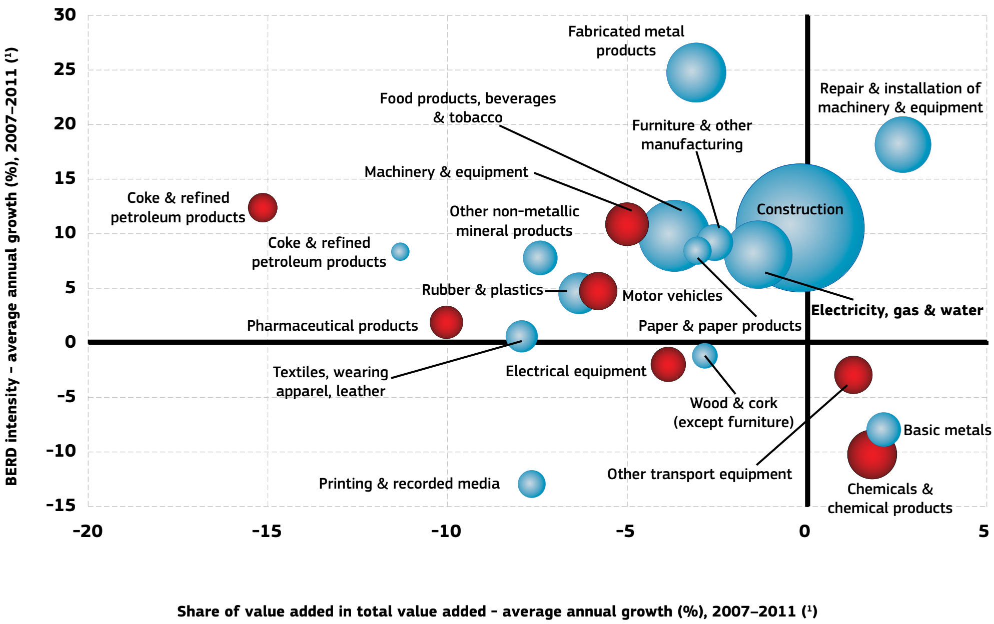
Tourism (leading to corresponding service exports) is an important economic sector in France, which partly explains the relatively low share of knowledge-intensive service exports. Furthermore, French companies collect a relatively high amount of royalties and licence fees, which are classified as not knowledge intensive.

France performs well as regards the average innovativeness scores of fast-growing firms in relation to the total employment in fast-growing firms. This is a result of a high share of employment in ICT and in professional, scientific and technical activities in employment in fast-growing enterprises. However, the growth of these innovative fast-growing firms might be dampened by the administrative thresholds once they reach a specific size (10 or 50 for instance, as was highlighted in the Commission's 2014 in- depth review of France).

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries for the period of 2007-2011. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline of manufacturing in the overall economy of France. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in all sectors presented on the graph. The red sectors are high-tech or medium-high-tech sectors.

France – Share of value added versus BERD intensity: average annual growth, 2007–2011 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Coke and refined petroleum products': 2010–2011.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The graph above shows that almost all manufacturing sectors have seen their weight in the economy decrease (horizontal axis) between 2007 and 2012. The only exceptions are basic metals, other transport equipment, and chemicals & chemical products, the last two belonging to high- or medium-high-tech sectors. Since manufacturing high-tech and medium-high-tech sectors (in red) are the most research-intensive sectors in the economy, the shrinking of these sectors in particular has a negative effect on total business R&D intensity in France. In contrast, research intensity (vertical axis) has increased in the majority of the manufacturing sectors, including a majority of high-tech and medium-high-tech sectors. This of course enhances the overall business R&D intensity.

Overall, the second effect has proved stronger than the first – overall business R&D intensity increased from 1.31 % of GDP to 1.44 % between 2007 and 2011. France's manufacturing industry is dominated by food products, beverages and tobacco, and the fabricated metal products sector, which do not belong to high-tech and medium-high-tech sectors. This contributes to limiting the R&D intensity of the French business sector. The graph above shows very significant growth in the BERD intensity in the fabricated metal products sector.

Key indicators for France

FRANCE	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	1.19	1.16	1.20	1.30	1.40	1.49	1.59	:	:	6.9	*1.81*	16
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	496	:	:	497	:	:	495	-0.6 (3)	495 (4)	12 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	1.34	1.31	1.33	1.31	1.33	1.40	1.42	1.44	*1.48*	*2.4*	1.31	8
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.78	0.77	0.75	0.75	0.77	0.84	0.80 (5)	0.78	*0.78*	*-1.1*	*0.74*	9
Venture capital as % of GDP	0.37	0.42	0.56	0.67	0.44	0.18	0.31	0.46	0.25	-17.9	0.29 (6)	5 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	41.9	:	:	:	:	49.5	3.4	47.8	10
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	9.8	10.0	10.0	10.3	10.4	:	:	:	1.8	11.0	12
International scientific co-publications per million population	:	509	537	569	601	648	668	699	707	4.4	343	15
Public–private scientific co-publications per million population	:	:	:	41	41	42	45	49	:	4.7	53	10
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	3.5	4.1	4.0	4.0	4.0	4.3	4.2	:	:	1.8	3.9	7
License and patent revenues from abroad as % of GDP	0.17	0.29	0.28	0.34	0.39	0.54	0.53	0.58	0.47	6.7	0.59	10
Community trademark (CTM) applications per million population	56	75	85	94	95	102	109	114	113	3.6	152	16
Community design (CD) applications per million population	:	24	26	26	27	27	27	27	28	1.6	29	11
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	:	:	13.2	:	14.7	:	:	5.5	14.4	9
Knowledge-intensive services exports as % total service exports	:	:	:	30.7	29.8	31.2	33.7	33.7	:	2.4	45.3	13
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	3.88	4.95	5.11	4.70	5.32	4.76	4.78	4.65	5.23	-	4.23 (7)	4
Growth of total factor productivity (total economy): 2007 = 100	97	99	100	100	99	96	97	98	97	-3 (8)	97	11
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	56.7	:	:	:	:	58.1	0.5	51.2	7
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	13.5	13.6	13.8	14.4	14.3	1.5	13.9	12
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	32.1	:	30.6	:	:	-2.4	33.8	16
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.26	0.31	0.33	0.36	0.40	0.46	:	:	:	12.4	0.44	7
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.63	0.59	0.55	0.54	0.57	0.55	:	:	:	1.5	0.53	9
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	67.8	69.4	69.3	69.8	70.4	69.4	69.2	69.2	69.3	-0.1	68.4	12
R&D intensity (GERD as % of GDP)	2.15	2.11	2.11	2.08	2.12	2.27	2.24 (5)	2.25	*2.29*	*1.0*	*2.07*	7
Greenhouse gas emissions: 1990 = 100	101	102	100	98	97	93	94	89	:	-9 (9)	83	15 (10)
Share of renewable energy in gross final energy consumption (%)	:	9.5	9.6	10.2	11.3	12.3	12.8	11.5	:	3.0	13.0	16
Share of population aged 30–34 who have successfully completed tertiary education (%)	27.4	37.7	39.7	41.4	41.2	43.2	43.5	43.3	43.6	1.0	35.7	9
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	13.3	12.2	12.4	12.6	11.5	12.2	12.6	12.0	11.6	-1.6	12.7	20 (10)
Share of population at risk of poverty or social exclusion (%)	:	18.9	18.8	19.0	18.5 (11)	18.5	19.2	19.3	19.1	0.8	24.8	8 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2010 and the previous years. Average annual growth refers to 2010–2012.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2012.
(12) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Take steps to simplify and improve the efficiency of innovation policy, in particular through evaluations, taking into account the latest reforms and if necessary an adaptation of the 'crédit d'impôt recherche'. Ensure that resources are focused on the most effective competitiveness poles and further promote the economic impact of innovation developed in the poles."

Germany

The challenge of maintaining a high innovation capacity for an export-oriented economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Germany. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **2.98 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+3.3 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **59.0** (EU: 47.8; US: 58.1) 2007-2012: **+2.2 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **124.2** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **47.1** (EU: 51.2; US: 59.9) 2007-2012: **+1.0 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Automobiles, environment, energy, and key production technologies	***HT + MT contribution to the trade balance*** 2012: **9.2 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+1.7 %** (EU: +4.8 %; US: -32.3 %)

Germany has expanded its R&I system over the last decade. Expenditure on R&D has grown substantially since 2000 to reach 2.98 % of GDP in 2012, which is already close to the 3 % national target for 2020. Public expenditure represents 30 % of investment in R&D, which is an increase compared to 2008 (28 %), but still below the EU average of 33 %. The government increased the public budget on R&I even during the 2009 economic crisis as part of a policy of prioritising spending on education and research. Business enterprise expenditure on R&D, which represents two-thirds of investment in R&D, also grew as a % of GDP over the period 2007-2011.

The increase in public and private expenditure on research and development in Germany has helped to maintain a high innovation capacity and a strong export performance. The German economy is based to a considerable extent on medium-high technology sectors, such as automobiles, electro-technical products, machinery, and chemical products. However, over the last decade, Germany has lost its strong market position in pharmaceuticals and in optical industries. Recently, it has only produced a few successful new international players in high-tech industries. There is also still underexploited growth potential as regards innovative and knowledge-intensive service economy sectors. Germany has come through the last economic crisis relatively well, partly as the result of a strong export sector. However, the German market position as regards medium-high-tech products may be challenged in the future by new players, such as the BRIC countries (Brazil, Russia, India and China). An ageing population with a declining share of young people represents further challenges for the German economy.

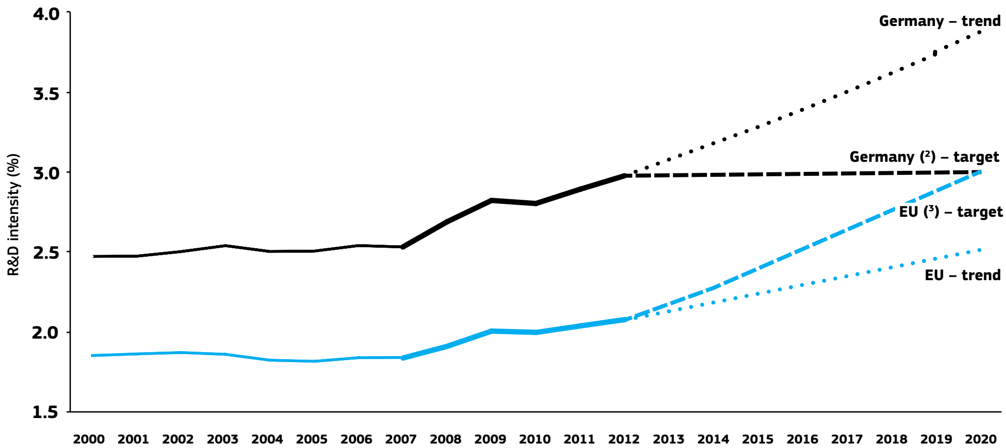
[1] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

[2] Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

The Federal Ministry for Education and Research (BMBF) has developed the so-called High-Tech Strategy to address several important challenges. However, further structural reforms of the education, research and innovation system are required. In view of the demographic situation, a particular focus is required on the quality of human resources and further incentives for excellence and internationalisation are needed. There is room for more public-private cooperation and for implementing targeted supply-side and demand-side measures to foster innovation and fast-growing innovative firms in Germany. Such measures should in particular be targeted at high-tech sectors such as ICT, biotechnology and medical technologies.

Investing in knowledge

Germany – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) DE: The projection is based on a tentative R&D intensity target of 3.0 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.

With an R&D intensity of 2.98 % in 2012, Germany is above the EU average and has almost reached the 3 % national target. The gap of only 0.02 % currently corresponds to EUR 0.5 billion (German GDP amounted to about EUR 2.6 trillion in 2012). About one-third of German R&D expenditure comes from public sources and two-thirds from private sources – a distribution that has remained fairly stable over the last decade.

In the period 2000-2011, the federal public research budgets, which represent more than half of public spending on research, were expanded substantially. Federal spending on research and education increased by a further 7 % in 2011 and by 12 % in 2012. However, at *Länder* level, growth in R&D expenditure, including university expenditure on R&D, was much lower. R&D intensities vary strongly between German *Länder*, ranging from 1.43 % in Schleswig-Holstein and 1.49 % in Saarland and Sachsen-Anhalt to 5.08 % (2011) in Baden-Württemberg, the European region (NUTS 1 level) with the highest research intensity. Berlin (3.56 %) and Bayern (3.16 %) also have R&D intensities that are already above the German national target.

Research intensity is especially high in the automobile sector, which represents nearly one-third of total German business R&D investment. A weak point for German R&D is the relatively low level of spending in high-tech areas such as pharmaceuticals and ICT.

Structural Funds are an important source of funding for R&I activities. Of the EUR 25.5 billion of Structural Funds allocated to Germany over the 2007-2013 programming period, around EUR 5.0 billion (20 % of the total) relate to RTDI[3].

[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

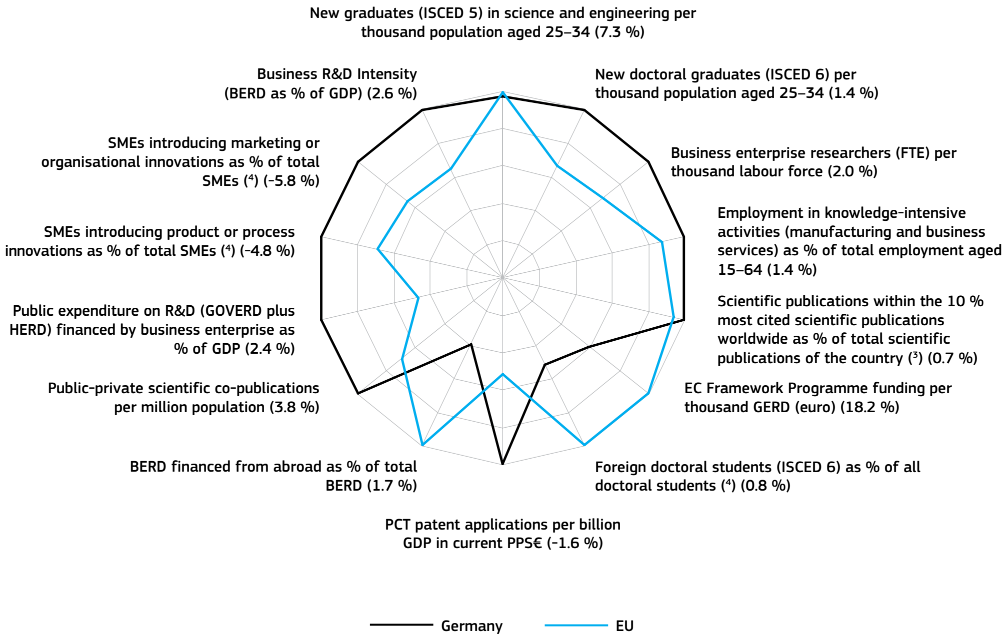
Germany counts 11 000 participants in the EU Seventh Framework Programme and receives the highest amount of FP7 funding in absolute terms (EUR 4.3 billion). Its application success rate is above average (24 % compared to an EU average of 20.4 %), but FP7 funding as a % of GDP is below the EU average.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the German R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation, and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.

Germany, 2012 [1]

In brackets: average annual growth for Germany, 2007–2012 [2]



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

In general, Germany's R&I system performs very well. However, the international dimension is below the EU average, in particular in relation to foreign investment in business R&D and EU Framework Programme funding. Possible explanations relate to the country-size effect, as well as to the high level of German domestic public and private expenditure on R&D. Despite the easy access to and relative abundance of national funding for research, Germany could better use the opportunities offered within the ERA and more specifically within the Framework Programme.

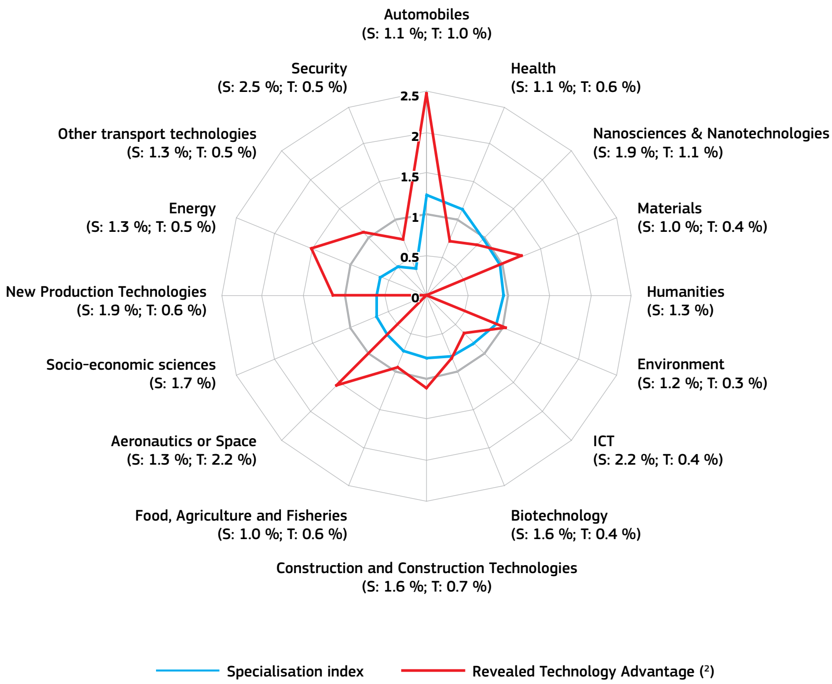
Germany has a particular strength in business R&D, especially in innovative small and medium-sized enterprises (SMEs), many of which are world leaders in their particular small market segments. However, the data above show a decline in the innovation rate of SMEs since 2007. The high level of patenting is an indication of industrial leadership in several domains, most notably in medium-high-tech industries, including engineering industries, automobiles and chemicals and also in environmental and energy technologies.

On the other hand, patenting in relation to GDP has fallen in recent years. Public-private cooperation in publications and in research is functioning well and is further supported by the federal government in the current new programme activities for innovation outlined in the High-Tech Strategy. While Germany performs well in terms of new doctoral graduates, its performance as regards new science and engineering graduates has only recently surpassed the EU average, and there is the risk of slower growth in the long term as a result of demographic trends, like the shrinking number of young people. In the long term, the risk of a scarcity of qualified human resources could endanger the strong German export position in engineering and science-based industries. In recent years, there has been an increase in the number of students in science and engineering subjects (MST/MINT), but efforts should be maintained to further reduce drop-out rates and improve the gender balance in terms of students and teaching staff.

Germany's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Germany shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Germany – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)

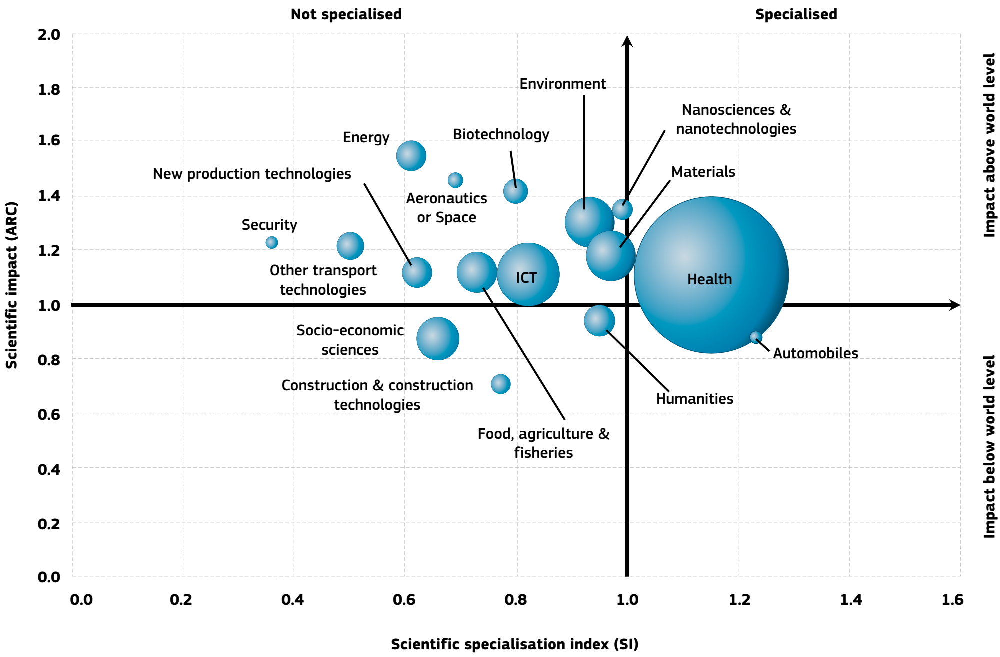


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

As illustrated by the graph above, there is a notable difference in performance between scientific production (publications) and technological production (patents) in Germany. As regards publications, Germany shows specialisations only in the fields of automobiles and health. There is a lack of specialisation in the energy, other transport technology and security sectors. As regards patents (technological output), Germany displays strengths in automobiles, materials, aeronautics, new production technologies and energy.

The graph below illustrates the positional analysis of German publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Germany – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

Germany shows a high specialisation in publications in the fields of health and automobiles. However, in both areas the scientific impact is only at or below the world average. As regards the other areas, Germany shows no specialisation. However, for energy, aeronautics/space and biotechnology the impact of publications are noticeably above world level.

Policies and reforms for research and innovation

The High-Tech Strategy 2020, launched in August 2006 and updated in July 2010, is seen as an instrument to improve cooperation between science and industry, and to improve the conditions for innovation with a view to enhancing the international competitiveness of technology-intensive manufacturing products in key sectors of the German economy. The 2010 update of the High-Tech Strategy prioritises the targeting by public-private partnerships of prospective markets related to important societal challenges in 10 so-called forward-looking projects (Zukunftsprojekte). Strategic priorities of the High-Tech Strategy 2020 are health, nutrition, climate and energy security, and communication and mobility.

Another important element in the research policy of the federal government and the *Länder* is the 'Pakt für Forschung und Innovation' (Pact for research and innovation). In 2005, the Federal Government and the *Länder* agreed to regularly increase their joint funding for the major public German research organisations: the Fraunhofer Society, the Helmholtz Association of German Research Laboratories, the Leibniz Association, the Max Planck Society, as well as the German Research Foundation, which is the major funder for universities. The initiative aims to enable science organisations to continue to improve strategic measures, enhance the quality and quantity of existing instruments, and develop, test and establish new instruments. In 2009, the initiative was updated and the annual growth of institutional funding increased from 3 % to 5 % between 2011 and 2015.

As regards fiscal policies, Germany is one of the few countries that have not introduced R&D tax credits. Such credits tend to be requested by large international companies.

The university system, which is the responsibility of the *Länder*, is meeting challenges, given the recent strong increase in student numbers and limited funding at *Länder* level. Because of a significant rise in the number of new entrants in recent years, the Hochschulpakt (higher education pact) – voluntary agreements between the federal and the *Länder* levels – has been set up. This pact was renewed in 2009 and additional resources were allocated in March 2011 and June 2013.

As regards human resources, Germany has taken measures to remove restrictions on in-bound researcher mobility in view of a skills shortage in some science and technology domains. The federal government recently decided to reform the Immigration Act to facilitate the processing of residence permits, on an action programme to ensure an adequate supply of labour, and on programmes for enhancing international mobility. The legal parameters for the employment of foreign graduates from German universities have been improved and new initiatives are facilitating recognition of qualifications acquired abroad. This could help to increase the share of professors (2012: 6.3 %) coming from abroad. Researcher salaries in Germany are above the EU average, but below those in the United States and Switzerland, one of the reasons for a net outmigration to these countries. Better conditions for career planning and greater transparency of academic pathways could enhance the attractiveness of German universities for foreign researchers.

In June 2008, a national pact to attract more women to science and engineering (Komm mach MINT-mehr Frauen in MINT-Berufen) was set up on the initiative of the Research Ministry (BMBF) and a second phase of this pact was launched in December 2011.

In operation since 2008, the BMBF's Female Professors Programme promotes outstanding women researchers. Since then, 270 additional women professors have been appointed in German higher education institutions. In 2012, following a positive evaluation of the programme's contribution to developing equal opportunities in higher education institutions, the Joint Science Conference of the Federal Government and the Heads of Government of the *Länder* (GWK) decided to continue the programme for a second period of five years until 2017. The programme aims to promote the equality of men and women at universities, increase the representation of women at all levels of qualification in the research system on a long-term basis, and boost the number of female scientists in leading positions in the science system.

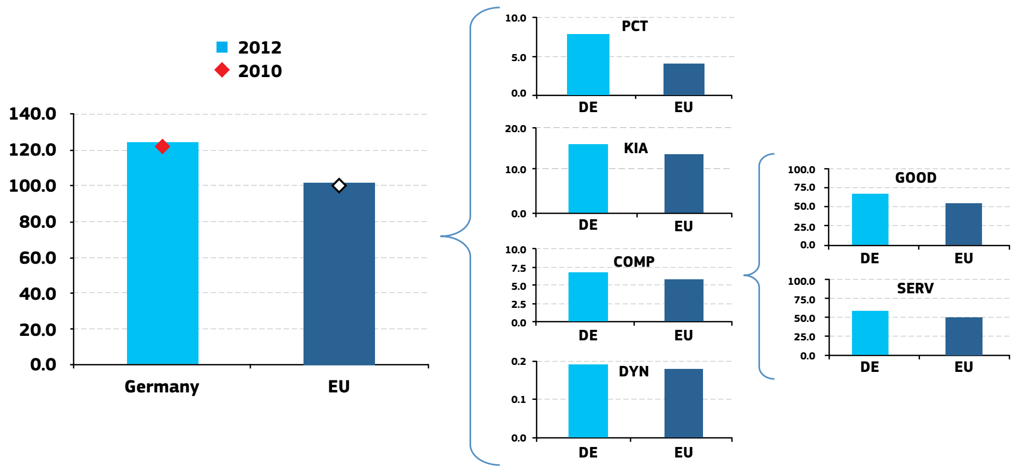
As regards the 'knowledge triangle' and fostering innovation activities, the BMBF and the Federal Ministry for Economic Affairs (BMWi) are taking steps to better focus their activities. The BMBF fosters public/private partnerships through activities such as the 'Leading-edge cluster competition' (Spitzencluster-Wettbewerb), which promotes the formation of clusters of business and science to boost Germany's innovative strengths in specific areas and, more recently (August 2011), the 'Research Campus' (Forschungscampus), a competitive funding scheme to strengthen cooperation between companies and research organisations. The BMWi uses the EXIST programme to stimulate an entrepreneurial environment at universities and research institutions. This programme is aimed at increasing the number of technology and knowledge-based business start-ups. The Hightech Gründerfonds stimulates start-ups and young technology companies by providing venture capital.

To help SMEs to enhance R&I, a Central Innovation Programme for SMEs (ZIM, Zentrales Innovationsprogramm Mittelstand) was set up in 2008 and will run until 2014. Funding is provided for individual research projects and for national and international cooperation between research organisations and companies as well as between companies. More than 5000 projects are financed each year.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Germany's position regarding the indicators' different components:

Germany– Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Germany is the top EU performer in the European innovation indicator. This is a result of good performance as regards all the indicator's components.

The country's performance is notably high on patents and on the share of medium-high/high-tech exports in total goods exports, where it is the second best performer in the EU.

The good performance in patents is explained by the above-average share of industries with a high patent intensity in Germany (ICT, automobile industry, medical equipment, and energy technology). Companies like Siemens, Bosch and BASF are among the top patent producers in Europe. The large and export-oriented automobile and machinery industry also explains the high score as regards the contribution of medium-high/high-tech exports to trade balance[4]. When it comes to the export share of knowledge-intensive services, the good performance is partially explained by the fact that Germany is an important transportation hub for air and waterborne transport (both classified as KIS), an important software exporter, and a major exporter of research, professional and technical services. Germany also performs above the EU average in the share of knowledge-intensive activities as the result of a high share of employment in the manufacture

4 Germany also performs above the EU average in Community trademarks and designs, but the difference compared to the EU average is smaller than for patents.

of electronic and optical production, in publishing activities and in employment activities.

Germany performs well as regards the innovativeness of fast-growing firms. This is the result of a high share of activities with high innovativeness scores, such as computer programming and information service activities, among the fast-growing firms.

Framework conditions for entrepreneurship in Germany have improved, as indicated by the country's improved ranking in the World Bank's 'ease of doing business index'. Germany has also made progress in reducing the administrative burden related to reporting obligations in the business sector. In 2011, the Bureaucracy Reduction and Better Regulation programme was extended to cover other compliance costs. However, Germany remains at around the EU average regarding the administrative burden of the regulatory framework.

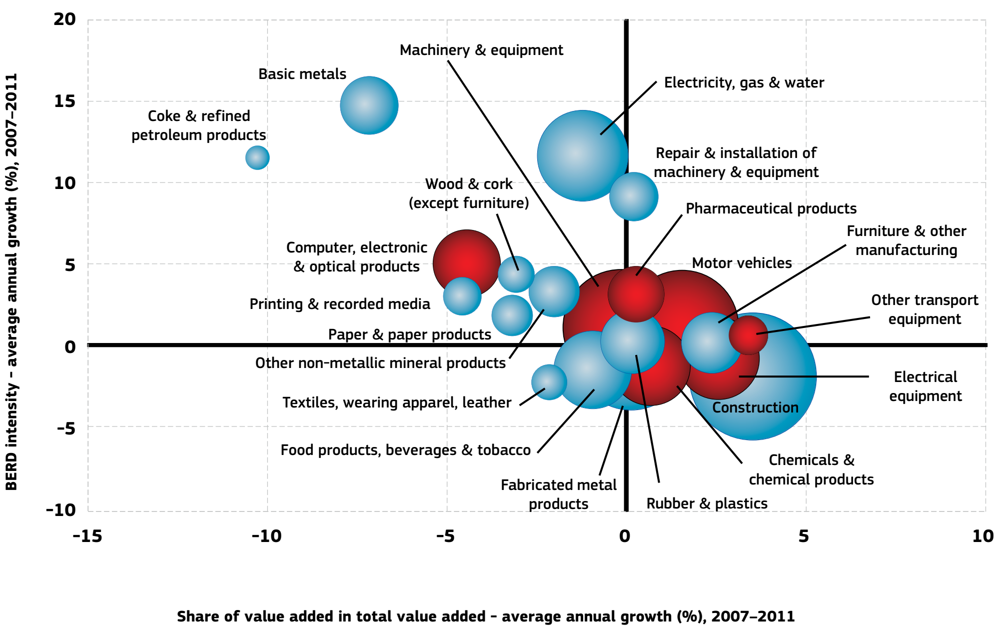
Labour productivity in the country is high and SMEs' access to bank lending is above the EU average. The quality of the infrastructure is good and the legal and regulatory framework is perceived as appropriate by business. Any remaining weak points concern the availability of broadband and use of e-government services. Furthermore, the availability of venture capital in Germany (0.19 % of GDP in 2012) remains below the EU average (0.29 %).

In the Global Competitiveness Report 2013-14, Germany is ranked second highest among EU countries (after Finland) in capacity for innovation, second highest (after Finland) in company spending on R&D, and fourth in the EU on university-industry collaboration on R&D.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented in the graph). The red sectors are high-tech or medium-high-tech sectors.

Germany – Share of value added versus BERD intensity: average annual growth, 2007–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: ([1]) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The German economy is characterised by a relatively strong manufacturing industry. Nevertheless, as in many countries, the trend in manufacturing industries' share of value added in total value added is one of decline (illustrated by a shift to the left in the graph above). This is linked to rationalisation and a relative fall in the price levels of manufactured goods, the expanding services sector, and also to globalisation and competition from lower-wage, emerging economies.

The distribution of business expenditure on R&D reflects the concentration of German industry in medium-high-tech sectors, with more than 30 % of R&D spending carried out by the automobile sector alone. Other important medium-high-tech sectors in terms of R&D expenditure are machinery and equipment and chemicals excluding pharmaceuticals. These three sectors represent around 50 % of business expenditure on R&D in Germany. Spending levels are relatively lower in high-tech areas with pharmaceuticals, radio, TV and communication equipment, and medical precision and optical instruments together accounting for only around 20 % of business expenditure on R&D. Furthermore, research is concentrated in large companies and research intensity is lower in the services sector than in manufacturing.

Compared to other EU Member States, the German manufacturing industries present an above-average dynamic of upgrading knowledge through R&D. Since 2007, growth in business research intensity has been moderate, although still faster than the EU average. The motor vehicles industry, a key sector of the German economy, has maintained its high research intensity and has succeeded in increasing its share of value added. A second important medium-high-tech sector, machinery and equipment, has kept its share of the economy and its research intensity stable. The computer, electronics and optical products sector has increased research intensity but its share of value added has declined, partly as a result of falling product prices. Research intensity has increased strongly in a number of medium- and low-tech sectors such as basic metals and coke and refined petroleum products, although from a low level.

Key indicators for Germany

GERMANY	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	2.12	2.59	2.53	2.52	2.65	2.64	2.68	2.79	2.70	1.4	*1.81*	2
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	504	:	:	513	:	:	514	9.7 (3)	495 (4)	6 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	1.74	1.74	1.78	1.77	1.86	1.91	1.88	1.96	*2.02*	*2.6*	1.31	4
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.73	0.77	0.76	0.76	0.83	0.92	0.92	0.94	*0.96*	*4.8*	*0.74*	4
Venture capital as % of GDP	0.23	0.12	0.15	0.33	0.29	0.11	0.19	0.17	0.19	-10.5	0.29 (5)	8 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	52.9	:	:	:	:	59.0	2.2	47.8	8
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	11.5	11.7	11.5	11.7	11.6	:	:	:	0.7	11.0	7
International scientific co-publications per million population	:	517	542	588	609	654	689	729	746	4.9	343	14
Public–private scientific co-publications per million population	:	:	:	65	63	66	73	76	:	3.8	53	9
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	7.2	7.8	7.8	7.9	7.1	7.8	7.5	:	:	-1.6	3.9	3
License and patent revenues from abroad as % of GDP	0.16	0.26	0.24	0.25	0.30	0.54	0.45	0.41	0.40	9.7	0.59	11
Community trademark (CTM) applications per million population	119	134	165	189	189	197	224	244	245	5.3	152	5
Community design (CD) applications per million population	:	36	38	42	41	40	41	43	43	0.4	29	7
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	19.2	:	17.4	:	15.5	:	:	-5.5	14.4	4
Knowledge-intensive services exports as % total service exports	:	49.7	51.0	53.9	55.1	53.1	55.8	55.6	:	0.8	45.3	5
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	9.23	8.00	7.78	8.48	8.90	7.67	7.76	8.54	9.24	-	4.23 (6)	1
Growth of total factor productivity (total economy): 2007 = 100	94	96	98	100	100	94	98	100	99	-1 (7)	97	6
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	44.8	:	:	:	:	47.1	1.0	51.2	14
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	14.9	15.4	15.3	15.0	15.8	1.4	13.9	7
SMEs introducing product or process innovations as % of SMEs	:	:	52.8	:	53.6	:	48.6	:	:	-4.8	33.8	1
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	1.03	0.78	0.81	0.80	0.91	1.06	:	:	:	14.8	0.44	2
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	1.06	1.13	1.04	1.01	0.90	0.93	:	:	:	-4.0	0.53	3
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	68.8	69.4 (8)	71.1	72.9	74.0	74.2	74.9	76.3	76.7	1.0	68.4	3
R&D intensity (GERD as % of GDP)	2.47	2.51	2.54	2.53	2.69	2.82	2.80	2.89	*2.98*	*3.3*	*2.07*	4
Greenhouse gas emissions: 1990 = 100	84	81	81	79	79	74	77	74	:	-5 (9)	83	9 (10)
Share of renewable energy in gross final energy consumption (%)	:	6.0	7.0	8.3	8.4	9.2	10.7	12.3	:	10.3	13.0	14
Share of population aged 30–34 who have successfully completed tertiary education (%) (10)	25.7	26.1 (8)	25.8	26.5	27.7	29.4	29.8	30.7	32.0	3.8	35.7	17
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	14.6	13.5 (8)	13.7	12.5	11.8	11.1	11.9	11.7	10.6	-3.2	12.7	15 (10)
Share of population at risk of poverty or social exclusion (%)	:	18.4	20.2	20.6	20.1	20.0	19.7	19.9	19.6	-1.0	24.8	9 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) Break in series between 2005 and the previous years.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Use the available scope for increased and more efficient public investment in infrastructure, education and research."

Greece

Promoting innovation as a driver of a less-dependent and sustainable economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Greece. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.69 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+0.6 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **27.2** (EU: 47.8; US: 58.1) 2007-2012: **-1.9 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **76.3** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **31.6** (EU: 51.2; US: 59.9) 2007-2012: **+0.8 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Food, agriculture and fisheries, security, construction, health, and environment	***HT + MT contribution to the trade balance*** 2012: **-5.4 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

In 2012, Greek national R&D intensity was 0.69 % of GDP showing a 3.5 % increase compared to the previous year. However, it remains significantly below the EU average of 2.06 % of GDP. Regarding the excellence in science and technology indicator, Greece remains below the EU average as its performance has declined compared to 2007. It has managed to slightly raise its performance in the knowledge-intensity indicator compared to 2007, but remains well below the EU average indicating that there is still room for structural change towards more knowledge-intensive activities. In terms of innovation output, Greece is also below the EU average, which can be partly explained by its poor performance in technological innovation, measured by means of patent applications. In terms of the economy's competitiveness, the consistently negative trade balance relating to high- and medium-tech products implies the necessity to concentrate on innovative products to make the country more self-sustainable and possibly more competitive by increasing exports of cutting-edge products.

Some of the key bottlenecks and challenges for Greece include the lack of an integrated legal framework for research performers (overall the system is dominated by the universities) and the weak articulation of R&I policy with other policies, with particularly weak links in the knowledge-triangle sectors. Moreover, exploitation of research results by the business sector is very limited, with very low patenting activity.

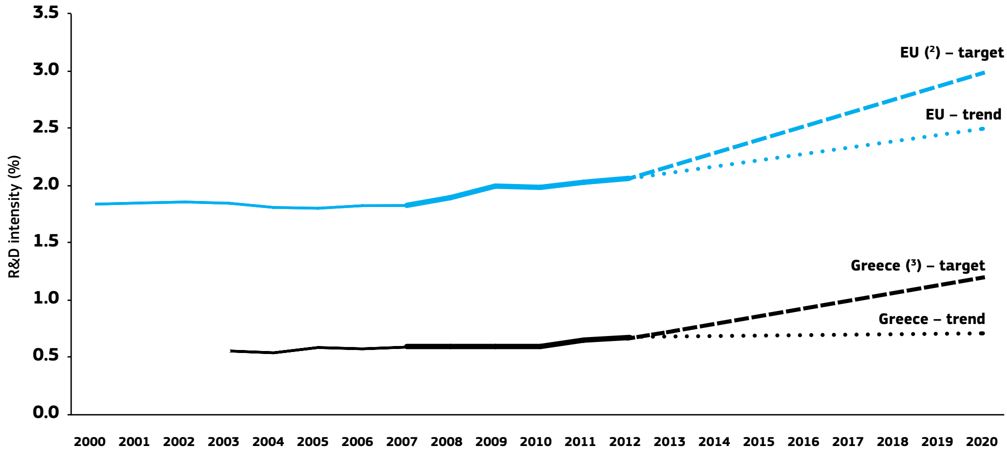
Since 2013, significant actions have been undertaken to reform the Greek R&I system, in order to make it more modern, efficient and adaptable to the country's current economic situation. Indeed, given the current financial situation in Greece, an opportunity has been presented to move towards more knowledge-intensive activities and to concentrate more on high-tech innovative products, which will be identified through the national and regional smart specialisation processes. Such an approach will help decrease the dependency and increase the sustainability of the Greek economy, eventually driving the country out of the economic crisis.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Investing in knowledge

Greece – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2001–2007 in the case of Greece.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) EL: The projection is based on a tentative R&D intensity target of 1.21% for 2020.
(4) EL: There is a break in series between 2011 and the previous years; the values for 2008, 2009 and 2010 were estimated by DG Research and Innovation.

Gross domestic expenditure on R&D (GERD) in Greece was 0.69 % of GDP in 2012, a slight increase compared to the previous year (0.67 %), but still much lower than the EU average of 2.06 % in 2012.

The latest EU2020 R&D target set by Greece in the context of the 2013 European Semester process of 0.67 % of GDP has already been achieved, and the Greek authorities have set a new revised and more ambitious target of 1.21 % of GDP.

In 2012, business expenditure on R&D (BERD) increased to reach 0.24 % of GDP compared to 0.17 % in 2007. This can probably be coupled with Greek participants performing well in the EU Framework Programmes, and shows significant potential nationally in the R&I field, opening up opportunities for the country on the road to recovery.

EU Structural Funds are an important source of funding for R&I activities in Greece. Of the EUR 20.210 million of Structural Funds allocated to Greece over the 2007-2013 programming period, around EUR 2.020 million (10 % of the total) relate to RTDI[3]. The 2007-2013 Operational Programme (OP) 'Competitiveness and Entrepreneurship' has a total budget of EUR 1.52 billion for which Cohesion policy provides EUR 1.29 billion (EC contribution), representing approximately 6.32 % of the total EU sum invested in Greece under the Cohesion policy (2007-13). It includes Union support for Greek regions that are eligible under the Convergence objective (Eastern Macedonia and Thrace, Thessaly, Epirus, Western Greece, Peloponnese, Ionian Islands, Crete and North Aegean). The OP includes R&I activities mainly in two of its priority axes: 'Stimulation and development of innovation, supported by research and technological development' and 'Improvement of the entrepreneurial environment'. In 2013, the Greek authorities decided to reduce the allocation to the OP's above-mentioned R&I core priority axes by EUR 67 million, as the result of implementation difficulties and absorption problems.

Greece has been relatively successful in terms of its participation in the Seventh Framework Programme

[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally-friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

for Research and Technological Development (FP7). Up until March 2014, 3587 participants from Greece had benefited from FP7, absorbing a total of EUR 974 million with around 15 % of that funding going to Greek small and medium-sized enterprises (SMEs). Despite the fact that Greece ranks 11th in the EU-28 in terms of budget share and ninth in terms of number of participants, success rates in FP7, both in terms of applications and of EU financial contribution, remain relatively low. On the one hand, this shows greater interest from Greek entities in EU funding programmes, while on the other, the potential for raising the level of excellence in the proposals submitted in an effort to make them more successful and to increase their chances of being retained for EU funding.

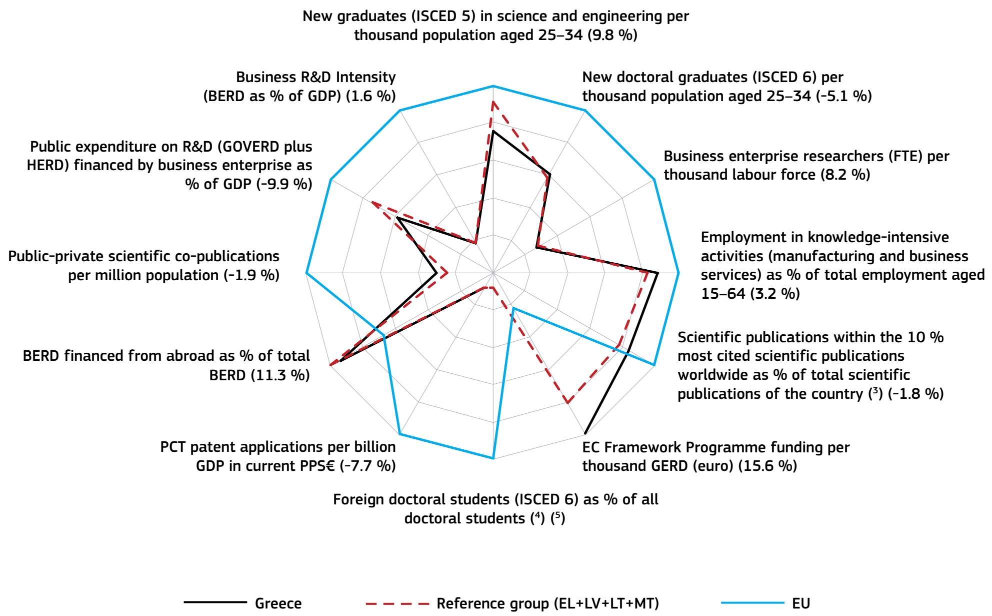
Greece's most active and successful participation in FP7 is in the ICT field, as well as in Marie-Curie actions. The most active Greek entities in FP7 are mainly research organisations and universities – the top-performing entities are the research organisations FORTH and CERTH, both ranked in the top 100 most successful performers in FP7. Greece has most FP7 collaborative links with the Germany, Italy, the United Kingdom, Spain and France.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses in the Greek R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Greece, 2012 (1)

In brackets: average annual growth for Greece, 2007–2012 (2)



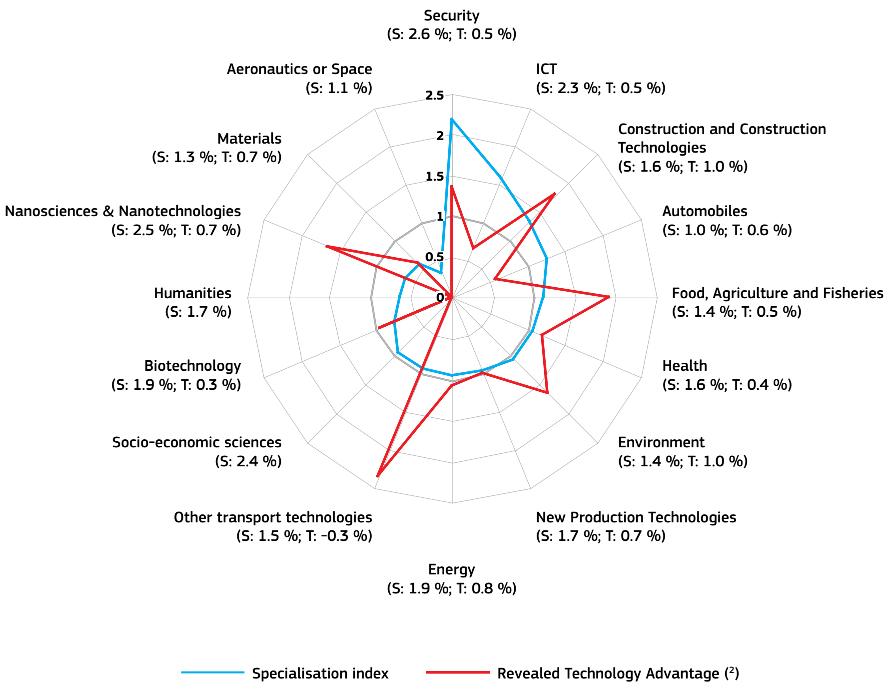
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EL is not available and is not included in the reference group.
(5) EU does not include EL.

The graph above shows that R&D financing in Greece relies significantly more than the EU average on external funding (EC Framework Programme, private R&D funding from abroad); in particular, since 2007, there has been a significant upward trend for Framework Programme funding. On the other hand, the main challenges for the Greek R&I system lie in human resources with low levels of business enterprise researchers, foreign doctoral candidates and new doctoral candidates aged 25-34 years, with the latter indicator declining substantially since 2007. Furthermore, Greece is also lagging behind in technological innovation and business investment, with the biggest gaps between Greece and the EU average occurring for BERD as % of GDP and PCT patent applications per GDP. These findings underline the conclusion that significant efforts are needed domestically regarding both human capital and technological innovation.

Greece's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Greece shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Greece – S&T National Specialisation ([1]) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications ([3]) (S) and in number of patents ([4]) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: ([1]) Values over 1 show specialisation; values under 1 show a lack of specialisation.
([2]) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
([3]) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
([4]) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Comparison of the scientific and technological specialisation in selected thematic priorities creates an interesting picture for Greece. In particular, technology production shows a strong specialisation in various fields, namely, other transport technologies, the environment, nanosciences and nanotechnologies, security, construction technologies, and food, agriculture and fisheries. When looking for co-specialisations in both the scientific and technological aspects, there is a match between security, construction and construction technologies, food, agriculture and fisheries, health, and the environment.

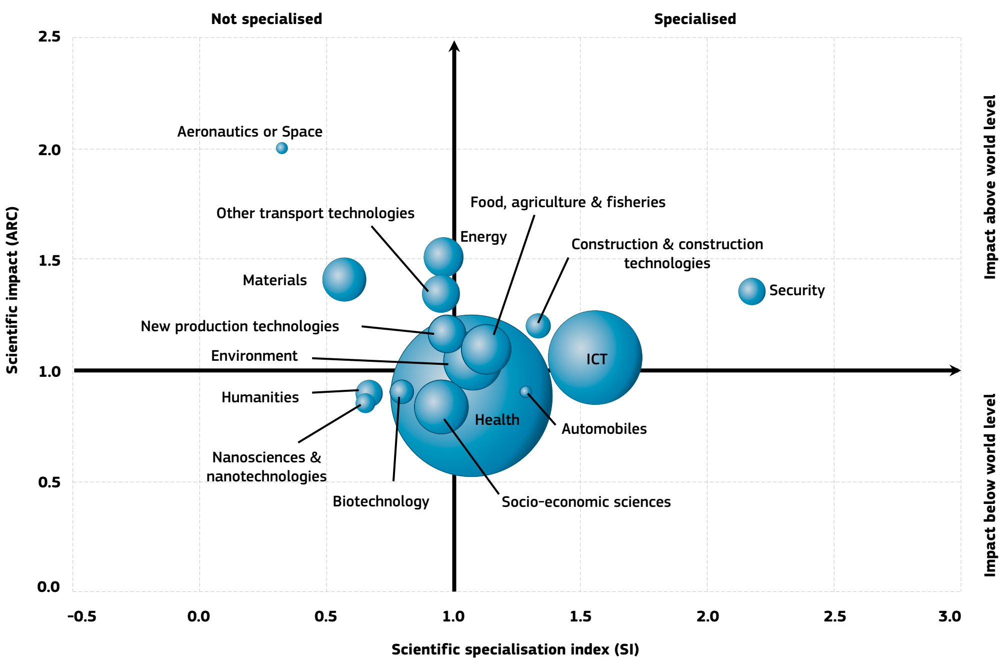
In other transport technologies, where Greece has a very strong technology advantage, it is interesting to note that there is only a marginal advantage in scientific specialisation. Some of the key areas identified in this graph seem to be in line with the key priority areas identified in the Greek national Smart Specialisation Strategy, in which transport and logistics and key enabling technologies have been identified as horizontal priority areas.

The graph below illustrates the positional analysis of Greek publications (specialisation versus impact). It can be seen that in the key area of scientific specialisation, which is the security sector, the impact made is above the world average, which is particularly important for Greece.

Furthermore, it should be highlighted that despite the relatively low levels of scientific specialisation in such areas as energy and materials, these are areas with strong potential impact, which suggests that Greece would probably benefit from concentrating efforts towards the energy technologies and materials sectors.

The graph below illustrates the positional analysis of Greek publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Greece – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

Policies and reforms for research and innovation

Since the 1990s, Greece has experienced high growth rates exceeding those in many EU Member States and the EU average. However, such rates were not the result of a highly competitive economy. They were mainly driven by internal consumption, so the trade balance remained highly negative indicating a significant disadvantage in competitiveness. In Greece, the financial crisis, which started in 2008, was transformed into a debt crisis in 2009-2010, cutting off access to the international financial markets and leading the economy into recession. The debt and the persistence of the crisis indicated that relying on domestic demand could not be a reliable option for recovery. Since 2010, the economic adjustment programme for Greece has tackled the imbalances accumulated in the pre-crisis years through the stabilisation of public finances and the financial sector and a very comprehensive set of growth-enhancing structural reforms and measures to foster growth by strengthening external competitiveness, stimulating exports and accelerating the reallocation of resources from the non-tradable to the tradable sector.

A combination of structural problems and significant institutional and bureaucratic obstacles, together with a volatile policy environment induced Greek businesses to invest in activities with either high rates of return in the short-term or very low risk. To a large extent, this has shifted economic activity towards less knowledge-intensive and low value-added thematic areas. The sectors with high growth and holding dominant positions are those with relatively low exposure to international competition, such as retail trade, construction, and non-tradable services. At the same time, the share of the primary and manufacturing sectors is shrinking, resulting in a further increase in the trade deficit. The limited exposure to international competition and the privileged access to public-sector procurements have enabled significant segments of the economy to grow without investing in R&D and innovation.

Since 2013, substantial actions have been undertaken by the General Secretariat for Research and Technology (GSRT) regarding the upgrading, modernisation and improvement of the Greek R&I system. In line with policy conditionality under the adjustment programme and the *ex-ante* conditionalities for the 2014-2020 NSRF, some of the measures announced include the completion of the National Strategy for Research, Technological Development and Innovation 2014-20, the main implementation mechanism of which will be a national Framework Programme for Research and Innovation that will also be linked to the national Smart Specialisation Strategy's identified thematic priority sectors. In addition, more emphasis is expected to be given to research infrastructures with the announced imminent completion of the National Roadmap of Research Infrastructures linked to the European Strategy Forum on Research Infrastructures (ESFRI) process.

Furthermore, other structural measures being announced by the GSRT to improve the national R&I system include evaluation of research centre structures in view of meeting the requirements stemming from the administrative reform of the public sector. In addition, an in depth assessment of research centres is under consideration in terms of excellence and management in order to make them more efficient and align them with the societal challenges and current needs of the Greek economy.

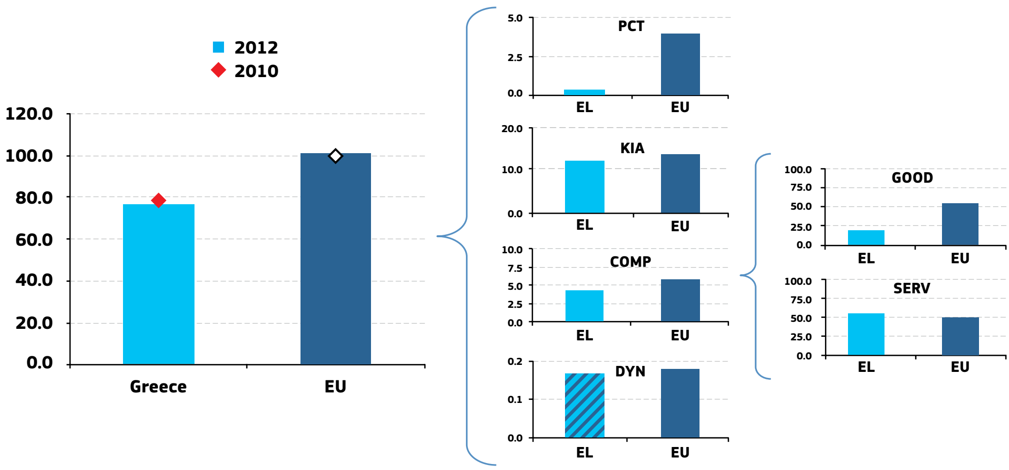
Most of the above-mentioned measures and actions will be implemented within the context of the new institutional framework for research and innovation which is in its final stages of preparation. This new Law for the Development of Research, Technological Development and Innovation, went through a public consultation that was completed at the end of 2013 and was expected to be submitted to the Parliament for adoption in July 2014, as stipulated in the adjustment programme.

In Greece, EU Cohesion funding from the European Structural and Investment Funds (ESIF) is expected to be an important source of funding for R&I activities for the 2014-20 period. As indicated in the draft Partnership Agreement for Greece, around EUR 1.2 billion is expected to be allocated to Thematic Objective 1, 'Strengthening Research, Technological Development and Innovation', which amounts to about 6.5 % of the total Cohesion funding for Greece.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Greece's position regarding the indicator's different components:

Greece – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average); estimated value.
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Greece is a low performer in the European innovation indicator. In most components it is performing below the EU average and its performance is not improving.

The relatively low performance in patents is linked to the country's economic structure with a very small capital goods sector and the lack of large manufacturing companies in technology-intensive sectors, which normally show high patenting activities[4].

Employment in knowledge-intensive activities (KIA) is low. However, employment in agriculture, construction and in tourism-related services, not classified as KIA, still plays an important role in the Greek economy.

Greece exports few capital goods while the export share of agricultural products, mineral fuels and lubricants is high. Hence, its score is low as regards the share of medium-high/high-tech goods in total goods exports. The country performs better in knowledge-intensive services exports, thanks to an important maritime freight transport sector.

[4] Performance is similar in other IP-related outputs such as trademarks and designs.

Key indicators for Greece

GREECE	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	:	0.74	:	1.44	0.83	:	1.14	1.05	1.11	-5.1	*1.81*	19
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	459	:	:	466	:	:	453	-6.2 (3)	495 (4)	24 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.15	0.19	*0.18*	0.17	:	:	:	0.23 (5)	0.24	*1.6*	1.31	25
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	0.40	*0.40*	*0.42*	:	:	:	0.43 (5)	0.45	4.6	*0.74*	22
Venture capital as % of GDP	0.14	0.004	0.01	0.04	0.10	0.02	0.01	0.004	0.00	-42.3	0.29 (6)	20 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	29.9	:	:	:	:	27.2	-1.9	47.8	18
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	8.9	8.3	9.6	9.5	9.3	:	:	:	-1.8	11.0	15
International scientific co-publications per million population	:	343	405	442	459	516	519	564	590	6.0	343	17
Public–private scientific co-publications per million population	:	:	:	17	16	15	15	16	:	-1.9	53	21
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.3	0.5	0.4	0.5	0.4	0.4	0.4	:	:	-7.7	3.9	25
License and patent revenues from abroad as % of GDP	0.00	:	0.03	0.02	0.01	0.01	0.02	0.02	0.03	14.0	0.59	24
Community trademark (CTM) applications per million population	15	22	35	43	38	36	34	38	40	-1.1	152	25
Community design (CD) applications per million population	:	1	1	3	2	3	4	4	3	4.0	29	26
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	25.6	:	:	:	:	:	:	-	14.4	*3*
Knowledge-intensive services exports as % total service exports	:	:	:	:	55.8	50.6	53.0	:	:	-2.5	45.3	6
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-10.44	-5.39	-5.60	-5.49	-3.80	-5.71	-4.20	-5.69	-5.41	-	4.23 (7)	28
Growth of total factor productivity (total economy): 2007 = 100	88	96	99	100	98	95	91	88	88	-12 (8)	97	27
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	30.3	:	:	:	:	31.6	0.8	51.2	27
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	10.8	10.9	10.9	11.4	12.3	3.2	13.9	18
SMEs introducing product or process innovations as % of SMEs	:	:	37.3	:	:	:	:	:	:	-	33.8	13
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.04	0.05	0.12	0.04	0.01	0.04	:	:	:	-0.9	0.44	22
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.07	0.08	0.05	0.13	0.05	0.07	:	:	:	-23.9	0.53	22
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	61.9	64.6	65.7	66.0	66.5	65.8	64.0	59.9	55.3	-3.5	68.4	28
R&D intensity (GERD as % of GDP)	:	0.60	*0.59*	*0.60*	:	:	:	0.67	0.69	*0.6* (9)	*2.07*	24
Greenhouse gas emissions: 1990 = 100	120	128	125	128	125	118	112	110	:	-18 (10)	83	24 (11)
Share of renewable energy in gross final energy consumption (%)	:	7.2	7.4	8.4	8.3	8.5	9.8	11.6	:	8.4	13.0	15
Share of population aged 30–34 who have successfully completed tertiary education (%)	25.4	25.3	26.7	26.2	25.6	26.5	28.4	28.9	30.9	3.4	35.7	18
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	18.2	13.6	15.5	14.6	14.8	14.5	13.7	13.1	11.4	-4.8	12.7	17 (11)
Share of population at risk of poverty or social exclusion (%)	:	29.4	29.3	28.3	28.1	27.6	27.7	31.0	34.6	4.1	24.8	25 (11)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2011 and the previous years. Average annual growth refers to 2011–2012.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking. Average annual growth refers to 2007–2011.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) Average annual growth refers to 2001–2007.
(10) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(11) The values for this indicator were ranked from lowest to highest.
(12) Values in italics are estimated or provisional.

Hungary

Improving the effectiveness of national research system and fostering innovation in enterprises

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Hungary. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.30 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+5.7 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **31.5** (EU: 47.8; US: 58.1) 2007-2012: **+2.4 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **92.0** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **54.4** (EU: 51.2; US: 59.9) 2007-2012: **+2.3 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Food and agriculture, automobiles, health, and environment	***HT + MT contribution to the trade balance*** 2012: **5.6 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+4.5 %** (EU: +4.8 %; US: -32.3 %)

Over the last decade, the Hungarian R&I system has made obvious progress in the level of private-sector investment and in overall R&D intensity, as well as in scientific quality, patent revenues and structural change towards a more knowledge-intensive economy. Although public sector R&D intensity and the internationalisation of science remains less dynamic than the EU average, Hungary's innovation performance improved in 2007-2012, despite some fluctuations.

Hungary is still facing some key challenges in R&I. These include: weaknesses in the knowledge base and knowledge production; a low level of innovation activity, especially by small and medium-sized enterprises (SMEs), together with a low level of cooperation in innovation activities among the key actors; unfavourable framework conditions for innovation, in particular an unstable business environment, a high administrative burden, and competition not conducive to innovation; and insufficient human resources for research. The policy evaluation culture is weak in Hungary and the separation between science policy and R&I policy makes it difficult to coordinate the overall STI policy governance. Moreover, public R&D funding has fallen in Hungary since 2007 which points to some risks regarding the continuous policy commitment needed to further address these important challenges.

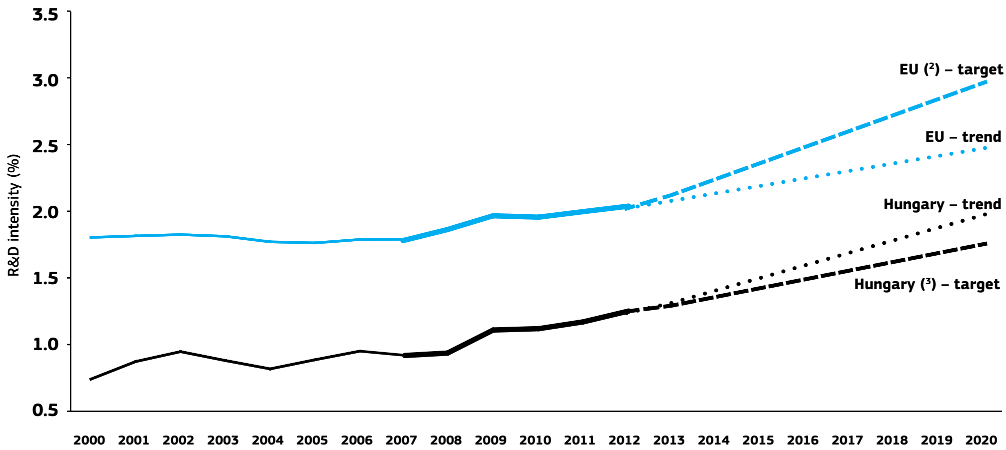
The new Innovation Strategy 2013-2020 focuses on three main areas of intervention: knowledge creation, knowledge transfer, and knowledge utilisation. Encouraging intelligent specialisation, building a sustainable system able to create equal opportunities, providing stable financing conditions, raising public awareness and strengthening the acknowledgment of knowledge and technology, and creating a stable, innovation-friendly economic and regulatory environment – these could all lead to rising levels of R&D intensity in the coming years. The strategy and its implementation are being supplemented by the Strategy of Intelligent Specialisation (S3) which is currently being developed. The Science Policy Strategy 2014-2020 (under preparation) aims to enhance the attractiveness of the research environment, increase scientific excellence, and reverse the brain drain.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Investing in knowledge

Hungary – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) HU: The projection is based on a tentative R&D intensity target of 1.8 % for 2020.
(4) HU: There is a break in series between 2004 and the previous years.

In the recently adopted National Research and Development and Innovation Strategy (2013-2020), entitled 'Investment into the Future', Hungary commits to increasing its research and development expenditure to 1.8 % of the GDP by 2020 and to 3 % by 2030. A complementary target for the strategy is that BERD will reach 1.2 % by 2020. Moreover, the implementation of the R&D&I Strategy aims to reach the R&D intensity targets as priority indicators for an investment in the future.

Since the R&D intensity grew in 2007-2012 each year by 5.7 % on average to reach 1.3 % of GDP in 2012, Hungary is on track to achieve its national R&D intensity target of 1.8 % by 2020. This is mainly due to an increasing trend in business expenditure on R&D which grew by 11.4 % on average during 2007-2012. However, public R&D intensity (public-sector expenditure on R&D as % of GDP) fell from 0.48 % in 2009 to 0.43 % in 2012. Hungary, Bulgaria and Croatia are the only EU countries in which public R&D intensity has declined since 2007. This trend threatens to undermine the already weak supply of human resources for science and technology and the quality of the research performed.

In 2009-2012, the breakdown of total R&D expenditure by funding source and performance sector was similar to the EU-28 average. The share of R&D financed and performed by the business enterprise sector increased from 57.2 % to 65.6 % during this period, which is above the EU average of 63.0 %. On the other hand, the share of R&D performance by Higher Education Institutes (HEIs) decreased from 21.7 % in 2009 to 18.4 % in 2012, receding from the EU average of 23.8 %. The research performance of the government sector also fell in the period 2009-2012 from 20.1 % to 14.4 % which is close to the EU average of 12.4 %.

Up to February 2014, Hungary's participant success rate in the EU's Seventh Research Framework programme (FP7) reached 20.2 %, which is close to the EU-28 average of 20.5 %. However, the Hungarian EC financial contribution success rate of 15.0 % is lower than the EU-28 rate of 19.1 %. Structural Funds are an important source of funding for R&I activities. Of the EUR 24.908 billion of Structural Funds allocated to Hungary over the 2007-2013 programming period, around EUR 2.126 billion (8.5 % of the total) relate to RTDI[3].

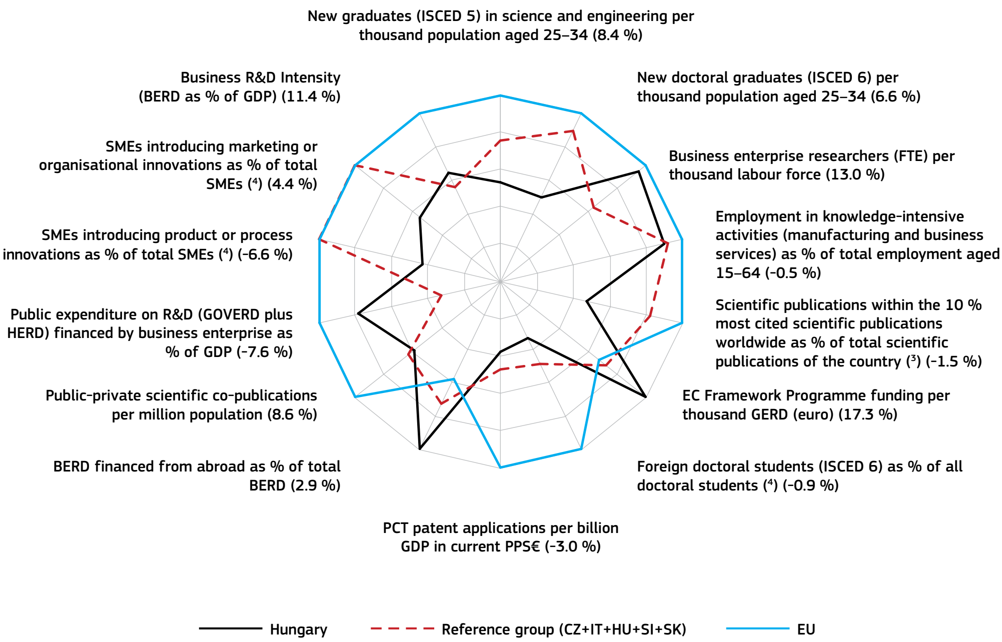
[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally-friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Hungary's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.

Hungary, 2012 (1)

In brackets: average annual growth for Hungary, 2007–2012 (2)



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(3) Fractional counting method.
(4) EU does not include EL.

Hungary is below the EU average in most of the areas. However, the rate of BERD financed from abroad and EU FP7 funding are significantly higher than the EU average. The share of employment in knowledge-intensive activities and the number of business enterprise researchers are very close to the EU average.

Vulnerable areas include human resources, scientific production, innovation, and technology production. Innovation activities in small firms are at a low level with only around 14.7 % of Hungarian small and medium-sized enterprises (SMEs) innovating by introducing a new product or a new process and 22.4 % introducing marketing or organisational innovation.

Only 5.2 % of Hungarian scientific publications are in the top 10 % of most-cited scientific publications, compared to the EU average of 11.0 %. Hungary has a low level of PCT patent applications and this trend is on the decline. The country performs better in terms of licence and patent revenue from abroad (not shown on the graph), which is probably due to the increased role of large foreign-owned enterprises in business R&D investment.

Hungary seems to be relatively well integrated in pan-European research collaborations in FP7. The top collaborations involving Hungarian researchers are mainly with colleagues from Germany, the United Kingdom, Italy, France and Spain.

Hungary's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Hungary shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Hungary – S&T National Specialisation (1) in thematic priorities, 2000–2010
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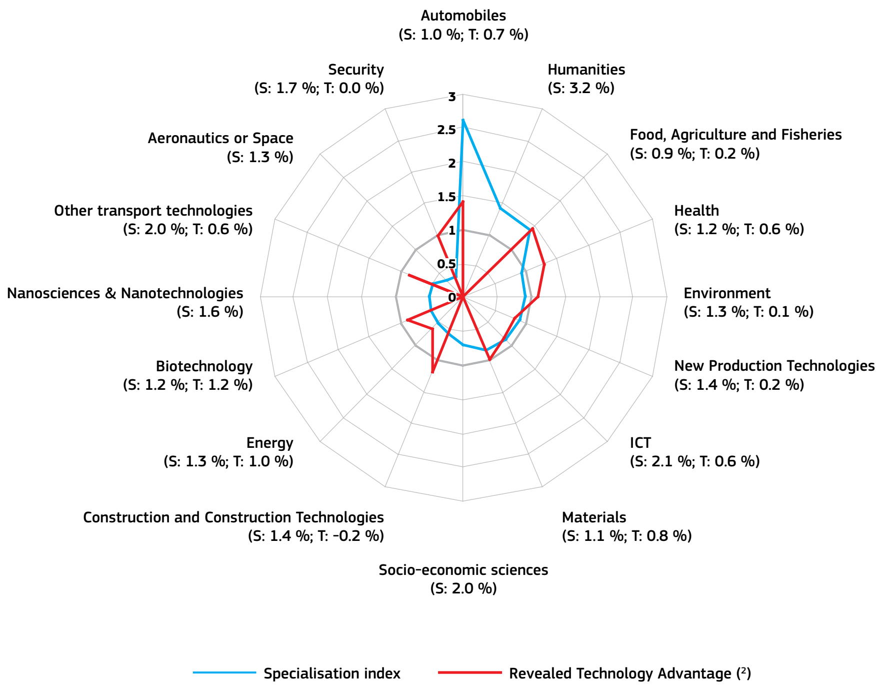


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Comparison of the scientific and technological specialisation in selected thematic priorities shows a mixed situation with some co-specialisations as well as some mismatches. Technology production is strongly specialised in food, agriculture and fisheries, health, environment, construction and construction technologies, security and automobiles. A strong corresponding scientific S&T co-specialisation is noted for automobiles, food and agriculture, while a marked potential for co-specialisation is observed for health, and the environment.

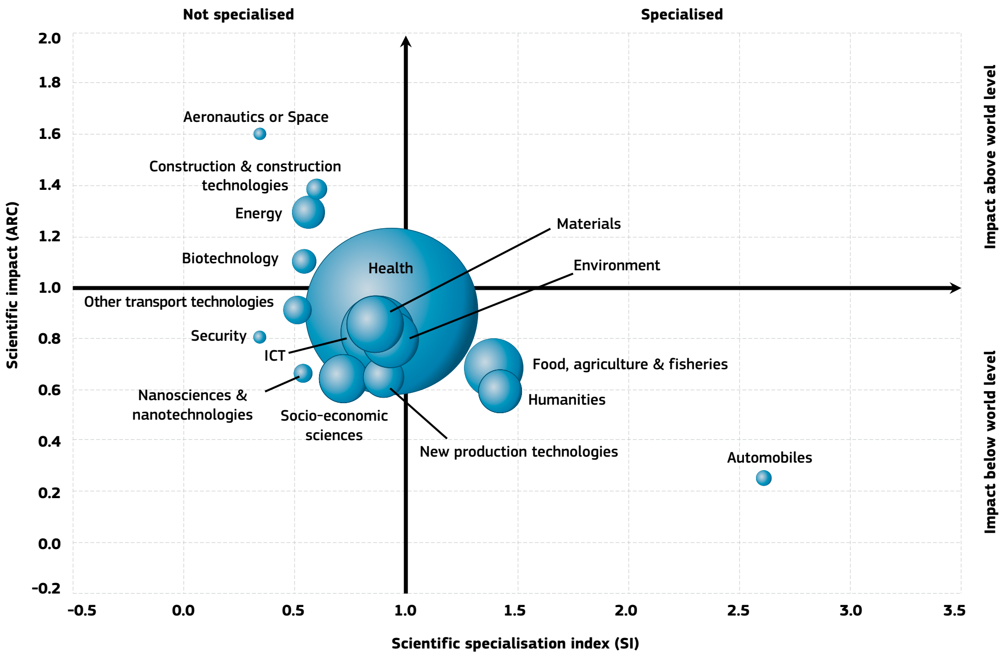
Together with the Czech Republic, Slovakia, Slovenia and Italy, Hungary is classified as having a medium-low knowledge capacity with an important industrial base[4]. Among those countries, Hungary does not exhibit a broader technology development compared to the country's science base. Given that the general quality of science is not high, it may be the case that industry's technological base is founded less on high-tech and medium-tech products than in the other three countries in the same group (except Slovenia).

4 Source: Innovation Union Competitiveness report 2011.

Following this rationale, Hungary will benefit both from intensifying efforts to attract Foreign Direct Investment (FDI) for more knowledge-intensive activities and from continuing to improve the quality of the science base in order to create the basis for raising knowledge-transfer from science to technology and industry.

The graph below illustrates the positional analysis of Hungary publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Hungary – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

It would appear there is room for improvement regarding the scientific impact of some of the sectors in which Hungarian science is strongly specialised, i.e. automobiles, food, agriculture and fisheries, humanities, and health. It is very interesting to note the high level of scientific excellence attained by the country in aeronautics, energy, construction, and biotechnology, although all those fields have a rather low scientific specialisation index. Taking into account Hungary's technological specialisation in energy and construction, it would probably benefit from fostering a scientific specialisation in those fields.

As its excellence in research is correlated to more cooperation with researchers from other European countries and beyond, Hungary would benefit from actively supporting and providing incentives for its researchers to connect to Horizon 2020 networks. Considering its share of grants in FP7 fields, there is room for improvement, for example in the ICT sector.

From the EU perspective, production fragmentation and the specialisation of different countries and regions in certain production activities can yield overall benefits for all the partners involved. Hungary, together with Germany, Austria and a number of Eastern European countries, has used this strategy to develop an automobile cluster which enables these countries to integrate their respective production lines.

Policies and reforms for research and innovation

The recently adopted new national RDI Strategy (2013-2020) entitled 'Investments into the Future' aims to raise RDI investments and, as result, to mobilise the Hungarian economy and strengthen its competitiveness. To ensure that the public and private resources spent on the country's RDI sector will be profitable for its economy, the strategy builds around three priority axes: internationally competitive knowledge bases which can underpin economic and social progress; cooperation in knowledge and technology transfer which is efficient at both national and international levels; and innovative enterprises intensively utilising the results of modern science and technology.

The strategy focuses on knowledge creation and knowledge transfer and aims to reconsider and renew the incentive system to promote market-driven and society-driven innovation processes. By proposing measures explicitly directed at innovative enterprises, the strategy aims to overcome the main weakness in the Hungarian RDI system which is the low share of domestic innovative companies. According to the strategy, Hungary will increase its gross domestic expenditure on R&D to 1.8 % by 2020 and to 3 % by 2030. Moreover, the results expected for the specific targets set in the strategy are the stimulation of RDI demand, establishment of an efficient support and funding system, as well as completion of the start-up ecosystem.

The strategy is the guiding document for planning the budget allocations for RDI for the next programming period 2014-2020. The regional-technological-sectoral aspects of the RDI Strategy will be determined by the national Smart Specialisation Strategy (S3). Preparations for this began at the beginning of 2013, with the drawing up of strategy documents by the Regional Innovation Agencies and, according to the government resolution on the collaborative governance of the planning of the Smart Specialisation Strategy, draft S3 should be ready by the end of September 2014. The correct implementation of the newly introduced and planned strategies will be crucial for the creation of an effective national R&I ecosystem.

The new advisory body, the National Science Policy and Innovation Board (NTIT) was established by government decree in September 2013 with the aim of providing advice, evaluation, and making recommendations on strategic issues concerning RDI programmes. The president of the NTIT is the prime minister, co-chaired by the president of the Hungarian Academy of Sciences (MTA). However, to date the NTIT has not held any meetings, and one activity in the RDI Strategy action plan is actually to revise the governance system for the STI policy.

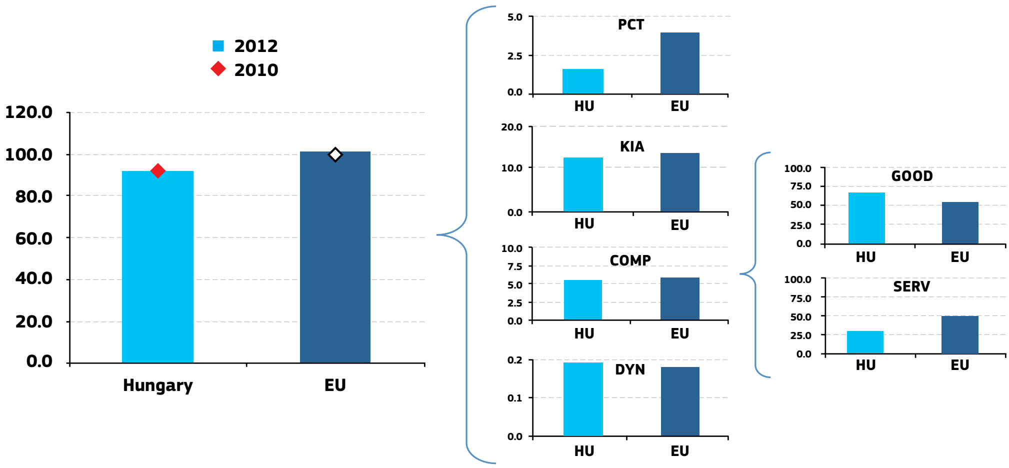
A new scheme 'Start-up_13' was launched in June 2013 in order to support the development of young, technology companies. Based on an international peer-review organised by the National Innovation Office (NIH), in October 2013, four companies received the title of 'accredited technology incubator' which would enable them to participate in the Start-up_13 programme.

Until now, the allocation of institutional funding to higher education institutions and research-performing organisations is based on student numbers, disciplines taught, number of full-time professors and the number of professors holding scientific degrees, meaning that the allocation of academic funding is not based on competition. A working group was set up for the preparation of a science policy strategy which aimed to improve the system for supporting fundamental research and financing in the academic sector. This strategy will also improve access to scientific information and publications, strengthen the links between science and business, and foster international cooperation and networks. Moreover, the 'TOP 200 programme' aims to develop the scientific, research and innovation capacity at major universities to enhance their international prominence.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Hungary's position regarding the indicator's different components:

Hungary – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Hungary is a medium performer in the European innovation indicator scoring slightly below the EU average. This is the result of an above-average performance in two components and below-average performance in patents and knowledge-intensive service (KIS) exports. The country's performance is currently stagnating.

The relatively low performance in patents is linked to limited research capacity, economic structure and the division of work within international companies, including motor-vehicle producers which have production facilities in Hungary but tend to do research and patenting in the headquarter country. The export of power-generating machines, telecommunication equipment, and road vehicles results in high scores as regards the share of medium-high/high-tech goods in total goods exports (the highest share in the EU).

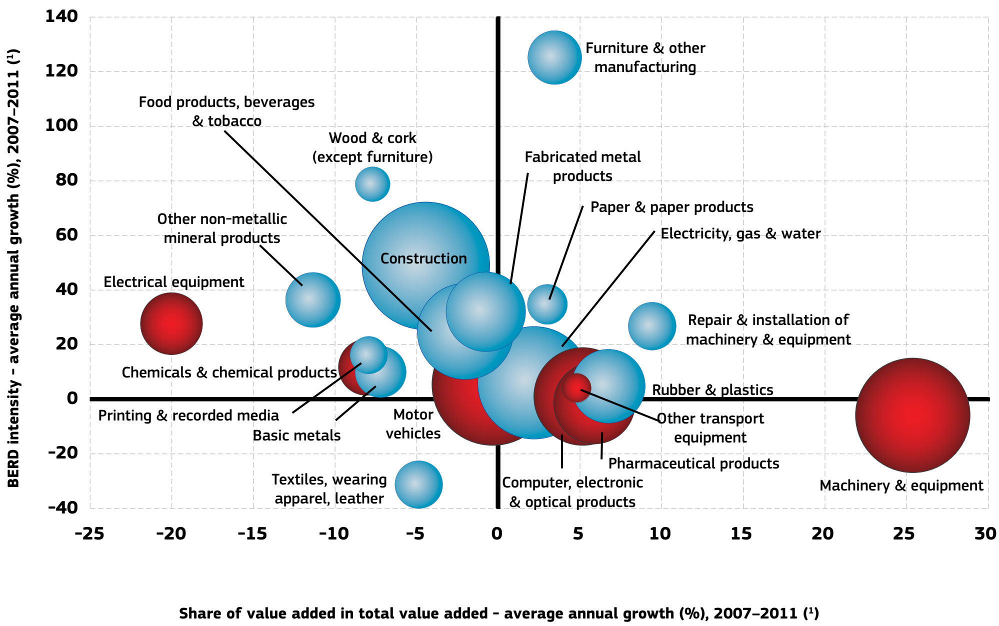
The low share of knowledge-intensive service exports is explained by the relatively high level of non-KIS transport services (road transport) and of tourism-services exports, which are not compensated for by any strongholds in KIS exports.

Hungary performs well regarding the innovativeness of fast-growing firms. This is the result of a high share of employment in innovative sections of the manufacturing sector among fast-growing enterprises, such as the manufacture of motor vehicles and of computer, electronics and optical products.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Hungary – Share of value added versus BERD intensity: average annual growth, 2007–2011 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Electricity, gas and water', 'Printing and reproduction of recorded media': 2007–2010.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The graph shows that throughout the economic crisis the shares in total value added of numerous manufacturing sectors declined between 2007 and 2011, which is particularly notable in high-tech and medium-tech sectors such as electrical equipment and chemicals.

On the contrary, 'machinery and equipment' had very good dynamics of strong growth in value added although coupled with a strong decline in R&D expenditure. Manufacturing in Hungary is concentrated mainly in low-skills sectors, such as construction or electricity, although some high-tech sectors, mainly machinery and equipment, motor vehicles and computer, electronic and optical products, display a significant weight in the economy.

It is important to note that Hungary is one of the countries in which business R&D intensity made the most progress between 2007 and 2011 in relation to the 2007 level. The sectors for which R&D intensity increased the most in 2007-2012 include numerous low-tech sectors such as furniture & other manufacturing, wood and cork, and construction. Along with Poland and the Czech Republic, Hungary is one of the countries in which employment in manufacturing has declined the least in recent years.

Key indicators for Hungary

HUNGARY	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.50	0.67	0.63	0.66	0.71	0.86	0.82	0.82	0.90	6.6	*1.81*	24
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	491	:	:	490	:	:	477	-13.9 (3)	495 (4)	22 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.36	0.41	0.49	0.49	0.53	0.67	0.70	0.76	0.85	11.4	1.31	15
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.40	0.50	0.50	0.47	0.46	0.48	0.45	0.44	0.43	-1.8	*0.74*	23
Venture capital as % of GDP	0.10	0.05	0.04	0.05	0.03	0.21	0.05	0.08	0.11	17.0	0.29 (5)	14 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	28.0	:	:	:	:	31.5	2.4	47.8	13
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	4.8	5.3	5.4	4.8	5.2	:	:	:	-1.5	11.0	21
International scientific co-publications per million population	:	313	313	338	341	356	362	396	412	4.0	343	21
Public–private scientific co-publications per million population	:	:	:	22	23	25	31	31	:	8.6	53	15
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	1.7	1.4	1.4	1.6	1.4	1.5	1.5	:	:	-3.0	3.9	16
License and patent revenues from abroad as % of GDP	0.24	0.76	0.49	0.67	0.56	0.65	0.80	0.75	0.88	5.6	0.59	6
Community trademark (CTM) applications per million population	2	17	19	27	28	30	39	36	37	6.9	152	26
Community design (CD) applications per million population	:	4	3	6	5	6	7	5	6	-1.5	29	25
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	10.5	:	16.4	:	13.7	:	:	-8.8	14.4	13
Knowledge-intensive services exports as % total service exports	:	21.0	23.5	26.0	25.9	26.1	26.5	26.3	:	0.3	45.3	20
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	2.25	4.64	5.74	4.47	5.20	6.15	5.99	5.84	5.56	-	4.23 (6)	3
Growth of total factor productivity (total economy): 2007 = 100	89	100	102	100	100	94	94	95	93	-7 (7)	97	21
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	48.6	:	:	:	:	54.4	2.3	51.2	11
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	12.8	12.3	12.8	13.0	12.5	-0.5	13.9	16
SMEs introducing product or process innovations as % of SMEs	:	:	16.8	:	16.8	:	14.7	:	:	-6.6	33.8	25
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.08	0.08	0.06	0.21	0.14	0.06	:	:	:	-46.5	0.44	18
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.40	0.29	0.16	0.27	0.21	0.26	:	:	:	-0.4	0.53	14
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	61.2	62.2	62.6	62.6	61.9	60.5	60.4	60.7	62.1	-0.2	68.4	24
R&D intensity (GERD as % of GDP)	0.81	0.94	1.01	0.98	1.00	1.17	1.17	1.22	1.30	5.7	*2.07*	17
Greenhouse gas emissions: 1990 = 100	80	81	79	77	75	68	69	67	:	-10 (8)	83	7 (9)
Share of renewable energy in gross final energy consumption (%)	:	4.5	5.0	5.9	6.5	8.0	8.6	9.1	:	11.4	13.0	21
Share of population aged 30–34 who have successfully completed tertiary education (%)	14.8	17.9	19.0	20.1	22.4	23.9	25.7	28.1	29.9	8.3	35.7	19
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	13.9	12.5	12.6	11.4	11.7	11.2	10.5	11.2	11.5	0.2	12.7	19 (9)
Share of population at risk of poverty or social exclusion (%)	:	32.1	31.4	29.4	28.2	29.6	29.9	31.0	32.4	2.0	24.8	23 (9)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(9) The values for this indicator were ranked from lowest to highest.
(10) Values in italics are estimated or provisional.

Ireland

Prioritising increased public investment in research while better exploiting results

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Ireland. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.72 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+6.1 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **60.9** (EU: 47.8; US: 58.1) 2007-2012: **+14.6 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **116.5** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **68.2** (EU: 51.2; US: 59.9) 2007-2012: **+3.5 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Food and agriculture, medical technologies, nanotechnologies, biotechnology, ICT, and new production technologies	***HT + MT contribution to the trade balance*** 2012: **2.0 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+11.6 %** (EU: +4.8 %; US: -32.3 %)

Ireland has expanded and consolidated its research and innovation system over the last decade. Investments in R&I have grown substantially, and public investment in R&I grew considerably until the financial crisis. Since 2007, however, business enterprise investment in R&D has increased at a much higher rate than public investment in R&D.

The considerable increase in public and private R&D expenditure since 2000 has resulted in a clear shift to a knowledge-based economy, including a trend towards services. The Irish economy has a high proportion of knowledge-intensive products and services, which has not changed substantially over the last decade. Although the recession hit Ireland particularly hard, since then the economy has partly recovered because of the strength of exports by companies in the high-tech sectors. These firms are mainly affiliates of multinational enterprises (MNEs).

In contrast, in a number of sectors those domestic firms which do not have a propensity to export have struggled. Accordingly, the main challenges are to return to the previous policy of increasing public R&D expenditure and to complement the policy to promote the procurement of innovation with budgetary allocations to procurement authorities[3].

Prior to the crisis, policy was based on a Strategy for Science, Technology and Innovation which articulates the ambition to be a leading knowledge economy. More recently, the focus has been on accelerating growth and job creation. The government has also adopted the report of a research prioritisation group which sets out the basis for the country's national R&I Smart Specialisation Strategy which recommended targeted competitive research investment in 14 priority areas as well as a new IP protocol on putting public research to work for Ireland.

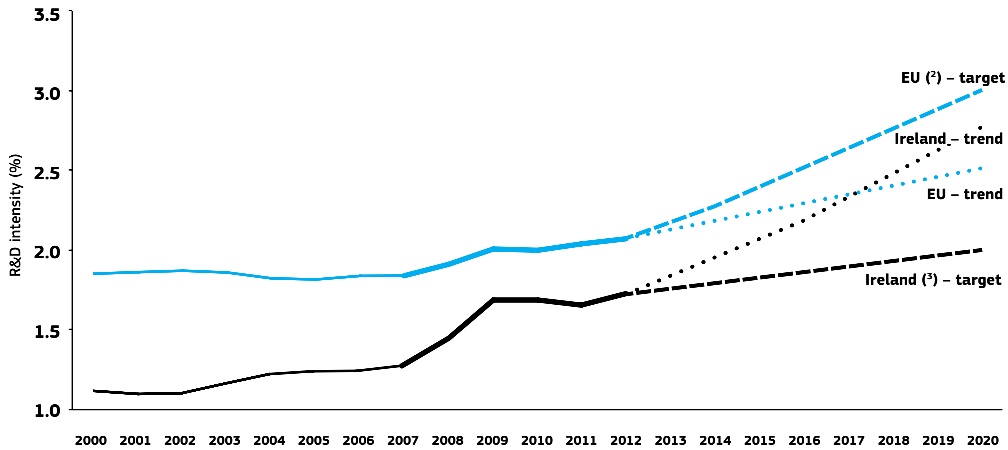
1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

3 Concrete measures were presented in the Commission Communication Europe 2020 Ireland, June 2012.

Investing in knowledge

Ireland – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) IE: The projection is based on a tentative R&D intensity target of 2.0 % for 2020.

Ireland has a national R&D intensity target for 2020 of 2.5 % of GNP (estimated to be equivalent to 2.0 % of GDP). In 2012, Ireland had an R&D intensity of 1.72 %, with a public sector R&D intensity of 0.53 % and a business R&D intensity of 1.20 %.

Over the period 2007-2012, R&D intensity in Ireland grew at an average annual rate of 6.1 %, which is the eighth highest growth rate in the EU. Whereas this increase is greater than that for the period 2002-2007, it occurred in the context of an economic contraction during which the government budget for R&D decreased steadily. Thus, one of the main challenges for Ireland would be to return to a trend of increasing public investment in R&D which, if it was better related to business needs, would raise the R&D intensity of Irish firms. If this line were followed, a shift in the Irish economy towards a knowledge-based economy, already very visible, could be pursued and a more ambitious target could be envisaged on the occasion of the mid-term review of the Europe 2020 targets (2014/2015). This would be more in line with the country's clear potential, illustrated by the trend in R&D intensity above.

In absolute terms, public R&D funding reached a peak in 2008. R&D investment by firms appears not to have been seriously affected by the economic crisis. The increase of 42 % in BERD intensity over the period 2007-2012 was double that of public R&D intensity at 21 %. Ireland has a relatively low level of direct government support for BERD, although indirect support amounts to 75 % of public support of private R&D. In real terms, business R&D investment continued to rise and reached a peak in 2012. At 20.4 %, the share of GERD financed from abroad is more than double the EU average and reflects the policy of attracting foreign direct investment (FDI) with a large R&D component. In order to reach its national target by 2020, R&D intensity in Ireland would have to grow at an average annual rate of 1.9 % over the period 2012-2020. This growth would depend on sustained incentives to attract and boost business R&D investment.

Structural Funds are an important source of funding for R&I activities. Of the EUR 751 million of Structural Funds allocated to Ireland over the 2007-2013 programming period, around €155 million (21% of the total) relate to RTDI[4]. Under the Seventh Framework Programme (FP7), beneficiaries from Ireland have received EUR 528 million. Overall, Irish applicants had a close-to-average success rate.

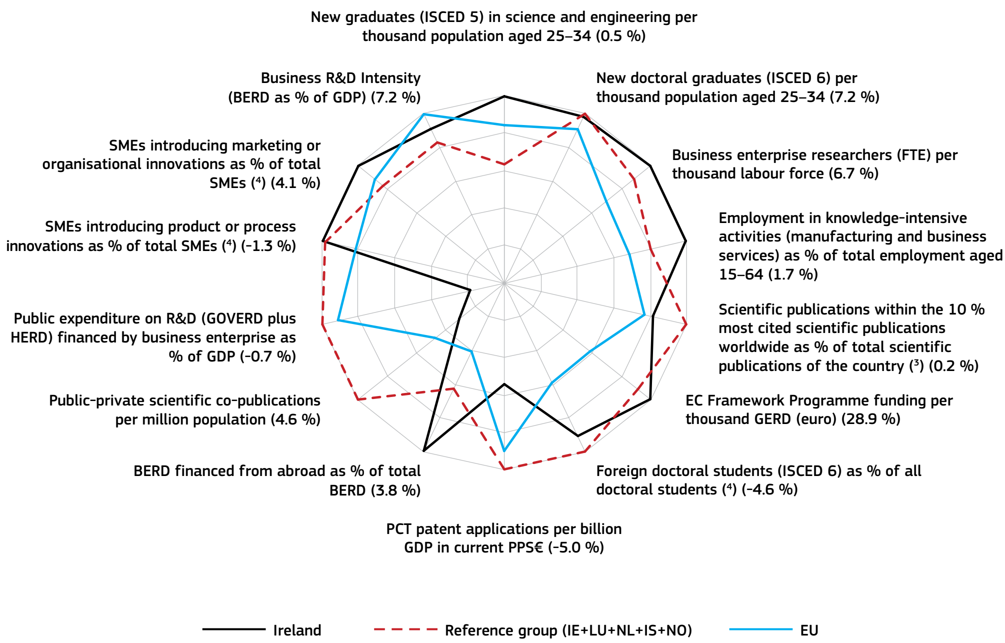
[4] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses in the Irish R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Ireland, 2012 (1)

In brackets: average annual growth for Ireland, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The graph shows in broad terms that Ireland's increasing investment in R&D has triggered stronger scientific production with increases in business R&D intensity, the number of new doctoral graduates, employment in knowledge-based activities, and scientific publications in the most highly cited journals. The number of researchers employed in business has also grown. The relative weaknesses of the Irish R&I system are the relatively low level of public-private co-publications, the low level of public expenditure on R&D financed by business enterprise, as well as a relatively low level of patent applications (PCT) per billion GDP. Recent policy is leading to the establishment of large research centres by Science Foundation Ireland (SFI) focusing on research and innovation aligned to the 14 research priority areas, and requiring the strong involvement and cash funding of industry. Establishment of the Industrial Development Authority/Enterprise Ireland Technology Centres is also being influenced by the 14 research priority areas.

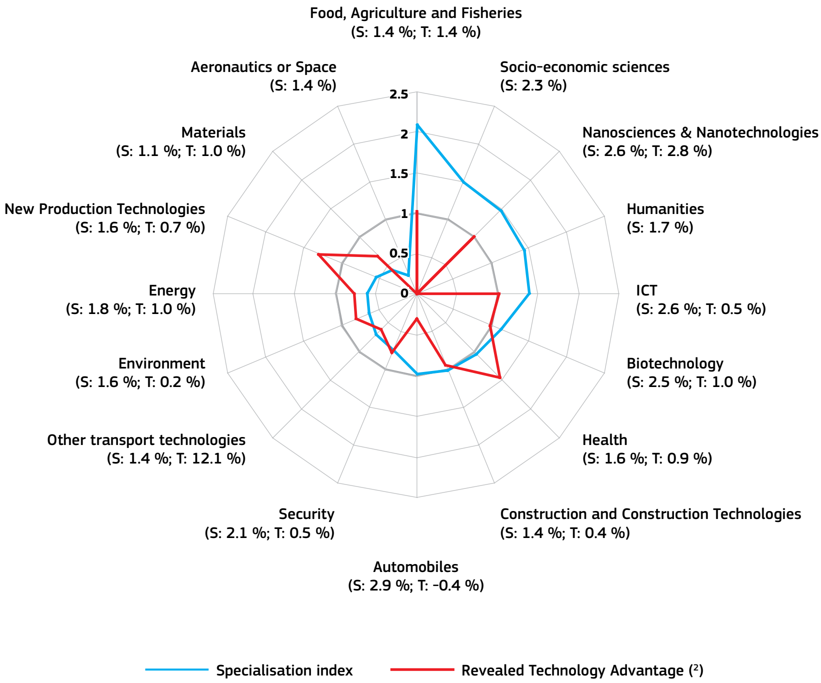
In 2011, Ireland had a small net outflow of tertiary students to the United States. In 2011, 1145 students at undergraduate, masters or doctoral level left Ireland to study in the United States, while there was a corresponding inflow of 1013 students from the United States to Ireland. The country has engaged in the European Strategy Forum on Research Infrastructures (ESFRI) process from the beginning and supports 20 of the 44 areas identified in the original roadmap as well as participating in seven FP7-funded research infrastructure preparatory phase projects.

On knowledge transfer, Ireland's efficiency is relatively high with regard to the amount invested in generating each patent application, licence agreement and spin-off.

Ireland's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Ireland shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Ireland – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)

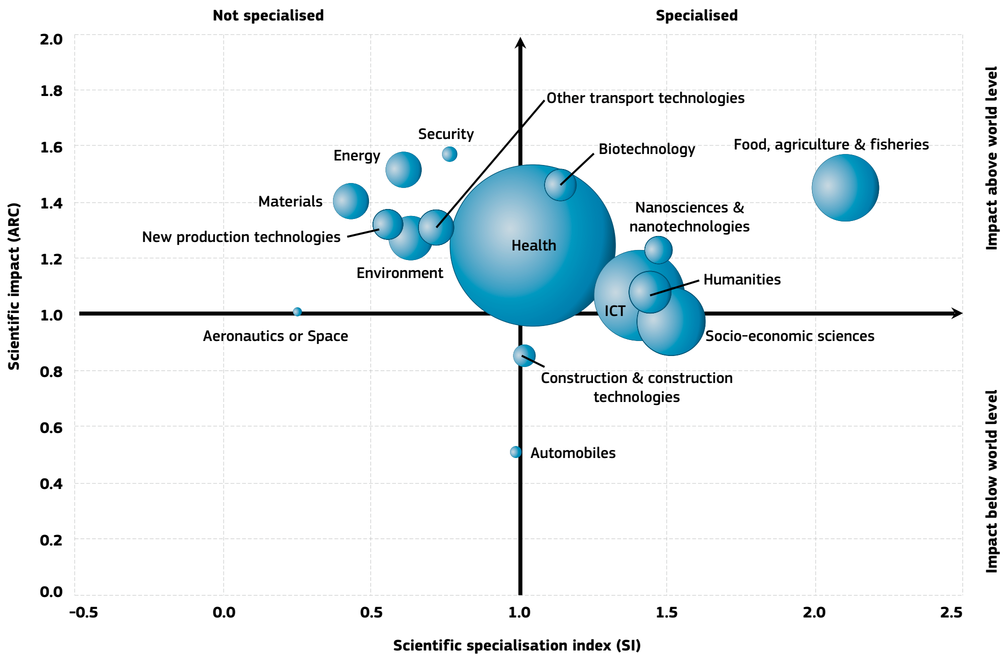


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Comparison of the scientific and technological specialisation in selected thematic priorities shows a strong technological specialisation in the sectors of health, and new production technologies, whereas significant scientific specialisation exists in the sectors of food, agriculture and fisheries, nanosciences and nanotechnologies, ICT, socio-economic sciences, and humanities. There is obvious potential for stronger scientific and technological co-specialisations in the fields of health, biotechnology, construction, ICT, nanotechnologies, and food and agriculture.

The graph below illustrates the positional analysis of Irish publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Ireland – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The graph above shows a positional analysis of scientific publications in Ireland. The country has a high specialisation in food, agriculture and fisheries with an impact well above the global average. Other specialised fields with impacts above the world level are biotechnology, nanosciences and nanotechnologies, ICT, and health. It is interesting to note that a number of non-specialised fields have high impacts at world level, including energy, materials, new production technologies, other transport technologies, and environment.

Policies and reforms for research and innovation

The Irish research system is centralised and whilst research policies are set nationally they address regional aspects and needs and take into account the effects of clustering which have led to regional specialisation. The significance of the Structural Funds for Ireland has been reduced, with funding for RTDI over the period 2007-2013 amounting to EUR 155 million which represents around 20 % of the annual government budget for R&D. Ireland comprises two NUTS II regions. The Border, Midland and Western region's key challenge is to develop its Institutes of Technology and to enhance the research, innovation and ICT infrastructure to promote enterprise development. The Southern and Eastern region has made a commitment to developing incubator spaces in close proximity to the institutes of Technology.

Policy before the economic crisis was based on a Strategy for Science, Technology and Innovation 2006-2013 which articulates the ambition to be a leading knowledge economy. Following the onset of the economic crisis, this policy is being implemented in the context of the Framework for Sustainable Economic Renewal which, through an Action Plan for Jobs, involves actions to deliver reform and create economic growth and includes measures related to science, technology and innovation. The government's programme for national recovery places increased emphasis on delivering and accelerating value from the state's investment in research, the approach being to direct the majority of competitive funding towards 14 research priority areas. These are identified in the National Research Prioritisation exercise which forms the basis for Ireland's national R&I Smart Specialisation Strategy. In addition, a portion of funding will be retained for research into policy and research for knowledge.

In 2004, fiscal measures involving R&D tax credits were introduced and provided a 25 % tax credit for qualifying incremental expenditure covering all categories of research from basic to applied research and experimental development. According to OECD surveys on tax incentives, indirect support of business R&D in Ireland is almost three times higher than direct support. The fiscal incentives for carrying out R&D were complemented by an expansion of tax credits in 2010 to enhance investment in intellectual property (including software) by excluding royalties income from withholding tax.

In 2012, the government adopted a proposal for the prioritisation of competitive research funding for activities related to areas of industrial strength. In addition, policy emphasis is being placed on increasing the innovation potential of indigenous firms and improving links between industry and higher education institutions, particularly in the establishment of SFI research centres and the Enterprise Ireland and IDA Ireland Technology Centres. Following the publication of the higher education strategy, the Department of Education and Skills and the Higher Education Authority are putting in place compact agreements with the higher education institutes which will set out performance indicators for the HEIs, including indicators relevant to R&I.

The existing national policies on IPR were reviewed by a task force and were found to be in line with international practice, including that emerging at EU level from the Commission Recommendation C(2008)1329 and the Responsible Partnering initiative from the key stakeholders. This has recently been updated with a new IP protocol (adopted in 2012) to clarify the rules on knowledge transfer in the context of collaboration between industry and HEIs. A key recommendation in the protocol is being implemented by setting up a central Technology Transfer Office due to be officially opened at the end of May 2014. This new office, branded 'Knowledge Transfer Ireland' (KTI), aims to make it easier for companies to access and use ideas developed through publicly funded research to develop new products and services and ultimately create jobs and exports. KTI will ensure that the IP protocol is responding to the needs of business and stakeholders, and its remit will include promoting, enabling and monitoring HEI/business engagement across the wide range of intellectual assets that occurring in the creation of and access to intellectual property, in all its forms.

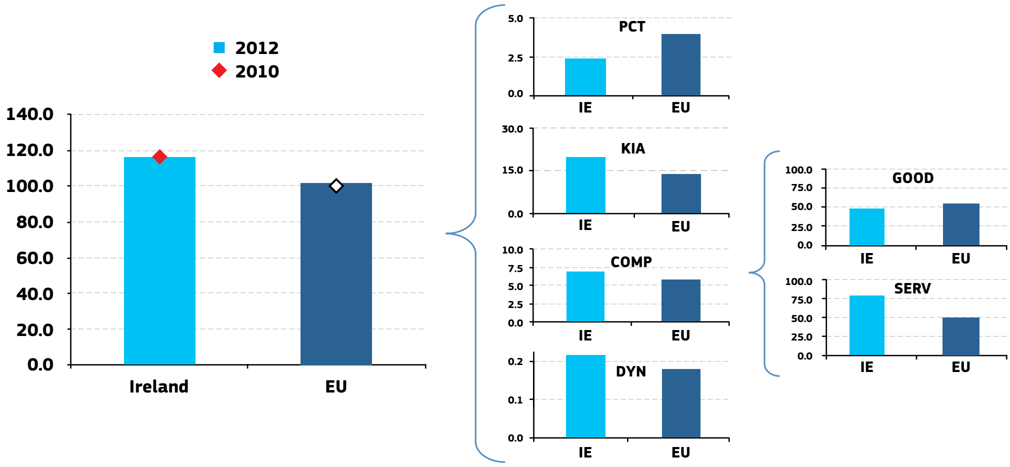
In 2009, an innovation task force was established. Key areas recommended for action include a better matching between supply and demand for innovation, a financial framework fostering innovation, high-quality and extended human capital, and international projection. It also takes in promotion of public procurement for innovative products and services. However, due to the need for strong fiscal consolidation, the implementation of some of these recommendations has been limited.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in medium/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms).

The graph below enables a comprehensive comparison of Ireland's position regarding the indicator's different components.

Ireland – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Ireland is one of the best performers in the EU in terms of the innovation output indicator. Only Germany and Sweden are ranked higher in the EU. Employment in knowledge-intensive activities in business industries and in high-growth innovative enterprises, as well as the share of knowledge-intensive services exports in total services exports is clearly above the EU average. Ireland is below the EU average in the indicators for PCT patent application per billion GDP and the share of medium-high and high-tech products in total goods exports. However, this should be seen in the context of the weight of ICT in the Irish economy and the fact that computer program patentability is limited.

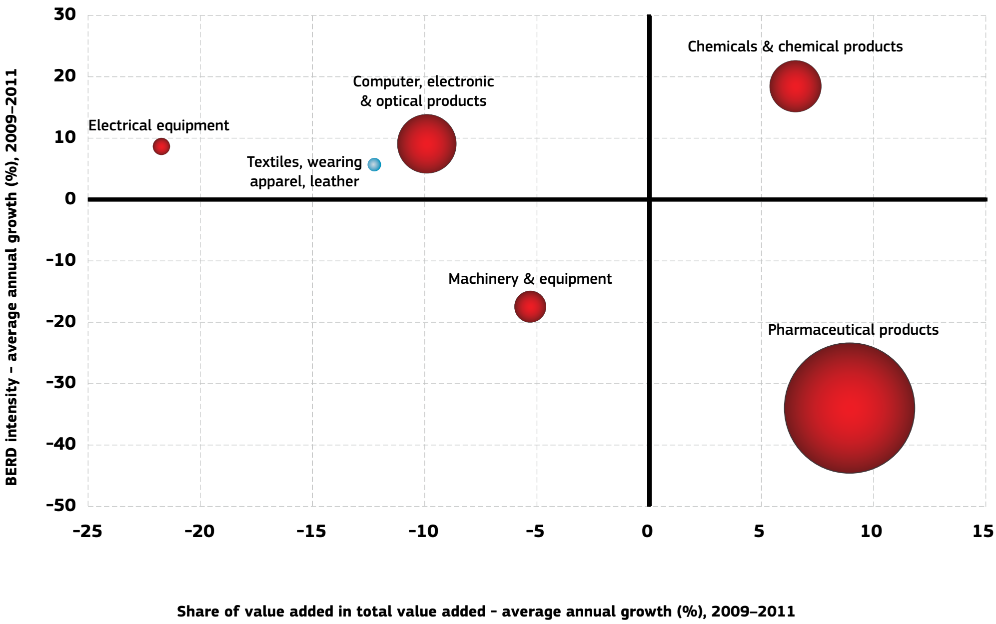
Ireland is ranked second in the EU (after Luxembourg) in terms of share of total employment in knowledge-intensive activities (20.1 %) and first in the share of knowledge-intensive services in total exports (78.6 %).

Foreign multinational firms perform a large part of the activity in the knowledge-intensive sectors while foreign direct investments have continued to support the more technology-intensive sectors. In 2012, at 24.8 %, Ireland had by far the highest technology balance of payments receipts as % of GDP among those OECD countries for which data are available. The corresponding average annual growth rate for Ireland over the period 2007-2012 was 14.8 %.This can be largely attributed to the high level of foreign direct investment in Ireland and the resulting intra-group transfers of technology. In general, Ireland has favourable framework conditions for innovation, in particular in terms of time taken to start a business, barriers to entrepreneurship, and corporate taxation. In contrast, it is below average in terms of percentage of self-employed people, women entrepreneurs and entrepreneurs under 45 years of age. Barriers to entrepreneurship (including regulatory, administrative burdens and barriers to competition) are lower than in many other EU Member States. However, following the financial crisis, ease of access to capital in Ireland have fallen to a very low level, and in 2012, the country was ranked in 16th place in the EU in terms of venture capital investment as a % of GDP.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented in the graph. The red sectors are high-tech or medium-high-tech sectors.

Ireland – Share of value added versus BERD intensity: average annual growth, 2009–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: ([1]) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

As recognised in Irish economic and industrial policy, the medium-term avenue for a more sustainable economy is to upgrade and move up on the value chain and internationalise its outreach. Compared to other countries, Ireland has scope to further increase both the R&D intensity in existing high-tech and medium-high-tech sectors and to boost knowledge intensity in the more traditional sectors of the economy.

The graph above illustrates recent structural change in the Irish economy. It shows that the economic expansion over the period 2009-2011 was mainly related to chemicals and pharmaceutical products, whereas the contribution of computer, electronic and optical products, and electrical equipment has fallen. The contribution from pharmaceutical products will also shrink as many of the medicines produced in Ireland have come off patent and thus their prices have fallen.

Key indicators for Ireland

IRELAND	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.89	1.20	1.38	1.38	1.41	1.56	1.59	1.90	1.95	7.2	*1.81*	11
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	501	:	:	487	:	:	501	0.0 (3)	495 (4)	8 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.80	0.82	0.83	0.85	0.94	1.15	*1.16*	1.14	*1.20*	*7.2*	1.31	11
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.32	0.43	0.42	0.44	0.51	0.53	0.53	*0.51*	*0.53*	*3.8*	*0.74*	18
Venture capital as % of GDP	0.21	0.07	0.06	0.17	0.04	0.04	0.03	0.04	0.05	-20.2	0,29 (5)	16 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	30.9	:	:	:	:	60.9	14.6	47.8	7
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	10.9	10.9	11.5	11.6	11.5	:	:	:	0.2	11.0	8
International scientific co-publications per million population	:	702	749	820	915	1003	1089	1133	1138	6.8	343	8
Public–private scientific co-publications per million population	:	:	:	29	26	22	29	34	:	4.6	53	12
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	2.3	2.4	2.4	2.7	2.9	2.8	2.3	:	:	-5.0	3.9	11
License and patent revenues from abroad as % of GDP	0.52	0.38	0.42	0.46	0.56	0.75	1.39	2.22	2.37	39.1	0.31	2
Community trademark (CTM) applications per million population	179	129	173	177	181	183	185	179	181	0.5	152	10
Community design (CD) applications per million population	:	15	14	13	14	14	18	15	16	4.3	29	20
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	12.6	:	11.0	:	9.3	:	:	-8.0	14.4	20
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	71.3	72.7	71.4	:	0.0	45.3	2
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.37	-1.20	-0.92	-1.33	1.28	2.43	2.38	2.53	1.99	-	4.23 (6)	14
Growth of total factor productivity (total economy): 2007 = 100	96	100	100	100	96	94	95	98	98	-2 (7)	97	7
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	57.5	:	:	:	:	68.2	3.5	51.2	1
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	18.2	19.1 (8)	19.5	19.7	20.2	1.7	13.9	2
SMEs introducing product or process innovations as % of SMEs	:	:	43.8	:	42.3	:	41.2	:	:	-1.3	33.8	7
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.10	0.05	0.08	0.09	0.23	0.17	:	:	:	35.8	0.44	12
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.53	0.55	0.39	0.62	0.60	0.75	:	:	:	10.0	0.53	6
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	70.4	72.6	73.4	73.8	72.3	66.9 (8)	64.6	63.8	63.7	-1.6	68.4	21
R&D intensity (GERD as % of GDP)	1.11	1.25	1.25	1.28	1.45	*1.69*	*1.69*	*1.66*	*1.72*	*6.1*	*2.07*	12
Greenhouse gas emissions: 1990 = 100	124	128	128	127	125	114	113	106	:	-21 (9)	83	21 (10)
Share of renewable energy in gross final energy consumption (%)	:	2.8	3.1	3.6	4.0	5.2	5.6	6.7	:	16.8	13.0	22
Share of population aged 30–34 who have successfully completed tertiary education (%)	27.5	39.2	41.3	43.3	46.1	48.9	50.1	49.7	51.1	3.4	35.7	1
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	12.5	12.1	11.6	11.3	11.7	11.5	10.8	9.7	-3.5	12.7	13 (10)
Share of population at risk of poverty or social exclusion (%)	:	25.0	23.3	23.1	23.7	25.7	27.3	29.4	:	6.2	24.8	20 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK, These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) Break in series between 2009 and the previous years. Average annual growth refers to 2009–2012.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Values in italics are estimated or provisional.

Italy

The challenge of structural change for a more knowledge-intensive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation performance in Italy. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.27 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+1.5 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **36.5** (EU: 47.8; US: 58.1) 2007-2012: **-0.5 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **84.3** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **37.2** (EU: 51.2; US: 59.9) 2007-2012: **+0.9 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Automobiles, food and agriculture, ICT, biotechnology, and new production technologies	***HT + MT contribution to the trade balance*** 2012: **4.8 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+2.5 %** (EU: +4.8 %; US: -32.3 %)

Italy's share of GDP devoted to R&D activities has increased moderately over the last ten years, reaching 1.27 % in 2012. Nevertheless, both public and private R&D intensities remain a long way from those of its competitors at the technology frontier, thus undermining progress made towards a more efficient research system, and missing the opportunity for the country to move away from specialisation in low-technology-intensive products. Therefore, Italy should commit to increasing R&D intensity and improving business framework conditions for innovation and economic structural changes.

The Italian R&I system is still suffering from structural weaknesses, such as a low proportion of people with tertiary education and insufficient orientation of the education system towards technology-intensive specialisations. Recent budget cuts have made this situation worse: the number of university professors has fallen across all departments, while the Italian system is no longer able to retain national researchers or attract foreign ones. At the same time, Italy's business environment is stifled by complex bureaucratic procedures. This causes significant delays which have a very negative impact on innovation, in particular, when market advantages are considered. In addition, the low availability of venture capital, and the difficult commercialisation of results are further obstacles to innovation. For all of these reasons, Italy remains a moderate innovator.

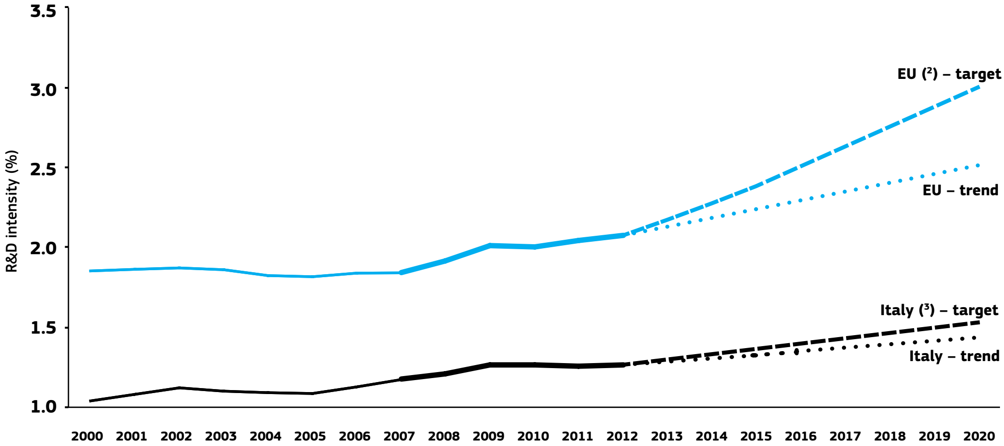
However, positive trends were registered between 2007 and 2012 in both the knowledge-intensity of the economy and the contribution of high-tech and medium-tech products to the trade balance. Moreover, the innovativeness of small and medium-sized enterprises (SMEs) and the excellent quality of scientific outputs remain two important strengths within Italy's R&I system. This clearly indicates that the country has huge innovation potential which simply needs additional support to be fully exploited.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Investing in knowledge

Italy – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) IT: The projection is based on a tentative R&D intensity target of 1.53 % for 2020.

In 2012, Italy's R&D intensity was 1.27 %, which represents a very small improvement compared to 2011, when the share was 1.25 %. However, this slight growth is due in part to the fall in GDP registered in the same period (-1.9 %). Thus, the country's R&D intensity remains a long way from the 1.53 % share of GDP set as the national target for 2020. In order to reach this target, which is already lacking in ambition as regards the country's potential and challenges, Italy needs to invest more in R&D activities. Both public-sector and private-sector expenditure on R&D grew in the period 2000-2012, but at a modest rate and still below the EU average. The difference between Italy's R&D intensity and the EU average (2.07 %) is mainly due to a lower business R&D. Indeed, business R&D intensity in Italy was 0.69 % in 2012, as opposed to the EU average of 1.31 %. Nevertheless, public-sector R&D intensity also remains at a lower level than the EU average (0.54 % instead of 0.74 %).

The low level of business R&D intensity is mainly linked to the structural composition of the Italian economy, which has a modest share of high-tech industries in total manufacturing, and is dominated by small and micro firms. In Italy, around 4.1 million of the 4.5 million firms have between one and nine employees. Those companies, often characterised by a family ownership structure, do not usually carry out R&D because they are unable to attract financial resources or highly skilled human capital. As regards public R&D investments, resources allocated to the higher education system appear inadequate. The 2013 budget for universities was about 20 % lower than in 2008, and the amount of resources for competitive funding has been reduced drastically in recent years. These budget cuts have also resulted in falling numbers of university staff: between 2006 and 2012 alone, the number of full and associate professors fell by 22 %.

On the other hand, Italy has been actively participating in the EU's Seventh Framework Programme. To date, Italian R&D institutions have received almost EUR 3.3 billion in EU contribution, making it the fourth most active country in FP7 projects. Structural Funds are another important source of funding for R&I activities. Of the EUR 27.9 billion of Structural Funds allocated to Italy over the 2007-2013 programming period, around EUR 6 billion (21.7 % of the total) relate to RTDI[3]. However, in spite of the crucial role these funds could play in the development and catching up of some regions, Italy has been unable to spend all those resources, preventing the country from taking full advantage of this important financial support.

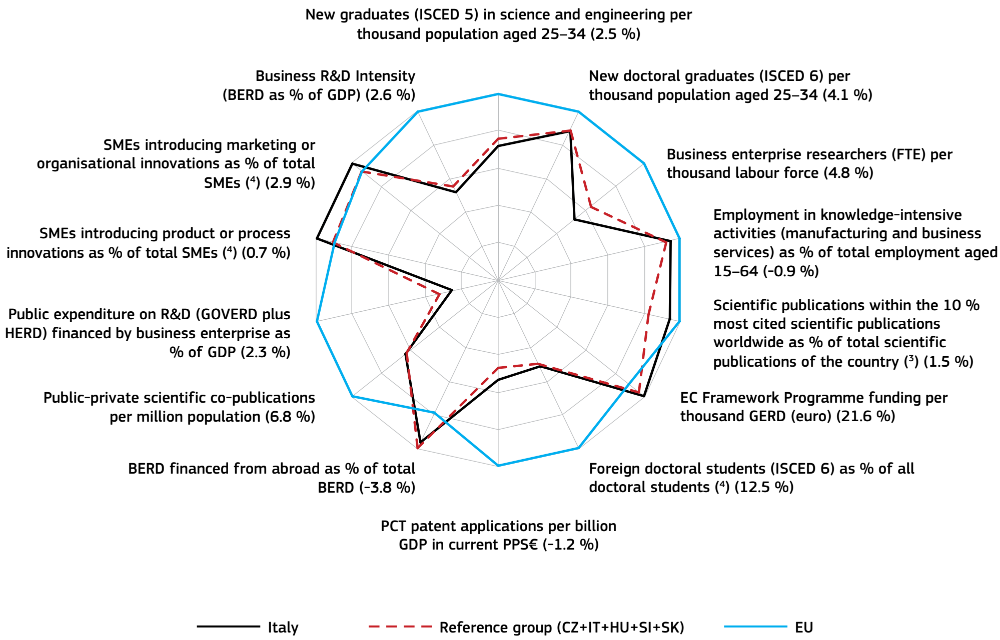
[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Italian R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation, and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Italy, 2012 (1)

In brackets: average annual growth for Italy, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The innovative attitude of its SMEs appears to be an emerging strength in the Italian R&I system. Italy scores above the EU average for both SMEs introducing marketing and organisational innovations, and those bringing in product and process innovations. Moreover, the overall quality of scientific publications is quite high, as is shown by the growing share of top publications. Nevertheless, the Italian system still suffers from a lack of skilled human capital and an unsatisfactory level of public-private collaboration.

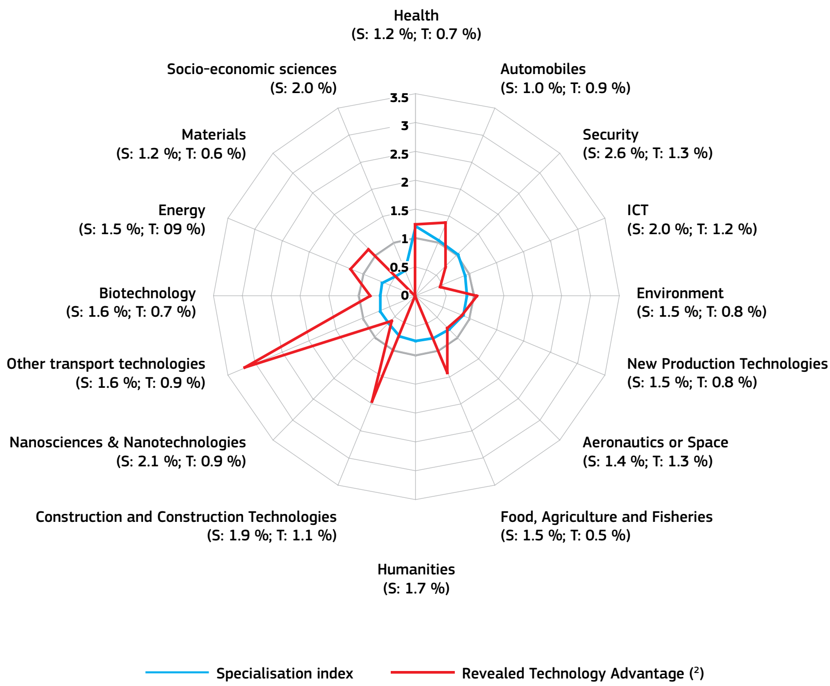
Although the number of new graduates in science and engineering and new doctoral graduates increased between 2007 and 2012, Italy is still a long way from the EU average. This may also be related to the generally low share of citizens with higher education qualifications, which is a traditional weakness of the Italian system: in 2012, the proportion of people aged 30-34 years with tertiary education qualification was only 21.7 % (EU-28: 35.7 %). Furthermore, there is still a relatively high share of Italian researchers working in other EU countries and a relatively low share of non-national researchers in Italy. This alarming brain drain may become a further barrier to efforts to shift Italy's economy towards more knowledge-intensive and innovative activities.

Public-private collaboration is also much lower than the EU average. Public expenditure on R&D financed by business enterprises represents only 0.013 % of GDP (EU: 0.052 %). Moreover, both the public-private scientific co-publications per million population and the number of business researchers per thousand of the labour force in Italy are well below EU average. Public-private cooperation often occurs on an ad-hoc basis in the absence of well-developed networks and formal structures (i.e. knowledge-transfer offices) which could act as intermediaries between the public research sector and businesses.

Italy's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Italy shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Italy – S&T National Specialisation ([1]) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications ([3]) (S) and in number of patents ([4]) (T)



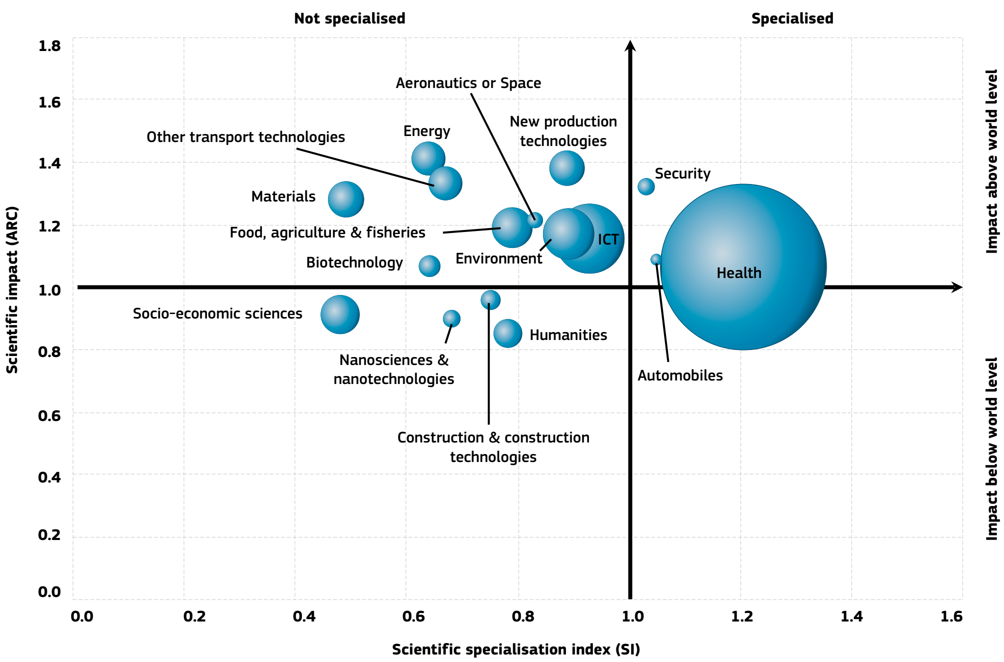
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: ([1]) Values over 1 show specialisation; values under 1 show a lack of specialisation.
([2]) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
([3]) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
([4]) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

In June 2013, the Italian National Agency for the Evaluation of University System and Research (ANVUR) published a report highlighting the fact that overall the share of Italian publications is growing faster than the EU average, and that the country's share of top publications (those receiving the top ten citations in each field) is above the world average. Thus, Italy's productivity output for both universities and public research organisations ranks among the best-performing countries.

However, scientific specialisation in Italy presents a large and diversified science base which only partially corresponds to the technological dynamics. S&T activities show substantial scientific specialisation in the health, automobile, and security sectors, although only the first two sectors reveal a technological advantage. On the other hand, Italy's technology production is strongly specialised in the field of other transport technologies, which attracts the highest share of patents, as well as in construction technologies, food, agriculture and fisheries, energy, and materials. These relative strengths in patenting reflect the weight of the traditional sectors and do not have a corresponding scientific specialisation.

There is room for improvement in matching Italy's science base to the needs of its industrial structure. However, translating the relative strengths in scientific publication into economic activities and revealed technology advantages requires stronger collaboration between public and private R&D actors, more investments and favourable market conditions. To foster this collaboration, the Ministry of Education, University and Research (MIUR) launched a competitive call for new technological clusters and carried out the first mapping of regional sectoral specialisation. Among the eight clusters selected, some follow Italian co-specialisations (aerospace, new production technologies, green chemistry, and life sciences), while others have been created in areas where there remains an important mismatch between science and technological development (food and agriculture, transport technologies, and smart communities). Those clusters may deploy their potential for structural change towards more knowledge-intensive activities by injecting knowledge into both existing and new industrial and services sectors.

Italy – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The graph above illustrates the positional analysis of Italian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

While the country is only specialised in the health, security, and automobiles sectors, the scientific impact of publications in all sectors (apart from socio-economic sciences and humanities, nanosciences and construction) is above the world level. This aspect is confirmation that the quality of science is an important strength in the Italian R&D system, although the commercialisation of scientific results and the collaboration between academia and industry remain difficult. In the ICT sector, for example, the quality of scientific publishing is extremely good and the sector is close to the scientific specialisation, but there is no revealed technology advantage in that field.

Policies and reforms for research and innovation

In March 2013, the MIUR launched Horizon 2020 Italia (HIT2020), a strategic document aimed at boosting the Italian R&I system by implementing the Europe 2020 strategy while, at the same time, focusing on specific national challenges. The new National Research Programme 2014-2020, which was presented to the Italian Council of Ministers in January 2014, is based on this strategy. For the first time, this programme will run for seven years (previously it was a three-year programme) in line with European policies. It acknowledges the obstacles that have made the development of a research policy in Italy difficult, and proposes an array of actions dedicated to removing those obstacles while making the best use of the positive characteristics within the existing production structure. In particular, it assigns strategic value to public-private partnerships and knowledge transfer to improve Italy's competitiveness, and focuses specifically on the importance of creating good working conditions to retain Italian researchers and attract foreign ones.

Important steps have already been taken in the direction of a more open and competitive research system, in line with the objectives of the European Research Area. In 2013, for the first time, 13.5 % of institutional funding was distributed on the basis of the results of the Quality Evaluation for Research carried out by ANVUR. This share of institutional funding, based on quality criteria, is expected to further increase to 16 % in 2014, 18 % in 2015 and 20 % in 2016. At the same time, international peer review for evaluating open calls for proposals has been introduced into the system, and its use is now widespread. Furthermore, a national system for the scientific certification of professorship candidature has been set up to guarantee transparent and merit-based recruitment, while the regulation introducing the reform of the Italian doctoral training system was adopted in February 2013. This regulation will be implemented in the academic year 2014-2015 with a view to creating attractive and competitive doctoral schools in Italy, especially for foreign students. However, the low level of institutional funding, along with a constant decline in competitive project funding, and the lack of career opportunities in universities could reduce the positive effects of those reforms significantly. Moreover, the Italian system is still suffering from high fragmentation which sometimes leads to duplications and inefficiencies.

Several measures have also been developed to foster Italy's innovation capacity and public-private collaboration. In addition to defining the eight technological clusters, the first mapping of regional sectoral specialisations, which will contribute to the design of smart specialisation strategies, was finalised in 2013. Furthermore, new legal frameworks have been devised for innovative start-ups and actions have been undertaken to simplify access to finance for SMEs. Nevertheless, implementation for some of these policy measures is still lacking and the administrative burden on businesses remains high. At the same time, fiscal credit or tax incentives remain inadequate.

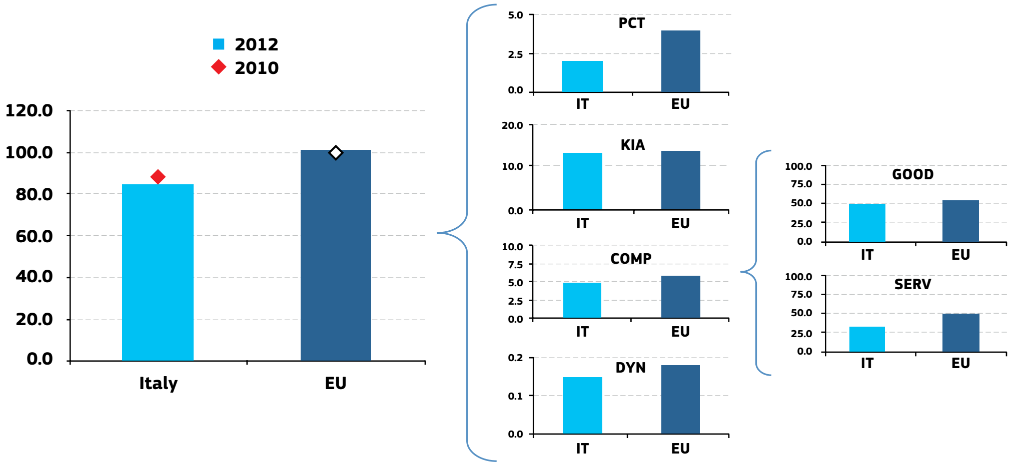
MIUR and MISE (the Ministry of Economic Development) are jointly responsible for the National Operational Programme for Research and Competitiveness 2007-2013 (PONREC), which is the main instrument for implementing R&I policies in the four convergence regions, namely Calabria, Campania, Puglia and Sicilia. This programme focuses on three main priorities: (i) supporting structural changes and scientific and technological improvement for a transition towards a knowledge economy; (ii) improving the innovative context for the development of competitiveness; and (iii) technical support and coaching. The PONREC has joined the Cohesion Action Plan, which was launched in November 2011 to overcome delays in using the Structural Funds, transferring part of its own funding there. In August 2013, the Italian authorities announced the creation of a public agency for territorial cohesion which is expected to become operational in autumn 2014. This agency should ensure the efficient management of Structural Funds – an objective which is still far from being reached – and support local governments running national and European projects.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator on innovation focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms).

The graph below enables a comprehensive comparison of Italy's position regarding the indicator's different components.

Italy – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

The Innovation Union Scoreboard 2014 considers Italy as a 'moderate innovator' since its innovation performance remains below the EU-27 average. This seems to be in line with the Innovation Output Indicator results in the graph above, where Italy is a medium-low performer with scores below the EU average in all components. The country comes closest to the EU average in employment in knowledge-intensive activities as a % of total employment. Overall, Italy's performance declined in the period 2010-2012.

Its low performance in patenting is partly explained by the country's economic structure, which comprises a high number of small and micro enterprises, in which patenting activities are more difficult because of economies of scale and scope and less capacity to attract venture capital. Moreover, despite Italy's specialisation in some technology-intensive sectors such as machinery, automotive and aerospace, the patent-intensive ICT sector is smaller than in other large economies, while sectors like textiles and footwear, which tend to have low patenting activities, are relatively more important than in other EU countries.

Italy also performs worse than the EU average in the innovativeness of fast-growing innovative firms. This is the result of a high share of low-tech manufacturing companies, transport, and administrative and support activities among the fast-growing enterprises.

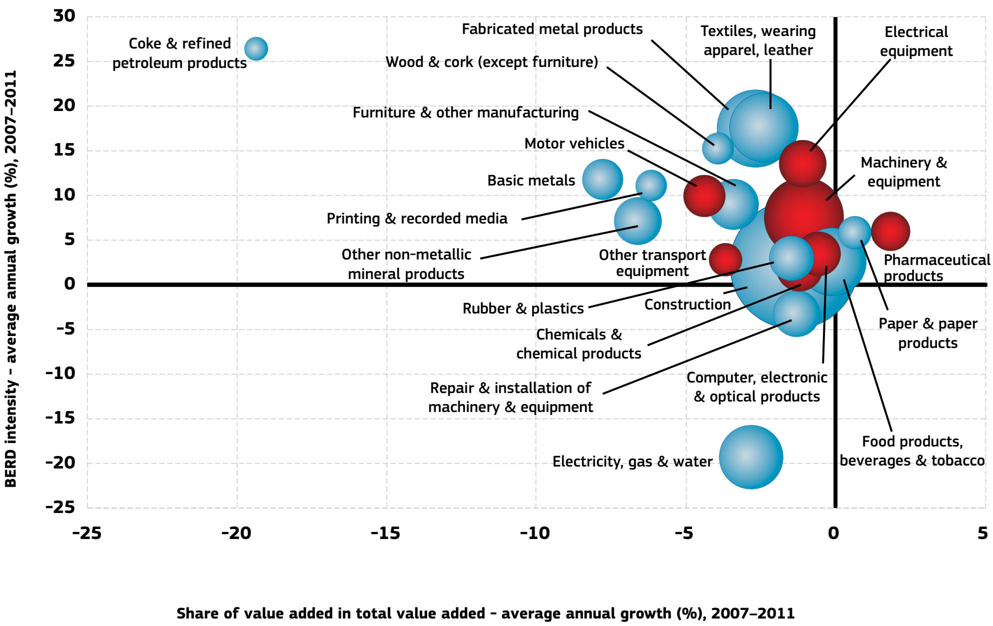
Italy is the second largest exporter of machinery in the EU, after Germany. However, it is also an important exporter of low-tech goods, such as textiles and shoes. As a result, it has a slightly below EU average share of medium/high-tech goods in total goods exports. The Italian economy is also characterised by a low share of knowledge-intensive services exports. This is partly explained by the huge weight of the tourism sector which, together with business travel, represents 40 % of all services exports in Italy, and is classified as non-KIS. In contrast, exports of software, classified as KIS, remain relatively low.

In addition to the above-mentioned aspects, the disparity between regions in terms of innovation performance remains an issue for the country. The most innovative Italian regions are Piemonte, Emilia Romagna, Friuli Venezia Giulia and Lombardia, which are all located in the northern part of the country. Unfortunately, the serious inefficiency registered in the use of Structural Funds, along with the negative effect of the economic crisis, are further widening these territorial imbalances.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries for the period 2007-2011. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Italy – Share of value added versus BERD intensity: average annual growth, 2007–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: (1) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The shares in total Italian value added of nearly all manufacturing sectors declined between 2007 and 2011. This evolution reflects both the shift towards a more service-oriented economy, similar to that observed at EU level, and the higher competition of emerging economies in traditional sectors experienced by the country in recent years.

In spite of this de-industrialisation process, manufacturing still carries an important weight in the Italian economy and is mainly concentrated in low and medium-low technology sectors (i.e. construction, fabricated metal products, textiles, and clothes). However, Italy maintains a strategic position in some high-tech sectors, like machinery, automotive, and space. The graph shows the country's diversified industrial structure, where a wide range of industries account for a relatively small share of the Italian economy. This reflects a lack of specialisation in the Italian economy.

Between 2007 and 2011, the growth in business research intensity was moderate but concerned all manufacturing sectors except electricity, gas and water. The highest growth rate in BERD intensity was registered in traditional sectors like coke and refined petroleum products (which, on the other hand, saw a drastic reduction in their share of value added), fabricated metal products, textiles, and wood and cork. During the same period, all high-tech and medium-high-tech sectors also increased their business research intensity, in particular electrical equipment, machinery, and motor vehicles. In spite of those positive trends, the Italian economic system still suffers from insufficient R&D intensity in its knowledge-intensive industries.

Key indicators for Italy

ITALY	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.45	1.14	1.23	1.32	1.60	:	:	1.56	1.62	4.1	*1.81*	17
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	462	:	:	483	:	:	485	23.6 (3)	495 (4)	17 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.52	0.55	0.55	0.61	0.65	0.67	0.68	0.68	*0.69*	*2.6*	1.31	17
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.52	0.52 (5)	0.54	0.52	0.52	0.55	0.54	0.53	*0.54*	*0.5*	*0.74*	17
Venture capital as % of GDP	0.25	0.15	0.23	0.18	0.21	0.09	0.06	0.08	0.07	-16.6	0.29 (6)	15 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	37.5	:	:	:	:	36.5	-0.5	47.8	11
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	9.6	9.8	10.1	10.3	10.4	:	:	:	1.5	11.0	13
International scientific co-publications per million population	:	347	372	412	431	457	483	511	532	5.2	343	19
Public–private scientific co-publications per million population	:	:	:	26	26	29	32	33	:	6.8	53	14
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	1.4	2.1	2.3	2.2	2.1	2.1	2.1	:	:	-1.2	3.9	13
License and patent revenues from abroad as % of GDP	0.05	0.06	0.06	0.05	0.17	0.18	0.18	0.18	0.20	33.4	0.59	14
Community trademark (CTM) applications per million population	75	89	107	122	122	122	133	133	133	1.7	152	15
Community design (CD) applications per million population	:	29	28	28	29	29	30	31	29	0.7	29	10
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	9.1	:	11.8	:	14.9	:	:	12.3	14.4	8
Knowledge-intensive services exports as % total service exports	:	21.6	23.7	23.9	27.3	24.7	28.4	27.5	:	3.6	45.3	19
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	2.10	3.31	4.49	4.36	5.04	4.14	4.02	4.82	:	-	4.23 (7)	5
Growth of total factor productivity (total economy): 2007 = 100	100	99	100	100	99	95	97	97	95	-5 (8)	97	16
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	35.6	:	:	:	:	37.2	0.9	51.2	22
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	13.6	13.5	13.7	13.4	13.2	-0.9	13.9	15
SMEs introducing product or process innovations as % of SMEs	:	:	33.0	:	36.9	:	37.4	:	:	0.7	33.8	12
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.14	0.19	0.20	0.22	0.24	0.24	:	:	:	4.3	0.44	10
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.41	0.45	0.42	0.37	0.38	0.35	:	:	:	-1.9	0.53	12
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	57.4	61.6	62.5	62.8	63.0	61.7	61.1	61.2	61.0	-0.6	68.4	25
R&D intensity (GERD as % of GDP)	1.04	1.09	1.13	1.17	1.21	1.26	1.26	1.25	*1.27*	*1.5*	*2.07*	18
Greenhouse gas emissions: 1990 = 100	107	112	110	108	105	96	97	95	:	-13 (9)	83	18 (10)
Share of renewable energy in gross final energy consumption (%)	:	5.1	5.5	5.5	6.9	8.6	9.8	11.5	:	20.2	13.0	17
Share of population aged 30–34 who have successfully completed tertiary education (%)	11.6	17.0	17.7	18.6	19.2	19.0	19.8	20.3	21.7	3.1	35.7	28
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	25.1	22.3	20.6	19.7	19.7	19.2	18.8	18.2	17.6	-2.2	12.7	25 (10)
Share of population at risk of poverty or social exclusion (%)	:	25.0	25.9	26.0	25.3	24.7	24.5	28.2	29.9	2.8	24.8	21 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2005 and the previous years.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Implement a growth-friendly fiscal adjustment [...] preserving growth-enhancing spending like R&D, innovation, education and essential infrastructure projects. [...] Ensure that public funding better rewards the quality of higher education and research."

Latvia

A better R&I-business partnership as a step forward towards competitiveness

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Latvia. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.66 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+2.0 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **19.9** (EU: 47.8; US: 58.1) 2007-2012: **+6.5 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **63.8** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **37.6** (EU: 51.2; US: 59.9) 2007-2012: **+3.5 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Materials, health, other transport technologies (other than automobiles and aeronautics), biotechnology, and food	***HT + MT contribution to the trade balance*** 2012: **-4.9 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

Over the last few years, Latvia's performance in research and innovation has not improved significantly. The several changes that were made in the governance of the R&I system aimed to improve the quality of the system and to strengthen the links between the research and industry sectors. Some of the measures have yet to prove their effectiveness since overall R&I performance is not showing any significant improvements. One particular aspect of this situation is that these measures are mainly dependent on Structural Funds since the national budget is contributing less and less. The main areas targeted by the measures included governance of the R&I system, modernisation of the scientific infrastructure and an improvement in human resources by attracting foreign academics, and industry's capacity to innovate, by developing better links between research and industry.

Latvia's poor innovation performance still impairs its competitiveness. The country has one of the lowest business R&D intensities in the EU (0.15 % in 2012). The national innovation system is overshadowed by low scientific performance, as measured by the share of scientific publications in the top 10 % most cited which at just 4 % is significantly below the EU average. There is little R&D investment by domestic companies or large foreign affiliates to support specialisation in knowledge-intensive and innovation-driven sectors.

As mentioned by one of the Country Specific Recommendations, Latvia needs to modernise its research institutions in order to improve the quality of the R&I system and increase its international competitiveness. Taking into account the thematic priorities and budgetary constraints, Latvia should improve the quality of the science base and rationalise the research and higher education institutions. There would be fewer results achieved

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

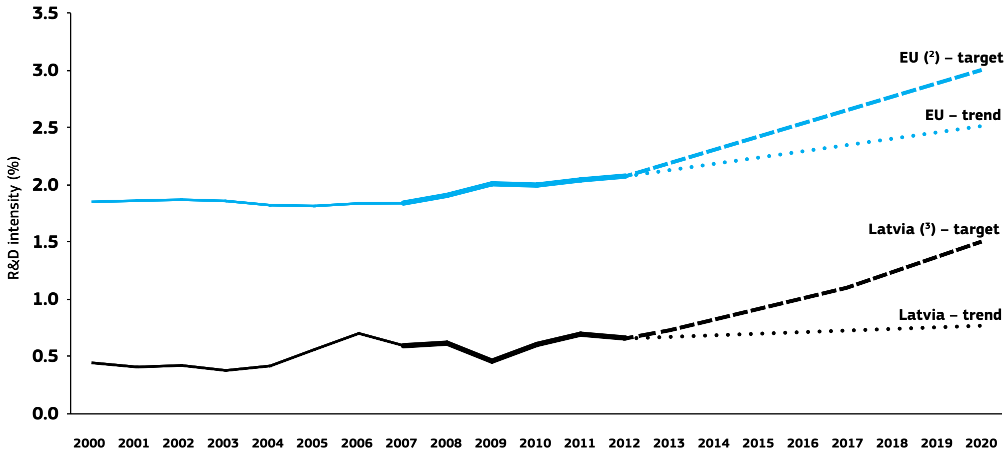
2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

but larger entities would be more able to build up critical mass in specialised areas of education and research, with a greater opportunity to innovate. Moreover, the use of resources would become more focused, enabling the country to be more efficient in the allocation of budgetary resources for R&I.

Latvia would also benefit from the R&I strategy for smart specialisation, which would facilitate a more efficient use of EU Structural Funds and improve the synergies between different EU and national policies, as well as increasing public and private investment in R&D.

Investing in knowledge

Latvia – R&D intensity projections: 2000–2020 (¹)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (¹) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(²) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(³) LV: The projection is based on a tentative R&D intensity target of 1.5 % for 2020.

In Latvia, the effect of the crisis heavily influenced the R&D funds allocated in 2009. Compared to 2008, the total funds for R&D fell by 40 %, while the government budget for R&D was 49 % lower. Thanks to the country's rapid economic recovery, the public R&D budget partially recovered, reaching the same level in 2011 as it achieved in 2008, and continuing to rise in 2012 (by 10 %). As regards innovation policy, Latvia does not have plans in the field of innovation procurement which is mostly supply-led rather than demand-side led. To increase private investments in R&I, the government plans to adopt tax incentives as of 1 July 2014.

In strategic terms, Latvia has set a national R&D intensity target of 1.5 %. In 2012, it had an R&D intensity of 0.66 %, with public R&D intensity at 0.51 % and business R&D intensity at 0.15 %. Latvia needs to increase R&D intensity in both the public and business sectors as a prerequisite to maintaining a performing R&I infrastructure and boosting innovation in firms. Over the period 2007-2012, Latvian R&D intensity grew at an average annual rate of 2.0 %, which is slightly below the EU average. The country needs to increase this rate significantly if the national 2020 R&D intensity target is to be achieved (in fact, an average annual growth rate of 10.8 % is required over the period 2012-2020 to reach the 1.5 % target). Public-sector R&D intensity had an average annual growth rate of 4.8 % over the period 2007-2012, where the 2012 value increased slightly compared to 2011 (a 1.3 % increase). On the other hand, private-sector R&D intensity recorded a fall of 5.3 % during 2007-2012, with a significant decline compared to 2011 (a 21 % decrease).

Latvia's success rate among participants in the EU's Seventh Framework Programme was 21.9 %. These participants received a total EC financial contribution of EUR 40.6 million. Structural Funds play a major role in the financing of R&I in Latvia – with 16 % of the total funds for the 2007-2013 period allocated to RTDI[3]. The R&I financing from the Structural Funds still exceeds national public funding for R&D, representing nearly half of the total R&D expenditure (2007-2012).

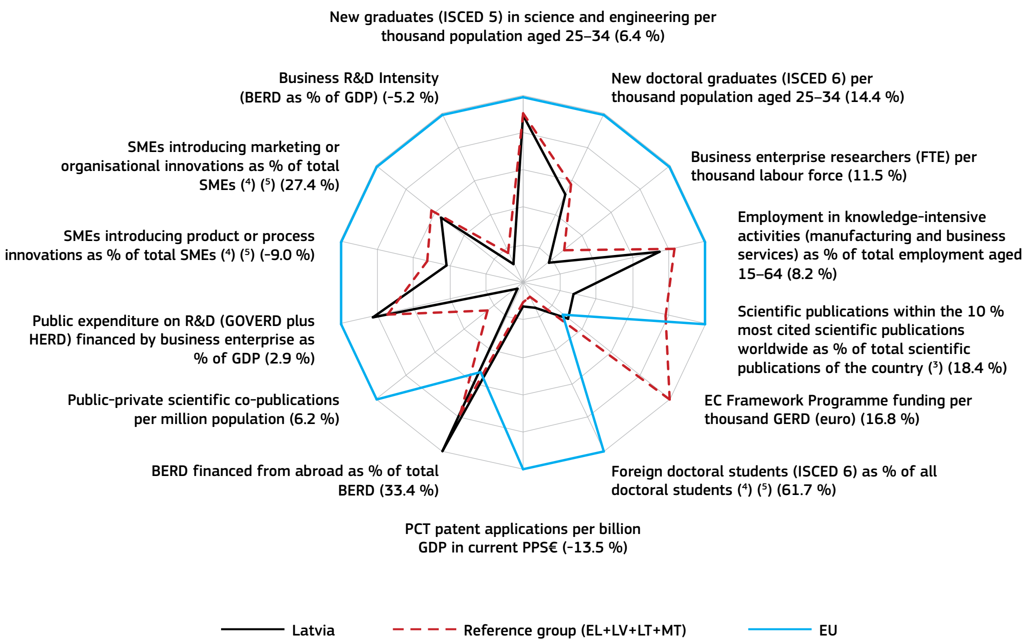
The low level of business expenditure on R&D is seen as a critical challenge for Latvia. Business expenditure on R&D increased by 14 % between 2008 and 2010, when it reached a value close to that of 2007. The downward trend continued with a fall of 19 % over the next two years. The initial increase was due to a large extent to the activities funded under Structural Fund programmes designed to improve industry's innovative capacity. The growing share of Structural Funds in R&D funding has also affected the previous balance between institutional and competitive funding which is now moving more towards project-based, competitive funding.

An effective research and innovation system building on the European Research Area

The graph below provides a synthetic picture of strengths and weaknesses in the Latvian R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.

Latvia, 2012 (1)

In brackets: average annual growth for Latvia, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.
(5) EL is not included in the reference group.

[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally-friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

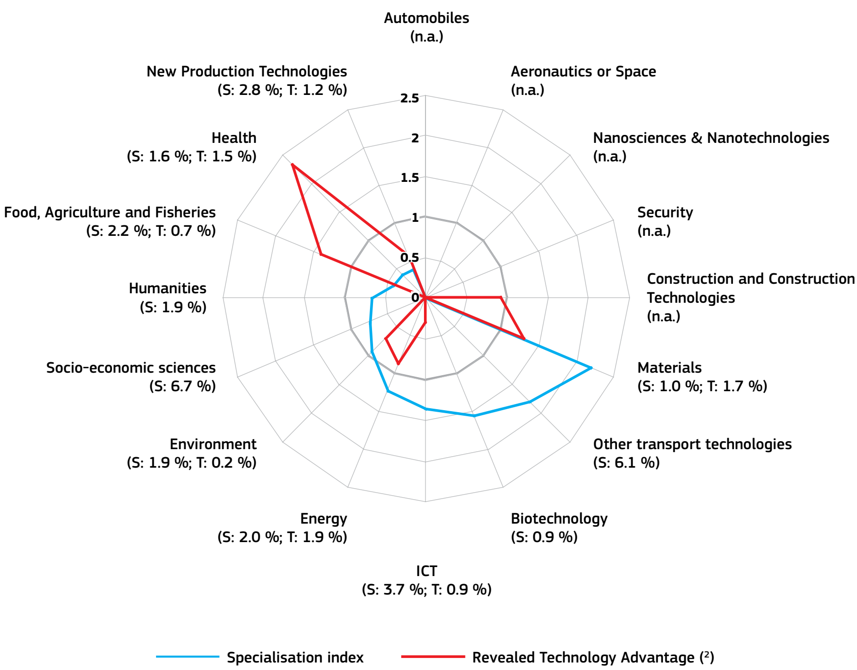
One important aspect of the Latvian R&I system remains the lack of highly qualified scientists and engineers, fairly correlated to the low numbers of new doctorates awarded and graduates in science and engineering. The share of researchers in business enterprise remains extremely low and although employment in knowledge-intensive activities is rising slowly, it is still below the EU average. In fact, Latvia suffers from a significant outflow of graduates and researchers to other countries, many scientists preferring to pursue their careers abroad. In addition, the country is failing to attract significant numbers of non-nationals in the field of R&I and the already low number of foreign doctoral students is falling even further.

The national innovation system is severely affected by low scientific performance (the share of scientific publications in the top 10 % of the most cited is 4 % and falling) and low licence and patent revenues. Moreover, the country needs to enhance the quality of the higher education system and to address the need to better attune Latvian research to the needs of local industry, while reinforcing the capacity of the latter to develop R&I activities. Public-private scientific cooperation is very low and investment in R&I by foreign affiliates in support of specialisation in knowledge-intensive and innovation-driven sectors has been declining. The results produced by the technology transfer contact points operating in several universities remain modest, although recent actions, such as the development of a Smart Specialisation Strategy and changes to the legal framework for protecting intellectual property rights, could improve their impact and increase the current low-level commercialisation of research results.

Latvia's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Latvia shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Latvia – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

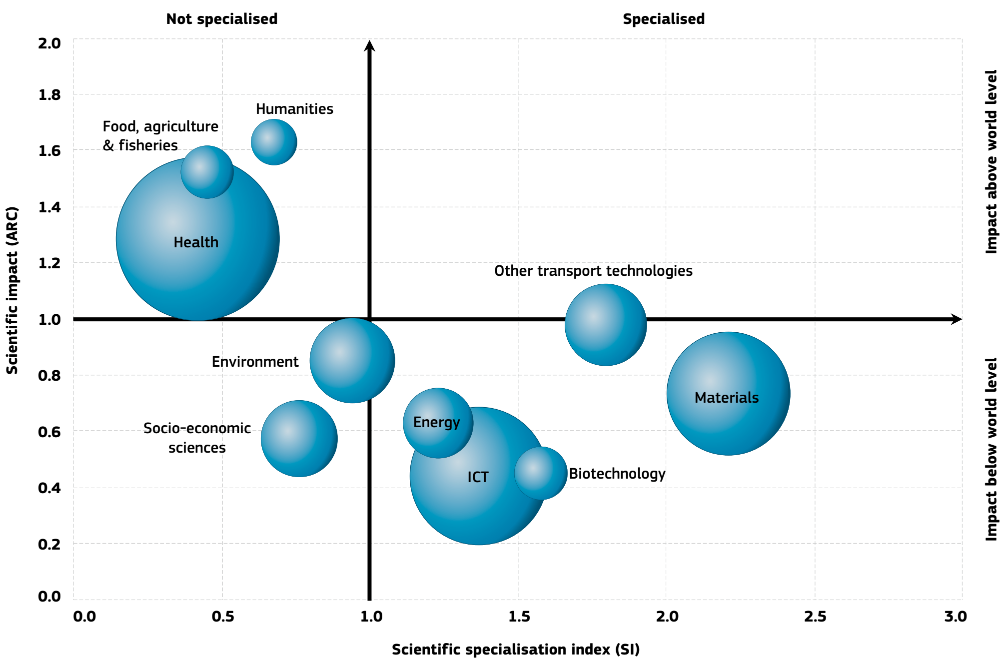
Latvia, together with Greece, Lithuania and Malta, is part of a group of countries characterised by medium-knowledge-capacity systems with a strong role in agriculture and low-knowledge-intensive services. As can be seen in the graph above, there is no sound correlation between the science and technology specialisation in general for Latvia. This could be a common characteristic among small-size countries, where in the debates regarding distribution of financial and human resources there is a continuing dilemma between a narrow specialisation with emphasis on niche areas versus a larger one which will not miss new emerging fields. Overall, the issue of critical mass remains vital for small countries in identifying priority areas.

However, there are some fields where Latvia is specialised and where it has some potential for specialisation. The country shows a good level of specialisation in materials (excluding nanotechnologies), in both science and technology, and has good potential in health, especially in the technological area. In addition, there are other areas where Latvia displays good potential for specialisation in science: environment, energy, ICT, biotechnology and other transport technologies.

In Latvia, a relative growth in technology fields have been recorded in construction, as well as good dynamics in science – measured by growth rates in publications – which can be seen in the fields of other transport technologies and ICT.

The graph below illustrates the positional analysis of Latvian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Latvia – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

In terms of the quality of science, Latvia portrays a slightly different picture. In the field of materials, where the country has shown specialisation in both science and technology, the quality of science does not have an impact at world level and thus it needs further improvement. On the other hand, the scientific production in health has a good quality with impact above the world level, even though the country has a low specialisation level.

A similar case is the food, agriculture and fisheries field, where Latvia has small but good scientific results while the specialisation index has a very low value. The science quality in the two fields mentioned above is apparently directly supported by good technological specialisation. Moreover, over the last period, the country has improved its scientific and technological performance both in food, agriculture and fisheries, and in health.

Other areas where Latvia could increase the level of its scientific performance are other transport technologies, and environment, where the scientific quality is good compared to the world level. There is also good potential for scientific development in ICT, biotechnology, and energy, but further steps are needed to improve the quality of the science in order to become competitive at an international level.

In fact, the new Guidelines for Science, Technologies and Innovations Development 2014-2020, approved in December 2013, include a component of the Smart Specialisation Strategy that has identified five specialisation fields offering potential for Latvia: knowledge based bio-economics, bio-medicine, medical technologies, bio-pharmacy and biotechnologies; advanced materials; technologies and engineering; smart energy; and ICT. When comparing these fields with the country's scientific potential it can be noted that they rely on specialised fields, such as ICT, materials, energy, and biotechnology, but also take into consideration the field with a good quality in scientific output (health).

Policies and reforms for research and innovation

The national R&I system faces a number of challenges:

- There is limited capacity to design, implement and coordinate R&I policy: Latvia has a complicated decision-making process for such a small country and the effectiveness of policy measures has been undermined by a lack of systematic evaluations.
- There is a lack of highly qualified scientists and engineers with pockets of excellence around few scientific areas; the number of new doctorates awarded remains low and many scientists pursue their careers abroad.
- The fragmented scientific and research infrastructure is underdeveloped and the limited R&I resources available are spread too thinly to be efficient.
- The level of commercialisation of research is low: the technology transfer contact points operating in several universities produce modest results, in part due to the incomplete legal framework for protecting intellectual property rights.
- Cooperation between businesses and academics continues to be poor: companies are barely using the research potential of universities or state research institutes and their participation in the ongoing competence centres programme is rather low.

In recent years, Latvia has taken several measures to tackle these weaknesses, the most significant of which include:

- Development of innovation financing tools to encourage innovation in the business sector, such as risk capital and seed/starting venture capital funds, mezzanine loans for risky projects;
- Development of business incubators to support new entrepreneurs across the country;
- Lowering administrative fees, simplifying administrative procedures, and reducing the time taken to register a business for entrepreneurs;
- Development of a long-term cooperation platform for enterprises and scientists – a framework for efficient cooperation between scientists and entrepreneurs in order to support joint research and to foster technology transfer.

The new Guidelines, mentioned above, have introduced a number of measures to improve the R&I system. These include the improvement of technology transfer possibilities, access to research infrastructure, development of competence centres, and introducing a new model for the management of the R&I system. Moreover, the Patent Law and the Copyright Law will ensure the protection of intellectual and industrial rights, whereas the Law on Scientific Activity will guarantee the annual increase of funding for R&I, thus strengthening the system's overall capacity.

The Guidelines also include the Smart Specialisation Strategy in part. The primary goal set in the strategy is to transform the economy towards higher-value-added products and technology-based growth. Five specialisation fields have been identified in the strategy:

1. Knowledge-based bio-economics;
2. Bio-medicine, medical technologies, bio-pharmacy and biotechnologies;
3. Advanced materials, technologies and engineering;
4. Smart energy;
5. ICT.

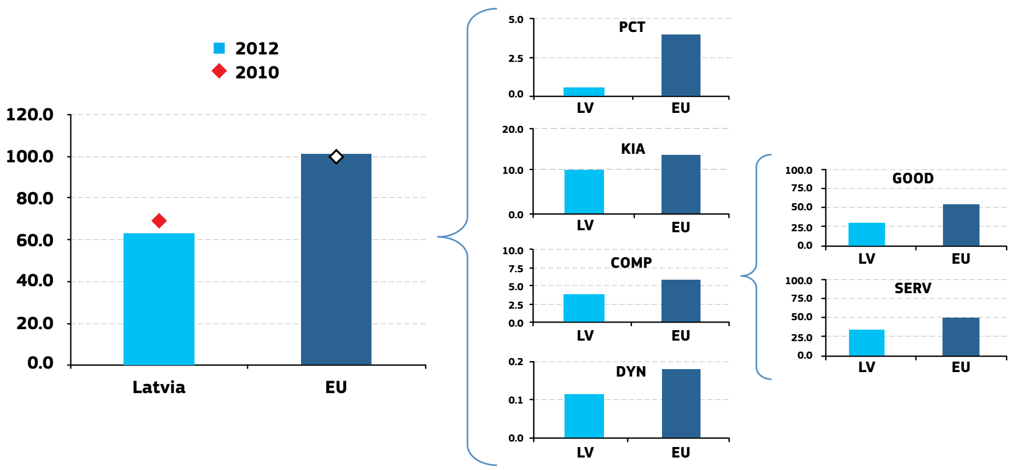
The strategy has mainly been used to focus on and plan the allocation of Structural Funds in the Partnership Agreement and Operational Programme, although the fields mentioned above are used to synchronise national budget allocations with other public resource allocations. The principles outlined in the strategy will serve as criteria for assessing the allocation of Structural Funds at the project level. The peer-review of the strategy has been scheduled for February 2014 in Latvia.

Moreover, in order to increase private investments in R&D, amendments were made in the Corporate Income Tax Law that will be applicable to costs incurred as from 1 July 2014.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Latvia's position regarding the different indicator components:

Latvia – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Latvia is a low performer in the European innovation indicator. This is a result of low performance in all components – a performance which, furthermore, is declining.

The low performance in patents is linked to the country's economic structure, with a relatively small capital goods sector and the lack of large manufacturing companies, which often show high patenting activities if linked to a well-performing research system. This structure and the high export share of agricultural and wood products also explain the low export share of medium-high/high-tech goods.

Agriculture, construction, and transport are relatively important sectors of the Latvian economy, contributing to a low share of employment in knowledge-intensive activities.

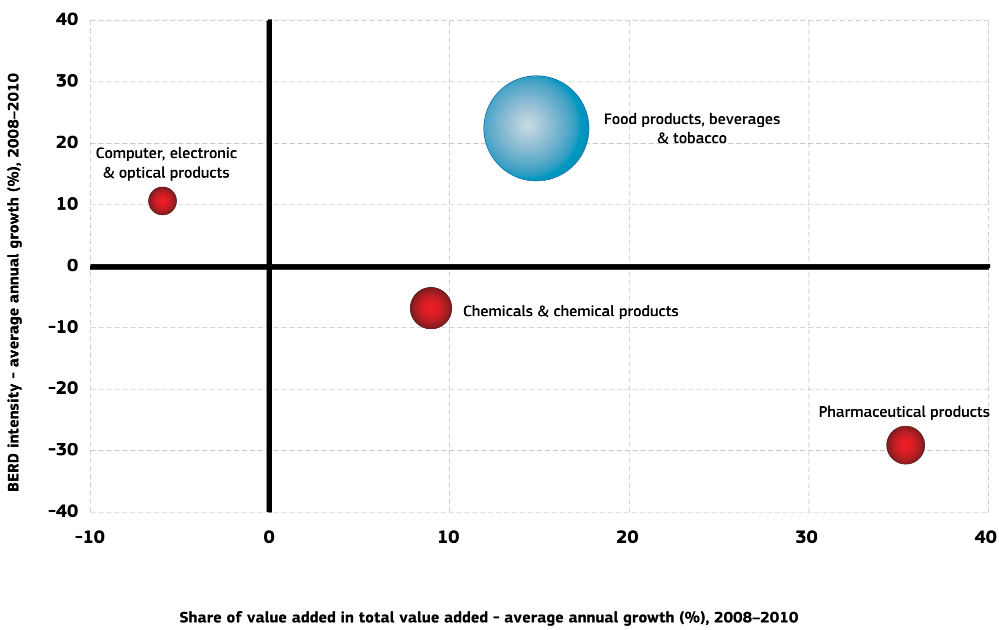
Freight transport services (transit traffic to/from Russia) such as pipeline, rail and road, and auxiliary transport services linked to sea transport – none of which are classified as KIS – play a key role in Latvian service exports. Combined with a lack of specialisation in KIS, this leads to a relatively low share of knowledge-intensive service exports.

Latvia performs at a low level as regards the innovativeness of fast-growing enterprises. This is the result of a high share of employment in low-tech manufacturing, construction, and transport companies among the fast-growing enterprises.

Upgrading knowledge and technologies in the manufacturing sector

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors represented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Latvia – Share of value added versus BERD intensity: average annual growth, 2008–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: (1) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The contribution of manufacturing to Latvia's total gross value added (14.5 % in 2012) has slightly increased compared to last year but is still lower than the EU average (15.2 % in 2012).

Based on the available data, in the period of 2008-2010, the food products, beverages & tobacco industry (a traditional industry) increased its contribution to Latvia's gross value added. At the same time, some more knowledge-intensive industries, such as pharmaceutical products and chemicals and chemical products, have also increased their contribution to Latvia's gross value added. Overall, the country remains specialised in sectors with low and medium-low research intensities, such as metal processing and machinery, wood and wood products, and food processing, but it is slowly moving towards more knowledge-intensive industry. Latvia's economic structure is highly biased towards small enterprises in traditional sectors, such as sawmilling and wood planing, as well as fish processing.

According to the results of the 2012 EU Industrial R&D Investment Scoreboard, there are no Latvian companies in the top 1000 EU companies listed by publication, highlighting the fact that there are no large R&D intensive firms in the Latvian economy, which is mainly characterised by SMEs and microenterprises.

Key indicators for Latvia

LATVIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.12	0.37	0.35	0.49	0.46	0.58	0.45	1.05	0.95	14.4	*1.81*	23
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	486	:	:	482	:	:	491	4.4 (3)	495 (4)	14 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.18	0.23	0.35	0.19	0.15	0.17	0.22	0.19	*0.15*	*-5.2*	1.31	27
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.27	0.33	0.35	0.40	0.46	0.29	0.38	0.50	*0.51*	*4.8*	*0.74*	19
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	14.6	:	:	:	:	19.9	6.5	47.8	25
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	4.7	3.2	2.2	3.7	3.0	:	:	:	18.4	11.0	28
International scientific co-publications per million population	:	128	116	125	147	142	141	196	196	9.4	343	27
Public–private scientific co-publications per million population	:	:	:	2	2	2	3	2	:	6.2	53	28
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.9	1.0	0.9	0.7	0.8	1.2	0.5	:	:	-13.5	3.9	21
License and patent revenues from abroad as % of GDP	0.02	0.07	0.05	0.04	0.04	0.03	0.05	0.04	0.04	-1.1	0.59	23
Community trademark (CTM) applications per million population	:	14	14	26	36	27	51	50	57	17.0	152	22
Community design (CD) applications per million population	:	5	10	8	5	13	17	15	9	2.2	29	23
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	3.3	:	5.9	:	3.1	:	:	-26.9	14.4	28
Knowledge-intensive services exports as % total service exports	:	35.3	35.3	34.6	34.9	35.8	35.1	32.8	:	-1.3	45.3	14
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-14.39	-10.47	-9.59	-8.87	-6.08	-2.83	-4.98	-5.42	-4.89	-	4.23 (5)	26
Growth of total factor productivity (total economy): 2007 = 100	81	99	100	100	95	84	86	88	91	-9 (6)	97	26
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	31.7	:	:	:	:	37.6	3.5	51.2	21
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	8.2	9.1	9.6	8.9 (7)	10.4	8.2	13.9	21
SMEs introducing product or process innovations as % of SMEs	:	:	14.4	:	17.2	:	14.3	:	:	-9.0	33.8	26
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.03	0.00	0.07	0.02	0.00	0.04	:	:	:	32.0	0.44	24
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.34	0.41	0.16	0.18	0.11	0.32	:	:	:	34.2	0.53	13
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	63.5	70.3	73.5	75.2	75.8	67.1	65.0	66.3 (8)	68.1	-4.7	68.4	15
R&D intensity (GERD as % of GDP)	0.45	0.56	0.70	0.60	0.62	0.46	0.60	0.70	*0.66*	*2.0*	*2.07*	25
Greenhouse gas emissions: 1990 = 100	38	42	44	46	45	42	47	45	:	-2 (9)	83	2 (10)
Share of renewable energy in gross final energy consumption (%)	:	32.3	31.1	29.6	29.8	34.3	32.5	33.1	:	2.8	13.0	2
Share of population aged 30–34 who have successfully completed tertiary education (%)	18.6	18.5	19.2	25.6	27.0	30.1	32.3	35.9 (8)	37.2	8.1	35.7	16
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	14.4	14.8	15.1	15.5	13.9	13.3	11.6 (8)	10.6	-4.1	12.7	16 (10)
Share of population at risk of poverty or social exclusion (%)	:	46.3	42.2	35.1	34.2 (11)	37.9	38.2	40.1	36.2	1.4	*24.8*	26 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) EU is the weighted average of the values for the Member States.
(6) The value is the difference between 2012 and 2007.
(7) Break in series between 2011 and the previous years. Average annual growth refers to 2008–2010.
(8) Break in series between 2011 and the previous years. Average annual growth refers to 2007–2010.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2012.
(12) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Take steps for a more integrated and comprehensive research system also by concentrating financing towards internationally competitive research institutions."

Lithuania

Developing a stronger and thematically focused science base

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Lithuania. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.90%** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+2.2 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **14.1** (EU: 47.8; US: 58.1) 2007-2012: **+1.2 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **57.9** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **32.7** (EU: 51.2; US: 59.9) 2007-2012: **+1.7 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Other transport technologies (other than automobiles and aeronautics), construction technologies, energy, and food	***HT + MT contribution to the trade balance*** 2012: **-0.8 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

The main strengths of Lithuania's research and innovation system remain the size of its public research sector and the good supply of new graduates. The weaknesses reveal scarce private and public R&D investments undertaken in a dispersed way and currently not linked to a smart specialisation strategy.

The country remains well below its 2020 R&D intensity target of 1.9 % of GDP, at least half of which is planned to come from private investments. R&D intensity is very limited in the business sector: almost three-quarters of all R&D expenditure in Lithuania is performed by the public sector. The low share of medium-tech and high-tech industries, low numbers of knowledge-intensive start-ups and the low rate of entrepreneurship have made it difficult for the private sector to reach the national commitment to the R&D target. Public R&D intensity has grown in recent years and, at 0.66 % in 2012, is no longer far from the EU average (0.74 %).

However, this is due to several major programmes funded by the Structural Funds, while the allocation to R&D from the national budget has declined significantly since 2007. Public R&D funding has become excessively dependent on the Structural Funds and it will not be possible to consolidate and further develop the public research system without increased national support for the basic functioning of the scientific institutions. Lithuania's science base is insufficiently competitive and is not well connected to European networks. There is an overall lack of knowledge transfer and the country's business environment is not geared towards facilitating innovation and entrepreneurship. Business investment in R&D will only improve if the quality, relevance and openness to the private sector of both the science base and higher education in Lithuania increase.

Reforms linked to the European Research Area agenda have been driven towards removing

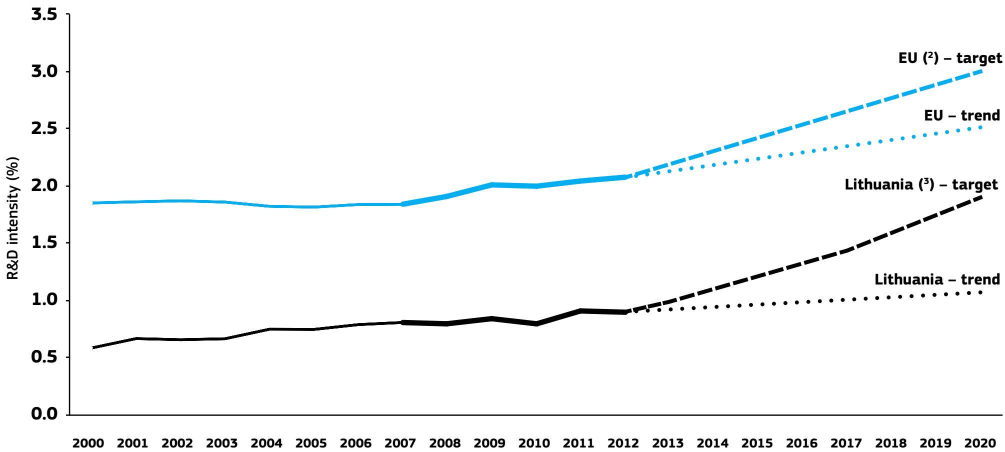
1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

obstacles in relation to the transnational collaboration of R&D teams, fostering the competitive allocation of research funding based on peer review, a more open and merit-based market for hiring researchers, notably in the public sector, as well as ensuring support to those public research organisations putting gender equality strategies in place. Nonetheless, strong weaknesses remain to be addressed. Lithuania needs to ensure the effective use, management and financing of large research infrastructures and the relevance of focusing the country's science and technology strengths in those areas linked to the societal challenges where Lithuania has the greatest potential to increase its economic impact. Improving the country's capacity to exploit R&I results commercially will not just require developing a business environment prone to innovation but will also need a better skills base in higher education with the right incentives for researchers in the public sector to engage in knowledge transfer and commercialisation activities.

Investing in knowledge

Lithuania – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) LT: The projection is based on a tentative R&D intensity target of 1.9 % for 2020.

Following a substantial increase in Lithuania's R&D intensity in 2011, progress slowed in 2012 and the country remains well below its 2020 target. In 2012, R&D intensity reached 0.9 % of GDP, which is less than half of Lithuania's R&D intensity target of 1.9 % for 2020. Most of R&D intensity continued in the public sector and is due to progress in implementing R&D-related projects financed with EU Structural Funds. The business sector finances only about 26 % of total R&D expenditure, which is one of the lowest shares of business funding in the EU. The economic crisis hit the national R&D budget, which was cut by around 20 % between 2007 (LTL 503.1 million) and 2010 (LTL 407.5 million). It increased slightly in 2011 (LTL 435.6 million) and fell again in 2012 (LTL 412.6 million). Overall, the share of the R&D budget in total government expenditure fell back from 1.07 % in 2004 to 1.01 % in 2012. Lithuanian R&D intensity is planned to reach 1.9 % by 2020, at least half of which should be contributed by business investments.

Continuity in public funding of R&D has been ensured by Structural Funds and with a good absorption rate. Of the EUR 6.8 billion of Structural Funds allocated to Lithuania over the 2007-2013 programming period, around EUR 1 billion (14.6 % of the total) related to RTDI[3]. In 2011-2012, Lithuania simplified the

[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

use of Structural Funds in favour of RTDI. The forecast of R&D intensity for 2014-2020 is maintaining the same trend – i.e. to keep the EU Structural funds as the key funding source across a large set of schemes and instruments.

Lithuania also benefited by about EUR 55 million from the EU's Seventh Framework Programme (FP7). In the period 2007-2013, 410 participants received funding from FP7 which indicates a good success rate for Lithuanian applicants (20.19 % vs. 21.89 % for the EU average). This success rate places Lithuania 15th among the EU-28. In terms of requested EC financial contribution, the success rate is 14.75 %, putting Lithuania in 16th place. Additional government support for investment in R&D and in new technologies is being provided through R&D tax incentives, which have been in place since 2008.

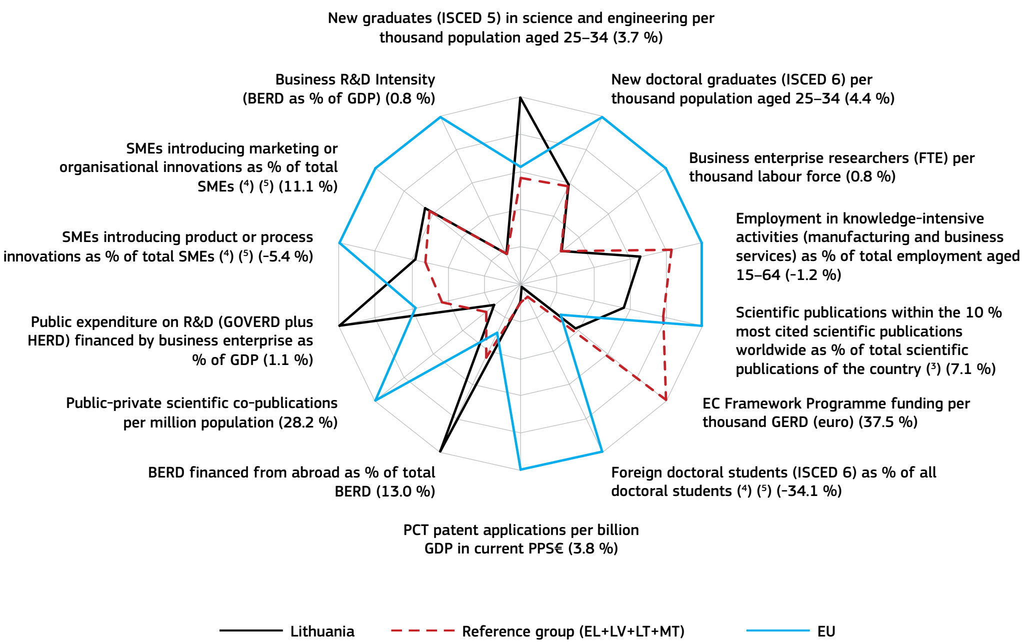
In 2012, business R&D as a percentage of total GDP amounted to only 18 % of the EU-28 average. Following some progress in the early 2000s, business R&D intensity hardly changed between 2006 (0.22 %) and 2012 (0.24 %). It was seriously affected by the economic crisis, hitting the lowest point of 0.19 % in 2008, but started to rise slowly in 2009 and is currently at 0.24 % for the second consecutive year. Business R&D intensity has been most affected in the services sector with a fall of 19 % in nominal terms between 2008 and 2009. On the other hand, it increased in the manufacturing sector by 13.5 % in the same period[4].

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Lithuania's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Lithuania, 2012 (¹)

In brackets: average annual growth for Lithuania, 2007–2012 (²)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (¹) The values refer to 2012 or to the latest available year.
(²) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(³) Fractional counting method.
(⁴) EU does not include EL.
(⁵) EL is not included in the reference group.

4 Data from Eurostat, Business R&D expenditure (BERD) by economic activity based on the company's 'main activity'.

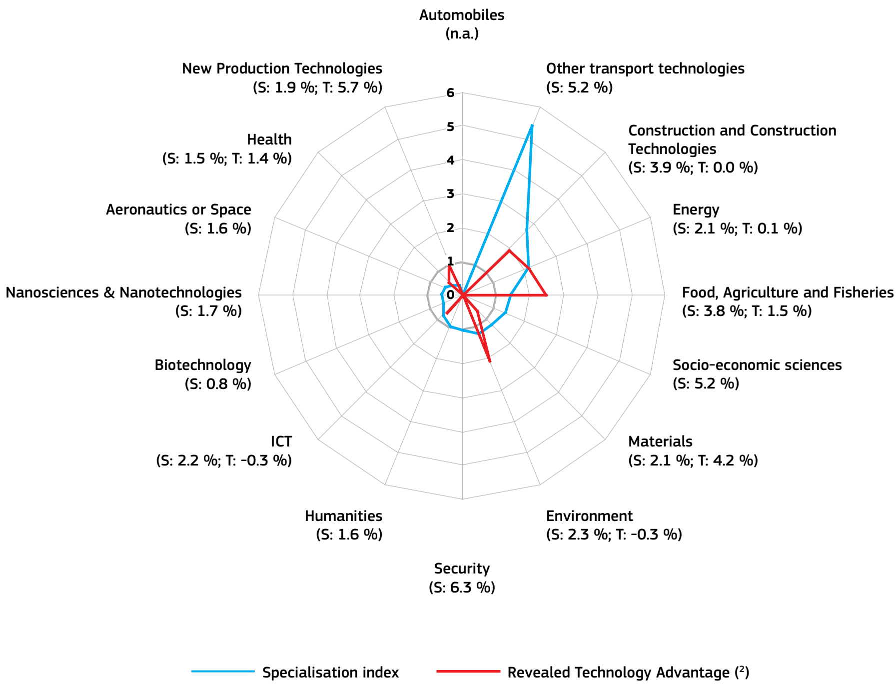
Lithuania's performance faces challenges in all four dimensions (human resources, scientific production, technology development, and innovation), for most of the main R&I indicators. Particular strengths are the number of new graduates in science and engineering (S&E) per population aged 25-34 years, public expenditure on R&D financed by business enterprises, and the financing of business R&D expenditure from abroad (mainly EU Structural Funds). The level of patenting activities and public-private collaboration are both very low and require improvement. Although business financing of university research appears to be relatively strong, the number of researchers employed by business remains low with only a small increase over the period 2007-2012.

This leads to two observations: (i) Lithuania's R&D relies to a larger extent than the EU average on EU funds, be it Structural Funds or FP7 funding; (ii) a large share of the young population receives tertiary education in S&E in Lithuania, which is also reflected in the good share of total knowledge-intensive activities in total employment in the country. However, at the doctoral level, the number of new doctoral graduates per thousand population aged 25-34 years is considerably below the EU average, indicating that doctoral studies and Lithuania's research system are less attractive to students.

Lithuania's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Lithuania shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Lithuania – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

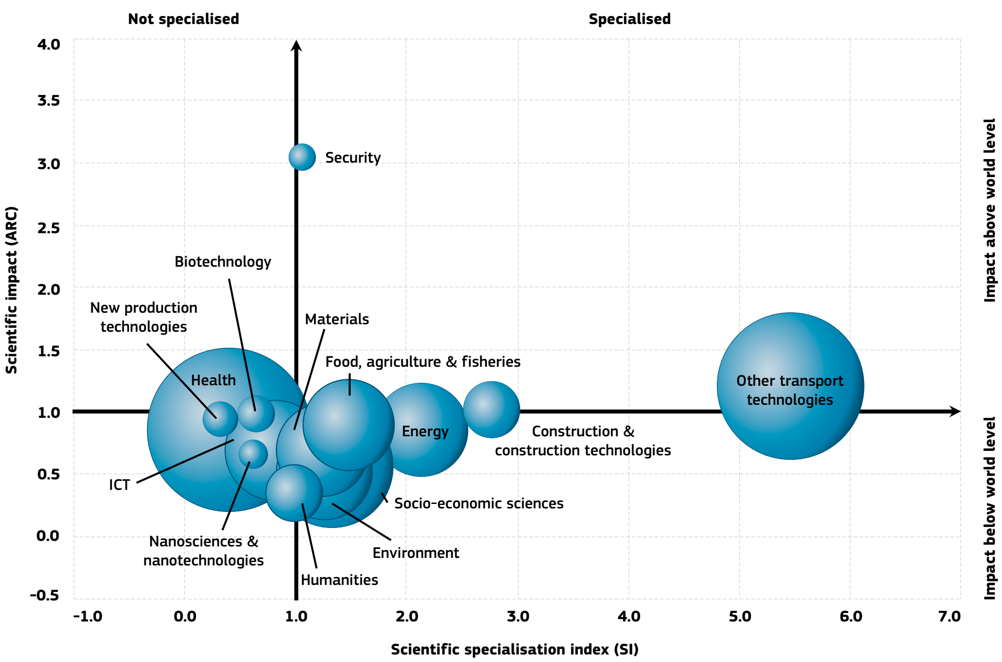
Lithuania, together with Greece, Latvia and Malta, is classified as a medium-knowledge-capacity system with a strong role being played by agriculture and low knowledge-intensive services[5]. In general, there is no sound correlation between science and technology specialisation for Lithuania, and overall the issue of critical mass remains vital in identifying priority areas. Patenting activity in the country is generally extremely low and does not show any statistically significant technological specialisation.

Comparison of the scientific and technological specialisation in selected thematic priorities reveals a mixed situation with some co-specialisations as well as some mismatches. In terms of volume of scientific publications, Lithuania performs best in other transport technologies (i.e. transport other than automobiles and aeronautics), but the field is not supported by patenting activity. The scientific co-specialisation exists in some sectors, such as construction and construction technologies, energy, food, agriculture and fisheries, and the environment. The recently defined Lithuanian R&I priorities for smart specialisation identify six broader priority areas, each with two to four specialisations – specific priorities, which include sectors with important innovation potential: energy and sustainable environment, health technologies and biotechnologies, agro-innovation and food technologies, new processes, materials and technologies, transport, logistics and ICT, and creative society.

Relative growth in technology fields has been recorded in new production technologies and materials. However, the figures should be considered carefully because of the small number of patent applications. Policy decisions at national level could consider further supporting science in these fields in order to match the technology developments. Overall, scientific activity shows a positive dynamic as measured by growing numbers of publications, with significant improvements in the fields of security and other transport technologies[6].

The graph below illustrates the positional analysis of Lithuanian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Lithuania – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

5 Innovation Union Competitiveness report, 2013

6 Innovation Union Competitiveness report, 2013

In terms of the quality of scientific results, Lithuania is below the world level in almost all specialisations related to the thematic priorities. Exceptions to this are the security and other transport technologies. The security field indicates scientific results of high quality with a low number of publications. In the case of other transport technologies, the quality of science is slightly above the world level but scientific production is much larger, being the second biggest in the country (after health). Therefore, there is room for improvement in the scientific quality of results in Lithuania. The food, agriculture and fisheries sectors lead the country's technological specialisation index list while, at the same time, occupying a modest position in scientific specialisation and scientific impact dimensions. Lithuania could probably benefit from fostering a scientific specialisation in the latter.

Policies and reforms for research and innovation

Lithuania has been carrying out reforms in its R&I system since the end of the last decade. These ongoing reforms are far-reaching and on the whole drive the research system towards what is accepted as international good practice. A number of reforms have been geared towards strengthening public-private R&D collaboration and commercialisation (e.g. setting up innovation vouchers and backing industrial PhDs). Furthermore, recent initiatives have been implemented to strengthen knowledge transfer (e.g. consultancy support for knowledge and technology transfer). These are boosting the exploitation of research results, and encouraging the use of new financial instruments, including debt and equity finance, with a series of business accelerators and seed and venture capital funds to support the creation and growth of innovative firms, although their contribution remains very modest. Measures have been taken to both facilitate and lower the costs of starting new businesses. These include, in particular, a very successful business voucher scheme and a legal entity called 'small partnership'.

Autonomy and a new mode of governance have been given to universities. The network of public research institutions has been reorganised and rationalised. The share of project-based funding has risen considerably and institutional funding is increasingly being allocated in relation to the performance of research institutions. Researchers' salaries have increased and dedicated schemes to attract local and international talent are now being implemented.

The creation and development of five clusters (called 'valleys') integrating higher-education institutions, research institutions and businesses around a number of scientific and technological areas is intended to strengthen links between higher education, science and businesses and improve knowledge transfer and the valorisation of research results in the country. However, these clusters have still to be used efficiently and with the necessary scale and scope to support scientists and business innovation activities.

Recently, three main programmes were adopted with the overall aim of enhancing the country's R&I potential:

- The Programme for the Development of Studies, Research and Experimental (social and cultural) Development for 2013–2020 aims to encourage the sustainable development of people and society, thereby improving the country's competitiveness and creating conditions for innovation by developing higher education and implementing studies, and R&D development;

- The Innovation Development Programme for 2014-2020 aims to promote the development and implementation of innovative products and technologies, the creation and internationalisation of value chains, and to foster public-sector innovation;

- The Programme for the Development of Priority Areas of Research and Experimental (social and cultural) Development and Innovation (smart specialisation) and Implementation of Priorities will develop the priority fields of R&D&I and implement their specialisations with the aim of achieving structural changes in the Lithuanian economy. This will determine the impact of the growth of high-value-added, knowledge and highly skilled labour-intensive economic activities on the country's GDP. During implementation of this programme, 20 action plans will be launched in close cooperation with adequate ministries and services.

Since public R&D funding has become excessively dependent on Structural Funds, it will not be possible to foster consolidation and further development of the public research system without increasing national support for the basic functioning of scientific institutions. The forecast for 2014-2020 relies on the same trend to maintain the EU Structural Funds as the key funding source through a large set of schemes and instruments. Such excessive dependency is not in line with the principles of the Structural Funds.

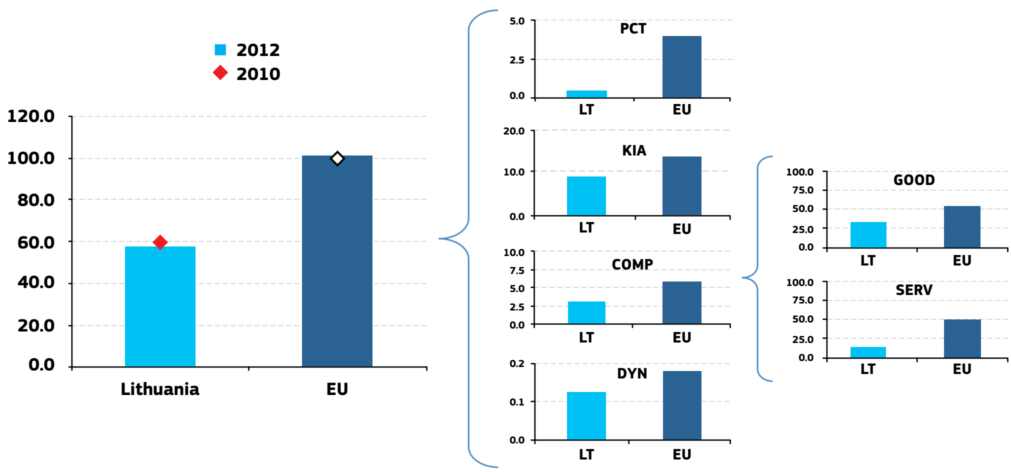
In addition to the existing innovative public procurement scheme, initial steps are being taken to facilitate the pre-commercial procurement of R&D. The plan is to develop a legal basis model towards the end of 2014 which should allow public authorities to use up to 5 % of their procurement budgets to purchase R&D-related products and services.

Government policy towards transnational collaboration, the internationalisation of science, and opening the national research system to researchers from other countries is still underdeveloped. The lack of strategic R&I internationalisation policy is impeding the internationalisation of quality Lithuanian research. The absence of policy relating to opening up the national research system stems from the need to first address the national problems related to unattractive career paths for researchers and limited research capacity. ERA priorities are only formally addressed and attention must be paid to the objectives of transnational collaboration, an open market for researchers, gender equality and mainstreaming.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator on innovation focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Lithuania's position regarding the indicator's different components.

Lithuania – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Lithuania is a low performer in the European innovation indicator, resulting from its low performance in all components. Furthermore, the country's performance is not improving.

The low performance in patents is linked to its economic structure with a lack of large manufacturing companies in technology-intensive sectors which, in certain fields, typically show high patenting activities. This structure, the lack of a sizeable car, pharmaceutical or machinery industry, and the high export share of agricultural products and food all explain the low score as regards the export share of medium-high/high-tech goods.

Relatively high employment in agriculture, construction, and transport is contributing to a low share of employment in knowledge-intensive activities.

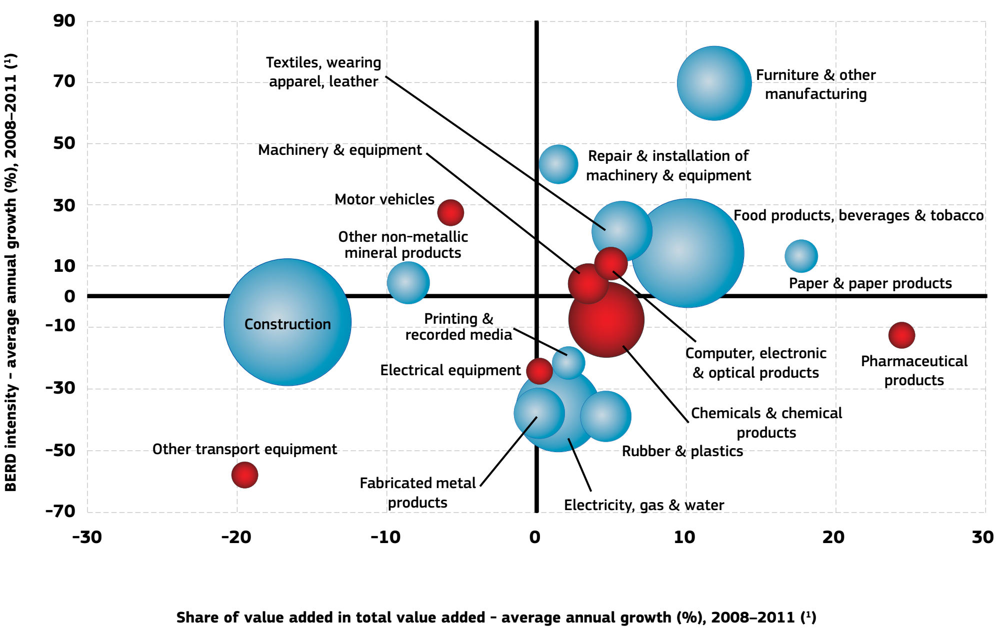
Lithuania has one of the lowest shares of knowledge-intensive service exports among EU countries. This is explained both by the low volume of KIS exports and by the high level of non-KIS transport services exports (road transport, rail transport, and auxiliary transport services).

Lithuania performs at a low level regarding the innovativeness of fast-growing firms. This is the result of a high share of employment in low-tech manufacturing, transportation, and construction companies among fast-growing enterprises.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries for the period of 2008-2011. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline of manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Lithuania – Share of value added versus BERD intensity: average annual growth, 2008–2011 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Furniture and other manufacturing': 2009–2011.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The graph above shows that Lithuania's manufacturing industry is dominated by low-tech and medium-low-tech sectors, which are intrinsically less research intensive than high-tech and medium-high-tech sectors (coloured in red). The only sizeable medium-high-tech sector is chemicals although in recent years it has received fewer business R&D investments and now accounts for less weight in the economy. All other high-tech and medium-high-tech sectors in Lithuania are small and import and re-export comprises a large part of the activity for some of them. As a result, the structure of this sector limits the overall level of business R&D intensity in the country. The graph includes data on the crisis in 2009-2010 which affected some sectors – notably, the construction sector has declined significantly since that period. Two sizeable sectors enjoyed positive growth trends during 2008-2011: food products, beverages and tobacco, and furniture and other manufacturing.

Structural change towards a more research-intensive economy is being driven mainly by high-tech and medium-high-tech manufacturing sectors. In Lithuania, no clear trend emerged for these sectors for the period 2000-2011: in the economy, the weight of some of these sectors increased (machinery and equipment, pharmaceutical products, and computer, electronic and optical products), while others decreased (motor vehicles). In the case of the other transport equipment sector, in the period 2008-2011, the share of both business investments and value added showed a significant declining trend. In the high-tech and medium-high-tech sectors, the research intensity has increased in the sectors of motor vehicles, computer, electronic and optical products, and machinery and equipment, but has fallen in the remaining sectors (chemicals and chemical products, pharmaceutical products, and electrical equipment).

The total effect of the evolution of the high-tech and medium-high-tech manufacturing sectors on overall business R&D intensity in Lithuania has been limited. The chemical sector is clearly the most important medium-high-tech/high-tech sector in Lithuania in terms of size, although in terms of evolution its importance has decreased (positive evolution in economic weight and fluctuating research intensity).

Key indicators for Lithuania

LITHUANIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.87	0.71	0.75	0.86	0.88	0.96	1.00	0.92	1.07	4.4	*1.81*	20
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	486	:	:	477	:	:	479	-7.6 (3)	495 (4)	20 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.13	0.15	0.22	0.23	0.19	0.20	0.23	0.24	*0.24*	*0.8*	1.31	24
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.46	0.60	0.57	0.58	0.61	0.63	0.56	0.67	*0.66*	*2.7*	*0.74*	12
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	13.3	:	:	:	:	14.1	1.2	47.8	27
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	3.3	4.9	5.4	6.1	6.2	:	:	:	7.1	11.0	19
International scientific co-publications per million population	:	168	181	202	228	238	236	290	304	8.5	343	24
Public–private scientific co-publications per million population	:	:	:	4	5	7	8	10	:	28.2	53	23
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.2	0.4	0.3	0.4	0.6	0.3	0.4	:	:	3.8	3.9	24
License and patent revenues from abroad as % of GDP	0.000	0.01	0.002	0.0004	0.002	0.001	0.002	0.002	0.009	83.1	0.59	26
Community trademark (CTM) applications per million population	0.3	11	21	21	34	35	31	46	69	27.4	152	20
Community design (CD) applications per million population	:	2	1	1	3	3	5	5	11	55.2	29	22
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	12.4	:	9.6	:	6.6	:	:	-16.8	14.4	27
Knowledge-intensive services exports as % total service exports	:	14.3	12.3	11.8	12.2	15.6	13.8	12.5	:	1.5	45.3	27
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.87	-5.79	-5.83	-5.11	-2.30	-1.62	-1.10	-1.27	-0.85	-	4.23 (5)	22
Growth of total factor productivity (total economy): 2007 = 100	76	96	98	100	99	86	93	97	98	-2 (6)	97	9
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	30.1	:	:	:	:	32.7	1.7	51.2	25
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	7.5	8.1	9.4 (7)	8.9	9.2	-1.2	13.9	25
SMEs introducing product or process innovations as % of SMEs	:	:	19.7	:	21.9	:	19.6	:	:	-5.4	33.8	23
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.03	0.00	0.00	0.01	0.00	0.02	:	:	:	32.0	0.44	27
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.01	0.03	0.02	0.06	0.04	0.08	:	:	:	15.9	0.53	21
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	65.6	70.6	71.6	72.9	72.0	67.2	64.3 (7)	66.9	68.5	3.2	68.4	13
R&D intensity (GERD as % of GDP)	0.59	0.75	0.79	0.81	0.80	0.84	0.79	0.91	*0.90*	*2.2*	*2.07*	19
Greenhouse gas emissions: 1990 = 100	40	48	49	54	51	42	43	44	:	-9 (8)	83	1 (9)
Share of renewable energy in gross final energy consumption (%)	:	17.0	17.0	16.7	18.0	20.0	19.8	20.3	:	5.0	13.0	9
Share of population aged 30–34 who have successfully completed tertiary education (%)	42.6	37.9	39.4	38.0	39.9	40.6	43.8	45.7	48.6	5.0	35.7	4
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	16.5	8.1	8.2	7.4	7.4	8.7	7.9	7.4	6.5	-2.6	12.7	6 (9)
Share of population at risk of poverty or social exclusion (%)	:	41.0	35.9	28.7	27.6	29.5	33.4	33.1	32.5	2.5	24.8	24 (9)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) EU is the weighted average of the values for the Member States.
(6) The value is the difference between 2012 and 2007.
(7) Break in series between 2010 and the previous years. Average annual growth refers to 2010–2012.
(8) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(9) The values for this indicator were ranked from lowest to highest.
(10) Values in italics are estimated or provisional.

Luxembourg

The challenge of fostering the emergence of a genuine R&I ecosystem

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Luxembourg. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.46 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **-1.6 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **23.5** (EU: 47.8; US: 58.1) 2007-2012: **+1.6 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **116.4** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **68.1** (EU: 51.2; US: 59.9) 2007-2012: **+1.5 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Environment	***HT + MT contribution to the trade balance*** 2012: **-4.4 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

Luxembourg has rapidly built up its public research capacities from a situation where, 30 years ago, the public research system was non-existent: the oldest public research centres were set up in 1987 and the University of Luxembourg was established in 2003. Public sector R&D intensity steadily increased from 0.12 % of GDP in 2000 to 0.46 % of GDP in 2012 but still remains well below the EU average of 0.74 %. Luxembourg's scientific performance, as measured by the share of its scientific publications which are among the top 10 % most-cited publications worldwide (12.4 %, above the EU average of 11 %) is impressive considering that its public research system has only been in existence since the mid-1980s.

However, as reflected in the decline in business R&D intensity (from 1.53 % in 2000 to 1.00 % in 2012) and in the limited level of cooperation between public research institutions and firms, the Luxembourgish R&I ecosystem remains very weak. Its public components are not yet able to play a decisive role in fostering innovation-led growth. While the prosperity of the Luxembourgish economy in recent decades has been based on the expansion of the financial sector, its significant dependence on this sector creates a strong structural risk. In addition to its 'sovereignty niches', upon which the financial sector's expansion is based, crucially, the Grand Duchy needs to develop 'competence niches' as a springboard for innovation-led growth.

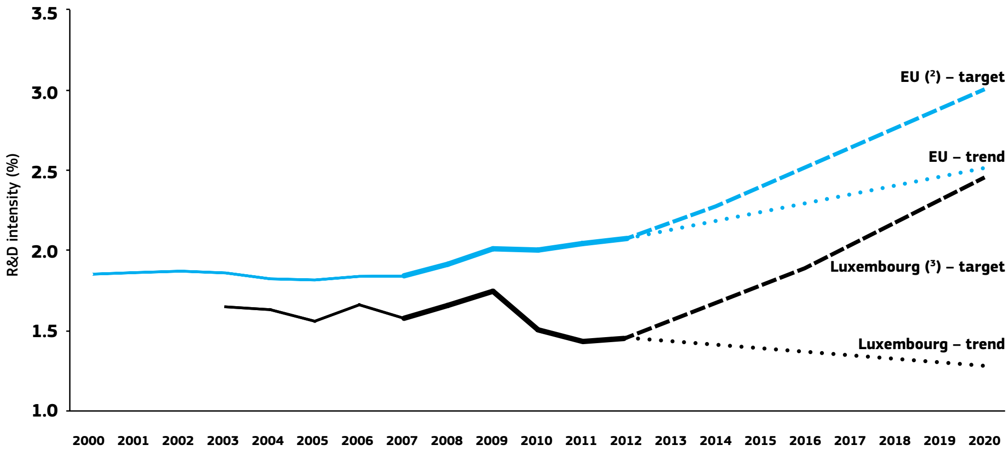
The government's resolve to make investment in RDI part of a long-term policy for Luxembourg's economic development and diversification has been translated into continued budgetary efforts. R&D project-funding targets thematic priorities selected through a Foresight exercise. Many actions are developed to foster public-private cooperation and more generally business R&D and innovation, including, for instance, a cluster programme, the setting up of business incubators, and the specification of IP/spin-off requirements in the performance contracts of public research organisations.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Investing in knowledge

Luxembourg – R&D intensity projections: 2000–2020 ([1])



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: ([1]) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
([2]) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
([3]) LU: The projection is based on a tentative R&D intensity target of 2.45 % for 2020.

Luxembourg is not at all on track to reach its R&D intensity target for 2020 of 2.3 % to 2.6 %, as its R&D intensity reveals a declining trend. This is explained by the sharp decrease in business R&D intensity (from 1.53 % of GDP in 2000 to 1.00 % in 2012). Conversely, public sector R&D intensity steadily increased from 0.12 % in 2000 to 0.46 % in 2012. This fourfold increase reflects the willingness of the Grand Duchy to build up its public research capacities from a situation where, 30 years ago, the public research system was non-existent. Public efforts to support R&D have continued in recent years but at a more moderate pace since 2009: between 2009 and 2012, the government budget for R&D increased in real terms by 16 %. In 2012, for the first time, the government budget for R&D caught up with the EU average in percentage of total government expenditure (1.4 %). However, if Luxembourg is to reach its 2020 R&D intensity target, the private sector's contribution should rise: 48 % of Luxembourgish private investment in R&D is made in the manufacturing sector, compared to 19 % in financial services and about 33 % in other services[3]. The level of R&D investment in financial services fell by 43 % between 2007 and 2012, which explains a major part of the negative trend in business R&D intensity, but not the totality.

Private and public R&D investment can also receive support via co-funding from the European budget, in particular through successful applications to the Seventh Framework Programme (FP7). A total of 191 Luxembourgish participants have been partners in a FP7 project, with a total EC financial contribution of almost EUR 40 million. The 19 % success rate of applicants is just below the EU average success rate of 22 %. As regards the Structural Funds – the other main source of EU funding for R&I – of the EUR 50 million of Structural Funds allocated to Luxembourg over the 2007-2013 programming period, around EUR 18 million (36 % of the total) related to RTDI[4].

3 However, it must be borne in mind that these other services include R&D services to the manufacturing sector.

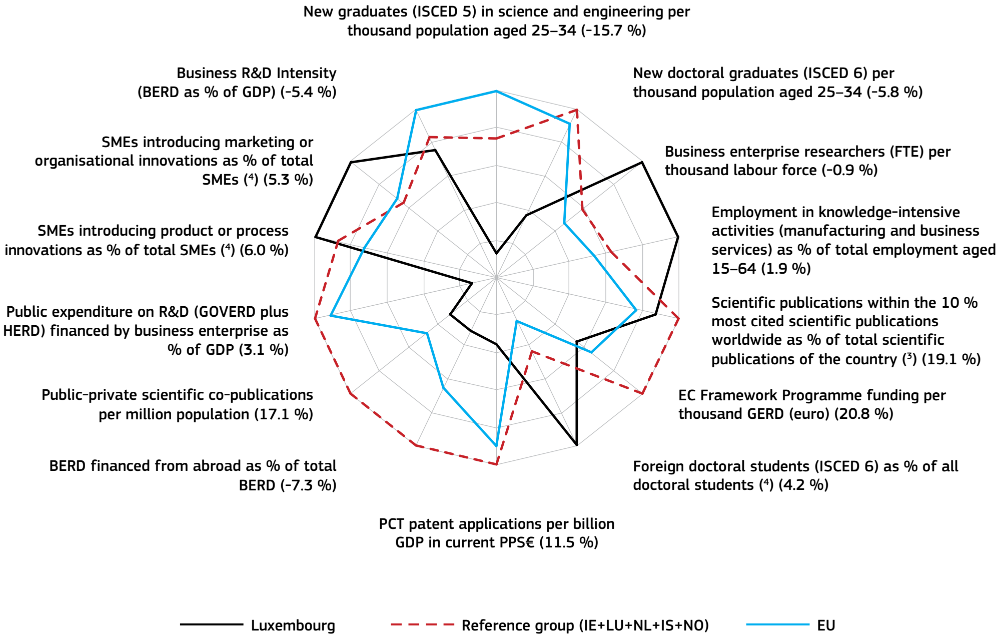
4 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Luxembourg's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Luxembourg, 2012 (1)

In brackets: average annual growth for Luxembourg, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The situation of Luxembourg's research system is marked by the contrast between public-sector R&D and private-sector R&D:

- The Luxembourgish public research system is very young, but is developing fast (see section Investing in knowledge above). Its scientific performance (as measured by the share of its scientific publications which are among the top 10 % most-cited scientific publications worldwide[5]) has progressed very rapidly and is now above the EU average. This is mainly due to a policy of attracting outstanding foreign researchers to work in Luxembourg.

- Despite its decline (see section Investing in knowledge above), the volume of business R&D is still quite high. This is reflected in a very high share of business enterprise researchers and a business R&D intensity which is also relatively high, taking into account the structure of the Luxembourgish economy (marked by the lowest share of manufacturing amongst all the EU Member States). This high volume is explained by the combination of significant R&D activities in the financial sector with the long-standing presence in the Grand Duchy of several R&D centres run by large multinational manufacturing companies (such as ArcelorMittal, Goodyear and DuPont de Nemours) and of smaller 'home-grown' technologically innovative companies (such as IEE, Paul Wurth and Rotarex).

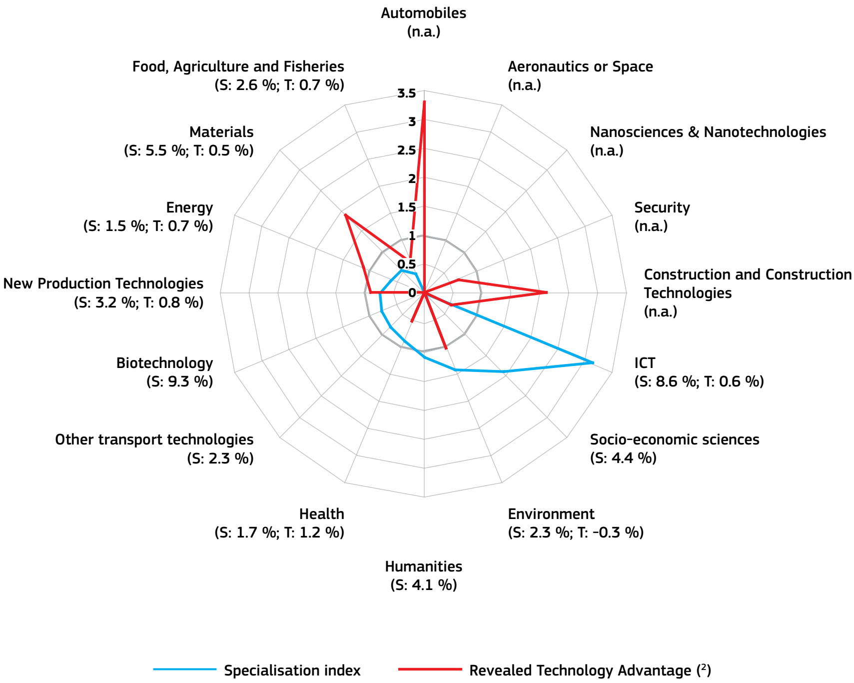
Luxembourg's performance on the two indicators on cooperation between public research institutions and firms is well below the EU average, reflecting the current disconnect between private-sector R&D centres and the public research system.

5 12.4 % vs. an EU average of 11 %: on this indicator, Luxembourg ranks sixth among EU Member States.

Luxembourg's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Luxembourg shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Luxembourg – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



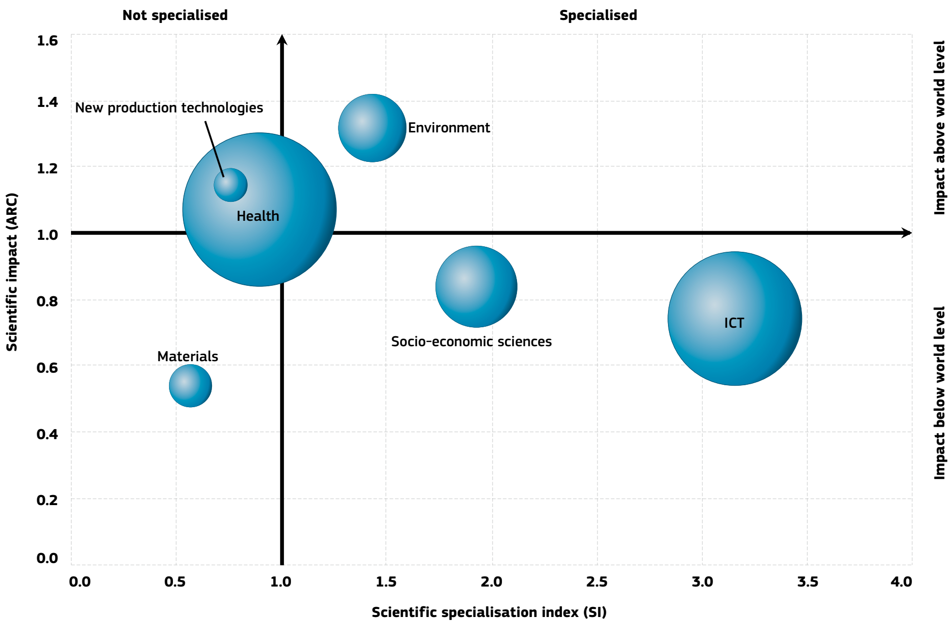
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

The graph above shows a mismatch in Luxembourg between the science base (as measured through the number of publications) and the technological specialisations (as measured through the number of patents). Technological specialisation reflects business R&D activities, essentially: for instance, the very strong specialisation in automobiles reflects the presence of a very significant cluster of technologically innovative companies supplying the automotive industry (such as Delphi Automotive Systems and IEE). While Luxembourg has technological specialisations in automobiles, materials, construction, as well as to a lesser extent in energy, new production technologies, and the environment, only this last technological specialisation is supported by a corresponding specialisation in the science base. Besides environment, science base specialisations are ICT, socio-economic sciences, humanities, and health.

The mismatch between the specialisations of the public research system and those of private-sector R&D is probably a key factor behind the low level of public-private cooperation.

The graph below illustrates the positional analysis of Luxembourg's publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Luxembourg – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

With reference to the quality of the science base, too (using as a proxy the scientific impact measured through citations), the graph above shows highly contrasting situations in various areas:

- Environment, the only sector where there is a scientific and technological co-specialisation, is also the area with the highest quality science base. This quality supports technological innovativeness, thus the situation in this theme looks very promising.
- Despite a strong science-base specialisation in ICT, its impact as measured through citations is rather low, placing a question mark over the situation in this area.
- Despite the fact that materials is a sector with major industrial R&D activities in Luxembourg, there is lack of corresponding specialisation within the science base and the quality attained so far seems low. To achieve a higher level of public-private cooperation, the strengthening of the science base in materials is probably required.

Policies and reforms for research and innovation

The steady increase in the public R&D budget between 2000 and 2009 reflects the government's resolve to make investment in RDI part of a long-term policy for Luxembourg's economic development and diversification. The country's national RDI strategy is founded on multi-annual planning and focuses on targeted priorities. Following the establishment of the public research centres (PRCs) and of the university between 1987 and 2003, key steps have included the OECD review of Luxembourg's national research system in 2006 and a Foresight Study in 2006-2007 that identified the thematic domains which now make up the CORE public research funding programme. A major outcome of the OECD review was the recommendation to implement performance contracts between the ministry and the National Research Fund (FNR), the university, the PRCs and Luxinnovation.

Two important draft laws are currently in the legislative process, with adoption expected in 2014:

- The first one aims to consolidate the public research organisations with, in particular, the merger of the Tudor and Lippmann Public Research Centres. This merger should allow for the building of critical mass in areas with major prospects for cooperation with Luxembourgish industry, such as materials and sustainable development, with some less-promising research subjects being discontinued.

- The second one aims to reform FNR, which allocates funds on a competitive basis. This reform targets better valorisation of research results, notably through enabling actions to support 'proof-of-concept'. In this context, a reform of the FNR's researchers training scheme (AFR) is foreseen. It will foster inter-sectoral (public/private) mobility.

Many initiatives have been developed to foster private R&D, public-private cooperation, innovation and entrepreneurship:

- The law of 5 June 2009 provides state aid for the private sector with a special focus on SMEs and services-sector innovation. The law of 18 February 2010 provides public aid to the private sector in the field of eco-innovation. The law on Intellectual Property (IP) tax incentives (21 December 2007) encourages companies to patent and licence the results of their R&D work, and also fosters spin-offs and start-ups based on IP.

- Measures to encourage the development of small innovative companies include: IP/spin-off requirements in PRCs' performance contracts, the creation of a Master's degree in Entrepreneurship and Innovation, the setting up of business incubators, a partnership with a business accelerator located in Silicon Valley (Plug and Play Tech Center) in order to help start-ups in Luxembourg to gain access to the United States market.

- The massive (EUR 565 million) infrastructure project Cité des Sciences aims at reinforcing relations between research, education and innovation, by hosting on one site all of Luxembourg's major public R&D institutes, as well as private and start-up companies, a new technical school, the university campus, the national archives and some cultural centres. It will provide facilities for public-private partnerships and a business incubator.

- Luxembourg has set up a cluster programme around five thematic clusters (in materials, ICT, space, bio-health, and eco-innovation). This policy was reinforced in 2013, with new missions given to clusters in relation to internationalisation and business developments as well as the setting up of a new cluster in the automotive field.

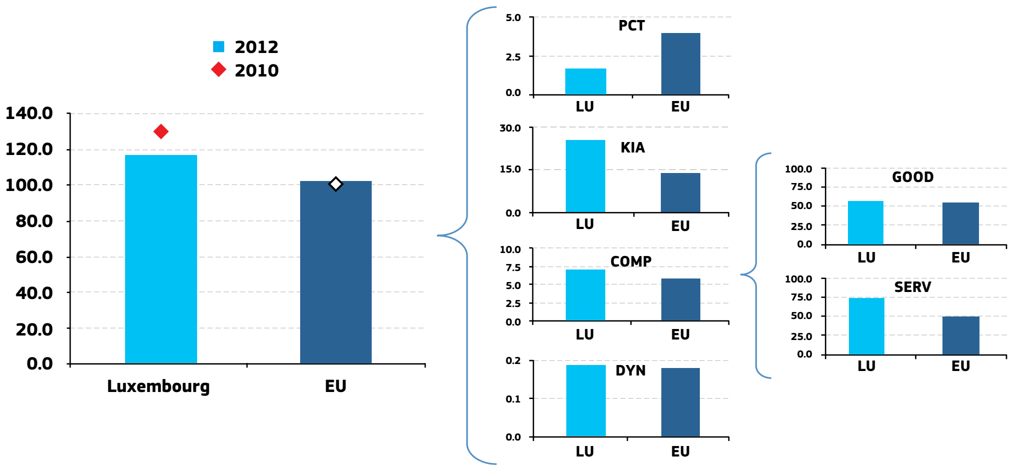
Moreover, the new government announced its intention to put in place a process to enable public research organisations and firms to develop common research agendas focused on middle- and long-term targets.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms).

The graph below enables a comprehensive comparison of Luxembourg's position regarding the indicator's different components:

Luxembourg – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

The country's high score on the European innovation indicator is mainly the result of its share of employment in knowledge-intensive activities which is the highest of all EU Member States (25.4 %, nearly twice the EU average) and its share of knowledge-intensive services in services exports, which is the second highest of all Member States. These situations are the result of a very strong specialisation in the financial services sector, which has been Luxembourg's main growth engine since the early 1980s. Its expansion has enabled the Luxembourgish economy to flourish despite the decline of its key manufacturing sectors, especially the steel industry. The country's good score on the DYN component is also linked to its economic structure oriented towards knowledge-intensive services, with a relatively high share of employment in fast-growing information services and financial and insurance activities.

The share of manufacturing in value added is now the lowest of all EU Member States and the limited role of high-tech and medium-tech manufacturing in the Luxembourgish economy explains the Grand Duchy's low scores on the indicator's PCT component. Nevertheless, the share of medium-high and high-tech goods in total goods exports is slightly above the EU average. This is explained by the country's role as an air-transport hub, with the high-tech goods transiting the country counted as Luxembourgish exports.

Although Luxembourg's financial sector is relatively healthy, the economy's significant dependence on this sector poses a strong structural risk. It is uncertain to what extent the financial sector will be able to continue to play such an important role in driving Luxembourgish prosperity in the future. Even if financial activities around the world remain as buoyant after the crisis as they were before it, the question arises as to whether Luxembourg will be able to preserve and continue to develop the competitive advantages, in terms of fiscal, legislative and regulatory environment, that have made it an attractive environment for this type of activity. It is therefore crucial for the Grand Duchy that, in addition to its 'sovereignty niches' upon which the financial sector expansion has been based, it also develops and strengthens 'competence niches' as a springboard for innovation-led growth.

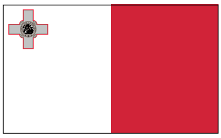
Key indicators for Luxembourg

LUXEMBOURG	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	:	:	:	:	:	:	:	0.79	0.75	-5.8	*1.81*	25
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	490	:	:	489	:	:	490	-0.2 (3)	495 (4)	15 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	1.53	1.35	1.43	1.32	1.29	1.32	1.02	1.00	1.00	-5.4	1.31	14
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.12	0.21	0.23	*0.26*	0.37	0.42 (5)	0.49	0.44	0.46	2.8	*0.74*	21
Venture capital as % of GDP	:	:	:	0.18	1.11	0.23	0.26	0.58	0.56	25.7	0.29 (6)	2 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	21.7	:	:	:	:	23.5	1.6	47.8	22
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	7.2	7.9	8.8	9.4	12.4	:	:	:	19.1	11.0	6
International scientific co-publications per million population	:	386	591	670	837	1106	1281	1467	1559	18.4	343	3
Public–private scientific co-publications per million population	:	:	:	19	25	30	33	36	:	17.1	53	11
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	2.8	1.4	1.7	1.1	1.7	1.8	1.6	:	:	11.5	3.9	15
License and patent revenues from abroad as % of GDP	0.66	0.78	0.92	0.77	0.62	0.76	0.92	0.80	1.31	11.1	0.59	4
Community trademark (CTM) applications per million population	803	891	1081	1525	1550	1710	1745	1932	1905	4.6	152	1
Community design (CD) applications per million population	:	52	100	107	103	111	112	121	141	5.7	29	1
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	12.4	:	8.9	:	8.3	:	:	-3.4	14.4	22
Knowledge-intensive services exports as % total service exports	:	78.4	81.3	81.8	78.9	76.7	77.4	75.3	:	-2.0	45.3	1
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.68	-5.11	-4.26	-5.16	-5.52	-3.61	-4.44	-3.89	-4.43	-	4.23 (7)	25
Growth of total factor productivity (total economy): 2007 = 100	102	98	99	100	94	88	89	88	85	-15 (8)	97	28
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	63.1	:	:	:	:	68.1	1.5	51.2	2
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	23.8	25.1	26.1	24.7	25.7	1.9	13.9	1
SMEs introducing product or process innovations as % of SMEs	:	:	44.7	:	41.5	:	46.6	:	:	6.0	33.8	3
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.72	0.55	0.52	0.23	0.36	0.16	:	:	:	-16.6	0.44	13
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.01	0.11	0.15	0.17	0.19	0.12	:	:	:	-15.3	0.53	19
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	67.4	69.0	69.1	69.6	68.8	70.4	70.7	70.1	71.4	0.5	68.4	10
R&D intensity (GERD as % of GDP)	1.65	1.56	1.66	*1.58*	1.66	1.74	1.51	1.43	1.46	*-1.6*	*2.07*	15
Greenhouse gas emissions: 1990 = 100	81	108	107	103	102	97	102	100	:	-3 (9)	83	20 (10)
Share of renewable energy in gross final energy consumption (%)	:	1.4	1.5	1.7	1.8	1.9	2.9	2.9	:	14.3	13.0	27
Share of population aged 30–34 who have successfully completed tertiary education (%)	21.2	37.6	35.5	35.3	39.8	46.6 (11)	46.1	48.2	49.6	2.1	35.7	3
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	16.8	13.3	14.0	12.5	13.4	7.7 (11)	7.1	6.2	8.1	1.7	12.7	9 (10)
Share of population at risk of poverty or social exclusion (%)	:	17.3	16.5	15.9	15.5	17.8	17.1	16.8	18.4	3.0	*24.8*	5 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2009 and the previous years. Average annual growth refers to 2009–2012.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK, These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Break in series between 2009 and the previous years. Average annual growth refers to 2009–2012.
(12) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Pursue the diversification of the structure of the economy, including by fostering private investment in research and further developing cooperation between public research and firms."



Malta

Building up a knowledge-based economy in a specialisation strategy

Overall performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Malta. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.84 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+8.1 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **23.3** (EU: 47.8; US: 58.1) 2007-2012: **+5.6 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **84.8** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **55.3** (EU: 51.2; US: 59.9) 2007-2012: **+2.1 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Materials, new production technologies, ICT, health, and environment	***HT + MT contribution to the trade balance*** 2012: **3.4 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **-18.4 %** (EU: +4.8 %; US: -32.3 %)

In preparation for Malta's accession to the EU in 2004, research was given increased prominence. This is particularly evident through the availability of reporting and monitoring commitments, as well as via the continued upward trend in R&I spending from 2004 onwards. In recent years, the stated aim of the Maltese government has been to place research and innovation (R&I) at the heart of the country's economy in order to stimulate knowledge-driven and value-added growth and to sustain improvements in its citizens' overall quality of life. This can only be achieved in the long term and its success will depend on implementation of the policies outlined in the National Strategic Plan for Research and Innovation 2020 in support of an environment favourable to innovation. In spite of the fact that R&D intensity remained low at only 0.84 % of GDP in 2012, significant progress was made over the period 2007-2012. The business sector is the largest R&D performer, accounting for 60 % of GERD, followed by the higher education sector with 36 % in 2012. The lowest component in R&D expenditure remains from the government and public sector. Performance and economic output indicators show that Malta is a medium-low performer in the European innovation indicator, with a stagnating trend over the period 2007-2012. However, in 2012, high-tech & medium-tech contribution to the trade balance was positive, thanks to the structural changes introduced in the economy towards specialisation in knowledge-intensive sectors, products and services. High growth is also observed in excellence and quality of scientific production; a slight improvement is noted for PCT patent applications while licence and patent revenues from abroad remain an area of weak performance.

It is important to highlight the problem of the volatility of indicators when these are reduced to Malta's micro-scale.

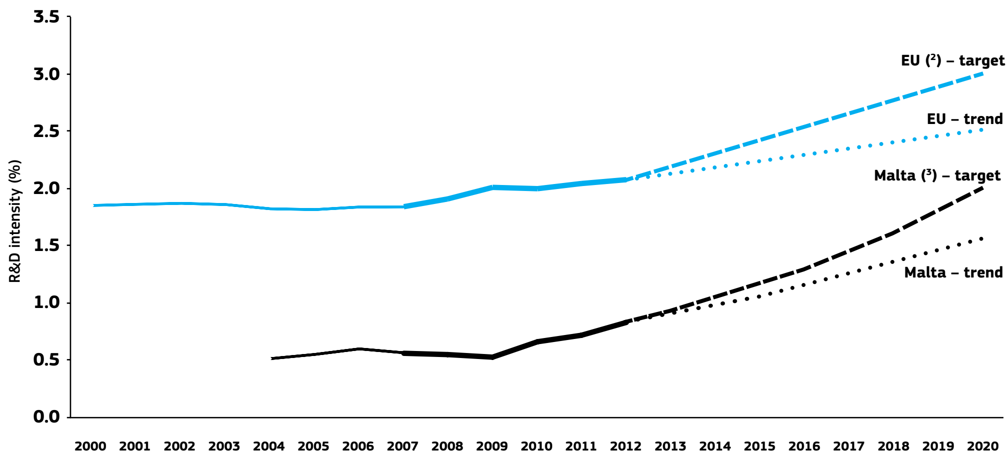
1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

The country's key challenges include building up R&I capacity and to encourage increased investments in R&I, so that it moves closer to the newly fixed national R&D 2020 expenditure target. To meet this, Malta will need to improve its enabling environment considerably to allow for better research-to-market capacity. In this respect, innovation support and entrepreneurship, particularly for small and medium-sized enterprises (SMEs), remain key focal factors. A fundamental challenge for Malta is to stimulate indigenous private-sector R&I. The strategic principles adopted to address these challenges are outlined in Malta's National Strategic Plan for Research and Innovation 2020. This includes greater focus on priority areas, specialisation in a select number of areas of economic importance, coordinating public and private resources, expanding the science, technology, engineering and mathematics human capital base, and building strong links between knowledge institutions and business.

Investing in knowledge

Malta – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) MT: The projection is based on an R&D intensity target of 2.0 % for 2020.

Following a revision in 2013, Malta has set itself an ambitious target at 2 % of GDP by 2020, notably compared to its trend in the overall period of 2007-2012. In 2012, Malta's R&D intensity accounted for only 0.84 % of GDP, one of the lowest figures in the EU-27. However, significant increases in R&D expenditure in recent years may have motivated the country to take this bold step. Nevertheless, Malta has to come forward with details of how the increased R&D intensity will be achieved; its National Reform Programme (NRP) for 2014 will be important in this respect.

The central government allocation for the National R&I Funding Programme was boosted from 0.7 million Euros in 2010 to 1.1million in 2011 and again to 1.6 million in 2012. Government funding of R&D increased steadily between 2007 and 2012 at an average annual real growth rate of 8.2 %. The increased government spending on R&D resulted from greater expenditure on both higher education and business of 36.3 % and 0.50 % respectively.

Malta is also ranked 19th in the EU in terms of business-enterprise expenditure on R&D as a % of GDP with a value of 0.50 % in 2012 compared to an EU average of 1.30 %. R&D financed by business enterprise increased in real terms between 2005 and 2012 at an average annual growth rate of 6.1 %. However, most of Malta's business R&D is carried out by a small cluster of foreign-owned companies. In view of this, continuous and firm commitment from the Maltese government during the upcoming period will be important to generate indigenous R&I, and to remain on the path towards meeting the new RDI intensity target by 2020.

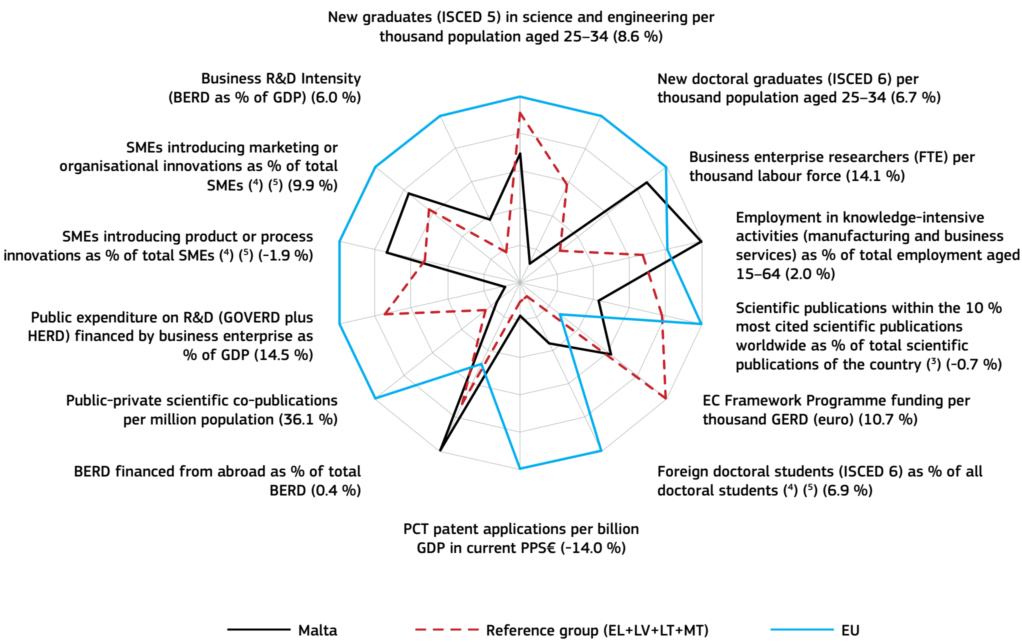
The country relies heavily on support from the EU's Seventh Framework Programme (FP7) and Structural Funds for the achievement of its R&I objectives. In financial terms, up to February 2014, 155 FP7 projects had been approved and awarded around EUR 20 million (Source: E-CORDA). The success rate of Maltese applicants for FP7 funding is 19.1 % compared to the EU average of 22.0 %. Of the EUR 840 million of Structural Funds allocated to Malta over the 2007-2013 programming period, around EUR 72 million (8.5 % of the total) related to RTDI[3]. One of the objectives of the National Strategic Plan for R&I 2020 is to put in place a supporting framework to exploit opportunities for participation in EU R&I funding programmes.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Malta's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Malta, 2012 (¹)

In brackets: average annual growth for Malta, 2007–2012 (²)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (¹) The values refer to 2012 or to the latest available year.
(²) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(³) Fractional counting method.
(⁴) EL is not included in the reference group.
(⁵) EU does not include EL.

³ RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

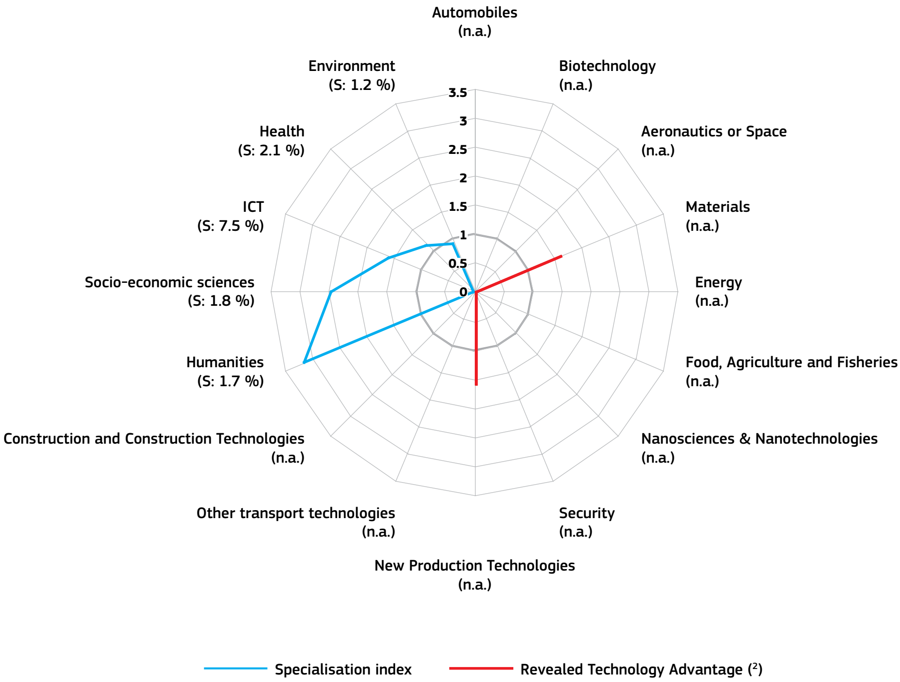
Despite a clear strategy, Malta is still below the EU average for most of its indicators. Nevertheless, its share of employment in knowledge-intensive activities is higher than the EU average, reflecting the dominance of high-tech multinationals in the private sector. Innovation activities by SMEs are also above the reference-group average but below that of the EU. This factor complements the increase in BERD over the period 2007-2012, which also rose above that of both the reference group and the EU average, as the country's economy not only resisted during the financial crisis, but steadily continued to attract business from abroad.

Knowledge creation as reflected in the production of highly cited scientific publications and public-private scientific co-publications remains weak, and the number of PCT patent applications is far below the EU average with a negative growth average, indicating a low scientific base. However, the establishment of the University of Malta Knowledge Transfer Office in 2009 is already contributing to reversing this trend. Malta's reliance on FP7 as a source of funding is shown in its above-average level of EC funding, although it is well below the reference group.

Malta's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Malta shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA), based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Malta – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

There is very limited ground for comparing Malta's scientific and technological specialisation in selected thematic priorities because of the lack of specific data, which is probably due to the small size of the country and its market. A revealed technological advantage is apparent in only two sectors – materials and new production technologies – but data on trends is missing. No corresponding scientific specialisation seems to exist for these two fields. The materials sector has not been identified in the national strategic documents in the area of research, development and innovation, although the new National R&I Strategy 2020 does identify high-value-added manufacturing, with a focus on 'processes' as a specialisation area.

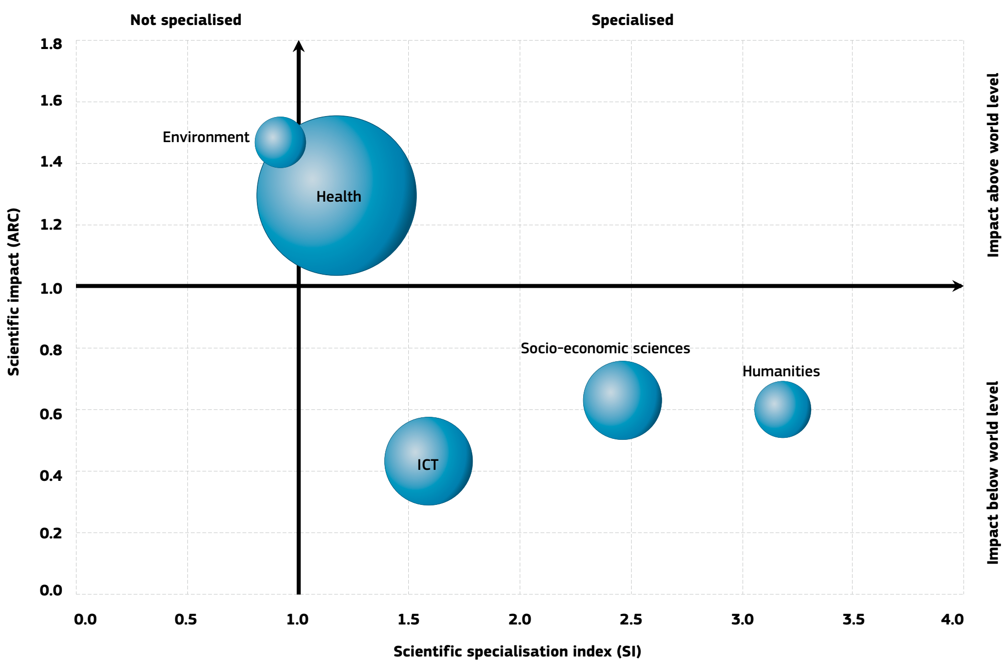
Malta's scientific specialisation indicator shows that the main scientific fields are ICT, health, environment, as well as humanities, and socio-economic sciences. Evidently, these sectors are mainly limited to scientific production, seemingly without corresponding technological production. This may be partly due to the fact that Malta is a small country with increasingly limited manufacturing and often with the research facilities of large multinationals based abroad. The increasing predominance of the services sector should also be considered in this respect.

In Malta, there is only one sector with a relatively high scientific impact, namely the environment, followed by health. An important task would probably be to foster technological specialisation in these two sectors. The three other specialised sectors identified are below average with regard to their impact.

Overall, as regards specialisation, Malta is ranked 25th in the EU-28 group. Because of this very low position, there is an apparent need to develop Malta's scientific and technological sectors in order to further enhance knowledge-based growth.

The graph below illustrates the positional analysis of Malta's publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Malta – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

Policies and reforms for research and innovation

Malta's National R&I Strategy 2020 responds adequately to the challenges facing the country in R&I. It is strongly business oriented and aims to build up R&I capacity by concentrating efforts on areas of economic importance. Resource concentration and smart flexible specialisation in specific sectors is a key part of the Maltese R&I strategy. The plan proposes an improved tailoring of schemes for enterprises, as well as providing support for particular target groups such as SMEs and start-ups. A new commercialisation programme to help technology owners move their technologies closer to market was piloted in 2012, and was replaced by the Innovation Voucher Scheme in October 2013. Efforts are being made to use government expenditure on R&D to leverage an increase in business R&D expenditure, particularly through a varied set of incentives to promote R&D and innovation in the enterprise sector.

Malta's draft National R&I Strategy 2020 was published for public consultation in September 2013 and the final, updated version was endorsed by the cabinet in February 2014. This strategy is built on the previous strategic plan, but introduces a number of new elements, whilst retaining the same key vision. The strategy articulates three main goals: building a comprehensive R&I ecosystem; developing a stronger knowledge base; and smart, flexible specialisation.

The Strategy proposes to address the serious shortfall in human capital for R&I by investing in human-resource development at all levels of education. Scholarship schemes supporting postgraduate studies in Malta and abroad are in place and are being synchronised with areas of national priority. Malta is also investing in the construction of a new National Interactive Science Centre in order to instil an active interest in science, research and innovation among the country's youth and to encourage them to pursue a career in science and technology, as well as helping to expand the science, engineering and technology human capital base. The Centre will open in 2015.

The European Research Area (ERA) dimension in Malta's national R&I system is limited in the extent of the policies and measures specifically addressing this aspect. This probably arises from the fact that the country's research-relevant policies are still in their infancy, but fuller participation is on track and some success has been achieved by putting in place a legal framework for the inward mobility of third-country researchers, and the very good participation rates in FP6 and FP7. International cooperation is an important cross-cutting element of the National Strategy for R&I, and a number of priority measures have been identified for implementation in the short term. Generally speaking, efforts for the immediate future are mainly focused on building and strengthening internal capacity, hopefully leading to improvements in order to shift the focus to fuller integration in the near future.

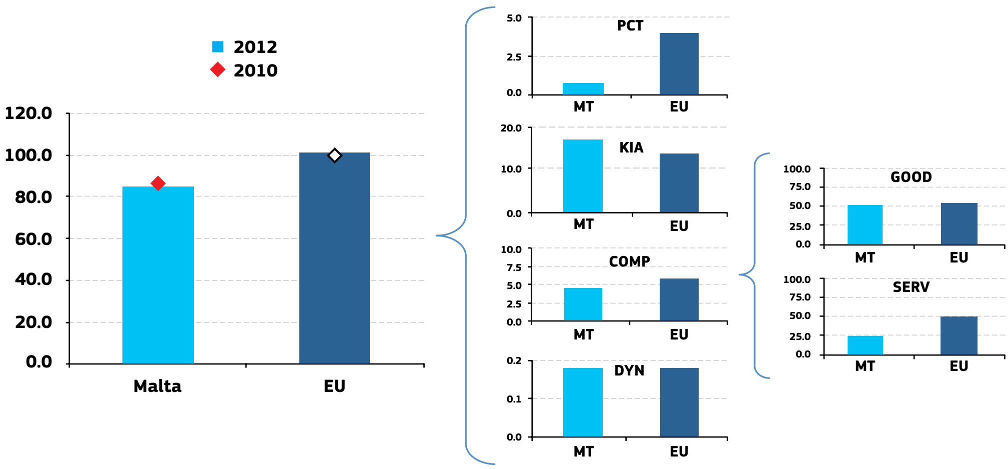
The National R&I Strategy 2020 places increased emphasis on the importance of innovation in all its forms. Indeed, Malta aims to support both research-based and non-research-based innovation by identifying key issues and opportunities and providing an appropriate enabling and support framework for potential innovators.

Malta's Smart Specialisation Strategy has been finalised and incorporated into the National R&I Strategy. It identifies seven national smart specialisations which have important innovation potential: tourism product development, maritime services, aviation and aerospace, health (with a focus on e-health as well as active living and healthy ageing), resource-efficient buildings, high-value-added manufacturing (with a focus on processes and design), and aquaculture. ICT was identified as a horizontal enabling technology as well as a source of innovation in itself (especially in health, digital gaming, financial services, and tourism product development). Malta's Smart Specialisation Strategy will be key in guiding R&I investments foreseen to be implemented through the European Structural and Investment Funds (ESIF) towards strategic areas considered to have high potential economic impact.

Innovation Output Indicator

The Innovation Output indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator on innovation focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Malta's position regarding the indicator's different components.

Malta – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Malta is a medium-low performer in the EU innovation indicator, scoring below the EU average and unable to improve its performance over the period 2010-2012. According to Eurostat data, Malta is positioned at the lowest European ranking in terms of number of patents filed to the European Patent Office at national level. However, other data sourced from the EPO website[4] for 2012 and 2013 indicate that applications filed with the EPO on the basis of per country of residence of the first named applicant increased significantly for Malta (from 23 in 2012 to 43 in 2013). Malta is also a low performer as regards PCT patents. Low performance in patents is seen as being linked to the economic structure of a country with a very small capital goods sector, and a lack of large manufacturing companies, which typically show high patenting activities.

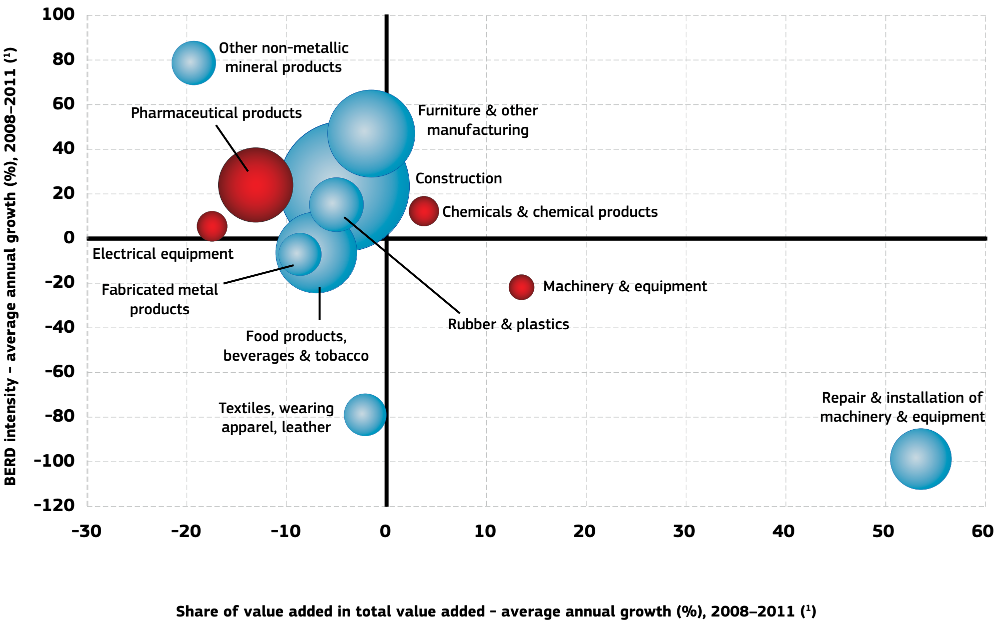
Most of the country's RDI expenditure comes from the business sector, notably from foreign companies with manufacturing plants in Malta; R&D activities, including patenting, tend to be carried out in the headquarter country rather than in Malta. Also, the exportation of knowledge-intensive services is far below the EU average, probably due to the high share of tourism in the Maltese economy. However, on a positive note, MT ranks fifth within the EU for employment in knowledge-intensive activities. Average rankings could also be observed for the other two components: the export share of medium-high and high-tech products (11th within the EU) and the innovativeness of high-growth enterprises (12th within the EU), thanks to a relatively strong financial and insurance sector.

[4] http://www.epo.org/law-practice/legal-texts/official-journal/2014/03/a34.html

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented in the graph). The red sectors are high-tech or medium-high-tech sectors.

Malta – Share of value added versus BERD intensity: average annual growth, 2008–2011 ([1])



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: ([1]) 'Chemicals and chemical products'; 'Construction', 'Fabricated metal products', 'Machinery and equipment', 'Other non-metallic mineral products'; 'Repair and installation of machinery and equipment': 'Textiles, wearing apparel, leather': 2010–2011.
([2]) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

In Malta, the services sector has been gaining in importance, mainly thanks to the emergence of new activities such as remote gaming, financial intermediation, and IT, legal and accounting services, which, in addition to more traditional services such as tourism, account for around 80% of total value added. Professional, scientific and technical activities, administrative and support service activities as well as information and communication and financial and insurance activities exhibited an increase in share of value added over the period 2010-2013. The contribution of manufacturing to the total value added has been in regular decline over the last decade. R&D activity is clustered around a few sectors. Since 2008, the pharmaceutical products and preparations (NACE Code Rev. 2.21) sector has undertaken around 20-22 % of R&D in the enterprise sector. This indicates that overall, and in spite of the progress noted in some of the sectors, as mentioned above, no clear interaction has been observed between R&D and business value added.

Key indicators for Malta

MALTA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.13	0.09	0.07	0.16	0.19	0.31	0.20	0.31	0.21	6.7	*1.81*	28
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	:	:	:	463	:	:	:	:	495 (3)	:
Business enterprise expenditure on R&D (BERD) as % of GDP	:	0.37	0.40	0.37	0.36	0.34	0.41	0.47	*0.50*	*6.0*	1.31	19
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	0.19	0.20	0.19	0.19	0.20	0.25	0.24	*0.33*	*11.8*	*0.74*	26
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	17.7	:	:	:	:	23.3	5.6	47.8	23
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	6.0	7.4	4.8	7.7	4.8	:	:	:	-0.7	11.0	22
International scientific co-publications per million population	:	219	200	180	245	219	302	335	400	17.3	343	22
Public–private scientific co-publications per million population	:	:	:	2	1	2	6	8	:	36.1	53	24
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.4	0.7	0.6	1.1	1.0	0.3	0.7	:	:	-14.0	3.9	19
License and patent revenues from abroad as % of GDP	0.04	0.78	2.19	0.68	0.51	0.56	0.36	0.27	0.21	-20.9	0.59	12
Community trademark (CTM) applications per million population	66	114	183	152	278	297	343	399	565	30.0	152	2
Community design (CD) applications per million population	:	2	7	7	5	10	5	14	19	21.1	29	16
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	28.6	:	15.2	:	7.4	:	:	-30.2	14.4	25
Knowledge-intensive services exports as % total service exports	:	12.0	15.4	17.8	14.5	13.4	13.7	11.2	:	-11.0	45.3	28
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	5.07	7.72	7.52	9.46	10.73	9.61	3.21	0.92	3.42	-	4.23 (4)	10
Growth of total factor productivity (total economy): 2007 = 100	100	99	99	100	101	98	99	99	98	-2 (5)	97	8
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	49.7	:	:	:	:	55.3	2.1	51.2	10
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	15.7	15.7	16.0	16.2	17.0	2.0	13.9	5
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	25.9	:	25.0	:	:	-1.9	33.8	22
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.00	0.10	0.13	0.19	0.00	0.12	:	:	:	-19.5	0.44	16
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.00	0.00	0.00	0.06	0.00	0.12	:	:	:	39.5	0.53	20
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	57.2	57.9	57.6	58.5	59.2	58.8	60.1	61.5	63.1	1.5	68.4	22
R&D intensity (GERD as % of GDP)	:	0.55	0.60	0.57	0.55	0.53	0.66	0.71	*0.84*	*8.1*	*2.07*	21
Greenhouse gas emissions: 1990 = 100	130	147	148	154	152	147	150	151	:	-2 (6)	83	28 (7)
Share of renewable energy in gross final energy consumption (%)	:	0.0	0.0	0.0	0.0	0.0	0.2	0.4	:	100.0	35.7	28
Share of population aged 30–34 who have successfully completed tertiary education (%)	7.4	18.3	21.6	21.5	21.1	21.3	21.5	21.4	22.4	0.8	35.7	26
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	*54.2*	33 (8)	33.1	32.7	29.3	28.0	25.9	23.6	22.6	-7.1	12.7	27 (7)
Share of population at risk of poverty or social exclusion (%)	:	20.2	19.1	19.4	19.6	20.2	20.3	21.4	22.2	2.7	24.8	13 (7)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(4) EU is the weighted average of the values for the Member States.
(5) The value is the difference between 2012 and 2007.
(6) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(7) The values for this indicator were ranked from lowest to highest.
(8) Break in series between 2005 and the previous years.
(9) Values in italics are estimated or provisional.

Netherlands

Towards enhanced cooperation between research institutions, businesses and public authorities

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in the Netherlands. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **2.16 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+0.9 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **79.7** (EU: 47.8; US: 58.1) 2007-2012: **+2.9 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **95.5** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **61.0** (EU: 51.2; US: 59.9) 2007-2012: **+0.1 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Food, agriculture and fisheries, ICT, and to a lesser extent, biotechnology, other transport technologies, nanosciences & nanotechnologies, and environment	***HT + MT contribution to the trade balance*** 2012: **0.9 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+24.0 %** (EU: +4.8 %; US: -32.3 %)

In terms of GERD (Gross Domestic Expenditure on R&D), the Netherlands is performing above the EU-28 average (2.16 % of GDP in 2012 of which 1.22 % came from the private sector) including the GBAORD (Government Budget Appropriations or Outlays on R&D) with 0.78 % of GDP. The R&D intensity in the business sector (BERD) is relatively low (1.22 % in 2012), but increasing.

According to the Innovation Union Scoreboard 2014, the Netherlands ranks second amongst the 'innovation followers'. However, the Netherlands is a 'moderate grower' maintaining its level of the 2011 Innovation Union Scoreboard with relative strengths in 'Open, excellent and attractive research systems' and for 'Linkages and entrepreneurship' and relative weaknesses in 'Firm investments' and 'Innovators'.

Further to the main policy response ('To the Top') to the national challenges launched in 2011, the next target for the Netherlands is to restore confidence and harness growth while simultaneously stabilising public finances and supporting the continued balance sheet adjustment at a measured pace. These challenges concern fiscal policy, the pension system, labour market regulation and the housing market. Efforts within fiscal constraints to promote innovation and safeguard growth-enhancing expenditure are key to achieving a balanced adjustment. Gradually improving the housing market at a sustainable pace is a defining element of the strategy. Moreover, additional efforts to reduce regulatory disincentives on labour would make work more attractive. Despite the overall good performance of the Dutch school system, there is a need to address quality and excellence across educational levels, in particular, engineering and technology-related professions that should be addressed.

The current government is continuing with its enterprise policy, including its 'top-sector' approach, and Strategic Agenda for Higher Education and Research (including joint roadmaps, Human Capital Agenda and the Technology Pact). R&I investments in

[1] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

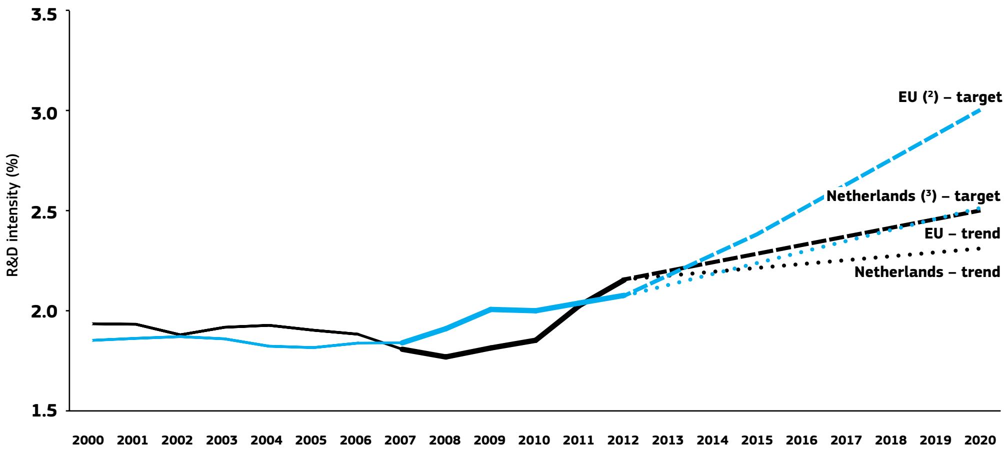
[2] Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

the private sector are being promoted through generic instruments such as tax incentives and financing innovative entrepreneurship through risk capital.

The Dutch R&I system has succeeded in maintaining its innovative capacity during the financial crisis, with high efficiency and effectiveness of public R&D investment, improved S&T excellence from an already high level and the development of hot spots in key technologies, and greater R&D intensity. These efforts are reflected in the competitiveness of the Dutch economy, which is benefiting from a positive contribution by high-tech and medium-tech products to the trade balance. The Dutch economy is very knowledge-intensive and Dutch enterprises – small and medium-sized enterprises (SMEs) in particular – are more innovative in product or process innovation than the EU average.

Investing in knowledge

Netherlands – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2007–2010 in the case of the Netherlands.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) NL: The projection is based on a tentative R&D intensity target of 2.5 % for 2020.
(4) NL: There is a break in series between 2011 and the previous years.

Over the period 2000-2008, Dutch R&D intensity fell from 1.94 % to 1.77 %, largely reflecting a parallel drop in business expenditure on R&D. In contrast, since 2008, the R&D intensity rapidly increased to reach 2.16 % in 2012, initially driven by public expenditure and, since 2011, by business expenditure, too. In spite of this rebound, the Dutch R&I system is still characterised by a relatively low R&D intensity in the business sector against a relatively high R&D intensity within the public sector. In 2012, business R&D intensity (1.22 %) was below the EU average (1.31 %) while public R&D intensity (0.93 %) was higher than the EU average of 0.74 %.

Tax incentives comprise WBSO[3], tax credit for private R&D wage costs, RDA[4] tax allowance for private non-wage R&D investment, and the Innovation Box offering a low tax rate for R&D-related profits. To address capital market shortcomings related to innovative projects and enterprises, the Netherlands has expanded those instruments to increase the availability of risk capital, especially through the Innovation Fund SME+ (innovation credit, seed capital and Fund of Funds) together with the European Investment Fund.

The Netherlands' participation in the EU's Seventh Framework Programme has been successful with an EC contribution of EUR 3.145 billion up to the end of 2013, representing 7.3 % of total EC funding, ranking fifth among the Member States. The success rate was 22.56 %, which is the second highest among participating countries.

3 WBSO – Wet Bevordering Speur- en Ontwikkelingswerk – R&D Promotional Law

4 RDA – Research & Development Aftrek – R&D Deduction

Structural Funds are also an important source of funding for R&I in the Netherlands. Of the EUR 1.6 billion of Structural Funds allocated to the country over the 2007-2013 programming period, around EUR 300 million (18 % of the total) related to RTDI[5].

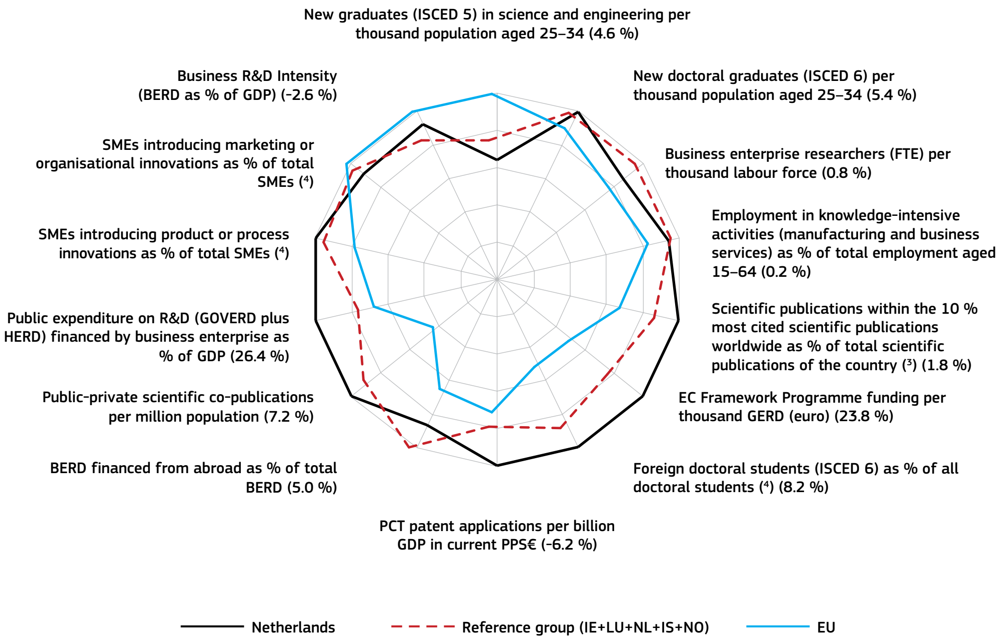
In addition to these challenges, the government announced its National Technology Pact 2020 which involves commitments from both public and private stakeholders. Their representatives from various horizons will ensure this strategy's implementation and foster the innovative capacity of Dutch companies.

An effective research and innovation system building on the European Research Area

The figure below illustrates the strengths and weaknesses of the Netherlands' R&I system providing information on human resources, scientific production, technology valorisation and innovation as well as the average annual growth (manufacturing and business services only) rates in the period 2007-2012.

Netherlands, 2012 (1)

In brackets: average annual growth for Netherlands, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

5 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

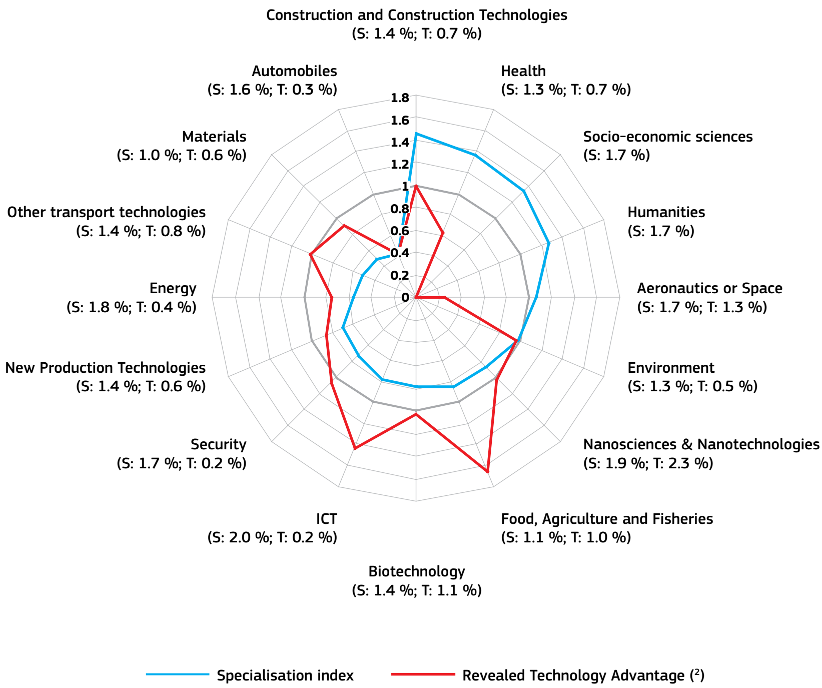
The Netherlands is performing better than the EU average on most S&T indicators and currently ranks first for the number of scientific publications within the 10 % most-cited scientific publications worldwide, a clear sign of the quality of its scientific output. Other areas of marked performance include public-private cooperation, intellectual property, attractiveness for foreign doctoral students, and international cooperation. Furthermore, strong dynamics are visible in the business funding of public research, business innovation expenditure (non-R&D), innovating SMEs, new doctorate holders, and international scientific co-publications.

In contrast, the two main weaknesses of the Dutch innovation system are the relatively weak business R&D intensity and a low level of science and engineering graduates amongst 25-34-year-olds. However, the latest European Patent Organisation (EPO) figures show an increase in patenting activities of 17.2 % in 2013, placing the Netherlands in eighth position worldwide. For the country's future innovation capacity, the government recognises that increasing the number of S&T graduates is an important goal, for which the 'Techniekpact' is instrumental.

The Netherlands' scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where the Netherlands shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. Each specialisation field provides information on the growth rate in the number of publications and patents.

Netherlands – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



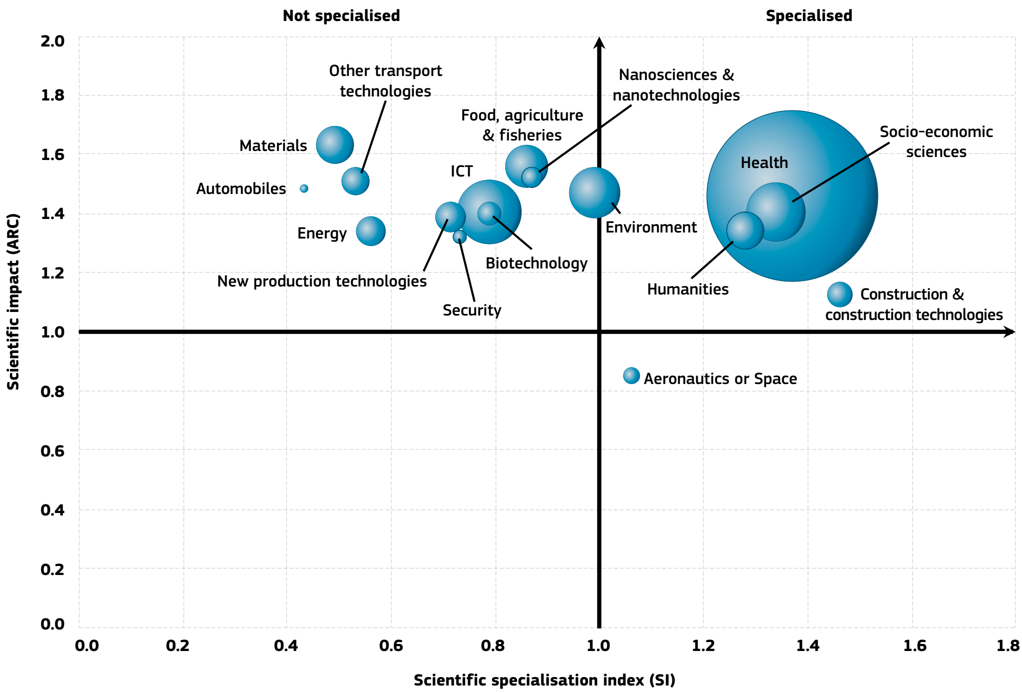
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

The Netherlands has a relative specialisation – either scientific or technological – in most of the selected thematic priorities shown above, in particular in health, socio-economics sciences, food, agriculture and fisheries, ICT, and construction and construction technologies, some of which coincide with the top sectors in the Dutch enterprise policy 'To-the-Top'. The only exceptions are automobiles, energy, and new production technologies.

However, a comparison of the Dutch scientific and technological specialisations in these priorities shows a mixed situation with some co-specialisations as well as some mismatches. Technology production is strongly specialised in food, agriculture and fisheries, and ICT, but also holds strong positions in the environment, nanosciences and nanotechnologies, biotechnology, security, and other transport technologies. In contrast, the main fields of scientific specialisation are construction and construction technologies, health, socio-economic sciences, and humanities and, to a lesser extent, in aeronautics and the environment. The best matches between science and technology specialisations are in environment, and construction and construction technologies, while partial matching can also be seen in nanosciences and nanotechnologies, food, agriculture and fisheries, biotechnology, ICT, and security.

The graph below illustrates the positional analysis of Dutch publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Netherlands – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The Netherlands has a very high level of scientific excellence, as evidenced by the impact of Dutch scientific publications which is clearly above both the EU and world average in all fields except aeronautics. Scientific excellence, in particular, supports the areas of S&T co-specialisation, which include the environment, and construction and construction technologies.

Policies and reforms for research and innovation

In 2013, the Netherlands faced the challenge of widening its innovation capacity and maintaining levels of funding for fundamental research, by providing suitable incentives through its enterprise policies, high-added-value production and services, and an increase in private investments in the R&I system.

Despite a slight growth in business R&D intensity, the numbers of new graduates in science and engineering and doctorates have declined in recent years. The reform undertaken in education should be closely linked to the top-sector strategy and should align the education system to the needs identified by businesses. Several programmes – 'Training for Teachers', Science Acquisition, Technology Pact and Human Capital Agendas, etc. – were set up to meet the needs, but it is too early to assess their results.

In 2014, the government adapted its fiscal innovation instruments to support R&D in order to encourage SMEs and offer more opportunities for growth among the innovative ones. The first of these lies with the WBSO (R&D salary costs) where the ceiling of the top layer is extended from EUR 200 000 to EUR 250 000 (with 50 % off for start-ups) and its tariff reduced from 38 % to 35 %. The other instrument relates to an increase in the percentage of RDA (reduction in R&D costs and investments) to 60 % (compared to 54 % in 2013 and 40 % in 2012). Together with the Innovation Funds (MKB) and other measures (WBSO, Innovation Box), the budget outlays for generic measures will reach more than EUR 2 billion in 2015.

So far, approximately 1800 enterprises have signed up for one or more knowledge and innovation (TKI[6] programmes, of which 70 % are SMEs. The enterprise policy will shift significantly from direct funding by the government to fiscal incentives for R&D. Total R&D funds allocated by the central government will reach EUR 6.400 billion in 2016, of which 52.62 % (as against 48.29 % in 2013) has been allocated to fundamental research and 26 % to fiscal R&D measures. The reduced budget for applied research to 10.72 % reflects the government's choice to provide better incentives to applied research institutes to earn more private funding through public private partnerships.

In addition to the generic instruments, the enterprise policy also uses specific policies delivered through the nine top sectors: chemicals, creative industry, logistics, health, high-tech, agro-food, water, energy, and horticulture. Primarily, these sectors serve as a coordination mechanism for public private partnerships (PPPs), linking knowledge, industry and government. These PPPs are served through 19 top consortia for TKI aimed at societal and business needs. To stimulate private contributions, the government grants TKI allowances (25 % of private contributions), and to encourage involvement from SMEs, the MIT[7] scheme provides several instruments, such as innovation vouchers, targetting SMEs' needs.

Through the signed 'innovation contracts' for 2014/2015, top sector stakeholders promised an annual research investment of almost EUR 2 billion (of which about EUR 970 million is provided by the private partners (enterprises) and EUR 1.06 billion by public investments). These innovation contracts – a mixed balance between fundamental research, applied research and valorisation – were tailored to the market needs and aligned to most thematic topics in the EU's Framework Programmes and Horizon 2020. For the period 2014-2017, an annual budget of EUR 50 million (JTI, Eurostars) and EUR 36 million for other programmes (e.g. ERA-net) has been agreed.

The TKIs have a goal of EUR 500 million in public-private research in 2015 with at least 40 % financed by private partners. This means a significant increase compared to the 10 to 35 % of private contributions to PPP programmes before 2012. From 2013 onwards, the cabinet will raise the TKI-allowance budget from EUR 56 million to EUR 130 million in 2017. The limited cooperation between enterprises and research institutions is addressed by part of the programmes for fundamental research in line with top-sector topics, while maintaining research excellence. To this end, NWO (The Netherlands Organisation for Scientific Research) will allocate an increasing amount (up to EUR 275 million in 2015) to those topics from various NWO instruments, while the Dutch ministries will contribute EUR 59.1 million to relevant TKI programmes to provide solutions to societal challenges.

Emerging skill shortages and mismatches, especially in engineering and technology, have been identified and represent a bottleneck for growth. Therefore, and in view of the European 2020 objectives, a 'Technology Pact' was signed in 2013 to complement the top sector's 'Human Capital Agendas'. For education and academic quality achievements, the budget will be raised to EUR 245 million in 2016, in addition to EUR 100 million to reward best universities' and colleges' performances. The 'Policy on Science' and the 'Science in Transition' programmes were also set up to leverage the shortage of skilled workers, but it would be premature to monitor their impacts at present.

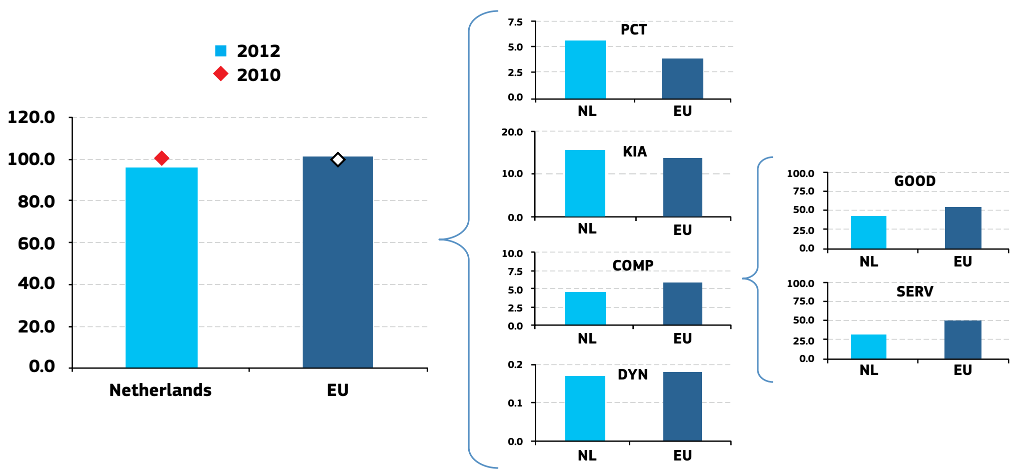
6 TKI – Topconsortia voor Kennis en Innovatie

7 MIT – MKB-Innovatiestimulering Topsectoren

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in fast-growing firms in innovative sectors). The graph below enables a comparison of the Dutch position regarding the indicator's different components.

Netherlands – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

The Netherlands is a medium performer in the European innovation indicator although its performance declined in the period 2010-2012. The relatively good performance in patents is partially explained by the strong electric products and electronics sector, with the Dutch companies Philips, NXP and ASML ranking among the largest patent producers in Europe[8].

The share of medium-high and high-tech goods in total goods exports is below the EU average, partly due to the relatively high exports of agricultural products and of natural gas, not listed as high- and medium-tech products. The relatively low performance in knowledge-intensive service exports can be explained by the very high level of licence fees and royalties, which are not classified as KIS, although they employ highly skilled labour.

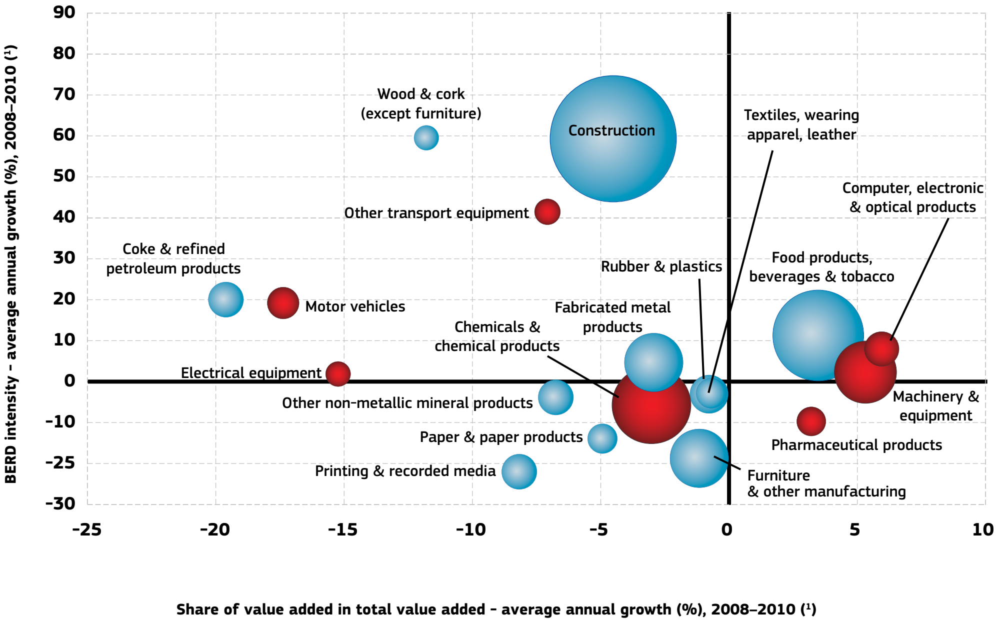
The Netherlands performs below the EU average in terms of the innovativeness of its fast-growing companies, which results from a high share of wholesale and retail trades, and administrative and support service activities among fast-growing enterprises.

8 The Netherlands also performs well in Community trademarks and designs.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech (HT) or medium-high-tech (MHT) sectors.

Netherlands – Share of value added versus BERD intensity: average annual growth, 2008–2010 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Furniture and other manufacturing': 2008–2011.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

Most manufacturing sectors contracted during the initial phase of the crisis (2008-2010), with the exception of food products, beverages and tobacco and of three HT and MHT sectors (pharmaceuticals; machinery and equipment, and computer, electronic and optical products). In comparison with the 1995-2007 period, during which all HT and MHT sectors had become more R&D intensive, the BERD intensity of pharmaceuticals and of chemicals and chemical products decreased between 2008 and 2010. Conversely, other sectors, in particular construction, substantially increased their R&D intensity. Overall, total BERD over GDP remained constant during 2008-2010 but the manufacturing sector as a whole became slightly more R&D intensive.

Key indicators for the Netherlands

NETHERLANDS	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	1.00	1.32	1.41	1.54	1.60	1.65	1.87	1.85	2.00	5.4	*1.81*	10
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	531	:	:	526	:	:	523	-7.7 (3)	495 (4)	1 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	1.07	1.01	1.01	0.96	0.89	0.85	0.89	1.14 (5)	*1.22*	*-2.6*	1.31	10
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.85	0.90	0.87	0.85	0.88	0.96	0.97	0.89	*0.94*	*2.0*	*0.74*	5
Venture capital as % of GDP	0.46	0.46	0.44	0.49	0.29	0.13	0.22	0.35	0.21	-15.4	0.29 (6)	7 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	69.1	:	:	:	:	79.7	2.9	47.8	3
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	14.5	14.6	15.1	15.2	15.6	:	:	:	1.8	11.0	1
International scientific co-publications per million population	:	898	979	1044	1100	1203	1288	1359	1457	6.9	343	4
Public–private scientific co-publications per million population	:	:	:	97	101	106	117	128	:	7.2	53	3
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	7.4	7.1	7.0	6.6	6.5	6.3	5.4	:	:	-6.2	3.9	5
License and patent revenues from abroad as % of GDP	0.56	1.60	1.52	1.75	2.25	2.61	3.16	3.70	4.01	18.0	0.59	1
Community trademark (CTM) applications per million population	92	139	172	192	196	238	229	234	237	4.3	152	8
Community design (CD) applications per million population	:	47	45	45	52	54	48	49	54	3.7	29	5
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	10.9	:	8.9	:	10.4	:	:	8.6	14.4	19
Knowledge-intensive services exports as % total service exports	:	37.3	35.2	33.9	32.4	30.7	26.3	28.8	:	-4.0	45.3	17
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-1.48	-0.04	-0.13	0.30	0.01	0.25	0.49	1.68	0.88	-	4.23 (7)	18
Growth of total factor productivity (total economy): 2007 = 100	93	97	98	100	100	96	98	98	97	-3 (8)	97	14
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	60.8	:	:	:	:	61.0	0.1	51.2	4
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	16.5	15.4	15.2 (9)	14.9	15.2	0.2	13.9	10
SMEs introducing product or process innovations as % of SMEs	:	:	32.9	:	31.6	:	44.5 (10)	:	:	-	33.8	4
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.41	0.33	0.48	0.47	0.50	0.54	:	:	:	6.9	0.44	6
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.97	0.90	1.11	0.85	0.89	0.93	:	:	:	4.3	0.53	4
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	74.3	75.1	76.3	77.8	78.9	78.8	76.8 (9)	77.0	77.2	0.3	68.4	2
R&D intensity (GERD as % of GDP)	1.94	1.90	1.88	1.81	1.77	1.82	1.86	2.03 (5)	*2.16*	*0.9*	*2.07*	10
Greenhouse gas emissions: 1990 = 100	103	102	100	99	99	96	101	95	:	-5 (11)	83	17 (12)
Share of renewable energy in gross final energy consumption (%)	:	2.1	2.3	3.0	3.2	4.0	3.7	4.3	:	9.4	13.0	24
Share of population aged 30–34 who have successfully completed tertiary education (%)	26.5	34.9	35.8	36.4	40.2	40.5	41.4 (10)	41.1	42.2	1.0	35.7	11
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	15.4	13.5	12.6	11.7	11.4	10.9	10.0 (10)	9.1	8.8	-6.2	12.7	10 (12)
Share of population at risk of poverty or social exclusion (%)	:	16.7	16.0	15.7	14.9	15.1	15.1	15.7	15.0	-0.9	24.8	1 (12)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2011 and the previous years. Average annual growth refers to 2007–2010.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) Break in series between 2010 and the previous years. Average annual growth refers to 2010–2012.
(10) Break in series between 2010 and the previous years.
(11) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(12) The values for this indicator were ranked from lowest to highest.
(13) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Protect expenditure in areas directly relevant for growth, such as education, innovation and research."

Poland

Improving the quality of the science base and fostering innovation in enterprises

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Poland. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance			
R&D intensity		***Excellence in S&T***[1]	
2012: **0.90 %**	(EU: 2.07 %; US: 2.79 %)	2012: **20.0**	(EU: 47.8; US: 58.1)
2007-2012: **+9.7 %**	(EU: 2.4 %; US: 1.2 %)	2007-2012: **+9.8 %**	(EU: +2.9 %; US: -0.2)
Innovation Output Indicator		***Knowledge-intensity of the economy***[2]	
2012: **81.4**	(EU: 101.6)	2012: **34.8**	(EU: 51.2; US: 59.9)
		2007-2012: **+1.5 %**	(EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations:		***HT + MT contribution to the trade balance***	
Food, agriculture and fisheries, construction, transport, environment, and materials		2012: **0.6 %**	(EU: 4.23 %; US: 1.02 %)
		2007-2012: **+14.7 %**	(EU: +4.8 %; US: -32.3 %)

Since 2007, Poland has increased its investment in R&D and improved its excellence in science and technology, while focusing on key technologies relevant to industry. The economy has been undergoing structural change towards higher knowledge intensity (an average growth of 1.5 % in 2007-2012) and Poland's global competitiveness is improving at a higher rate than the EU average. Poland scores below average in the Innovation Output Indicator although Polish innovation performance has improved over the last decade. Moreover, the country is still lagging behind the EU average in terms of investment, scientific excellence and knowledge-intensity in the economy, thus leaving room for further progress, illustrated by the ambitious Polish R&D intensity target for the Europe 2020 strategy (1.7 % of GDP by 2020).

Persistently low R&D spending, in particular severe under-investment in R&I in the private sector, and limited in-house technological innovation call for giving way to a new approach targeting different stages of the innovation cycle with well-designed incentives and effective support through public funding, including increased public-private cooperation. Poland has acknowledged the need for this new approach and over the last few years the Polish R&D system has undergone major restructuring. Reforms in the science and higher education systems (2010-2011) introduced significant changes, including the move towards more competitive funding and increased cooperation between science and industry. A major policy document – the Strategy for Innovation and Effectiveness of the Economy 2020 (SIEG) – was adopted in 2013 and focused on stimulating innovativeness and addressing key challenges in the R&D&I system, including stimulation of private expenditure on R&D, internationalisation and genuine innovation. Together with other documents, such as its executive programme PRP (Enterprise Development Programme), the National Smart Specialisation Strategy, the Operational Programmes 'Smart Growth' and 'Knowledge, Education, Development'), those

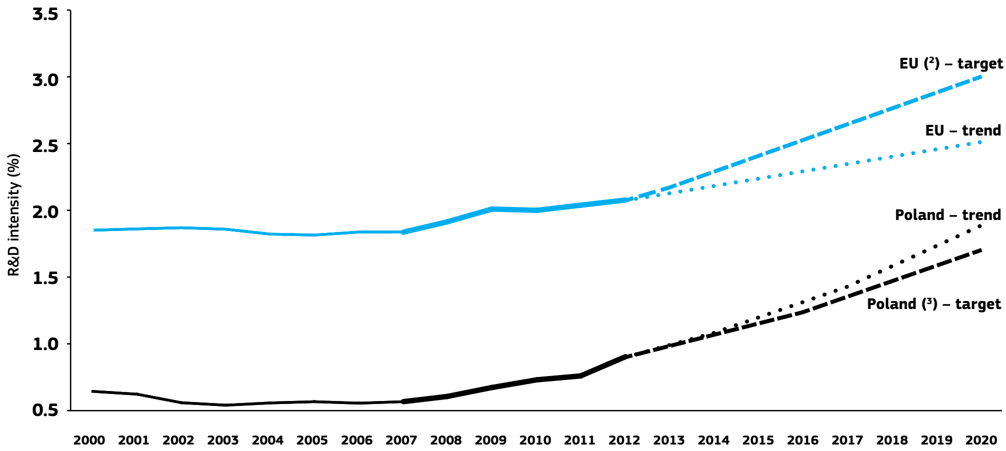
1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

policy developments form a coherent approach towards building a more effective R&I ecosystem. It remains to be seen if Poland will successfully move from the strategic level to the systemic and coordinated implementation of measures, which is required to ensure a visible improvement in the innovativeness of Polish companies as well as to maintain sustainable high growth of the economy.

Investing in knowledge

Poland – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) PL: The projection is based on a tentative R&D intensity target of 1.7 % for 2020.

Poland's R&D intensity experienced an average annual growth of 9.7 % between 2007 and 2012, reaching 0.9 % of GDP in 2012 (20th position in the EU). The average annual increase required to hit the ambitious Polish target of 1.7 % by 2020 is slightly lower but is still challenging at 8.3 %. The main weakness remains under investment by the private sector with business R&D expenditure accounting for only 0.33 % of GDP (23rd place within the EU). However, actual R&D expenditure by Polish firms may be underestimated due to the lack of appropriate incentives for businesses to report them. Since the existing tax incentives for R&D, only used by a limited number of big companies, are ineffective in inducing genuine innovations by Polish companies, a reassessment of these tax incentives is needed in view of increasing their effectiveness.

The breakdown of total R&D expenditure by funding source and performance sector illustrates the opposite picture when compared to the EU average. The government remains the main source of R&D funding, contributing 51.3 % of GERD, well above the EU average of 33.4 %. The share of R&D financed and performed by business enterprises declined slightly over the 2000-2010 period before starting to rise again since 2011. In 2012, private businesses performed 37.2 % of total R&D (compared to the significantly higher EU average of 63 %) while the government performed 27.96 % of total R&D (compared to the EU average of 12 %). These indicators do not reflect efforts recently undertaken to increase public R&D spending and trigger private-sector investment in R&D.

Structural Funds are an important source of funding for R&I activities. Of the EUR 67 billion of Structural Funds allocated to Poland over the 2007-2013 programming period, around EUR 9.4 billion (14 % of the total) related to RTDI[3]. As regards the

[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

EU's Seventh Framework Programme (FP7) signed grant agreements, Poland ranks 13th in number of applicants and 15th in terms of requested EC contributions. Almost 2150 partners from Poland have participated in FP7, receiving EC financial contributions of over EUR 392 million.

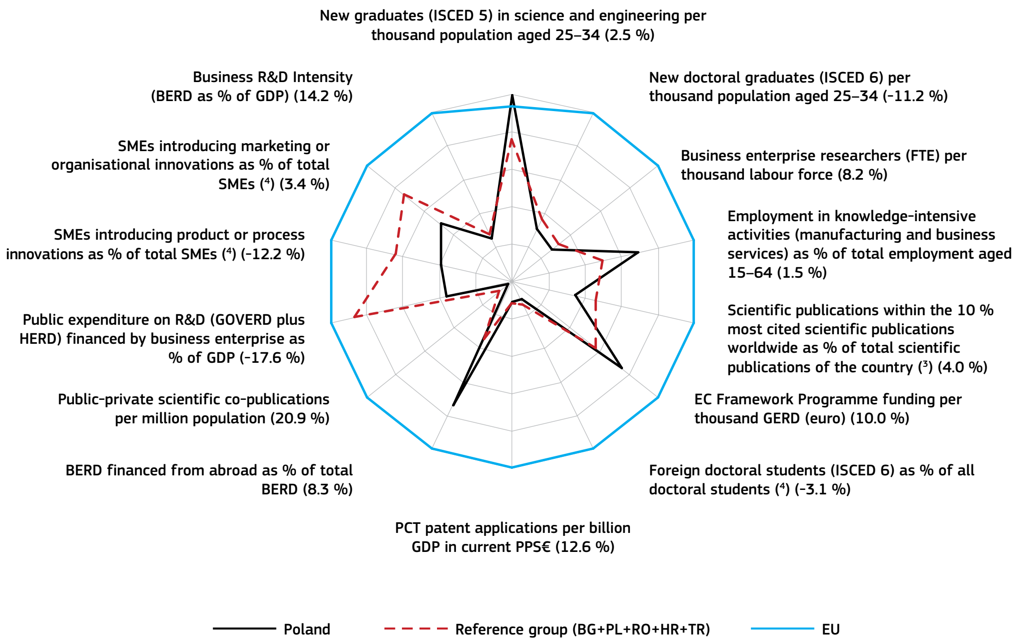
Given Poland's low level of participation in FP7 (19th in terms of applicants' success rate and 21st in terms of the success rate in financial contributions), clearly there are new opportunities available for Poland to engage in partnership with established centres of R&I excellence.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Polish R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Poland, 2012 (1)

In brackets: average annual growth for Poland, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The Polish R&I system is primarily public-based with only 37.2 % of research being performed by the business sector (the EU average is 63 %). Poland's relative weaknesses are mainly on the output side and relate to the private sector's innovation performance. Its relative strengths are pronounced in human resources, where the average annual growth of new graduates in science and engineering exceeds the EU average. However, the number of new doctoral graduates and foreign doctoral students shows a significant decline (-11.2 % over the 2007-2012 period for new doctoral graduates). Poland has a low intensity of business researchers which reflects the minor role the business sector plays in the national R&I system. On a more positive note, the number of business researchers increased in 2012, showing a positive average annual growth over the 2007-2012 period.

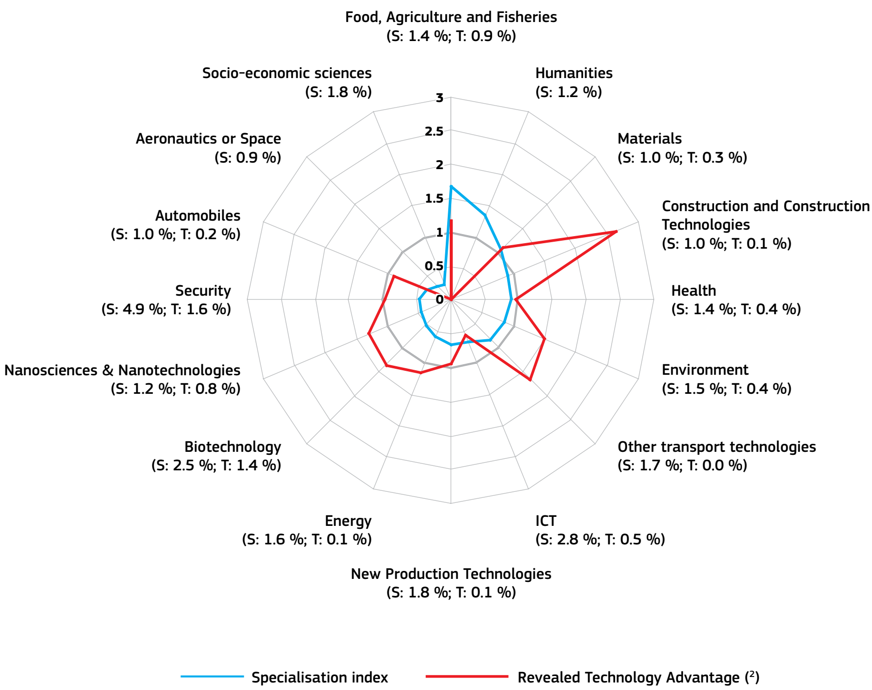
Poland relies on foreign technology transfers to upgrade its economy. Domestic knowledge production is limited, and it has low scores in terms of both high-impact scientific publications and patent applications, where the difference from the EU average is particularly large. Only around 4 % of Polish scientific publications qualify for the top 10 % of most-cited scientific publications worldwide. This is the third lowest ranking among EU countries. The level of public-private co-publications is equally very low, highlighting weak linkages and a lack of cooperation culture between science and industry. While Poland performs better than other countries in the reference group in relation to the level of employment in knowledge-intensive activities, this indicator remains one of the lowest in the EU. High growth is observed for business R&D intensity, PCT patent applications and BERD financed from abroad. An alarming decline can be seen in all the innovation activities performed by small and medium-sized enterprises (SMEs): the percentage of SMEs introducing a new product or process is falling significantly. The same trend is observed for public expenditure on R&D financed by businesses.

Overall, business enterprises' low level of R&D expenditure and low R&D and innovation activity, coupled with insufficiently favourable framework conditions, has resulted in a poor scientific and technological performance.

Poland's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Poland shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Poland – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

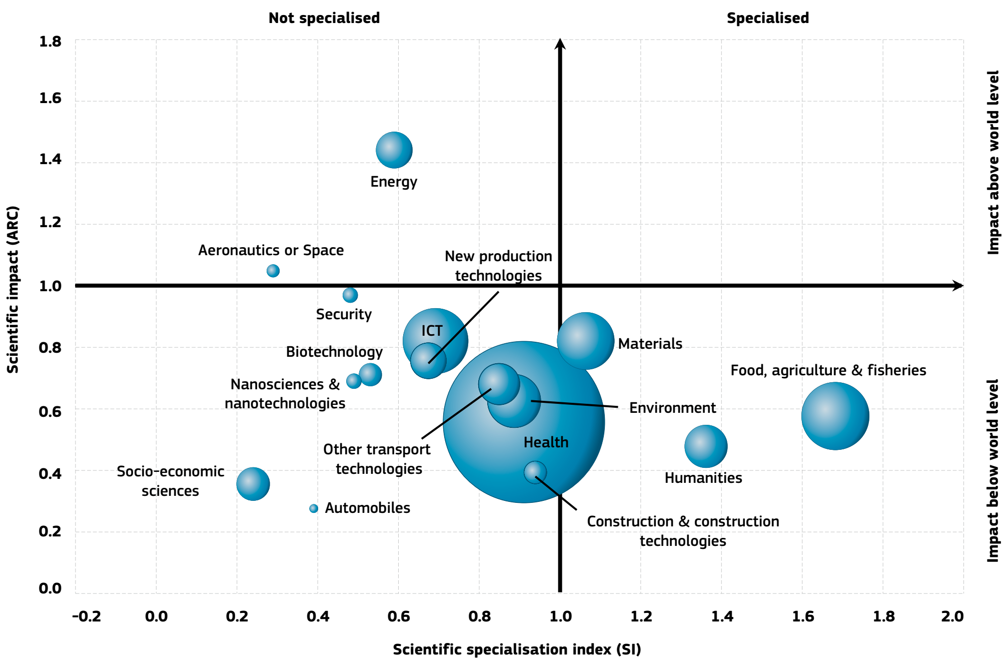
Comparison of the scientific and technological specialisation in selected thematic priorities shows a mixed situation with some co-specialisations as well as some mismatches. The technology production is strongly specialised in construction and construction technologies, transport, environment, biotechnology, nanosciences/nanotechnologies, and energy. However, no corresponding scientific specialisation can be found for those fields, with the exception of the science base in construction. These sectors mainly correspond to the scientific and economic fields identified in two national strategic documents in the area of research, development and innovation: the National Research Programme (KPB) and InSight2030 which formed the starting point for determining smart specialisation strategies at the national level.

Poland's scientific specialisation index shows that the main scientific fields are food, agriculture and fisheries, as well as humanities, and materials. In food, agriculture and fisheries, materials, and health, Polish technology production is quite important – these are the sectors with the corresponding matching between science and technology specialisations. The recently drafted Polish Smart Specialisation Strategy identifies 18 national smart specialisations in five thematic areas, which include sectors with important innovation potential: healthy society, bio-economy in the agri-food processing and environment, sustainable energy, natural resources and waste management, and innovative technologies and industrial processes.

Poland, together with Bulgaria, Romania, Turkey and Croatia, is classified as a low-knowledge-capacity system with a specialisation in low-knowledge intensity[4].

The graph below illustrates the positional analysis of Polish publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Poland – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

[4] Source: Innovation Union Competitiveness report

There is a room for scientific impact improvement in some of the sectors ranking high on the science specialisation index, i.e. food, agriculture and fisheries, materials, construction, and humanities (for which a strong level of co-specialisation in S&T has also been identified). It is interesting to note the high level of scientific excellence attained in energy, while this sector has a low scientific specialisation indicator. Taking into account Polish technological specialisation in this field, the country would probably benefit from fostering scientific specialisation in energy.

The excellence in research correlates to more cooperation with researchers from other European countries and beyond. Therefore, in order to increase its research excellence, Poland would benefit from actively supporting and providing incentives for its researchers to connect to Horizon 2020 networks. Considering its share of grants by FP7 fields, there is room for improvement, for instance, in the ICT sector. The availability of significant Structural Funds during the 2007-2013 period tended to reduce the attractiveness of participation in highly competitive European research programmes. Through the new financial perspective (2014-2020), more support instruments will enhance the participation of Polish applicants in international projects. The Operational Programme 'Smart Growth' includes instruments ensuring the complementarity of Polish R&D funding with Horizon 2020 and plans to support the preparation of applications in the Horizon 2020 and COSME programmes.

Policies and reforms for research and innovation

The challenges of increasing the quality and effectiveness of the Polish R&I system and linking science and industry have been addressed by reforms in higher education and science (2010-2011) which spurred significant changes, including a move towards more competitive funding schemes. In 2013, the Committee for Evaluation of Scientific Institutions (KEJN), an advisory body set up in 2010, conducted its first nationwide evaluation of scientific institutes by defining the levels of institutional funding on the basis of several criteria, including technology transfers to industry and collaborative projects. The Polish government has declared that by 2020 it will distribute 50 % of its entire science budget through competitive mechanisms. However, already in 2013, 44.1 % of all science funds were allocated through competitions (as against 30.9 % in 2007), which was largely due to the performance-based funding allocated by NCN[5] (a basic research executive agency established in 2010) and NCBiR[6] (an applied research executive agency established in 2007 and reinforced by the above-mentioned reforms).

Projects run by the NCBiR are successful in inducing substantial new investment in private R&D by focusing on the stimulation of science-industry cooperation and supporting the commercialisation of R&D. Recent initiatives, such as BRIdge VC, Bridge Alfa or DEMONSTRATOR+, the so-called 'fast-track support scheme', induce the use of financial instruments, venture capital funds, and enhance the transfer of research results to the economy. The sectoral programmes (INNOLOT, INNOMED) have been very successful in fostering cooperation within industry and between industry and academia. Further measures to encourage innovation, such as increasing the role of scientists in the process of knowledge commercialisation, and better matching the higher education system to business needs are foreseen in recently proposed amendments to the Acts on Higher Education and on the Principles of Financing Science. In addition, already adopted amendments to the Act on public procurement have relaxed the binding restrictions on R&D services, and the first project supporting the use of pre-commercial procurement by the Polish public administration was launched by NCBR in July 2013. Thirty 'brokers of innovation' selected during the first competition launched by the Ministry of Science and Higher Education (September 2013) will deal with the commercialisation of research, the creation of spin-off companies and the conclusion of licence agreements. The second edition of the competition for the Polish KNOW (National Leading Scientific Centres) is ongoing in parallel with the Top 500 innovators initiative which aims to improve the technology transfer skills of researchers and professionals. To strengthen the technology transfer of universities and public research organisations, in 2013, the ministry launched the 'Innovation Incubators' programme and the NCBiR launched the SPIN-TECH programme.

New policy documents are directed at boosting indigenous local innovation by Polish companies. In January 2013, the 'Strategy for the Innovation and Effectiveness of the Economy' (SIEG), the country's main document setting out its R&I policy priorities, was adopted. By addressing significant weaknesses within the Polish R&I system, the most important being the innovative output, the new innovation strategy foresees greater emphasis on financial engineering and demand-side measures. Its executive programme PRP introduces the proposition

5 The National Science Centre

6 The National Centre for Research and Development

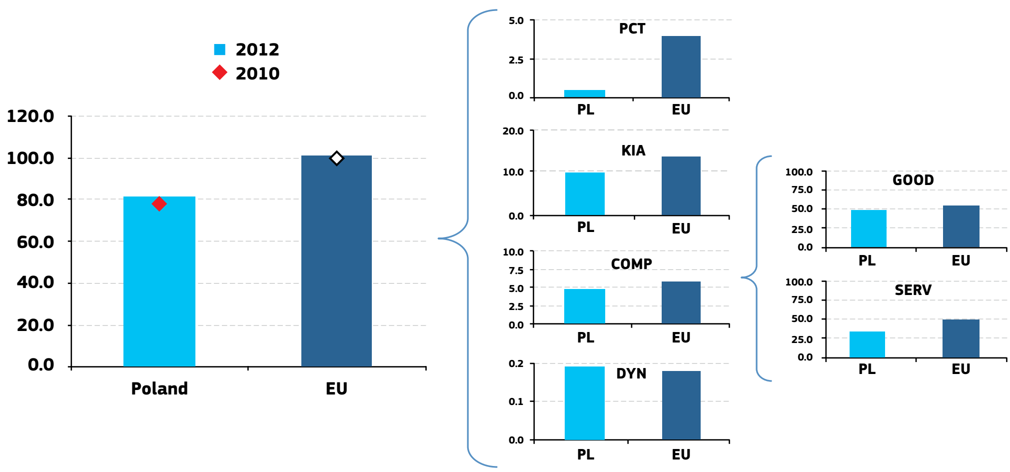
of tax incentives for innovative companies[7] and proposes adequate instruments for different phases of the innovation cycle, i.e. grants for projects with a higher risk level and financial instruments to help with implementation and internationalisation stages. The Smart Growth OP, adopted by the government in January 2014, will implement the PRP. With the proposed budget of EUR 8.6 million for R&D, it will focus on the development of in-house innovations "from idea to market", covering the entire innovation cycle, and on the business funding of R&D via financial instruments, such as loans, public guarantees and PPPs with venture capital funds. Until now, risk aversion remains a significant problem for participants in the Polish R&I system with only 30 % of entrepreneurs using outside funding, with conservative selection panels, and grants remaining the predominant source of funding even for less-risky projects. Together with the National Strategy for Smart Specialisation (KIS), which forms an integral part of the PRP, new policy documents aim at streamlining and prioritising the support measures and enhancing innovation, and will be used as the basis for supporting R&I in the period 2014-2020.

Raising the innovativeness of Polish companies and strengthening science-industry cooperation has been a long-standing challenge for which different policy responses have been proposed in recent years. Strategically, Poland is addressing those challenges well. The way forward would be to fully implement these innovation-oriented reforms and conduct the systematic evaluation of policies to determine whether and how policy interventions can achieve the desired change.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Poland's position regarding the indicator's different components:

Poland – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

[7] The introduction of tax relief for R&I is foreseen following the removal of Poland's excessive deficit procedure.

Improving the economic impact of innovation remains one of the main challenges for the Polish R&I system. Poland is a below average performer in the Innovation Output Indicator, even though its performance has clearly been improving since 2010. A very low performance in patents (PCT) is linked to the still overall limited research capacity, the low level of internationalisation of the science sector as well as to the Polish economic structure, which is characterised by businesses' limited investment and innovativeness. There is a lack of large Polish multinational manufacturing companies, and the international companies, including motor-vehicle producers, which have production facilities in Poland tend to do their research and patenting in the headquarter country.

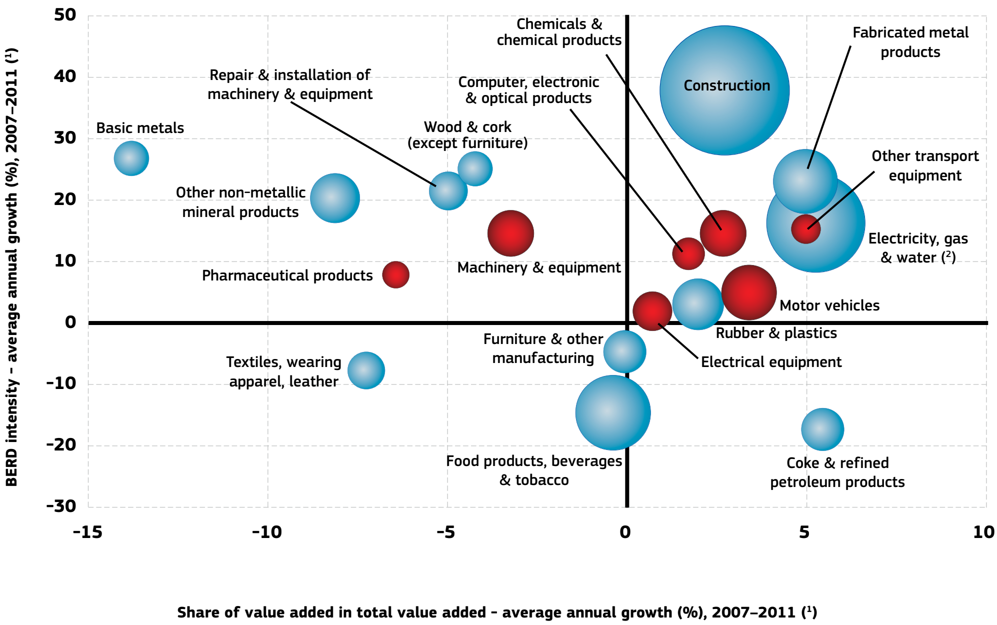
The importance of employment in agriculture and construction to the Polish economy contributes a low share of employment in knowledge-intensive activities (KIA). In addition, the low share of knowledge-intensive service exports (SERV) is explained by relatively high exports of non-KIS transport services (mainly road freight transport, but also pipelines) and construction services, not compensated by any strongholds in KIS exports. Poland performs above the EU average in the innovativeness of fast-growing innovative firms (DYN). This is the result of a high share of the financial services sector among fast-growing firms.

There is strong awareness of those challenges at national level and support mechanisms have been launched to encourage science-industry cooperation and foster the innovativeness of Polish companies. The new Strategy for the Innovation and Effectiveness of the Economy is aiming for an integrated approach to R&I embedded in a wider economic context.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries for the period of 2007-2011. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Poland – Share of value added versus BERD intensity: average annual growth, 2007–2011 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Electricity, gas and water', 'Wood and products of wood and cork': 2007–2010; 'Coke and refined petroleum products', 'Furniture and other manufacturing': 2008–2011.
(2) 'Electricity, gas and water' includes 'sewerage, waste management and remediation activities'.
(3) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

Comparison of the positioning of the high-tech or medium-tech sectors for 2007-2011, with their previous positioning illustrated in the 2013 country profile for the years 1995-2007, shows a clear increase in the R&D intensities in all the research-intensive sectors: machinery and equipment, chemicals and chemical products, motor vehicles, electrical machinery and apparatus, medical precision and optical instruments. For numerous sectors (with the exception of machinery and equipment and pharmaceutical products) this shift was accompanied by an increasing share of value added in the overall economy. This finding suggests that Poland is moving towards more research-intensive, higher-value-added products in high-tech and medium-tech industries. However, with the exception of motor vehicles, the share of those sectors (in value added) in manufacturing is not gaining any special importance.

Poland's economic structure is still dominated by less research-intensive sectors, mainly construction, fabricated metal products, and electricity, gas and water. The visible increase in Polish business R&D intensity, especially for construction, basic metals, wood and cork, fabricated metal products, repair and installation of machinery and equipment, furniture and other manufacturing, reflects the economy's continuous reliance on the country's traditional sectors.

The above economic structure is reflected in the sectors of activity of the top Polish corporate R&D investors. Poland has four out of 1000 companies analysed in the 2013 EU Industrial R&D Investment Scoreboard, coming from the fields of telecommunications, banking, software and computers. Overall, the relatively stable sectoral composition of Polish industry around low research-intensive sectors reflects the country's comparative weaknesses in terms of R&I performance.

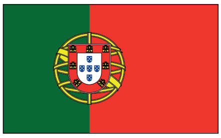
Key indicators for Poland

POLAND	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	:	1.00	1.01	1.02	0.92	0.82	0.53	0.48	0.56	-11.2	*1.81*	26
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	495	:	:	495	:	:	518	22.1 (3)	495 (4)	4 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.23	0.18	0.18	0.17	0.19	0.19	0.20	0.23	0.33	14.2	1.31	23
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.41	0.39	0.38	0.39	0.42	0.48	0.54	0.53	0.56	7.4	*0.74*	16
Venture capital as % of GDP	0.11	0.06	0.11	0.14	0.20	0.15	0.14	0.19	0.14	0.3	0.29 (5)	11 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	12.5	:	:	:	:	20.0	9.8	47.8	24
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	3.5	3.5	3.5	3.4	3.8	:	:	:	4.0	11.0	24
International scientific co-publications per million population	:	178	189	192	194	206	205	215	226	3.3	343	25
Public–private scientific co-publications per million population	:	:	:	2	3	3	4	5	:	20.9	53	26
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.3	0.2	0.3	0.3	0.4	0.5	0.5	:	:	12.6	3.9	22
License and patent revenues from abroad as % of GDP	0.02	0.02	0.01	0.02	0.04	0.02	0.05	0.05	0.05	14.9	0.59	21
Community trademark (CTM) applications per million population	0.8	20	25	33	42	41	46	51	56	10.9	152	23
Community design (CD) applications per million population	:	7	10	14	17	23	21	25	27	14.3	29	13
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	10.1	:	9.8	:	8.0	:	:	-9.8	14.4	23
Knowledge-intensive services exports as % total service exports	:	22.6	23.2	22.2	24.5	26.1	26.1	28.3	:	6.2	45.3	18
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-5.74	-1.99	-0.93	-0.39	0.34	0.45	0.37	0.88	0.58	-	4.23 (6)	19
Growth of total factor productivity (total economy): 2007 = 100	86	96	98	100	100	99	100	101	101	1 (7)	97	3
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	32.2	:	:	:	:	34.8	1.5	51.2	23
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	8.2	8.9	9.4 (8)	9.6	9.7	1.5	13.9	24
SMEs introducing product or process innovations as % of SMEs	:	:	20.4	:	17.5	:	13.5	:	:	-12.2	33.8	27
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.00	0.03	0.01	0.03	0.06	0.06	:	:	:	29.3	0.44	19
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.03	0.05	0.04	0.06	0.06	0.06	:	:	:	-1.2	0.53	24
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	61.0	58.3	60.1	62.7	65.0	64.9	64.3 (8)	64.5	64.7	0.3	68.4	19
R&D intensity (GERD as % of GDP)	0.64	0.57	0.56	0.57	0.60	0.67	0.74	0.76	0.90	9.7	*2.07*	20
Greenhouse gas emissions: 1990 = 100	84	85	89	89	88	83	88	88	:	-2 (9)	83	14 (10)
Share of renewable energy in gross final energy consumption (%)	:	7.0	7.0	7.0	7.9	8.8	9.3	10.4	:	10.4	13.0	18
Share of population aged 30–34 who have successfully completed tertiary education (%)	12.5	22.7	24.7	27.0	29.7	32.8	34.8	36.5	39.1	7.7	35.7	15
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	5.3	5.4	5.0	5.0	5.3	5.4	5.6	5.7	2.7	12.7	5 (10)
Share of population at risk of poverty or social exclusion (%)	:	45.3	39.5	34.4	30.5 (11)	27.8	27.8	27.2	26.7	-3.3	24.8	17 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) Break in series between 2010 and the previous years. Average annual growth refers to 2010–2012.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2012.
(12) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Improve the effectiveness of tax incentives in promoting R&D in the private sector as part of the efforts to strengthen the links between research, innovation and industrial policy, and better target existing instruments at the different stages of the innovation cycle."



Portugal

The challenge of fostering a more knowledge-intensive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Portugal. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.50 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **-0.1 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **27.3** (EU: 47.8; US: 58.1) 2007-2012: **+3.7 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **70.1** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **42.6** (EU: 51.2; US: 59.9) 2007-2012: **+2.3 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Security, ICT, materials, new production technologies, and other transport technologies	***HT + MT contribution to the trade balance*** 2012: **-0.3 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

Portugal has expanded its R&I system over the last decade, increasing its investment in research at a remarkable average annual real-growth rate of 7 % between 2000 and 2007. However, after 2009, R&D followed the overall macroeconomic trend and R&D intensity decreased by an average of 0.1 % from 2007 to 2012. Public expenditure on R&D was maintained at 0.68 % of GDP in 2012, despite the economic crisis. Business enterprise expenditure on R&D (BERD) as a % of GDP increased from 0.6 % in 2007 to 0.7 % in 2012.

Portugal has also shown significant progress in the number of new doctoral graduates per thousand population aged 25-34 years, and in the share of researchers in the labour force. These evolutions have had a positive impact on scientific production and excellence. However, despite the progress observed in recent years in R&D expenditure in the business sector and the large increase in the total number of researchers, Portugal remains below the EU average in terms of public-private cooperation, knowledge transfer and employment in knowledge-intensive activities.

Ensuring the sustainability of the R&I system, focusing on a set of priority research fields, stimulating the emergence of new companies, particularly in knowledge-intensive activities, and strengthening the in-house technological, organisational and marketing capabilities of small and medium-sized enterprises (SMEs) are some of the main challenges facing the Portuguese R&D system.

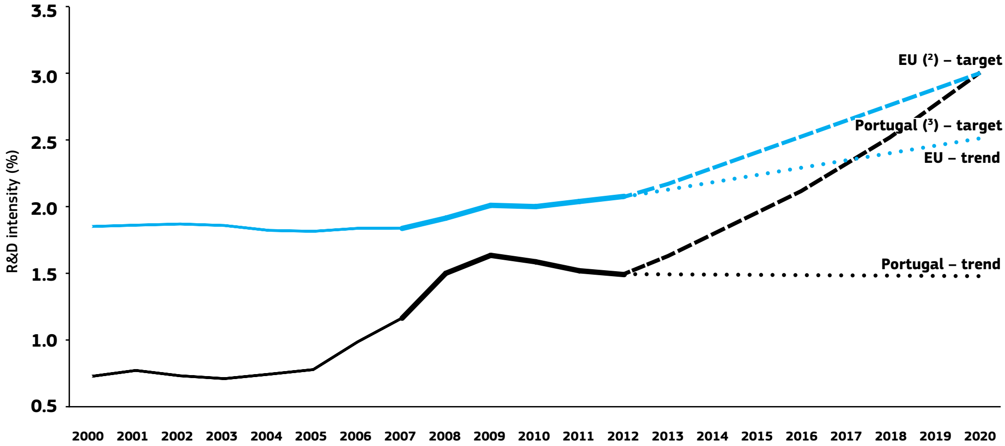
New initiatives, such as the System of Tax Incentives for Companies Investment in R&D (SIFIDE), the role of the Innovation Agency (AdI), the SWOT analysis of the country's R&D system, the Programme of Applied Research and Techno Transfer to Companies, or the reorientation of the cluster policy, aim to adequately support the structural change needed by the country to improve its productivity and competitiveness.

[1] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

[2] Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

Investing in knowledge

Portugal – R&D intensity projections: 2000–2020 (¹)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (¹) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2008–2012 in the case of Portugal.
(²) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(³) PT: The projection is based on a tentative R&D intensity target of 3.0 % for 2020.
(⁴) PT: There is a break in series between 2008 and the previous years.

Portugal has set a national R&D intensity target for 2020 of 3 %, where public-sector R&D intensity would reach 1 % and business R&D intensity 2 %. From 2005 up to the crisis years, Portugal made very significant progress towards the R&D intensity target. However, after 2009, R&D followed the overall macroeconomic trend, and by 2012, public-sector R&D intensity was 0.68 % and business R&D intensity 0.70 %.

Therefore, the main challenge for Portuguese R&D is to ensure the sustainability of the R&I system, to increase the share of business R&D investment in total national R&D investment, and to attract foreign business R&D investment. Business R&D investment reached its highest level in 2009 in both absolute and relative terms after some years of significant growth. The difficult national business environment and the contraction of domestic demand have put enterprises in the position of having to find external markets while facing challenges in terms of efficiency and financing. Public funding of R&D has been sustained, despite the pressures created by reducing public expenditure. However, the conversion of investments in R&I into company competitiveness in international markets remains weak.

Private and public R&D investment also receives support via co-funding from the European budget, in particular through the Structural Funds and from successful applications to the Seventh Framework Programme (FP7). Of the EUR 21.5 billion of Structural Funds allocated to Portugal over the 2007-2013 programming period, around EUR 4.5 billion (21 % of the total) related to RTDI[3]. The success rate of Portuguese applicants in FP7 is 18.4 %, lower than the EU average success rate of 28 %. By 2013, there were over 2157 Portuguese applicants in retained proposals, with a total EC financial contribution of EUR 450 million.

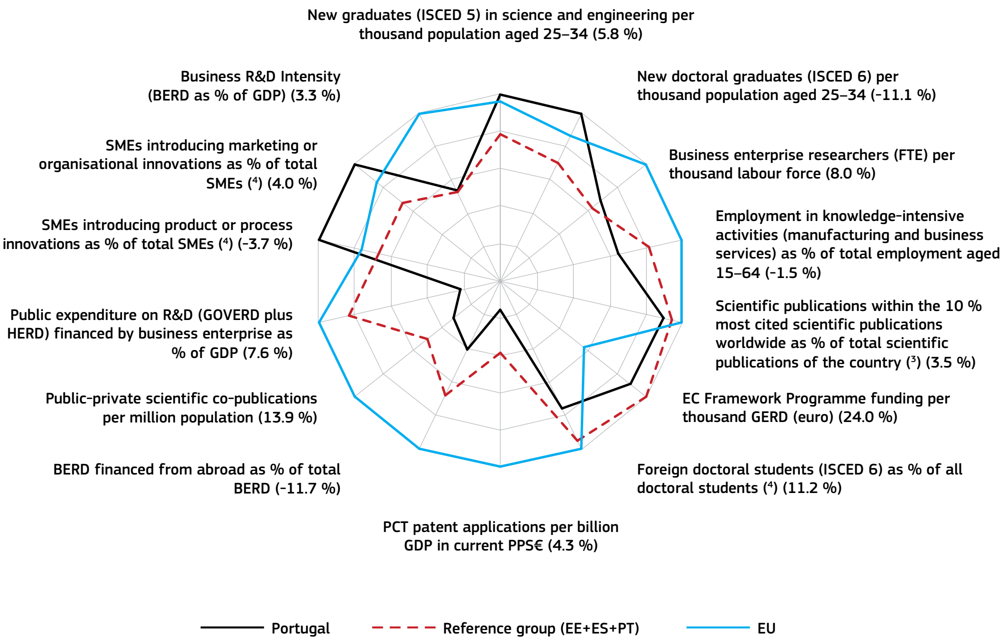
[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Portugal's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.

Portugal, 2012 ([1])

In brackets: average annual growth for Portugal, 2007–2012 ([2])



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: ([1]) The values refer to 2012 or to the latest available year.
([2]) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
([3]) Fractional counting method.
([4]) EU does not include EL.

In broad terms, the graph shows that the large increase in R&D investment over the period 2000-2011 has triggered a stronger human resources component, higher scientific quality and some innovation, but with less progress in technology valorisation. All in all, while there was a good effort in training young researchers, Portugal remains below the EU average on technology development, business R&D, and the knowledge-intensity of the economy.

In the field of human resources for R&I, Portugal is achieving significant progress in the number of new doctoral graduates, which is the consequence of strong public incentives. However, the share of employment in knowledge-intensive activities has not followed the same trend, reflecting a weakness as regards its capacity to move towards more knowledge-intensive sectors. The quality of scientific production improved significantly, achieving 10 % of national scientific publications in the 10 % most-cited scientific publications worldwide, which is close to the EU average.

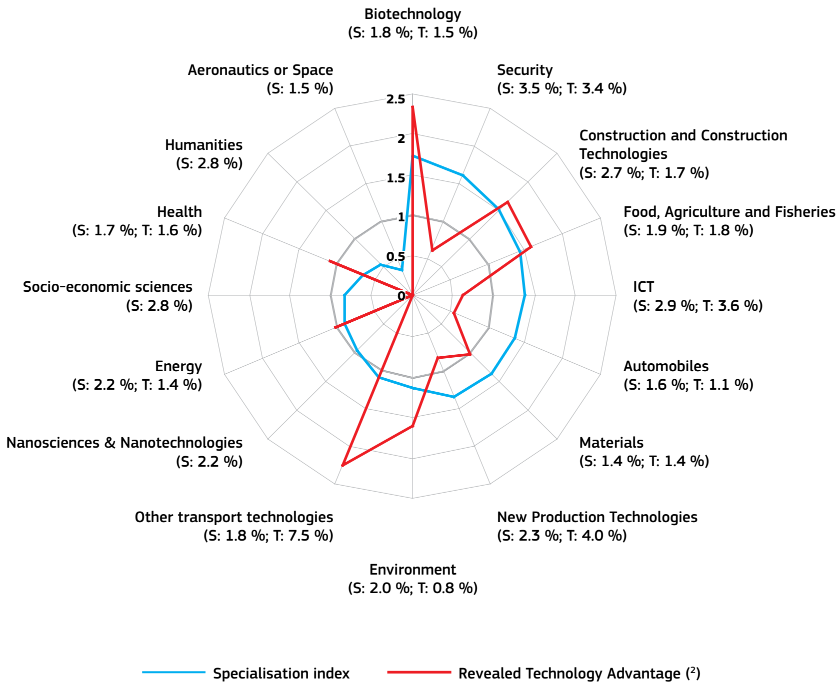
As seen in the graph above, the evolution of research output has been weaker on the business side. The overall technology development is well below the EU and reference group average. The same is true for public-private scientific co-publication, highlighting the need to emphasise the links between science and innovation.

Portugal's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Portugal shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Portugal – S&T National Specialisation (1) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies

Data: Science-Metrix Canada; Bocconi University, Italy

Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.

(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.

(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.

(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Comparison of the scientific and technological specialisation in selected thematic priorities shows a mixed situation with some co-specialisations as well as some mismatches. In most of the sectors, scientific quality is not combined with technological and industrial specialisation, while scientific production and quality is much more limited in other sectors relevant to its industry.

The country displays relevant scientific strength in several sectors, such as security, ICT, automobile, materials, and new production technologies, construction and construction technologies, food, agriculture and fisheries, and biotechnology. However, no corresponding technological specialisation can be found for those fields, with the exception of construction and construction technologies, food, agriculture and fisheries, and biotechnology, where the scientific profile is coupled with the country's technological profile.

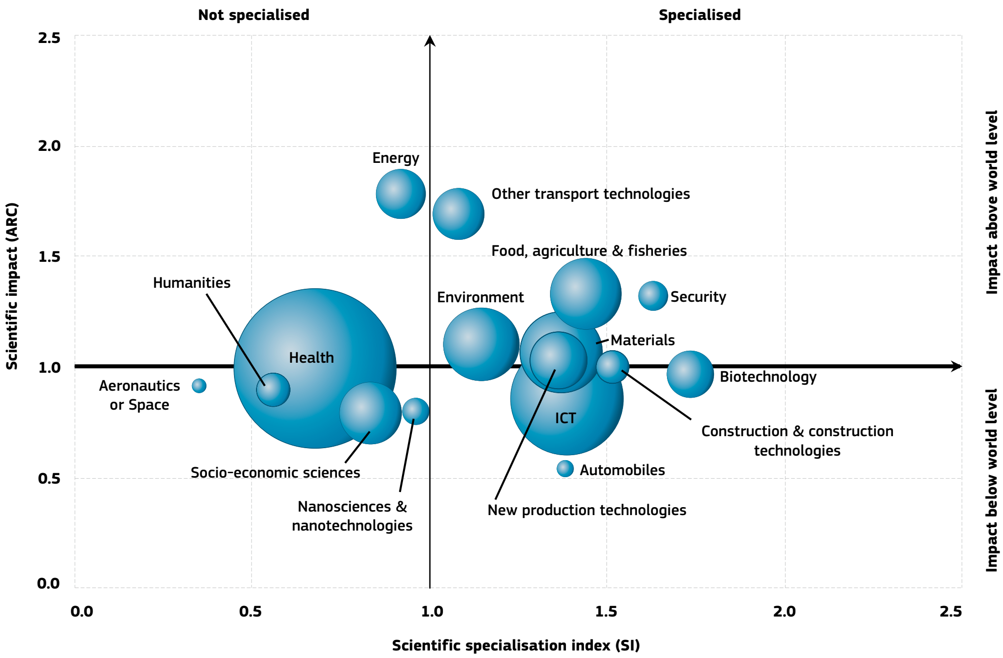
On the other hand, technological specialisation in other transport technologies is not backed up by a strong domestic scientific specialisation, despite the good quality of its publications. Taking into account the technological specialisation of Portugal in this field, it would probably benefit from fostering a scientific specialisation in this sector.

Portugal has established scientific strength in the field of food, agriculture and fisheries where scientific production and quality can be correlated with a certain technological specialisation. However, there is room for improvement in the scientific impact of some sectors which rank high on science specialisation indicator, i.e. ICT, automobile, materials, or new production technologies. Finally, scientific and technological specialisation in biotechnology is not coupled with the quality of domestic science. Conversely, scientific and technological specialisation in energy is not leveraged by the high scientific impact of domestic science in Portugal.

The definition of Research and Innovation Strategies for Smart Specialisation (RIS3) is more advanced at regional than national level, although at regional level the situations are different. Region Centro is the first of the five mainland Portuguese regions to design an RIS3 strategy which includes relevant sectors such as agriculture, materials or biotechnology[4].

The graph below illustrates the positional analysis of Portuguese publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Portugal – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

[4] In January 2014, a multi-level strategy for Portugal was submitted, including one national and seven regional strategies; the level of development varies among the regions.

Policies and reforms for research and innovation

R&I policy is characterised by a large political consensus and continuity over time that has enabled significant progress from a relatively low base. Long-term consistency has proved to be a positive determinant in ensuring the consolidation of the R&I system. However, a few relevant initiatives took place in 2013: (1) the National Strategy for Smart Specialisation (also included in the 2014-2020 Partnership Agreement), the operational competitiveness programme COMPETE and incentive schemes in dialogue with stakeholders (universities and technological centres); (2) revision of the regulation on financing R&D organisations; (3) reorientation of the SIFIDE; (3) AdI; (4) evaluation of the clustering strategy; (5) the creation of three advisory bodies; and (6) the Programme of Applied Research and Technology Transfer to Companies.

In recent decades, Portuguese research policy has been horizontal in nature and has covered a broad spectrum. However, the Foundation for Science and Technology (FCT) launched an initiative aimed at designing a Research and Innovation (R&I) Strategy for Smart Specialisation, in the context of the preparation of the new round of European support. The first task, already performed, was a SWOT analysis of the country's R&I system – up to December 2013, there was a series of stakeholder sessions to discuss the selected national priorities and to propose vision and policy recommendations. This is seen as an important step in the policy-making process, providing a basis for more informed and accurate strategic decisions in R&I policy.

The new regulation for the evaluation of R&D aims to encourage the needs of research units to achieve a critical mass in order to be effective and to stimulate the emergence of creative environments, namely through multidisciplinary approaches to addressing complex problems and challenges.

The main policy instrument associated with indirect R&D funding has been SIFIDE. The Budget Law for 2011 extended the system until 2015, and improved the conditions granted to R&D-performing companies. The instrument was reviewed in 2013 in order to positively discriminate towards projects involving cooperation with other entities and international cooperation, and to provide access to the results. SIFIDE includes two kinds of incentives for companies performing R&D: a basic tax incentive, corresponding to 32.5 % of eligible R&D expenditure undertaken in the relevant fiscal year, and an incremental incentive, corresponding to 50 % of the increase in R&D expenditure compared to an average of the two previous years. The amount of tax credits approved under SIFIDE has been close to EUR 100 million each year.

In this regard, the only relevant change in the innovation field concerns AdI, the innovation agency. AdI has played a role in providing finance to cooperative projects between research and industry as well as in managing SIFIDE. Following a decision to integrate the agency into the Institute for Support to Small and Medium-sized Enterprises and Innovation (IAPMEI), the new law ensures that AdI will remain an autonomous organisation, reporting to the Minister for the Economy.

Portugal has carried out an evaluation of the clustering strategy which recognises the merits of launching a cluster policy but points out that there is still a significant gap between expectation and achievement and has identified weaknesses in the governance model, insufficient capabilities among many organisations to manage poles (CTPs) and clusters, and the excessive inward-looking approach with very weak linkages with 'peer' organisations abroad, among the main problems.

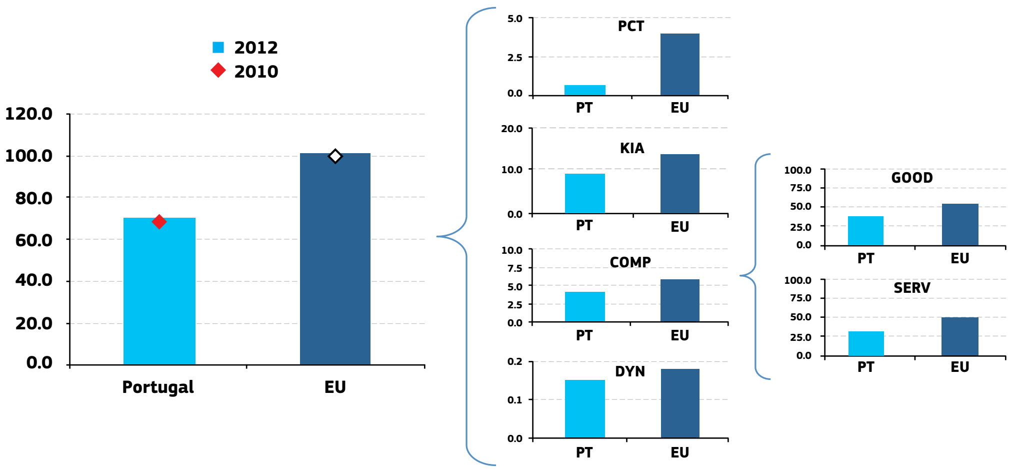
To enhance stakeholder involvement in defining R&I policies, three advisory councils have been created: the National Council for Science and Technology, the National Council for Entrepreneurship and Innovation, and the National Council for Reindustrialisation.

The Programme of Applied Research and Technology Transfer to Companies aims to promote 'hybrid' doctoral training, the revision of doctoral grants, and a greater focus of the programmes on entrepreneurship and innovation among US universities.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Portugal's position regarding the indicator's different components:

Portugal – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Portugal is a low performer in the European innovation indicator. This is the result of low performance in all components of the innovation indicator, although its performance has been improving since 2010.

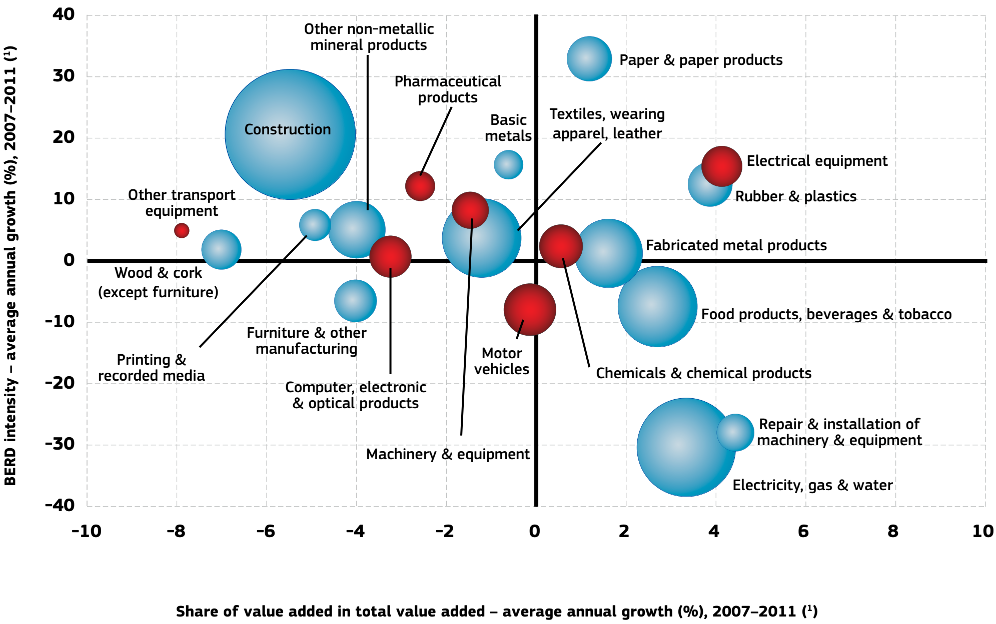
Portugal performs at a very low level in patents partly as a result of its economic structure, with no Portugal-based international players in patent-intensive manufacturing sectors. The structure of the economy, with a high share of low-tech production, such as food, textiles and shoes, also results in a low export share of medium-high/high-tech goods and a low share of employment in knowledge-intensive activities (KIA). In addition, significant employment in agriculture and tourism-related accommodation and food services contributes to the low employment share of KIA employment. The relatively low performance in the export share of knowledge-intensive services is explained by the importance of tourism, which is classified as non-KIS. Road freight transport services (also non-KIS) have a relatively high importance in services exports, too, while this pattern is not compensated for by any strongholds in KIS exports.

Portugal performs at a low level in the innovativeness of fast-growing firms. This is explained by a high share of employment in fast-growing enterprises in less-innovative sectors, such as construction, accommodation and food-service activities, and in administrative and support-service activities.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented in the graph). The red sectors are high-tech or medium-high-tech sectors.

Portugal – Share of value added versus BERD intensity: average annual growth, 2007–2011 ([1])



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: ([1]) 'Printing and reproduction of recorded media': 2008–2011; 'Furniture and other manufacturing': 2010–2011.
([2]) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

For a small country like Portugal, the road to growth leads to an extended market beyond the national boundaries, where competition must be confronted with high-quality actors in sectors providing more value added. This requires reinforcing the capacity of enterprises to move into more high-tech and medium-high-tech sectors. The graph above gives a general picture of manufacturing sectors over the period 2007-2011, showing reduced shares of value added but increased BERD intensities for most of the sectors. In particular, other transport equipment, wood and cork, printing and recorded media lost important positions in terms of valued added. Construction also lost an important share of value added despite growth in R&D intensity over the period.

Paper and paper products, rubber and plastics, and electrical equipment (considered as high-tech or medium-high-tech sectors) play an important role in manufacturing value added with a high growth rate in R&D intensity. Growth in the share of value added for chemicals and chemicals products is encouraging.

The 2013, the EU's industrial R&D scoreboard, ranking the top 1000 companies investing in R&D, shows six top Portuguese companies in the following sectors: banking (two), electricity, fixed-line telecommunication, pharmaceuticals and biotechnology, and software and computer services.

Key indicators for Portugal

PORTUGAL	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (¹) (%)	EU average (²)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	1.62	2.57	3.31	3.78	3.09	2.84	1.95	1.60	2.10	-11.1	*1.81*	9
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	466	:	:	487	:	:	487	20.9 (³)	495 (⁴)	16 (⁴)
Business enterprise expenditure on R&D (BERD) as % of GDP	*0.20*	0.30	*0.46*	0.60	0.75	0.78	0.73	0.71	*0.70*	*3.3*	1.31	16
Public expenditure on R&D (GOVERD + HERD) as % of GDP	*0.45*	0.39	*0.43*	0.46	0.63 (⁵)	0.72	0.70	0.69	*0.68*	*1.8*	*0.74*	11
Venture capital as % of GDP	0.14	0.16	0.11	0.12	0.23	0.14	0.12	0.21	0.14	2.6	0.29 (⁶)	12 (⁶)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	22.8	:	:	:	:	27.3	3.7	47.8	17
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	9.0	8.8	9.2	9.9	9.9	:	:	:	3.5	11.0	14
International scientific co-publications per million population	:	338	410	434	512	546	614	698	761	11.9	343	13
Public–private scientific co-publications per million population	:	:	:	10	11	12	14	17	:	13.9	53	20
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.2	0.5	0.5	0.5	0.6	0.7	0.6	:	:	4.3	3.9	20
License and patent revenues from abroad as % of GDP	0.02	0.02	0.04	0.04	0.03	0.06	0.02	0.03	0.02	-9.7	0.59	25
Community trademark (CTM) applications per million population	34	56	97	119	108	91	84	95	94	-4.6	152	18
Community design (CD) applications per million population	:	12	13	15	14	18	16	18	16	1.8	29	19
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	13.3	:	15.6	:	14.3	:	:	-4.2	14.4	11
Knowledge-intensive services exports as % total service exports	:	22.8	26.5	28.5	28.7	28.9	29.0	30.1	:	1.4	45.3	15
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-3.61	-2.36	-1.47	-1.66	-1.30	-2.98	-3.50	-1.20	-0.28	-	4.23 (⁷)	21
Growth of total factor productivity (total economy): 2007 = 100	100	98	98	100	99	97	100	100	100	0 (⁸)	97	5
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	38.1	:	:	:	:	42.6	2.3	51.2	16
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	8.8	8.8	8.6	9.1 (⁹)	9.0	-1.5	13.9	26
SMEs introducing product or process innovations as % of SMEs	:	:	38.7	:	47.7	:	44.2	:	:	-3.7	33.8	5
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.02	0.06	0.05	0.05	0.05	0.03	:	:	:	-27.2	0.44	26
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.05	0.09	0.09	0.10	0.10	0.06	:	:	:	-19.3	0.53	23
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	73.5	72.3	72.7	72.6	73.1	71.2	70.5	69.1 (¹⁰)	66.5	-1.0	68.4	17
R&D intensity (GERD as % of GDP)	*0.73*	0.78	*0.99*	1.17	1.50 (⁵)	1.64	1.59	1.52	*1.50*	*-0.1*	*2.07*	14
Greenhouse gas emissions: 1990 = 100	138	145	137	133	130	124	119	116	:	-17 (¹¹)	83	25 (¹²)
Share of renewable energy in gross final energy consumption (%)	:	19.8	20.9	22.0	23.0	24.6	24.4	24.9	:	3.1	13.0	6
Share of population aged 30–34 who have successfully completed tertiary education (%)	11.3	17.7	18.4	19.8	21.6	21.1	23.5	26.1	27.2	6.6	35.7	20
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	43.6	38.8	39.1	36.9	35.4	31.2	28.7	23.2	20.8	-10.8	12.7	26 (¹²)
Share of population at risk of poverty or social exclusion (%)	:	26.1	25.0	25.0	26.0	24.9	25.3	24.4	25.3	0.2	24.8	16 (¹²)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (¹) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(²) EU average for the latest available year.
(³) The value is the difference between 2012 and 2006.
(⁴) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(⁵) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2012.
(⁶) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(⁷) EU is the weighted average of the values for the Member States.
(⁸) The value is the difference between 2012 and 2007.
(⁹) Break in series between 2011 and the previous years. Average annual growth refers to 2008–2010.
(¹⁰) Break in series between 2011 and the previous years. Average annual growth refers to 2007–2010.
(¹¹) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(¹²) The values for this indicator were ranked from lowest to highest.
(¹³) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Enhance cooperation between public research and business and foster knowledge transfer."

Romania

The challenge of improving policy coordination of R&I and upgrading the economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Romania. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance			
R&D intensity		***Excellence in S&T*** [1]	
2012: **0.49 %**	(EU: 2.07 %; US: 2.79 %)	2012: **13.2**	(EU: 47.8; US: 58.1)
2007-2012: **-4.2 %**	(EU: 2.4 %; US: 1.2 %)	2007-2012: **+2.3 %**	(EU: +2.9 %; US: -0.2)
Innovation Output Indicator		***Knowledge-intensity of the economy*** [2]	
2012: **78.0**	(EU: 101.6)	2012: **27.5**	(EU: 51.2; US: 59.9)
		2007-2012: **+3.5 %**	(EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations:		***HT + MT contribution to the trade balance***	
Automobiles, ICT, new production technologies, energy, nanosciences and nanotechnologies, and security		2012: **0.4 %**	(EU: 4.23 %; US: 1.02 %)
		2007-2012: **-14.2 %**	(EU: +4.8 %; US: -32.3 %)

The key challenge for Romania remains its low level of competitiveness, which has significant consequences for the research and innovation system. The high-tech and medium-tech sectors of the economy do not contribute sufficiently to the trade balance, demand for knowledge remains weak, and the innovation culture continues to be underdeveloped. Romania is ranked as a modest innovator and has one of the lowest values in the EU for both R&D intensity and business R&D investments. To complete the picture of poor innovation, the Global Competitiveness Report 2013-14 still classifies the country as efficiency-driven (together with Bulgaria) while the rest of the EU economies are either in transition to, or are already at the innovation-driven stage.

Over the last decade, policy-makers have made significant efforts to reform the R&I system in Romania. Yet, the absence of a consistent long-term vision at the political level and the lack of awareness of the added value of R&I for enhancing competitiveness and securing high-quality jobs has hampered the full implementation of most of the adopted measures. In addition, a lack of both continuity in policy decisions from one government to another and coordination among ministries has also proved particularly detrimental in a domain that requires the development of capacities over time. In order to leverage the importance of R&I in the country's overall policy-mix, R&I policy measures need to be considered in the broader context of Romania's economic development and better integrated into its overarching policy objectives.

However, among the last developments, a new National Strategy for Research and Innovation for the period 2014-2020 has been developed and, following a public debate, is ready to be submitted for government approval. The new strategy is aiming at a gradual rebalance of research to innovation through a strong component of smart specialisation[3], and includes a well-developed

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialization, international specialization and internationalization sub-indicators.

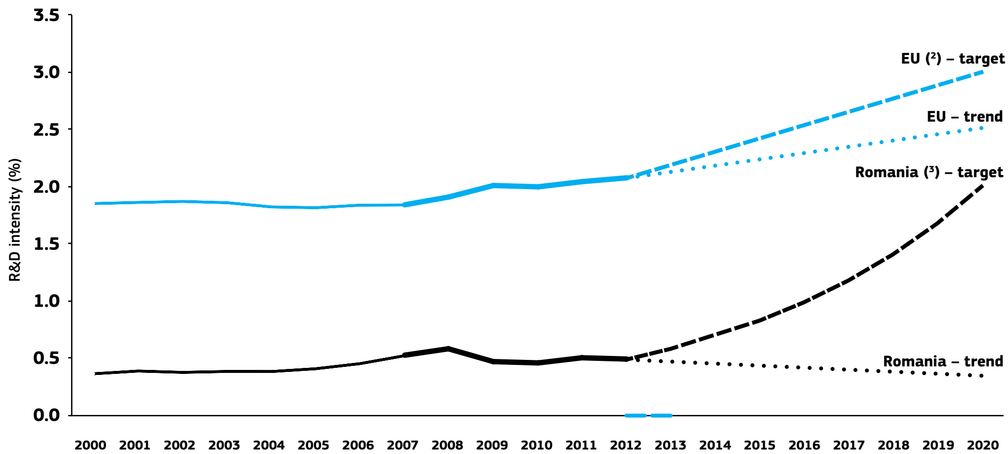
3 The strategy identifies the smart specialisation domains (bio-economy; ICT, space and security; energy, environment and climate change; eco-nano technologies and advanced materials) and outlines three fields of specific national interest (health; heritage and cultural identity; new and emerging technologies).

monitoring system and multi-annual budgetary planning. The Strategy also includes measures that strongly support the development of R&D activities in the private sector. Although it benefits from strong ownership by the research system, having been developed by means of a large consultation exercise with experts and stakeholders, its implementation remains uncertain. It depends on the government's commitment to finance the activities included in the Strategy's implementation instrument, which is the National Plan for R&I.

The public-private collaboration shows promising bottom-up initiatives for developing clusters in economic sectors (automotive, IT) and research fields (life sciences, nuclear physics). These clusters gather around researchers, businesses and policy-makers and are increasingly able to attract funding from European and national sources. It would be sensible for the government to design well-targeted top-down measures for supporting further development of these clusters since they are a concrete solution for improving public-private collaboration in the R&D field.

Investing in knowledge

Romania – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2007–2010 in the case of Romania.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) RO: The projection is based on a tentative R&D intensity target of 2.0 % for 2020.
(4) RO: There is a break in series between 2011 and the previous years.

Over the last decade, R&D intensity in Romania increased from 0.37 % in 2000 to 0.58 % in 2008, only to drop back to 0.49 % in 2012. Romania currently has the second lowest R&D intensity in the EU, at less than one-quarter of its 2 % target for 2020. In absolute terms, public R&D funding reached a peak in 2008, following the adoption of the 2007-2013 Strategy for R&D and Innovation. The Strategy foresaw a gradual rise in the R&D public budget, but the planned increase in 2009 did not take place due to the economic crisis which has severely affected the government's budget, including R&D appropriations. In absolute terms, government budget appropriations for R&D fell by 25.4 % in 2009, followed by an oscillating evolution over the period 2009-2013. The provisional value for 2013 is expected to be higher than the 2012 value (by 6.2 %). Higher education expenditure on R&D suffered a large reduction of 32.2 % in 2009, followed by a rise of 1.4 % in 2010, although it fell again by 4.2 % in 2012. The government has expressed its intention to increase the public budget in the years to come[4], by 10.8 % (2013) and by 13.8 % (2014).

In 2012, Romania had one of the lowest business R&D intensities in the EU (0.19 % of GDP and ranked 26th out of 28), and an average annual growth rate of -6.8 % between 2007 and 2010. No Romanian firm is among the top-1000 EU R&D investing firms. The recent trends show that the 2 % R&D intensity target for 2020 is very ambitious and will be difficult to reach,

[4] ERAC Survey, 2013

given both the recent low budgetary commitment and the very low level of business R&D activities. This target can only be achieved if the country prioritises R&I in the context of smart fiscal consolidation, whilst implementing – without delay – the key reforms outlined in the Action Plan for Research and Innovation, which were adopted by the government in July 2011.

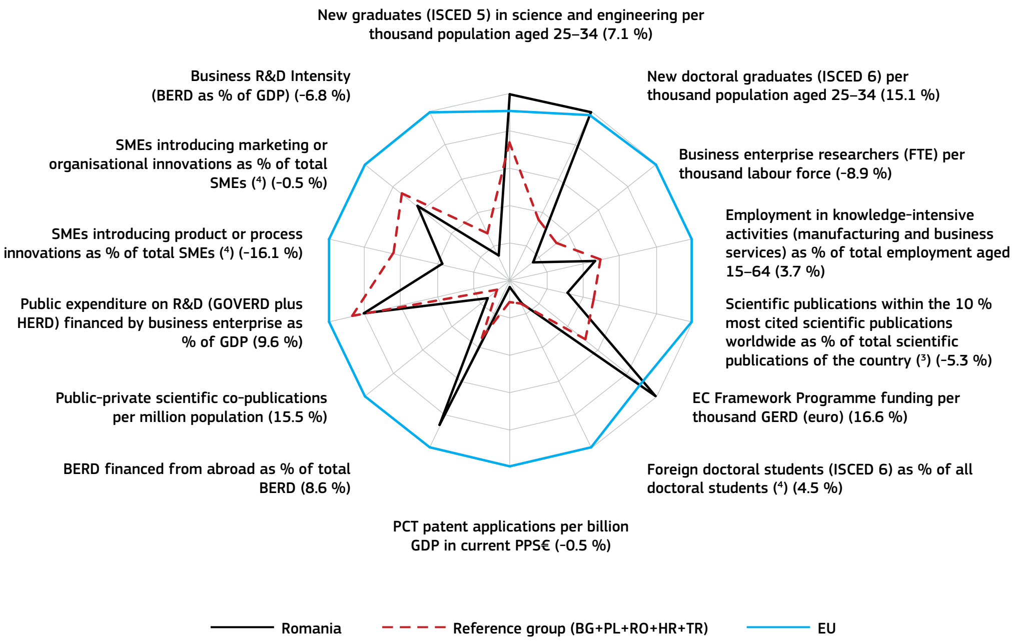
To date, the total number of Romanian participants in the EU's Seventh Framework Programme (FP7) is 1000 (out of 6848 applicants), and Romania has received EUR 148.2 million from successful applications. The participants' success rate is 14.6 %, below the EU average of 20.5 %. Romania receives the 19th largest share in the EU of FP7 funding and has most collaborative links with Germany, Italy, the United Kingdom, France and Spain. Private and public R&D investment also receives support via co-funding from the Structural Funds. Currently, only 5.9 % of the Structural Funds are allocated to RTDI[5], which is significantly below the EU average (15 %). A large part of the Structural Funds for R&I has been focused on programmes for developing R&I infrastructure and human resources, which have been developed to complement the national R&D programmes. However, the massive reduction in the R&D budget in 2009 hampered this complementarity. Although the absorption rate for Structural Funds in the R&I sector has reached 30 % (rate of approved payments), the national R&D budget has been severely cut.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Romania's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Romania, 2012 (1)

In brackets: average annual growth for Romania, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

[5] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

The Romanian R&I system is primarily public-based, with only 29 % of research performed by the business sector (the EU average is 63 %). The graph above shows that Romania scores well (above the EU average) as regards the number of new S&T and PhD graduates. The two indicators are linked with the performance potential of the research system as they refer to the supply of highly skilled human resources for research. However, the overall under-financing of R&I since the 1990s has created a brain-drain effect, making Romania an important exporter of researchers. The country is suffering a net outflow of researchers with an estimated 15 000 Romanian researchers working abroad (roughly three-quarters of the total number of researchers who are in the country). As a result, it risks being left with a pool of researchers of high average age and limited career prospects.

Another structural feature is the fragmentation of the public R&D system, which has a large number of research performers but a lack of critical mass of research results. Romania performs well as regards its international participation in the research area, scoring well in the indicators on EU FP funding and the BERD financed from abroad.

However, Romanian universities are under-performing in all major international rankings and their scientific production and staff composition are less internationalised compared to other Member States. While an increase in international scientific co-publications was noted over the period 2007-2011, the share of national scientific publications in the top 10 % most-cited publications worldwide has declined slightly in recent years. Overall, the number of international co-publications with other European countries is the lowest in Europe, suggesting that Romania does not benefit sufficiently from the international knowledge flows favoured by the ERA architecture. One positive aspect is that Romanian scientific and technological cooperation is well distributed across Europe, with France, Germany, Italy, the United Kingdom, and Spain as main co-publication partners and Germany and Ireland as co-patenting partners.

It is obvious that the Romanian business sector's interest in developing their own R&I activities is low, which is illustrated by the very low numbers of PCT patent applications and researchers employed by business enterprises, and a very low level of business R&D intensity, which is continuing to fall. The business sector is not promoting collaborative links with R&D institutes and universities in the public sector (as reflected by the very low number of public-private co-publications). Some improvements can be seen in public-private cooperation due to the development of cluster[6] initiatives that have succeeded in gathering policy-makers, public research institutions, large companies and SMEs around them. This type of initiative could be the solution for improving the overall lack of collaboration and coordination between the public sector, the private sector and the government. Well-targeted, top-down support measures will be instrumental in supporting their further development.

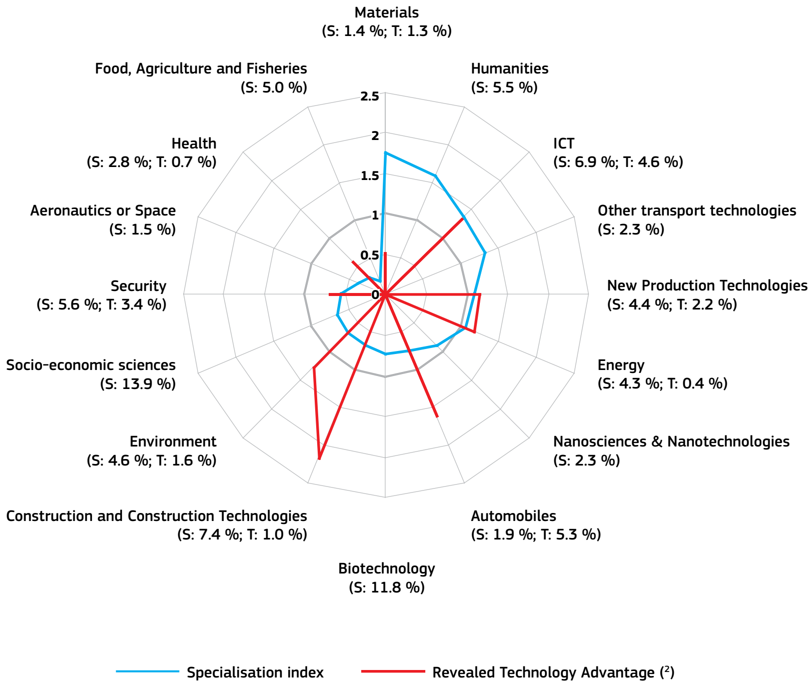
Romania's scientific and technological strengths

The spider graph below illustrates the areas, based on the Framework Programme thematic priorities, where Romania shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

[6] The scientific-driven cluster European Light Infrastructure in Măgurele, the strategic-driven cluster the Danube-Danube Delta-Black Sea Institute, and the business-driven cluster Cluj Innovation City (bottom-up initiative).

Romania – S&T National Specialisation ([1]) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications ([3]) (S) and in number of patents ([4]) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: ([1]) Values over 1 show specialisation; values under 1 show a lack of specialisation.
([2]) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
([3]) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
([4]) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

In Romania, there is no overall correlation between specialisation in science and specialisation in technologies. The science base is not generally of sufficient quality to support knowledge transfer through technologies towards industry. At the same time, the country has yet to benefit from sufficient inflows of foreign direct investments for technological activities, which would help shape more coherent industrial specialisation. Within the whole spectrum of fields analysed there are three with co-specialisation in both S&T: ICT, new production technologies, and energy. This shows a certain degree of knowledge transfer from science to technologies in these three fields, making them important candidates for a smart specialisation strategy. In addition, there are other fields, such as automobiles and construction, which show good technological specialisation. On the other hand, fields of nanosciences and nanotechnologies, aeronautics and health show no co-specialisation in S&T, no growth on the technological side over the last decade, and no science of any substantial quality.

In the field of materials – the best rated in terms of scientific production – there are several mismatches between scientific and technological developments. Despite considerable specialisation in science, the research field has been very static over the last ten years and not at all matched by technologies. In other words, industry is failing to absorb the large amount of high-quality knowledge being created in the field of materials. This may well be due to the fact that Romania's chemical industry has declined substantially over the last decade. Without an industrial revival in this field, it seems likely that research will continue to decline.
In the fields of ICT and new production technologies, co-specialisation in S&T has been backed up by visible growth rates in both publications and patents over the last decade, which is probably due to the existence of firms on the Romanian market absorbing the scientific results in related industries. Policy decisions should be oriented towards further increasing the quality of science publications,

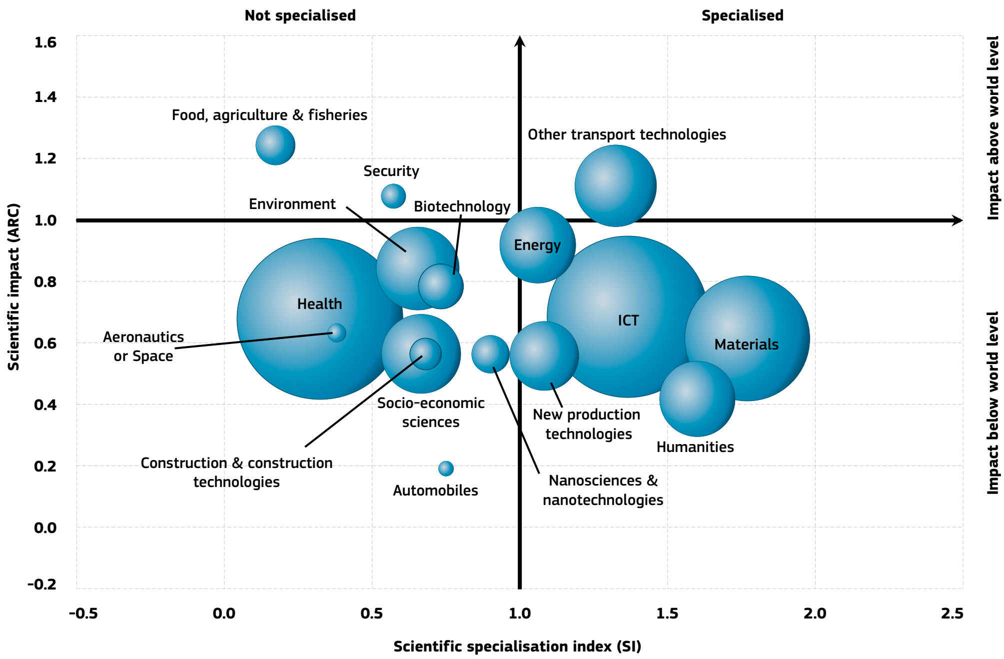
which is well below the world average in both fields. Compared to the two fields mentioned previously, the energy sector is more static as regards technologies, with few patents over the last decade. On the other hand, research results in the energy field are among the best in Romania, registering just below the world average as regards the quality of publications.

Technologies in the automobiles sector are stronger compared to other fields and show both specialisation and high growth rates in patents over the last 10 years. However, this is not sufficiently matched by science results, with the quality of publications needing substantial improvement. This seems to be a situation of apparent comparative advantage, with industrial development in place, but with the science side needing further improvements.

The field of construction and construction technologies reveals obvious development potential. Although specialisation in technology is already evident, it is the research field that has seen the most growth over the last ten years. However, the overall quality of science needs to be improved considerably. The environment field also presents certain dynamism, with specialisation in technologies and high growth rates in science.

The graph below illustrates the positional analysis of Romania's publications showing the country situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Romania – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The fields of food, agriculture and fisheries, and biotechnologies point to interesting developments. A serious decline in the food and agriculture field after 1990 was coupled with a lack of specialisation in science and industry, despite the massive potential in terms of natural resources and primary production factors. As developments can often be rebooted bottom-up in the case of existing latent comparative advantages, over the last decade the quality of science in this field rose spectacularly, accompanied by high growth in the number of publications in the biotechnologies sector. However, the country has not yet reached the critical mass of publications required to specialise in these fields, and the related technologies are missing. In this context, there is room to further boost science in the fields of food and agriculture, and biotechnology. This is backed up by a large domestic economy (over 30 % of the population is still employed in the agriculture and food industry) and the potential to upgrade these industries' positions in international value chains. However, neither of these sectors is substantially backed up by technologies.

Finally, the field of other transport technologies benefits from considerable specialisation in science, matched by a good quality of publications (just above the world average) although this is not yet matched by any specialisation in technologies.

Policies and reforms for research and innovation

Over the last 10 years, the country has undertaken a wide range of measures in the R&I field. Development of the last two strategies for R&I, both for 2007-2013 and 2014-2020, have been based on a broad consultation exercise; Romanian scientific journals have been promoted on the international circuit; the share of competition-based funding has surpassed the share of institutional funding for research; measures have been taken to improve science-industry links by means of grants for projects with industrial partners; and innovation vouchers and tax incentives have been introduced. The certification process is ongoing for national R&D institutes and the legal framework regarding the funding of these institutes has been amended. However, such measures would have a greater impact if they were supported by a long-term vision. Indeed, the adopted/planned measures need to be better interrelated within an overarching reform in order to improve the overall efficiency of the R&I system.

A new National Strategy for Research and Innovation for the period 2014-2020 is currently being debated publicly before being submitted for government approval. The new Strategy is aiming at a gradual rebalance of research to innovation through a strong smart specialisation component and includes a well-developed monitoring system and multi-annual budgetary planning. Although the Strategy benefits from the R&I system's strong ownership, having been developed through a large consultation exercise with experts and stakeholders, its implementation remains highly uncertain. It depends on the government's commitment to finance the activities included in the Strategy's implementation instrument, which is the National Plan for R&I. With a view to better positioning R&I policy in the country's economic development, it would be beneficial to improve coordination between the R&I Strategy and the 2014-2020 Competitiveness Strategy, as well as the SMEs Strategy and current industrial policy developments.

As regards the efficiency and effectiveness of the research system, an important process started in 2013 which aimed to better coordinate and concentrate research resources in order to address the fragmentation of the system and reach the critical mass needed for highly relevant and qualitative research results. The reorganisation of the Ministry of Education, Research, Youth and Sport[7] brought the different research institutions formally subordinated to other ministries under the umbrella of the new Ministry of National Education. It could be expected that these measures would improve the efficiency of these institutions, with effectively a concentration of institutional resources, besides the formal gathering of institutions under the same ministry umbrella. However, the impact of these measures on the research system's performance will be assessed in the future.

Also, an ambitious reform of universities has begun but has slowed down in the last year. The new system, which aims to pave the way towards more autonomy and differentiation between research universities and those more oriented towards teaching and local needs, has been contested by several universities. Thus, in 2014, the university funding system returned to the old system, which only looked at quality indicators and the number of full-time equivalent students.

Private-sector R&I investments remain underdeveloped and have seen a continuous decline since 2000. The existing measures to promote private R&I investments are not fully commensurable with the challenges faced by local innovative enterprises, multinationals and start-ups. Moreover, there is visible mismatch between the skills needed by the knowledge market and the qualifications provided by academia that must be addressed. It is worth considering whether or not the system could benefit from replacing the current 'one-size-fits-all' interventions by targeted ones for innovative enterprises with proven successful track records. Moreover, the current unclear and contradictory provisions of the national framework of intellectual property rights make large companies somewhat reluctant to invest in innovation. The finalisation of the Employees Patents Law and the implementation guidelines are essential steps towards increasing foreign direct investments for innovative activities in Romania. Nevertheless, it is worth mentioning a relatively recent, bottom-up trend in the country indicating a concentration of innovation resources

7 According to the Government Ordinance of 22.12.2012, the Ministry of Education, Research, Youth and Sport has been reorganised by splitting it into the Ministry of National Education (MNE) and the Ministry of Youth and Sport. The National Authority for Scientific Research (NASR) has been dissolved and all of its attributes will be taken over by the new MNE.

around economic sectors, such as automotive or IT, or major research infrastructures in fields such as life sciences or nuclear physics, such as:

- *Cluj Innovation City*, a business-driven cluster focused around four sectors: IT, energy, environment, and healthcare;

- *European Light Infrastructure* in Măgurele, a promising scientific-driven cluster;

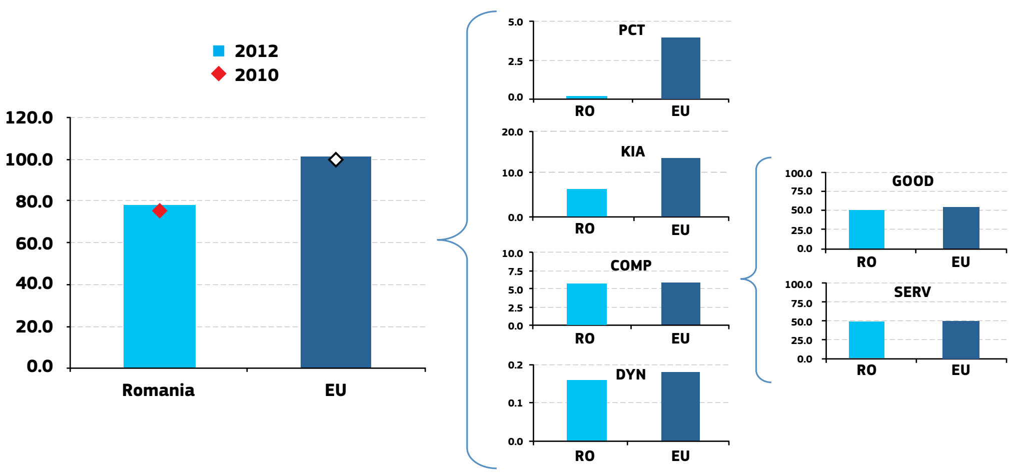
- *The Danube-Danube Delta-Black Sea Research Institute*, which builds on the Danube Delta's unique natural laboratory and, in addition, is strategically driven, as part of the Danube Strategy.

In this context, it would be sensible for the government to design well-targeted measures to support these clusters, given that they are solving in a bottom-up way problems in the system for which the top-down approach has not proved very successful to date. There are already some figures showing that these clusters are increasingly capable of attracting funding from both European and national sources. In addition, the problem of governance appears to have been sorted out in the case of concrete projects. These clusters gather around researchers, businesses and policy-makers, which represent the actual knowledge triangle in a national R&I system.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Romania's position regarding the indicator's different components:

Romania – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Romania is a low performer in the European innovation indicator. This is a result of low performance in several components of the innovation indicator, notably in patents. However, its performance has been improving since 2010.

The very low performance in patents is linked to the weak synergies between the research system and business activities and to the economic structure, notably the lack of large Romanian multinational manufacturing companies and the division of work within international companies, including motor vehicle producers, which have production facilities in Romania but tend to do research and patenting in the headquarter country.

Relatively strong employment in wholesale and retail trade, in low-tech manufacturing sectors such as food products, and in agriculture and construction, and the relatively small size of the financial sector contribute to a very low share of employment in knowledge-intensive activities.

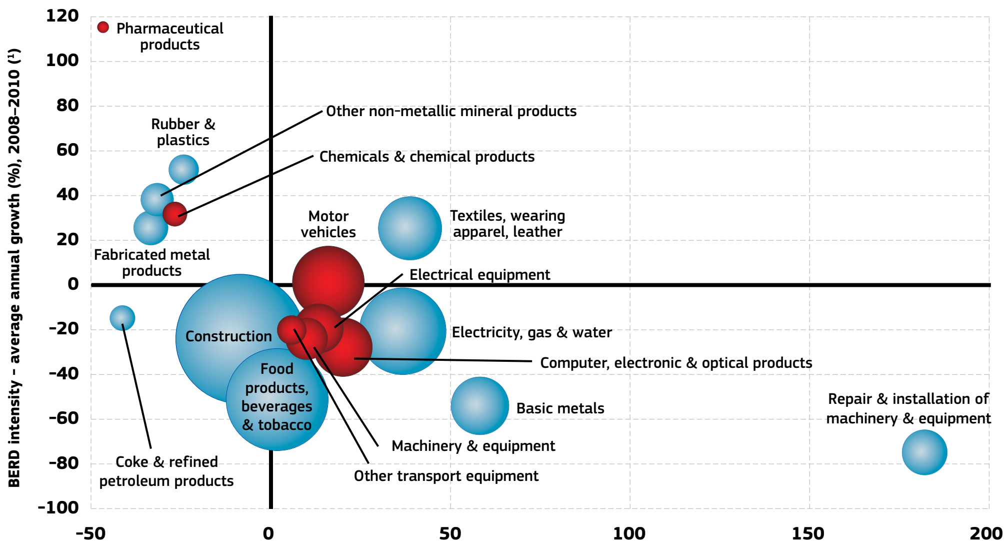
Romania is a strong performer in computer services exports, but also has significant road transport services exports, not classified as knowledge-intensive. As a result, the country performs near the EU average in the export of knowledge-intensive services.

The country performs below the EU average as regards the innovativeness of fast-growing firms in innovative sectors. This is also the result of a high share of employment in wholesale and retail trade and low-tech manufacturing sectors among employment in fast-growing firms.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented in the graph). The red sectors are high-tech or medium-high-tech sectors.

Romania – Share of value added versus BERD intensity: average annual growth, 2008–2010 (1)



Share of value added in total value added - average annual growth (%), 2008–2010 (1)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Computer, electronic and optical products': 2008–2011; 'Textiles, wearing apparel, leather and related products': 2009–2010.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

Romania's limited innovation performance is reflected in its economic structure in which low- and medium-technology sectors are still prevalent. Demand for knowledge is weak and there is an underdeveloped innovation culture.

In terms of trade and industry specialisation, Romania is part of the group of lower-income countries in the EU, with lower GDP per person than the EU average and specialisation in less technologically advanced sectors. It is highly specialised in labour-intensive industries (food products, wearing apparel and accessories), in capital-driven industries (cement), and market-driven ones (footwear).

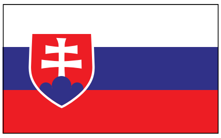
In terms of innovation, Romania is specialised in both low-innovation sectors (textiles, wearing apparel and leather) and medium-high innovation sectors (motor vehicles, computer, electronic and optical products).

In dynamic terms, a certain degree of structural change is shown in the graph above by the increasing added value in technology-driven and innovative sectors (motor vehicles, electrical equipment, computer, electronic and optical products and, to a lesser extent, machinery and equipment). On the other hand, fields with high-knowledge-intensity sectors, such as pharmaceutical products and chemical and chemical products, have declining shares of value added. However, although the quality of labour-intensive industries has improved, this is not yet the case for technology-driven ones.

Key indicators for Romania

ROMANIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	:	1.17	0.97	0.91	1.06	1.55	1.65	1.98	1.85	15.1	*1.81*	13
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	415	:	:	427	:	:	445	29.8 (3)	495 (4)	25 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.25	0.20	0.22	0.22	0.17	0.19	0.18	0.18 (5)	0.19	-6.8	1.31	26
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.11	0.20	0.23	0.30	0.40	0.28	0.28	0.32 (5)	0.30	-2.4	*0.74*	27
Venture capital as % of GDP	0.05	0.07	0.10	0.13	0.09	0.07	0.06	0.04	0.02	-33.0	0.29 (6)	18 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	11.8	:	:	:	:	13.2	2.3	47.8	28
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	3.7	3.7	3.9	3.5	3.5	:	:	:	-5.3	11.0	25
International scientific co-publications per million population	:	86	91	114	130	143	155	161	177	9.2	343	28
Public–private scientific co-publications per million population	:	:	:	5	5	6	8	8	:	15.5	53	25
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	:	:	-0.5	3.9	28
License and patent revenues from abroad as % of GDP	0.01	0.05	0.03	0.02	0.12	0.12	0.28	0.13	0.21	53.8	0.59	13
Community trademark (CTM) applications per million population	0.2	2	6	15	13	15	19	29	27	13.1	152	27
Community design (CD) applications per million population	:	0	0	1	1	1	2	2	3	18.8	29	27
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	18.5	:	14.9	:	14.3	:	:	-2.0	14.4	12
Knowledge-intensive services exports as % total service exports	:	41.0	44.9	43.8	42.0	44.9	43.3	45.2	:	0.8	45.3	7
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-10.69	-7.26	-6.00	-4.42	-2.33	0.60	0.25	0.38	0.38	-	4.23 (7)	20
Growth of total factor productivity (total economy): 2007 = 100	67	94	98	100	102	95	93	94	92	-8 (8)	97	23
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	23.1	:	:	:	:	27.5	3.5	51.2	28
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	5.6	5.8	6.0	6.5	6.5	3.7	13.9	28
SMEs introducing product or process innovations as % of SMEs	:	:	19.4	:	18.0	:	12.7	:	:	-16.1	33.8	28
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.00	0.02	0.01	0.01	0.01	0.02	:	:	:	33.0	0.44	28
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.01	0.03	0.02	0.01	0.01	0.002	:	:	:	-35.4	0.53	27
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	69.1	63.6	64.8	64.4	64.4	63.5	63.3	62.8	63.8	-0.2	68.4	20
R&D intensity (GERD as % of GDP)	0.37	0.41	0.45	0.52	0.58	0.47	0.46	0.50 (5)	0.49	-4.2	*2.07*	27
Greenhouse gas emissions: 1990 = 100	55	58	60	58	57	49	48	50	:	-8 (9)	83	3 (10)
Share of renewable energy in gross final energy consumption (%)	:	17.6	17.1	18.4	20.3	22.3	23.4	21.4	:	3.8	13.0	8
Share of population aged 30–34 who have successfully completed tertiary education (%)	8.9	11.4	12.4	13.9	16.0	16.8	18.1	20.4	21.8	9.4	35.7	27
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	22.9	19.6	17.9	17.3	15.9	16.6	18.4	17.5	17.4	0.1	12.7	24 (10)
Share of population at risk of poverty or social exclusion (%)	:	:	:	45.9	44.2	43.1	41.4	40.3	41.7	-1.9	24.8	27 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2011 and the previous years. Average annual growth refers to 2007–2010.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK, These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Values in italics are estimated or provisional.



Slovakia

The challenge of structural change to upgrade knowledge in the context of industrial globalisation

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Slovakia. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.82 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+12.3 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **25.2** (EU: 47.8; US: 58.1) 2007-2012: **+8.5 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **85.7** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **32.0** (EU: 51.2; US: 59.9) 2007-2012: **+0.6 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Food and agriculture, materials, and environment	***HT + MT contribution to the trade balance*** 2012: **3.9 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+12.2 %** (EU: +4.8 %; US: -32.3 %)

Over the 2007-2012 period, the country's performance achieved modest progress in research and innovation sectors while performance indicators remained below the EU average due to the low levels of R&D inputs corresponding with the low level of knowledge-intensive outputs. Therefore, the Slovak Republic faces the challenge of further developing its R&I system. Currently, the country ranks as the poorest R&I performer and is a moderate innovator which is catching up as regards competitiveness.

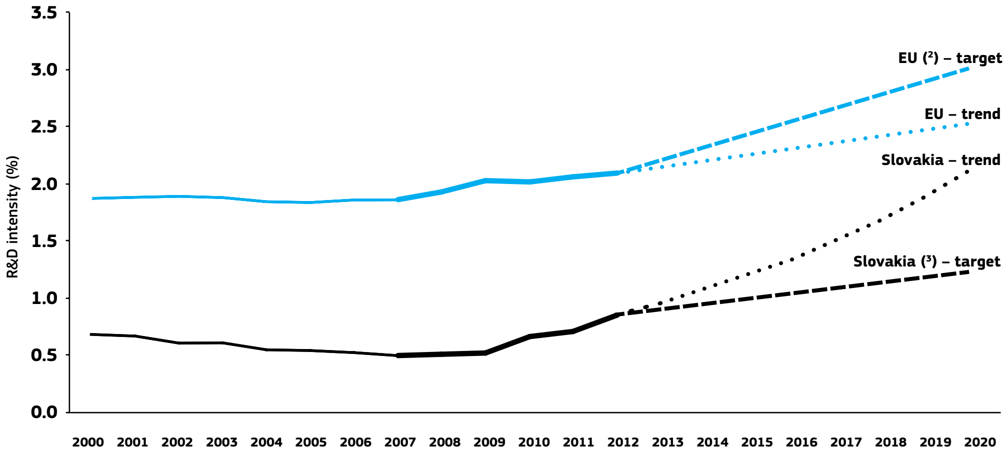
Over the last decade, R&D intensity steadily declined from a peak of 3.88 % in 1989 to 0.82 % in 2012. Slovakia's national 2020 intensity target for R&D is 1.2 %, which may be realistic providing that EU assistance to Slovakia's research system continues, and is combined efficiently with domestic funding and strategy implementation. The most important barrier to developing a strong private R&D sector and promoting innovations in Slovakia is its dual economy, which limits its indigenous R&D capacity in favour of the predominance of foreign multinational companies with high productivity, but lacking any domestic research activities. Thus, the Slovak economy is characterised by very low domestic patent production. For the first time, this weakness has been recognised clearly in the RIS3 (Research and Innovation Strategy for Smart Specialisation) document. The main challenge for the Slovak Republic is to raise knowledge intensity in Slovak firms through investments and spillovers. Moreover, existing public financing is suffering from inefficiency, a significant administrative burden and a lack of transparency concerning the procedures used – including those supporting regional innovation. The Slovak Republic has room to improve its thematic concentration, including stronger coordination between the responsible public authorities, the links between business and science, and the connexion with international S&T networks.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

Investing in knowledge

Slovakia – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) SK: The projection is based on a tentative R&D intensity target of 1.2 % for 2020.

The Slovak Republic has set a national R&D-2020 intensity target of 1.2 %. In 2012, the Slovak R&D intensity was 0.82 % of GDP, below the EU average of 2.07 %. Public sector R&D intensity amounted to 0.48 % and business R&D intensity to 0.34 %. To reach the national target it must raise its annual growth in both public and private R&D investments. Austerity measures to reduce the public deficit affected national R&D funding of the Operational Programme R&D (OPRD), which provided some 80 % of total public support to R&D in Slovakia. The new national intensity target can be achieved providing the right policies are implemented. Overall, the country's R&I system is characterised by a very low R&D intensity, one of the lowest in Europe and also compared to the reference group countries – Czech Republic, Italy, Hungary and Slovenia – with an average of 1.27 %.

However, and in spite of the overall decline in the R&D intensity in the Slovak Republic over the last decade, the Slovak gross expenditure on research and development (GERD) increased from EUR 219 million in 2010 (0.48 % of GDP) to EUR 585.2 million in 2012 (0.82 % of GDP), notably due to financing from EU resources (mainly through the Structural Funds). Between the two programming periods of 2000-2006 and 2007-2013, the Slovak Republic increased its RTDI[3] by 19 %. In the private sector, low R&D expenditure and productivity levels are characteristic of domestic firms, including a significant number of small and medium-sized enterprises (SMEs), and a few large companies. As a result, the production system is dominated by technology imports. In recent years, only modest national funding was allocated to address the low innovativeness among Slovak SMEs. Low shares of domestic innovative enterprises are limiting the country's competitiveness. Therefore, a major challenge facing Slovakia is to raise R&D intensity among its companies.

Slovakia achieved suboptimal performance in the EU's Seventh Framework Programme (FP7) projects. Its participation in FP7 projects in 2007-2013 period reveals a total of 1990 eligible proposals were submitted, with a success rate of 11.49 %, lower than the EU-27 applicant success rate of 22.0 % (E-CORDA database). Structural Funds are another important source of funding for R&I activities. Of the EUR 11.5 billion of Structural Funds allocated to Slovakia over the 2007-2013 programming period, around EUR 1.3 billion (11.3 % of the total) related to RTDI.

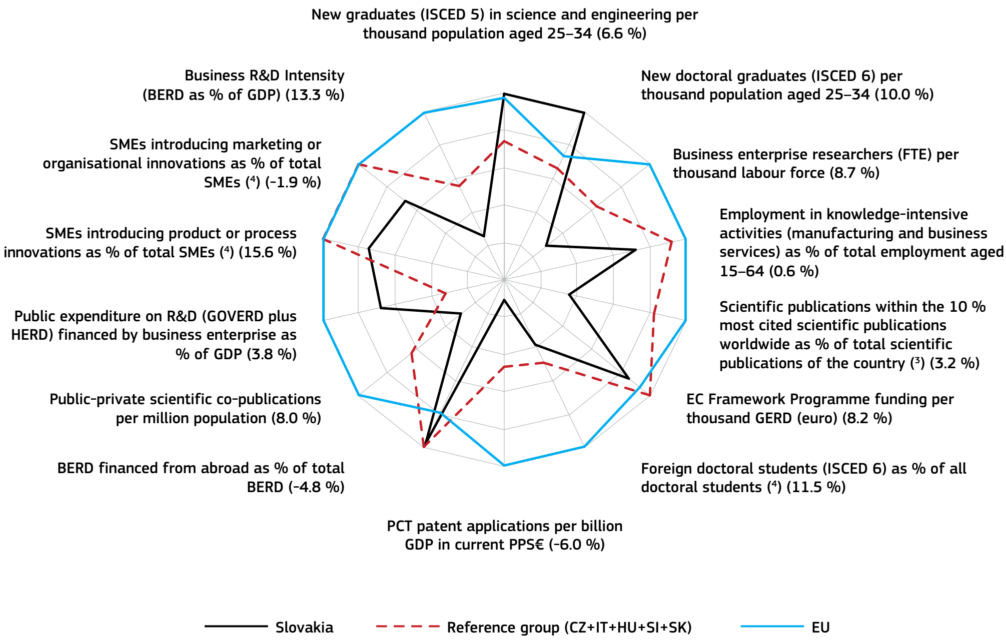
3 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The spider graph below provides a synthetic picture of strengths and weaknesses in the Slovak R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation and innovation. The average annual growth rates from 2000 to the latest available year are given in brackets under each indicator.

Slovakia, 2012 (¹)

In brackets: average annual growth for Slovakia, 2007–2012 (²)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (¹) The values refer to 2012 or to the latest available year.
(²) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(³) Fractional counting method.
(⁴) EU does not include EL.

The strengths in Slovakia's R&I system are found in human resources for R&I and in attracting business R&D investments from abroad. There has been a significant increase above the EU average in the number of new graduates in science and engineering and at PhD level as an alternative to unemployment for some tertiary graduates considering the shrinking numbers being employed in the business sector. However, there is need to enhance the quality and efficiency of the higher education system, and to increase the excellence and internationalisation of its universities, as the latter are not visible in major international rankings, and given the low number of scientific outputs.

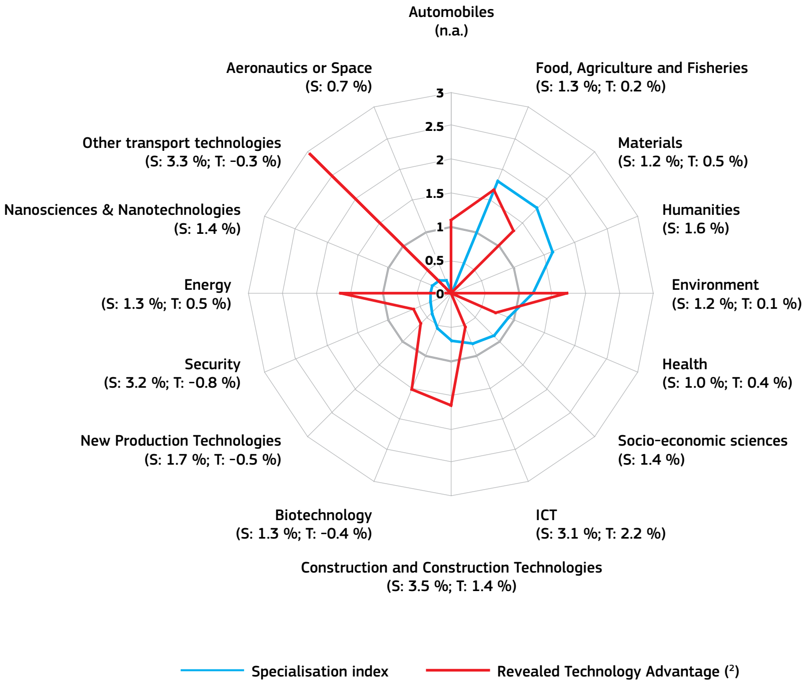
As regards the reference group, only a few Slovak indicators attain a better or similar position, and can thus contribute to future development. In contrast, the country's main weaknesses lay in business research activities (R&D spending over the 2007-2012 period reached on average 0.34 % of GDP as against the EU figure of 1.30 % of GDP), including very low patenting, numbers of business researchers, and R&D investments as the research field remained rather static and was not matched by technologies. In the public sector, the main challenges concern pursuing improvements in scientific quality and in public-private cooperation in R&D activities.

Slovakia's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Slovakia shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA), based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Slovakia – S&T National Specialisation (1) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)

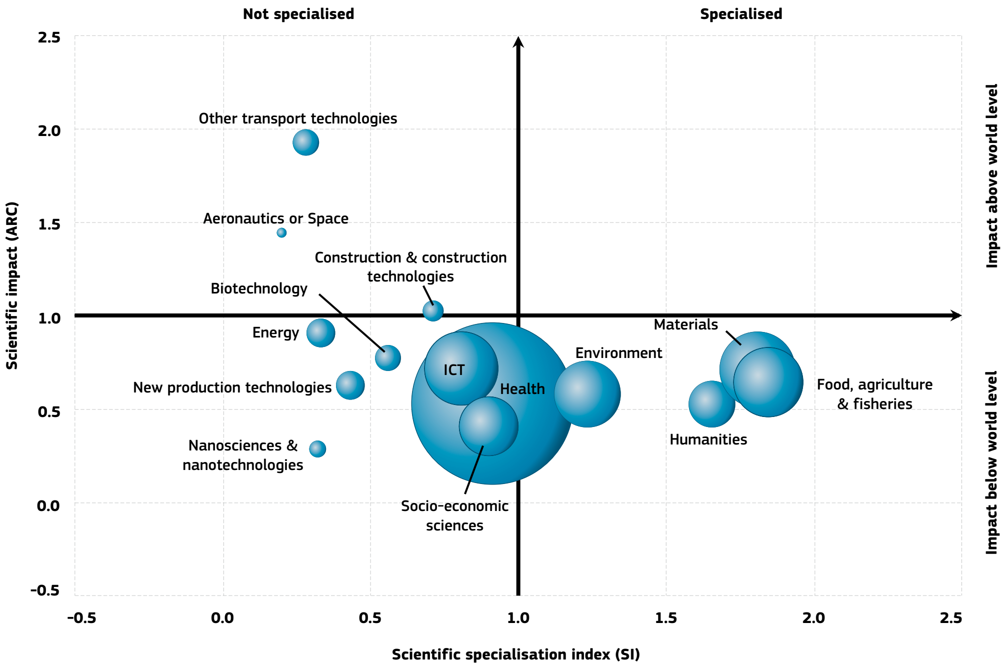


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

The graph above shows that the Slovak scientific and technological specialisation in selected thematic priorities is rather unbalanced. Naturally, sectors such as socio-economic sciences and humanities do not lead to any technological production. On the other hand, five other sectors with strong technology advantages are hardly covered by scientific specialisation (i.e. other transport technologies, energy, new production technologies, biotechnology, and construction and construction technologies). In Slovakia, the sectors with the best matches between science and technology are environment, materials, and food, agriculture and fisheries, where progress is quite well balanced, too.

The graph below illustrates the positional analysis of Slovakian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Slovakia – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

Slovakia is well specialised in food, agriculture and fisheries, materials, environment, humanities, and socio-economic sciences, although no above-average impact is generated. Three other sectors (other transport technologies, aeronautics or space, and construction and construction technologies), with a low level of specialisation, have a certain impact. Considering the scientific specialisation index, over the period 2000-2010, Slovakia did not significantly improve either its scientific production rate or, consequently, new production technologies, which resulted in a very poor performance in intellectual assets (PCT patent applications, licence and patent revenues).

Both graphs show clearly that Slovakia's scientific capacity remains very weak. The country's key challenges are illustrated – also in relation to national drafted policy documents – but have yet to be sufficiently addressed. Among them are the weak R&D system and poor cooperation between academia and industry sectors. Low inputs (in terms of public and business R&D spending) correspond with low knowledge-intensive outputs. The Slovak economy is largely dominated by multinational companies (MNCs), which are not linked to its universities and research institutes, and carry out their research in their headquarters abroad. A very large number of domestic SMEs have no research activities because of the cost and potential risks. The low share of domestic innovative enterprises is limiting the country's competitiveness. In addition, scientific production is not of a high level and there is room to improve excellence in the sciences and the university system at national and international level as regards quality co-publications. Furthermore, there is a need to set up a 'sciences and knowledge culture', which is somewhat missing in the nation traditionally. Therefore, Slovakia must also support progress towards the European Research Area (ERA) priorities and ensure transparency, openness and a regulated competition framework of the national governance and business environment.

Policies and reforms for research and innovation

The 2014 National Reform Programme (NRP) confirms targets in R&I for 2020. It focuses on GERD and business expenditure on R&D (BERD) respectively to protect expenditure which promotes economic growth. The NRP sets out the most recent innovation policies indicating a shift towards more up-to-date measures to be implemented in the near future in terms of support for clusters, target groups and methods of funding (innovation vouchers). Since the challenges faced by the Slovak Republic today remain the same, the government has committed to supplementing its policy statement, in the shortest possible time. Further, it considers it is important to ensure that expenditure on productive areas, such as education, remain among its long-term political priorities in subsequent years too, and it will take steps to improve the quality of higher education and its relevance to market needs. It will also focus on measures that ensure smart, sustainable and inclusive growth.

The research policy priorities and policy mix were set in the ‘Long-term Objective of the State S&T Policy up to 2015’ document. The country’s commitment to the EU-2020 targets was reaffirmed, especially regarding the country’s challenges, in particular in R&D intensity as the Slovak public research system accounts for a relatively high share of funding from the Structural Funds. At present, the new strategic policies are intended to streamline national objectives towards the new EU policies in Europe 2020 and Horizon 2020. In this context, NRP includes further measures to improve collaboration between the public and private sector in terms of financial and organisational arrangements and human capital through partnerships, joint ventures and long-term contracts. People should be encouraged to run innovative businesses and this will be promoted by systematically including entrepreneurship teaching (including lessons on tax compliance) in the curricula of primary, secondary and tertiary education establishments.

Traditionally, R&I policies in Slovakia were considered to be matters for central government. Thus, Slovak regions have no legislative power in these fields. No explicit regional R&I programmes and/or policy measures have been developed. A tentative proposal to create regional innovation centres (RIC) was abandoned as being too complex. Slovak regions are characterised by both high and growing regional disparities in the R&D system. Efforts have been concentrated in the Bratislava region.

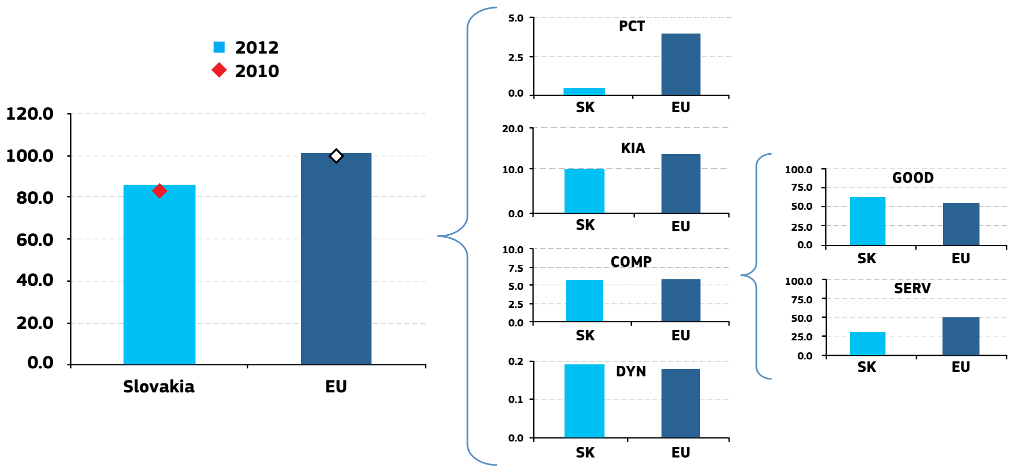
At the national level, the governance structure of the Slovak research system has changed little over last decade. Since 2007, responsibilities for the R&I policies have been divided between the Ministry of Economy (ME) and the Ministry of Education, Science, Research and Sport (MESRS). Innovation policy measures are implemented by the ME and its agencies. The ME implements the Operational Programme of Competitiveness and Economic Growth (OPCEG) and the MESRS implements the Operational Programme Research and Development (OPRD) and the Operational Programme Education (OPE). The 2014 NRP envisages the existing network of governmental implementing institutions to be merged into two integrated agencies: a research agency and a technology agency. The Research and Innovation Strategy for Smart Specialisation document suggested some important changes in innovation governance and identified key areas of economic and technology specialisation. The most important system change relates to the activities of the Slovak Government’s Council for Science, Technology and Innovation (SGCSTI), established in September 2011, but only in operation since April 2013. The Council, which is chaired by the prime minister, is a cross-cutting body involving representatives of key central government ministries, higher education institutes, research institutions, and industry and employer associations. Its main task is to reduce fragmentation and secure effective work in the public R&D&I institutions. It follows coordination of the agenda and policies at the inter-ministerial level, which are of paramount importance for the efficient spending of funds in the years to come.

Overall, there is also scope for improving Slovakia’s innovation capacity and business environment, in particular through more efficient public administration, and closer integration of the Slovak R&I system in the ERA would be an explicit objective of the national policy.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Slovakia's position regarding the indicator's different components:

Slovakia – Innovation Output Indicator



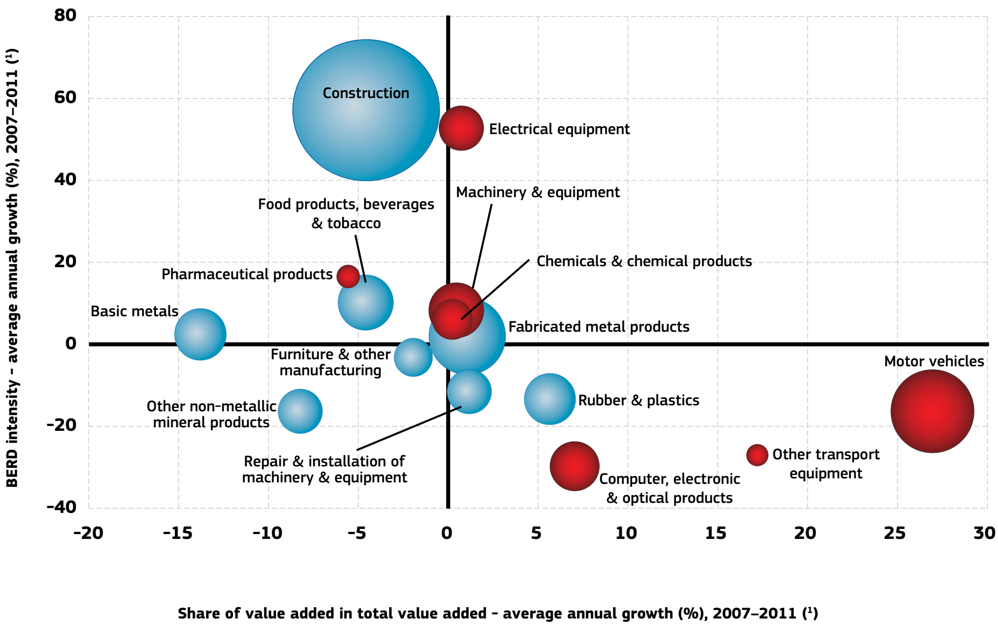
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Slovakia is a medium-low performer in the European innovation indicator, ranked well below the EU average. However, it performs not far from the EU average in most components, with the exception of patents, where the country performs at an extremely low level. On the other hand, the export share of medium-high/high-tech goods is above the EU average, similar to that of Germany. Slovakia is among the best European performers in this component, which can be explained by strong car exports as it has the highest per-capita car production in Europe. Slovakia is under-performing in the export share of knowledge-intensive services, which is explained by the relative importance of service exports such as tourism and land-based transport, not classified as KIS. Slovakia also performs at a low level in employment in knowledge-intensive activities in business industries as a % of total employment. It performs well as regards the innovativeness of fast-growing firms (above the EU average). To improve its overall performance, the country needs to improve its business environment by implementing innovative solutions (new start-ups, spin-offs), by providing administrative support to technology transfer from public R&D institutions, and by establishing a link between universities, the Slovak Academy of Sciences, and technology incubators.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates with four variables the upgrading of knowledge in different manufacturing industries. The position on the horizontal axe illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-aces are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (all sectors presented in the graph). The red sectors are high-tech or medium-high-tech sectors.

Slovakia – Share of value added versus BERD intensity: average annual growth, 2007–2011 ([1])



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: ([1]) 'Furniture and other manufacturing': 2007–2009; 'Basic metals', 'Repair and installation of machinery and equipment': 2008–2011; 'Construction', 'Motor vehicles', 'Other transport equipment': 2009–2011; 'Pharmaceutical products': 2010–2011.
([2]) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

As a small open economy with relatively high profitability and productivity growth, Slovakia enjoys a favourable external competitiveness position. Manufacturing plays an important role and accounts for 26 % of total value added against the EU-27 average of 15.5 %. However, Slovakia's industrial base is specialised in a few capital-intensive and cyclically sensitive sectors. While technology import has been a source of major productivity gains in the past ten years, this has made the country's economy quite vulnerable, being dependent on external demand.

The graph above synthesises the structural change in the Slovak manufacturing sectors over the 2007-2011 period. It shows that three medium- and high-tech sectors (motor vehicles, computer, electronic and optical products, and other transport equipment) have grown in economic importance (value added), while knowledge-intensity (as measured by R&D investments) in medium-sized, medium- or low-tech sectors, such as other non-metallic mineral products, repair and installation of machinery and equipment, and rubber and plastics, has declined. Economic expansion has been mostly related to the traditional automotive sector, followed mainly by the three sectors cited above. Nevertheless, most Slovak manufacturing industries did not upgrade their knowledge intensity over this period, which could indicate a medium-term risk to the sector in the context of increasing globalisation. Due to the weak innovation system, the innovation capacity of domestic firms remains limited.

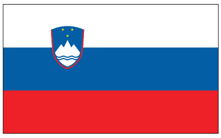
Key indicators for Slovakia

SLOVAKIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.57	1.17	1.37	1.52	1.82	2.13	3.18	1.86	2.44	10.0	*1.81*	4
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	492	:	:	497	:	:	482	-10.5 (3)	495 (4)	19 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.43	0.25	0.21	0.18	0.20	0.20	0.27	0.25	0.34	*13.3*	1.31	22
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.22	0.25	0.28	0.28	0.27	0.28	0.36	0.43	0.48	11.7	*0.74*	20
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	16.8	:	:	:	:	25.2	8.5	47.8	20
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	2.4	3.3	3.7	3.2	4.0	:	:	:	3.2	11.0	23
International scientific co-publications per million population	:	254	292	321	356	357	365	390	399	4.5	343	23
Public–private scientific co-publications per million population	:	:	:	11	11	12	15	16	:	8.0	53	22
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.7	0.5	0.5	0.5	0.3	0.4	0.4	:	:	-6.0	3.9	23
License and patent revenues from abroad as % of GDP	0.08	0.16	0.16	0.20	0.17	0.11	0.05	0.004	0.005	-52.8	0.59	28
Community trademark (CTM) applications per million population	:	7	17	20	29	38	34	50	50	19.6	152	24
Community design (CD) applications per million population	:	3	6	6	5	8	6	10	8	6.7	29	24
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	16.7	:	15.8	:	23.3	:	:	21.6	14.4	1
Knowledge-intensive services exports as % total service exports	:	15.5	19.8	22.1	21.4	19.0	19.7	22.1	:	-0.1	45.3	23
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	0.20	0.32	0.95	2.19	3.18	3.31	3.96	4.35	3.88	-	4.23 (5)	7
Growth of total factor productivity (total economy): 2007 = 100	77	90	94	100	102	97	101	102	104	4 (6)	97	1
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	31.1	:	:	:	:	32.0	0.6	51.2	26
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	10.0	10.1	10.1	10.6 (7)	10.1	0.6	13.9	23
SMEs introducing product or process innovations as % of SMEs	:	:	21.4	:	19.0	:	25.4	:	:	15.6	33.8	20
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.06	0.03	0.04	0.02	0.02	0.03	:	:	:	40.6	0.44	25
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.07	0.00	0.03	0.04	0.03	0.002	:	:	:	-80.1	0.53	28
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	63.5	64.5	66.0	67.2	68.8	66.4	64.6	65.0 (8)	65.1	-1.3	68.4	18
R&D intensity (GERD as % of GDP)	0.65	0.51	0.49	0.46	0.47	0.48	0.63	0.68	0.82	*12.3*	*2.07*	22
Greenhouse gas emissions: 1990 = 100	69	71	70	68	69	61	64	63	:	-5 (9)	83	6 (10)
Share of renewable energy in gross final energy consumption (%)	:	6.6	6.9	8.2	8.1	9.7	9.4	9.7	:	4.3	13.0	19
Share of population aged 30–34 who have successfully completed tertiary education (%)	10.6	14.3	14.4	14.8	15.8	17.6	22.1	23.2	23.7	9.9	35.7	25
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	6.3	6.6	6.5	6.0	4.9	4.7	5.1	5.3	-4.0	12.7	3 (10)
Share of population at risk of poverty or social exclusion (%)	:	32.0	26.7	21.3	20.6	19.6	20.6	20.6	20.5	-0.8	24.8	11 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) EU is the weighted average of the values for the Member States.
(6) The value is the difference between 2012 and 2007.
(7) Break in series between 2011 and the previous years. Average annual growth refers to 2008–2010.
(8) Break in series between 2011 and the previous years. Average annual growth refers to 2007–2010.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Improve the quality and relevance of the science base and implement plans to foster effective knowledge transfer and cooperation between academia, research and business."



Slovenia

Towards a knowledge-intensive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Slovenia. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **2.80 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+12.7 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **28.8** (EU: 47.8; US: 58.1) 2007-2012: **+9.9 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **87.4** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **50.3** (EU: 51.2; US: 59.9) 2007-2012: **+3.7 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: New production technologies, materials, food, ICT, security, and construction technologies	***HT + MT contribution to the trade balance*** 2012: **6.5 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+9.4 %** (EU: +4.8 %; US: -32.3 %)

R&D intensity in Slovenia increased from 1.38 % in 2000 to 2.8 % in 2012, thus its R&D intensity target of 3 % for 2020 seems achievable. In spite of the economic crisis, business expenditure on R&D as a percentage of GDP increased from 0.87 % in 2007 to 2.16 % in 2012, making Slovenia one of the top performers in the EU in terms of business R&D. The country ranks third in the EU, outperformed only by Finland and Sweden.

This is a clear signal that Slovenia regards investment in R&D as a priority for the development of medium-high and high-tech competitive enterprises and for increased and sustainable economic growth. It is meeting the challenge of reaching its 2020 R&D intensity target of 3 % by mobilising incentives and resources from public and private sources (human, financial, infrastructural) and providing a smooth path for more technological innovation. Improving the overall governance and ensuring a clearer research prioritisation with a stronger focus on knowledge transfer remain the main challenges for the Slovenian R&I system to support the efficient and effective use of available resources.

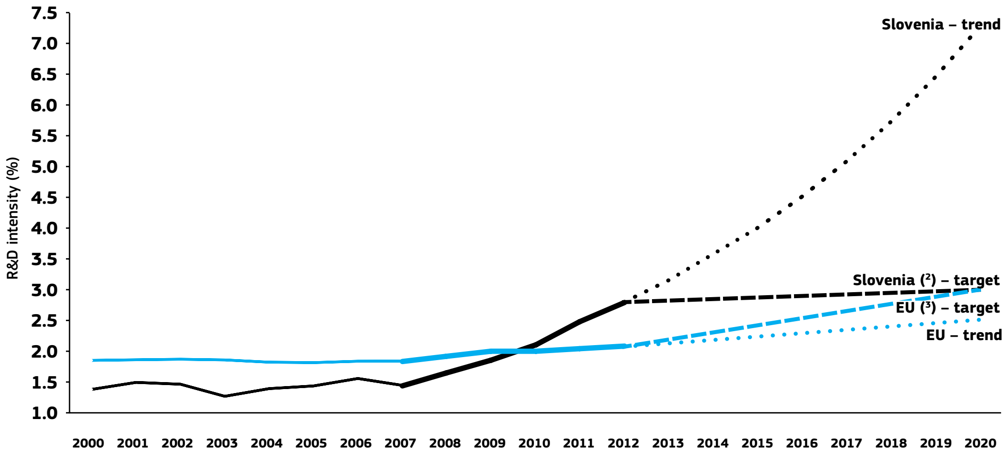
To tackle these challenges, the National Research and Innovation Strategy 2011-2020 needs to be implemented and coordinated with the 2013 industrial policy strategies as well as with the upcoming strategies on smart specialisation and transport, and to ensure their prompt implementation and assessment of effectiveness. Measures to foster knowledge transfer and commercialisation of research results – such as the introduction of funding linked to research performance, removal of obstacles to establishing university spin-offs and cross-border venture capital investments – would contribute to creating a favourable business environment for innovative companies in key sectors.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators

Investing in knowledge

Slovenia – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2008–2010 in the case of Slovenia.
(2) SI: The projection is based on a tentative R&D intensity target of 3.0 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(4) SI: There are breaks in series between 2008 and the previous years and between 2011 and the previous years.

Since 2000, the level of R&D investment in Slovenia has increased at an unprecedented and unparalleled rate, making it one of the leading EU Member States in this respect. R&D intensity in Slovenia increased from 1.38 % in 2000 to 1.45 % in 2007 and 2.8 % in 2012. Thus, Slovenia's R&D intensity target of 3 % for 2020 is clearly achievable despite the economic crisis. This remarkable achievement is the result of strong public support and a set of ambitious innovation measures.

In spite of the economic crisis, business expenditure on R&D as a percentage of GDP increased from 0.87 % in 2007 to 2.16 % in 2012, making it one of the EU's top performers in terms of business R&D. However, it should be noted that this performance has been achieved with a very high level of public support to business R&D.

Notwithstanding budgetary constraints, public sector expenditure on R&D in 2012 was 0.64 % of GDP, slightly below the EU average but above those countries with similar research and knowledge structures.

Slovenian R&I also receive support from the EU budget through two main instruments: the Structural Funds and the Seventh Framework Programme (FP7). Of the EUR 4101 million of Structural Funds allocated to Slovenia over the 2007-2013 programming period, around EUR 1013 million (24.7 % of the total) related to RTDI[3]. A total of 849 participants from Slovenia benefited by around EUR 152 million from FP7. The success rate of participants is 15.62 %, below the EU average of 19.62 %.

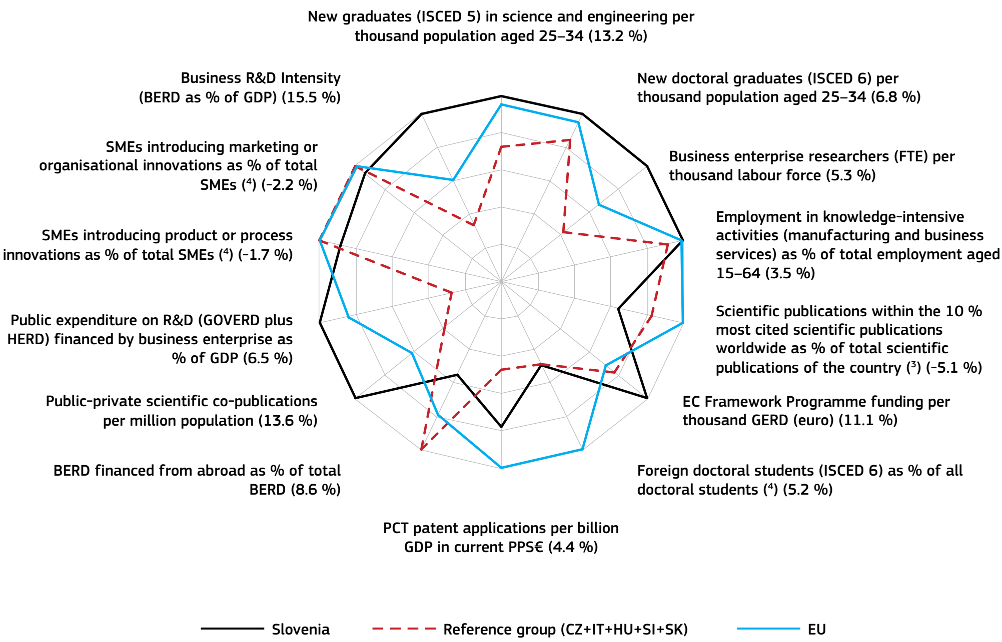
[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Slovenia's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.

Slovenia, 2012 (1)

In brackets: average annual growth for Slovenia, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The graph above shows that Slovenia's R&I system is performing well, with several indicators close to or above the EU average and showing positive trends. These include human resources, innovation in business, and R&D expenditure. Nevertheless, there are some weaknesses in the fields of knowledge commercialisation, private and public sector internationalisation, and research quality.

As regards human resources, Slovenia already has a high level of new doctoral graduates, above the EU average, but is still catching up in terms of new graduates in science and engineering. Employment of researchers by business enterprises and in knowledge-intensive activities is also at a high level. In this respect, it would appear that highly skilled graduates are readily absorbed into the Slovenian economy. However, despite its good performance in human resources, Slovenia is still not attractive enough for foreign doctoral students.

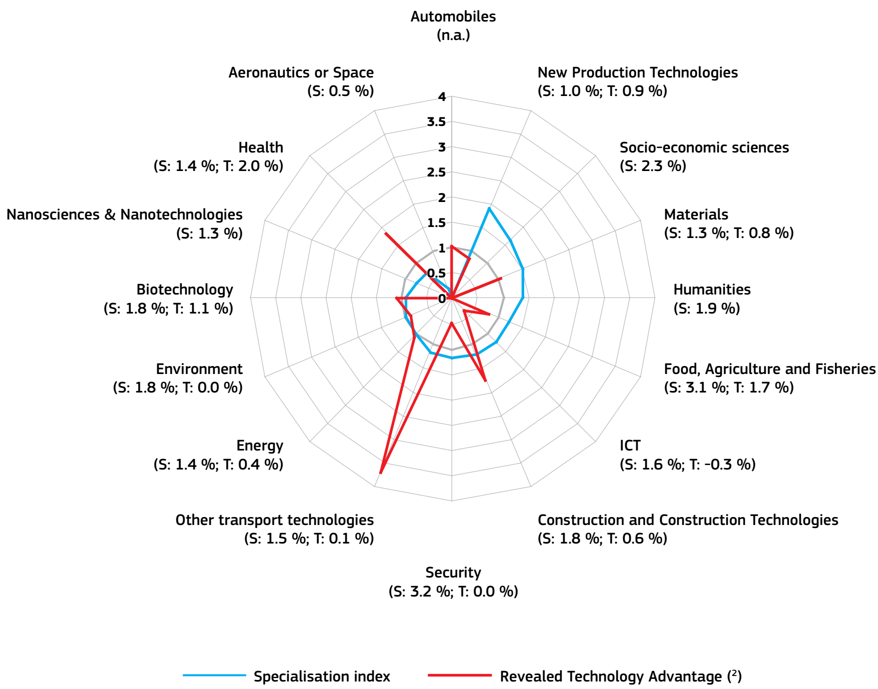
As regards scientific production, Slovenia produces high levels of international scientific co-publications and public-private scientific co-publications but needs to improve their quality in order to perform better in terms of scientific publications within the 10 % most-cited scientific publications worldwide. In terms of knowledge commercialisation, the country has an increasing number of PCT patent applications and a high level of patent applications to the European Patent Office (EPO) in the field of health-related technologies. However, the levels of both total PCT and total EPO patent applications are below the EU average. Slovenian small and medium-sized enterprises (SMEs) perform well in terms of (non-technological) marketing and organisational innovations and fairly well in introducing product or process innovations.

Slovenia's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Slovenia shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Slovenia – S&T National Specialisation (1) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Comparison of the scientific and technological specialisation in selected thematic priorities shows some co-specialisations with small mismatches. In most of the sectors, scientific production is combined with certain technological specialisation, although scientific quality is limited in sectors relevant to its industry.

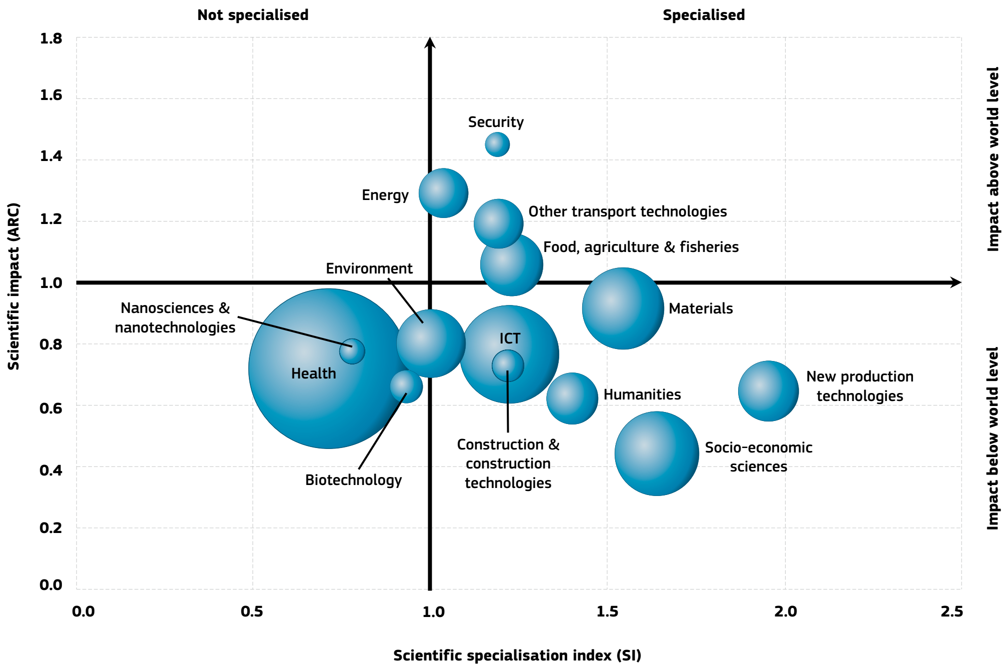
The country displays relevant scientific specialisation in several sectors, such as new production technologies, materials, food, agriculture and fisheries, ICT, security, construction technologies and, to less extent, in energy, environment, and biotechnology. The scientific profile is coupled with the country's technological profile in most of the sectors except for ICT and security.

On the other hand, the strong technological specialisation in health and in other transport technologies is not backed up by a strong domestic scientific specialisation. Taking into account the technological specialisation of Slovenia in these fields, the country would probably benefit from fostering scientific specialisation and scientific quality in this sector.

Slovenia has established strength in the field of energy, other transport technologies, food agriculture and fisheries, and energy where scientific production and quality are correlated with a certain technological specialisation. However, there is a room for improvement on scientific impact of some sectors ranking high on the science specialisation indicator – i.e. ICT, materials or new production technologies. Finally, the quality of domestic science in security is not coupled with the country's scientific and technological specialisation profile. In contrast, the strong technological specialisation in health is not leveraged by high scientific quality and specialisation of domestic science in Slovenia.

The graph below illustrates the positional analysis of Slovenian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Slovenia – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

As quality in research is correlated to more cooperation with researchers from other European countries and beyond, in order to increase its research quality Slovenia would benefit from actively supporting and providing incentives for its researchers to connect to Horizon 2020 networks.

Policies and reforms for research and innovation

In 2011, the Slovenian authorities approved its Research and Innovation Strategy 2011-2020 (RISS); however, the measures outlined therein have yet to be implemented and coordinated with the 2013 industrial policy strategies and with the upcoming strategies on smart specialisation and transport, and their prompt implementation and assessment of effectiveness ensured.

The Slovenian Research Agency is in charge of financing basic and applied research primarily in the public-research sector, while the newly formed SPIRIT, the agency combining the former Technology and Innovation Agency, the Public Agency for Entrepreneurship and Foreign Investment, and the Slovenian Tourism organisation should be in charge of entrepreneurial support and financing R&D activity in business sector. Yet, only some of the calls have been entrusted to the new agency and some have been performed directly by the Ministry of Economic Development and Technology. Support for business-sector R&D is also partially provided through the Slovenian Enterprise Fund, especially for start-ups in an innovation environment and bank guarantees for SMEs engaged in R&D projects and technological restructuring.

The RISS includes important measures for fostering knowledge transfer and the commercialisation of research results, such as the introduction of institutional funding linked to an assessment of research performance or the removal of obstacles to the establishment of university spin-outs and to cross-border venture-capital investments. This strategy proposed several changes in R&D financing, especially with regard to higher education institutions. The main argument for change was to give more independence and autonomy to universities and institutes, allowing them to allocate the funds internally, on one hand, and to increase the competitive funding, as suggested by the OECD and ERAC (European Research Area and Innovation Committee) evaluations, on the other. Such a change required a new or at least significantly amended Law on R&D (2002). In October 2013, the ministry appointed an expert group with the task of drafting the new law, but gave no directions in terms of new institutional/funding set-up. By the end of 2013, a draft of the new law had been prepared within the group, but it has not yet been presented to the government or the public.

The government significantly increased the R&D tax subsidy which, from 2012, has been at the level of 100 %. In 2011, a thousand companies had benefited from this measure, which has been welcomed in particular by larger enterprises that invest significantly in R&D (for example, pharmaceutical companies). The planned change of offering more subsidised credit rather than subsidies for R&D projects, which the government wanted to implement in 2012, proved not to be the measure Slovenian, especially small enterprises, would favour.

Lack of thematic funding has been identified as a weakness in several evaluations of the national innovation system. Slovenia currently only supports certain sectors through the funding of eight centres of excellence, seven competence centres and 17 development centres, all co-founded through the Structural Funds. The competence centres are led by businesses combining basic and applied research with a view to creating future market opportunities, and to some extent complement the centres of excellence, introduced in 2009. The latter focus on basic research carried out by public research organisations, in cooperation with business R&D units active in the same area. And finally, the development centres (consortia of business firms) support 'close to the market' research projects with a view to developing new products, processes and services. It is also noteworthy that tax allowances for R&I were increased in April 2012.

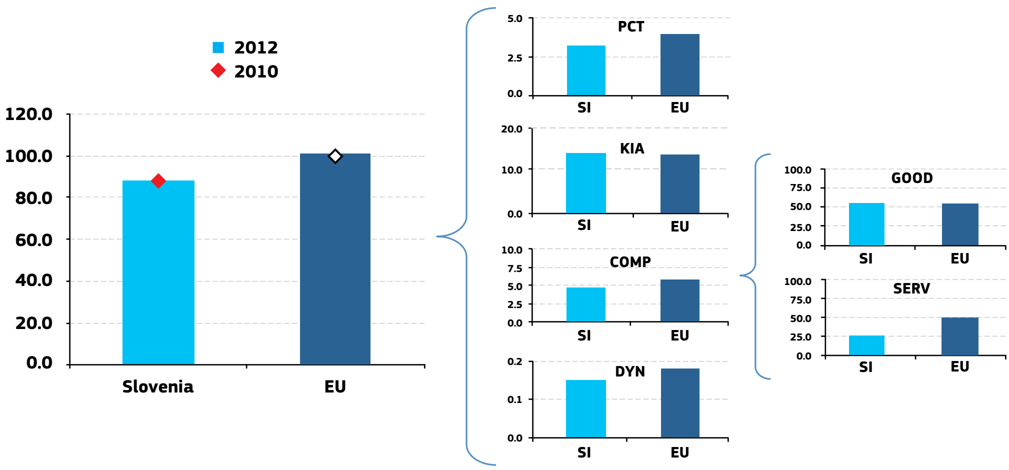
To improve cooperation between the public and private sectors, in 2012, Slovenia developed the research voucher (EUR 8 million) to help enterprises to commission research at R&D institutes and higher education organisations for a period of three years. The final aim was to connect companies with universities.

Slovenia has room to better address funding priorities. There is a need for more focus on, and critical mass in, sectors related to Slovenia's existing R&D strengths and economic strengths. The measures outlined in the Research and Innovation Strategy and in the Industrial Policy Strategy need to be implemented and coordinated with the smart specialisation process in order to harness the country's potential for smart growth and the knowledge economy.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Slovenia's position on the indicator's different components:

Slovenia – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Slovenia is a medium-low performer in the European innovation indicator. This is the result of a diversified performance in the indicator's components. It is near the EU average for employment in knowledge-intensive activities and for the share of medium-high and high-tech manufacturing goods in total goods exports, but low for knowledge-intensive service exports, for patents, and for the innovativeness of high-growth enterprises.

Slovenia performs near the EU average as regards the share of medium-high/high-tech goods in total goods exports. This is the result of a balance between, on the one hand, strong exports of pharmaceutical products, electrical machinery and road vehicles, and of wood products, food and textiles on the other.

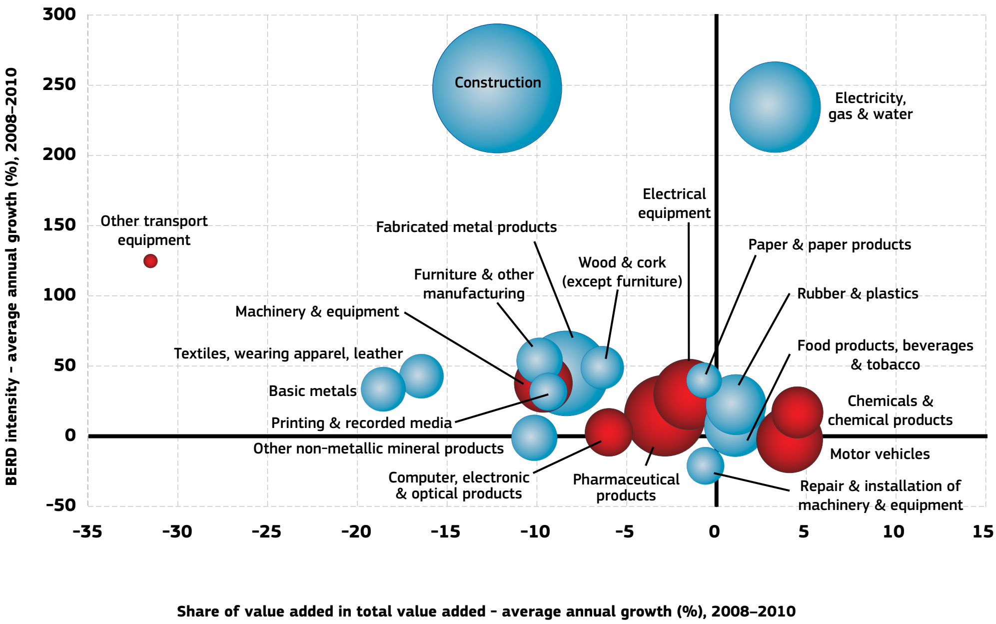
The low share of knowledge-intensive service exports is explained by the relative importance of tourism and of non-KIS transport services (mainly road freight transport, but also rail freight), not compensated for by any strongholds in KIS exports.

Slovenia also performs at a low level as regards the average innovativeness of fast-growing firms. This is the result of a high share of employment in fast-growing enterprises in manufacturing sectors with low innovation coefficients. Therefore, it seems that Slovenia may not have fully developed its innovative potential. One of the reasons is that some components of the business and competitive framework have changed very little: links between the public and private sector remain weak and some structural aspects of the business environment are hindering foreign direct investment. In order to improve competitiveness, it would be beneficial to consider developing a new industrial policy, including a strategy for attracting foreign capital, notably linked to R&I. Both should be consistent mutually as well as with other Slovenian strategic documents.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Slovenia – Share of value added versus BERD intensity: average annual growth, 2008–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: (1) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

The Slovenian economy is characterised by a relatively strong manufacturing industry. Manufacturing makes a higher contribution to total value added than the EU average. Nevertheless, as in many other countries, the share of manufacturing value added is moving towards a decline (as shown by the position of most of the sectors on the left side of the graph), due to a corresponding increase in services value added.

Although some industry sectors have achieved a slight increase in their share of the economy, specialisation in labour-intensive industries has decreased considerably over the last few decades. As the graph illustrates, Slovenia's manufacturing industries are moving towards higher research intensity in almost all sectors. Highly innovation-intensive sectors are: electrical equipment, machinery and equipment, electronic and optical products, pharmaceutical products, chemical and chemical products, and motor vehicles, with the latter showing increasing added value in the country's economy. Slovenia has two companies in the 2011 EU Industrial R&D Scoreboard, in the fields of pharmaceuticals, and construction and materials.

Key indicators for Slovenia

SLOVENIA	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	1.00	1.24	1.31	1.37	1.34	1.52	1.51	1.72	1.90	6.8	*1.81*	12
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	504	:	:	501	:	:	501	-3.3 (3)	495 (4)	9 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.78	0.85	0.94	0.87	1.07 (5)	1.20	1.43	1.83 (6)	*2.16*	15.5	1.31	3
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.59	0.59	0.62	0.58	0.59	0.66	0.68	0.65 (7)	*0.64*	5.3	*0.74*	13
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	18.0	:	:	:	:	28.8	9.9	47.8	15
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	6.9	6.8	7.8	7.5	7.0	:	:	:	-5.1	11.0	18
International scientific co-publications per million population	:	588	573	691	796	834	868	966	1042	8.5	343	10
Public–private scientific co-publications per million population	:	:	:	51	54	61	70	85	:	13.6	53	7
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	2.1	2.7	2.5	2.7	3.1	3.2	3.1	:	:	4.4	3.9	10
License and patent revenues from abroad as % of GDP	0.06	0.05	0.04	0.04	0.07	0.07	0.08	0.11	0.10	19.4	0.59	18
Community trademark (CTM) applications per million population	2	16	31	71	104	78	108	73	102	7.6	152	17
Community design (CD) applications per million population	:	9	19	20	24	28	30	32	36	12.3	29	8
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	13.3	:	16.3	:	10.6	:	:	-19.2	14.4	17
Knowledge-intensive services exports as % total service exports	:	18.6	17.7	18.9	23.8	21.7	20.8	21.4	:	3.1	45.3	25
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	1.34	3.74	3.96	4.16	4.77	5.79	6.06	6.05	6.54	-	4.23 (8)	2
Growth of total factor productivity (total economy): 2007 = 100	87	95	98	100	99	92	94	95	93	-7 (9)	97	22
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	42.0	:	:	:	:	50.3	3.7	51.2	12
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	12.2	13.0	13.4	13.8	14.0	3.5	13.9	14
SMEs introducing product or process innovations as % of SMEs	:	:	31.7	:	31.0	:	30.0	:	:	-1.7	33.8	17
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.10	0.08	0.08	0.03	0.07	0.16	:	:	:	118.4	0.44	14
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.26	0.81	1.19	1.19	1.15	0.76	:	:	:	-20.2	0.53	5
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	68.5	71.1	71.5	72.4	73.0	71.9	70.3	68.4	68.3	-1.2	68.4	14
R&D intensity (GERD as % of GDP)	1.38	1.44	1.56	1.45	1.66 (5)	1.85	2.10	2.47 (6)	*2.80*	12.7	*2.07*	6
Greenhouse gas emissions: 1990 = 100	103	110	112	112	116	105	106	106	:	-7 (10)	83	22 (11)
Share of renewable energy in gross final energy consumption (%)	:	16.0	15.6	15.6	15.0	19.0	19.6	18.8	:	4.8	13.0	10
Share of population aged 30–34 who have successfully completed tertiary education (%)	18.5	24.6	28.1	31.0	30.9	31.6	34.8	37.9	39.2	4.8	35.7	13
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	4.9	5.6	4.1	5.1	5.3	5.0	4.2	4.4	1.4	12.7	2 (11)
Share of population at risk of poverty or social exclusion (%)	:	18.5	17.1	17.1	18.5	17.1	18.3	19.3	19.6	2.8	24.8	10 (11)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2008 and the previous years.
(6) Break in series between 2011 and the previous years. Average annual growth refers to 2008–2010.
(7) Break in series between 2011 and the previous years. Average annual growth refers to 2007–2010.
(8) EU is the weighted average of the values for the Member States.
(9) The value is the difference between 2012 and 2007.
(10) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(11) The values for this indicator were ranked from lowest to highest.
(12) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Streamline priorities and ensure consistency between the 2011 research and innovation and the 2013 industrial policy strategies with the upcoming strategies on smart specialisation and transport, and ensure their prompt implementation and assessment of effectiveness."

Spain

The challenge of effective R&I for a more knowledge-intensive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Spain. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.30 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+0.5 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **33.2** (EU: 47.8; US: 58.1) 2007-2012: **+0.4 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **80.8** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **38.0** (EU: 51.2; US: 59.9) 2007-2012: **+2.1 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Food, agriculture and fisheries, transport technologies, construction technologies, environment and biotechnologies	***HT + MT contribution to the trade balance*** 2012: **3.3 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+15.9 %** (EU: +4.8 %; US: -32.3 %)

Spain's investment in research and development (R&D) grew faster than the EU average over the period 2000-2008. Total expenditure in R&D reached its peak in 2008.The strongest increase was in the business sector, where total investment in R&D grew faster than in the public sector. Recent reforms have reduced the costs of creating a business. Public investment in R&D even increased beyond the economic crisis, in a counter-cyclic effort up to 2010. However, fiscal constraints forced Spain to cut public R&D expenditure from 2011 onwards, and with the effect of the economic recession, business R&D investment has also fallen.

Excellence in science and technology improved slightly over the 2007-2012 period; nevertheless, Spain is falling further behind the EU average in terms of excellence. However, structural change towards a more knowledge-intensive economy is under way with increase growth registered in the knowledge-intensive activities (KIAs) as a % of total employment. The change in Spain is slow compared to both the EU and the USA. One positive sign is the rising contribution of high-tech and medium-high-tech goods to the trade balance, indicating that the growing Spanish competitiveness is not only based on cost factors but also on a strong technology component.

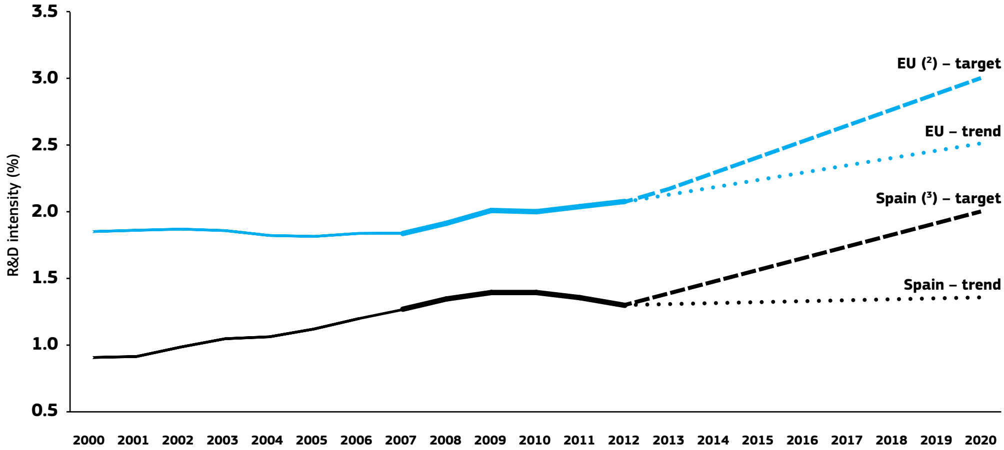
Thus, the main challenges remaining for Spain are to ensure smart fiscal consolidation by maintaining its investment in knowledge while ensuring a high quality of public spending. There is room to further improve the effectiveness of this investment with efforts towards a more performance-based funding allocation to R&I. Full implementation of the new Law for Science, Technology and Innovation, adopted in 2011, would also improve the quality of public spending, including accelerating the setting up of the national research agency and legal changes to stimulate researcher mobility between the public and private sectors.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D total expenditure, skills, sectorial specialisation, international specialisation and internationalisation sub-indicators.

Investing in knowledge

Spain – R&D intensity projections: 2000–2020 (¹)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (¹) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(²) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(³) ES: The projection is based on a tentative R&D intensity target of 2.0 % for 2020.

Spain is not on track to reach its national R&D target for 2020, despite a lowering of this target from 3 % to 2 % in the national reform programme 2013. Reaching this national target of 2 % R&D intensity would require an average annual growth of 5.5 % over the period 2012-2020, implying substantial efforts by the public sector combined with strong framework conditions spurring a change in business models in the private sector towards growth built on R&D and knowledge investments.

The public sector represented about half of total R&D investment in Spain. Total expenditures in R&D amounted to EUR 13.392 million in 2012, down by 5.6 % compared to 2011. By sector of performance, the fall over the last year was higher in the public sector (-7.4 %) than in the private sector (-4.1 %). At the same time, expenditure in higher education fell by 7.2 % in 2012, although higher education expenditure on R&D did experience an average annual growth rate of 5.4 % over the period 2007-2010.

Business-sector R&D investment fell slightly every year over the 2008-2012 period (the average annual growth rate of total BERD was 13.7 % over the period 2002-2007, which changed to a negative average annual growth rate of -3.2 % over the 2008-2012 period). In the business sector, 78 % of R&D investment is made by a company's own resources, while most of the remaining costs are financed by public administration and foreign capital.

Out of almost EUR 34.7 billion of Structural Funds allocated to Spain over the 2007-2013 programming period, around EUR 5.5 billion (15.8 % of the total) related to RTDI[3]. Spain also performs well in terms of the ratio of EC funding from FP7 to its GERD, well above the EU average and with a positive growth rate.

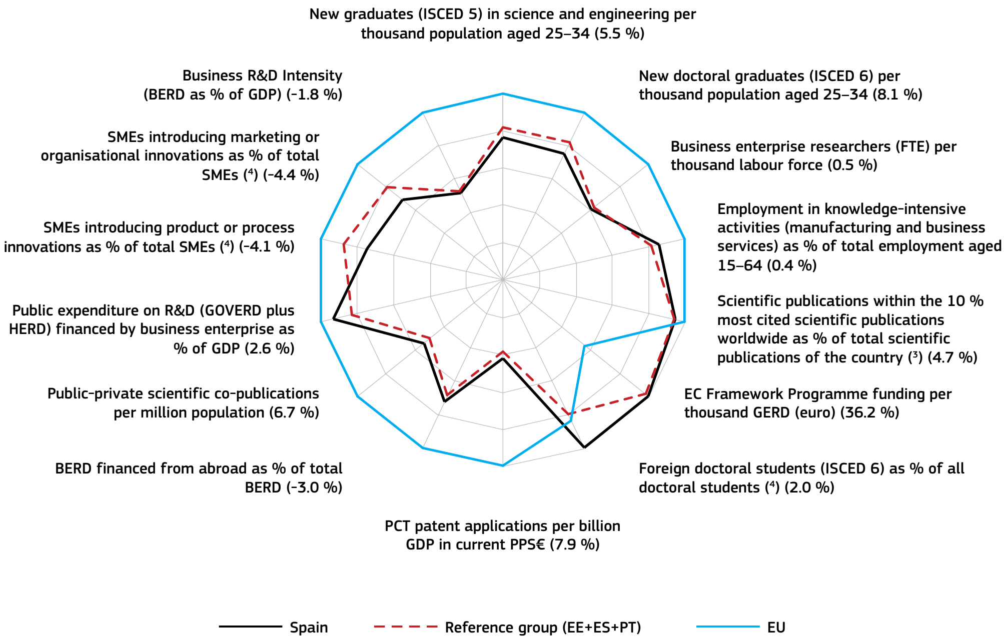
[3] RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Spanish R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Spain, 2012 (1)

In brackets: average annual growth for Spain, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

Spain's R&I system is building up obvious strengths in its internationalisation, in particular in terms of integration in the EU's Seventh Framework Programme (FP7) and in attracting foreign doctoral students. Positive trends are also visible in human resource training, public-private cooperation and the knowledge-intensity of the economy, although continued efforts are still needed to fully catch-up. The worrying trend over the period 2007-2012 was the shrinking R&I activity in the private sector, in particular among small and medium-sized enterprises (SMEs).

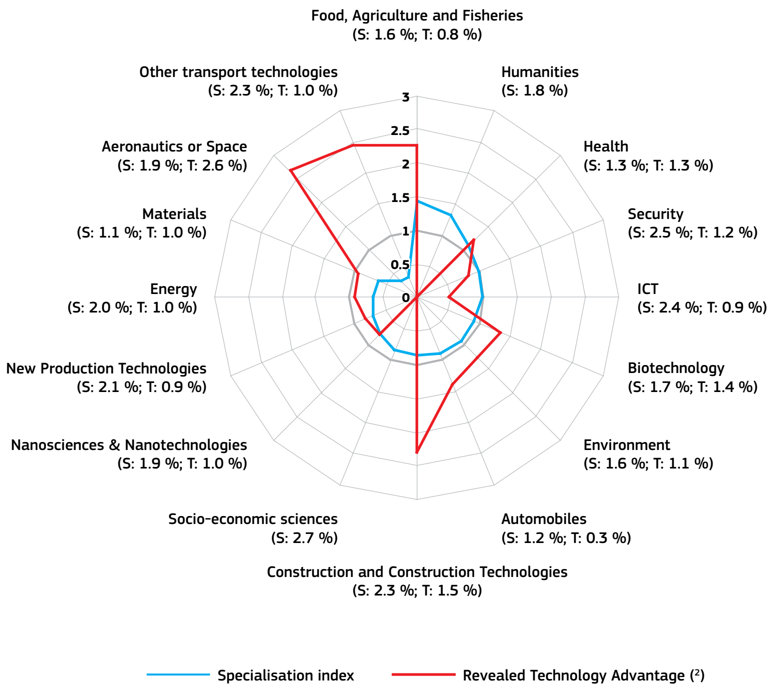
In terms of integration in the European Research Area (ERA) and beyond, Spain increased its international scientific co-publications (total number of international co-publications involving a Spanish author and at least one author from another country) by 16 % over the period 2000-2011. The level of Spain's international co-publication (29.1 %) is still below that of comparable European countries (France 35.2 % or Portugal 41 %), but is comparable to that of Italy (30.8 %). Overall, Spain is well connected to the major European research hubs, in particular in France, the United Kingdom and Germany, but also to Italy and Portugal. However, a closer look reveals that this is mainly in three autonomous communities – Cataluña, Valencia and Madrid – where close integration has developed with the European networks, while the other Spanish regions are mainly connected inside Spain.

Spain's scientific and technological strengths

The graph below illustrates the areas, based on the FP7 thematic priorities, where Spain shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Spain – S&T National Specialisation (1) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

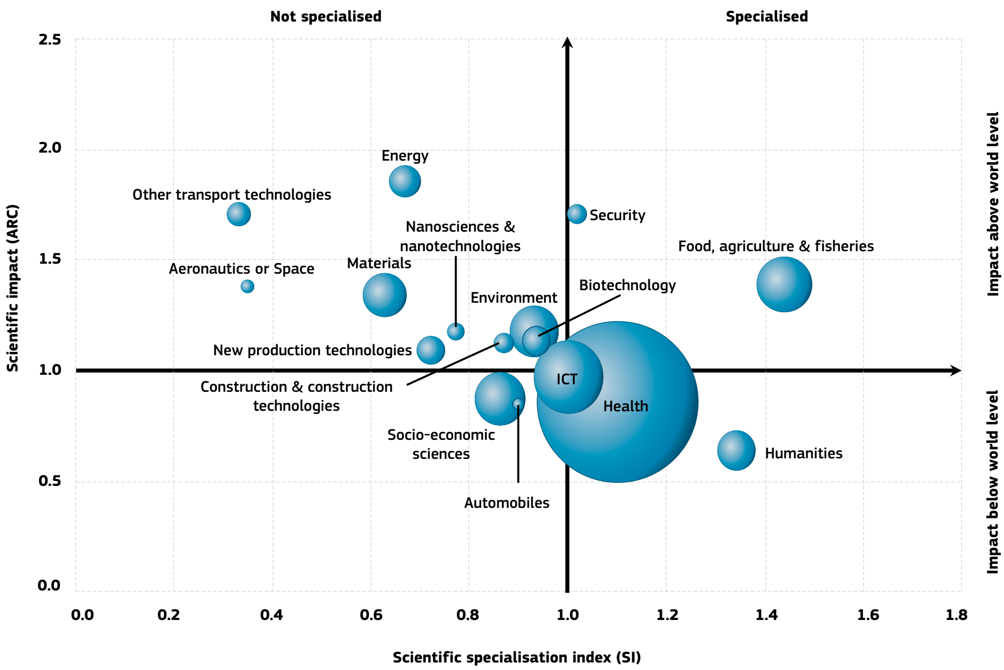
Comparison of the scientific profile with the technology profile shows a good match only in the field of food, agriculture and fisheries. Spain's technology production is also specialised in transport technologies, construction technologies and, to a certain extent, in the environment, and biotechnologies. In the fields where Spain is specialised in both science and technology (food and agriculture), the ERA offers good opportunities for cooperation, in particular scientific cooperation with researchers from several Northern and Eastern European countries, and technological cooperation with Norway, Iceland, Denmark, Lithuania, the Netherlands, Switzerland, Slovakia and Portugal[4].

[4] Innovation Union Competitiveness Report 2013, SWD(2013) 505

The relative strengths in patenting are visible in Cataluña, Madrid and the Basque country, although Aragon and Cantabria are also present in energy patenting. The main technology sectors are food and agriculture, biotechnology, ICT, aeronautics or space, other transport technologies and energy, although the core technology development in these sectors in Europe is taking place in regions outside Spain. The data on patenting in industrial sectors show that Cataluña has particular strengths in organic fine chemistry, pharmaceuticals, and food chemistry, while the Basque country has similar technology strengths in engines, pumps and turbines, thermal process and apparatus, furniture, games, other consumer goods, machine tools, electrical motors, and green energy.

The graph below illustrates the positional analysis of Spanish publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Spain – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

As shown in the graph above, scientific quality, as measured by the 10 % most-cited publications, has grown by 3.6 % over the period 2007-2012. The largest numbers of scientific articles are produced in the field of health, followed by ICT, environment, food, agriculture and fisheries. Scientific production in Spain is also important in the fields of energy, materials, and in socio-economic sciences. Scientific excellence can be found in particular in the field of energy, other transport technologies, security, materials science and in food, agriculture and fisheries. However, those areas with the highest impact are still underdeveloped in terms of the number of publications, with the exception of research in food, agriculture and fisheries. Likewise, scientific impact is only average in the fields where most scientific articles are produced, such as health, ICT, and socio-economic sciences.

Policies and reforms for research and innovation

The Spanish authorities are addressing these challenges in the Law for Science, Technology and Innovation, which was adopted with broad political support in 2011, as well as in the Spanish Strategy for Science, Technology and Innovation and the State Plan for Scientific and Technical Research and Innovation, adopted in February 2013. Reform proposals cover the governance system, the quality of human resources, the funding allocation system, and knowledge transfer between actors. Objectives and priorities are well aligned with the objectives of Europe 2020, the Innovation Union and Horizon 2020. The 2011 law simplifies the allocation of competitive funding for R&I by giving responsibility for the allocation of funds to two main bodies: the new national research agency (AEI) and the existing agency for innovation (CDTI). Public-private cooperation will be reinforced by the introduction of legal changes to researchers' contracts, thereby stimulating mobility between the public and the private sector. Legal reforms related to the recruitment and careers of researchers will encourage international outward mobility as well as inward mobility of foreign researchers with high levels of excellence. In addition to these legal reforms, agreed by all parties, a strong policy focus is being placed on technology transfer to the market and on instruments to stimulate private R&D.

The Europe 2020 country specific recommendation on R&I to Spain in 2014 (adopted by the Council on 8 July) indicates the need to identify sources of financing for the new national strategy for science, technology and innovation and to make operational the new State Research Agency.

The implementation of the law and the strategy for the Spanish R&I system is ongoing. With the development of smart specialisation strategies in the 17 Spanish regions predicted to be finalised early in 2014, it is essential to ensure inter-regional links and coordination between national and regional R&I policies. Most Spanish regions have finalised their smart specialisation strategies (RIS3). Considering the drafts and final strategies, most regions have chosen to focus on sustainable agriculture and natural resources (14 regions) and on intelligent and sustainable transport (13 regions). A considerable number of regions have also proposed specialisation in sustainable energy (9) and the digital society (9). In terms of economic sectors, the smart specialisation strategies are focus mainly on the agri-food sector, industrial sector, tourism, health, energy, communication, and water. In many regions, the smart specialisation strategies are cross-sectorial, proposing innovation in new combinations of industries and sectors, such as products and services combining biofood-health and tourism, or energy-ICT-renewables. The industrial profile of the region and its connectedness to global or European value chains are taken into consideration, as are a more forward-looking vision for society and the economy of the region in 2020 in some of the regions.

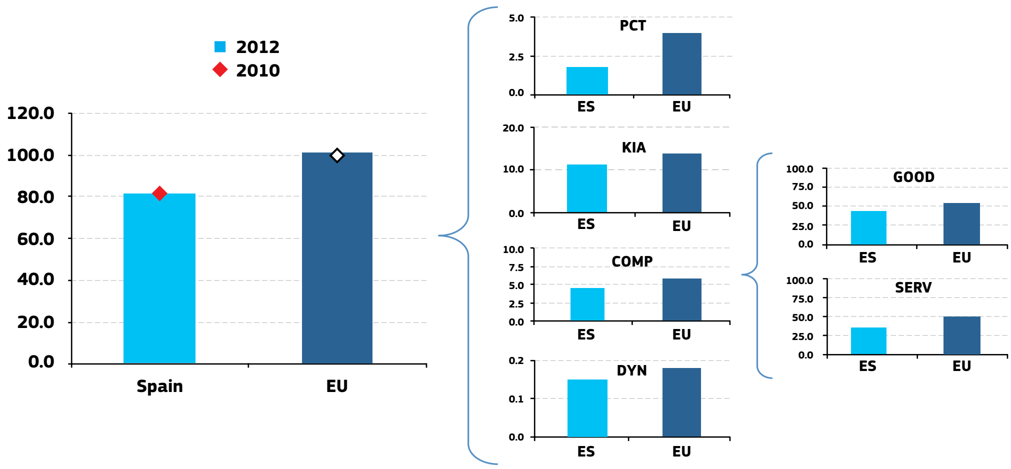
In 2013, the Spanish government also launched new programmes supporting risk and equity funding for innovation-based firms, such as the 'Isabel la Catolica' programme. Legal framework conditions for business angels have been reinforced, and measures have been taken to enhance the business environment, notably the market unity law and the law for the promotion of entrepreneurship and its internationalisation. The objective is to support the internationalisation of businesses, simplify the business environment of SMEs, and to promote a second chance for entrepreneurs. There is room for further reforms enhancing the quality of public spending on R&D in line with the structural reforms pushed forward by the ERA agenda. The allocation of institutional funding to public research organisations in Spain is currently, and for the most part, not based on performance criteria. In fact, a competitive allocation of institutional funding based on performance criteria would contribute to a higher quality of scientific outputs. Moreover, the system's science base is not reliant on international peer review. In 2013, a focused international peer review of the Spanish R&I system was launched in the context of ERAC.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms).

The graph below enables a comprehensive comparison of Spain's position on the indicator's different components:

Spain – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Spain is a medium-low performer in the European innovation indicator. It performs below the EU average in all components of the innovation indicator. Furthermore, its performance is stagnating, and is particularly low in PCT patents and in the share of knowledge-intensive service exports. The latter is explained by the importance of service exports not classified as knowledge-intensive services, such as tourism and related services, in the Spanish economy.

There are around 18 000 firms in Spain actively involved in innovation in their business models. During its economic crisis, the number of companies carrying out innovation has been reduced by half (from an estimated 36 000 in 2008). The sectors with the largest share of innovative firms were R&D services, transport equipment, pharmaceuticals, electronics, chemistry, telecommunications, ICT services, banking and assurance, and machinery. The innovation intensity (firm's investment in innovation as a share of overall revenue) fell from 2.2 % in 2009 to 1.75 % in 2012. In 2011, the innovative firms cooperated with both private and public actors in their innovation process: 47 % cooperated with suppliers for innovation, 37.7 % with universities, 34.7 % with technology centres, 30.2 % with private consultants, 29 % with clients and only 21.9 % with public research organisations. Compared to 2010, the innovative firms had slightly increased their cooperation with all these actors, except for a slight fall in the cooperation with suppliers. According to Spanish companies, the largest obstacles for innovation are costs (highlighted by 44 % of the firms), lack of interest in innovation (30 %), lack of markets for innovative products (27 %) and lack of knowledge (22 %)[5].

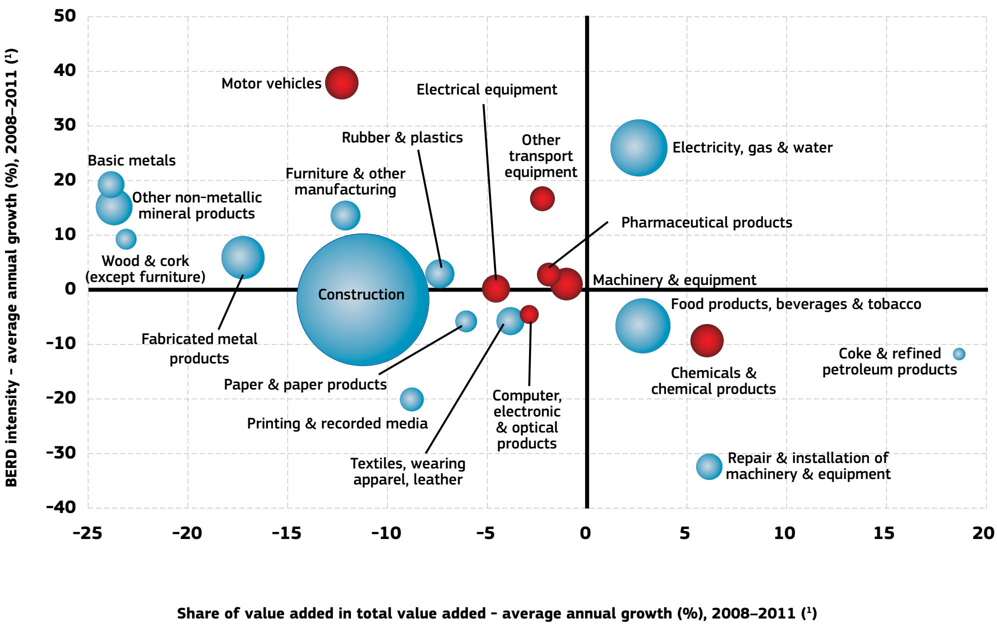
Access to finance is still among the top concerns of Spanish SMEs. In 2011, risk capital and private equity funding in Spain came mostly from foreign investors (82 %). Total risk capital reached a peak in 2007. A large number of the risk capital investments were concentrated in five large operations in 2011. However, investments (26.3 %) were also made in high-growth firms in their expansion phase. In the period 2001-2011, risk capital has invested in a total of 2930 firms in Spain. In addition, venture-capital investment fell in 2011, from EUR 242 million in 2010 to EUR 208 million in 2011. Venture capital was mainly invested in professional services, the health sector, industrial services and in the energy, and natural resources sectors.

5 INE 2012; COTEC 2013 report

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Spain – Share of value added versus BERD intensity: average annual growth, 2008–2011 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Basic metals', 'Electricity, gas and water', 'Fabricated metal products', 'Furniture and other manufacturing', 'Motor vehicles', 'Other non-metallic mineral products', 'Other transport equipment', 'Paper and paper products', 'Printing and reproduction of recorded media'', 'Repair and installation of machinery and equipment', 'Rubber and plastic products','Wood and cork (except furniture)': 2008–2009.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

In the business sector, R&D expenditures can be found mainly in the R&D services sector, representing 51.9 % of total BERD (not included on the graph), ICT, pharmaceutical, aeronautic construction, motor vehicles, and the chemical sectors. Motor vehicles, other transport equipment, electricity, gas and water, and basic metals and non-metallic mineral products were the business sectors that increased their R&D intensity most over the period 2008-2011. However, with the exception of the electricity, gas and water sector, their weight in the overall Spanish economy diminished. The chemical sector, and the computer and electronic sector, where international competitiveness is largely based on R&D, decreased their R&D intensity between 2008 and 2011. Broadly speaking, electrical equipment, pharmaceutical products, machinery equipment, and the construction sector maintained their R&D intensity.

Larger firms invested more in R&D (with over 80 % of total business R&D investment in aeronautics, motor vehicles, and the pharmaceutical sector). Among these larger firms, the mid-caps dominated. In particular, the sectors with large R&D investments by SMEs were ICT services, professional activities, programming consulting, commerce, chemicals, and machinery equipment. In total, SMEs represented 47.6 % of total business R&D investment in 2011, down from 50.2 % in 2010 (and the SMEs perform 57 % of the business R&D). Compared to other similar countries, one characteristic in Spain is SMEs' high contribution to the total business R&D investment, in particular in service sectors (COTEC report 2013).

Among the world's top 2000 R&D investing firms, Spain numbers 13. These companies are mainly active in the ICT services sector (Telefónica, Amadeus, Indra Systems), in the construction and materials sector (Acciona, ACS, Obrascon-Huarte-Lain), in the pharma and biotech sector (Almirall, Grifols, Zeltia) and in the energy or industrial engineering sectors (Gamesa, Abengoa, Repsol). There is also one bank (Banco Santander) in this list. In 2012, the R&D investments by these firms ranged from EUR 1000 million from Telefónica to around EUR 100 million in the energy sector. All but one of these companies increased their R&D investments from 3-12 % over the three-year period 2009-2012. The largest increases were made by firms in the construction and material sector, registering an R&D investment growth of 20-40 %. Other Spanish firms with considerable R&D investments (among the top 1000 R&D investors in Europe) are Iberdrola (electricity sector), Fagor Electrodomésticos, Amper (telecommunications), CAF (automobiles parts), Azkoyen (industrial machinery), Rovi pharmaceutical lab (pharmaceuticals), and Pescanova (agro-industry) (EU Industrial Scoreboard, 2013).

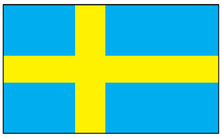
Key indicators for Spain

SPAIN	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.91	0.92	0.94	0.93	0.94	1.03	1.16	1.21	1.37	8.1	*1.81*	18
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	480	:	:	483	:	:	484	4.4 (3)	495 (4)	18 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	0.49	0.60	0.67	0.71	0.74 (5)	0.72	0.72	0.71	0.69	*-1.8*	1.31	18
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.41	0.52	0.53	0.56	0.61	0.67	0.67	0.65	*0.61*	*1.8*	*0.74*	14
Venture capital as % of GDP	0.18	0.29	0.29	0.28	0.15	0.09	0.24	0.19	0.14	-12.5	0.29 (6)	10 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	33	:	:	:	:	33	0.4	47.8	12
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	9.2	9.5	9.5	10.1	10.4	:	:	:	4.7	11.0	11
International scientific co-publications per million population	:	350	391	424	459	499	546	603	631	8.3	343	16
Public–private scientific co-publications per million population	:	:	:	22	22	24	26	29	:	6.7	53	16
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	0.9	1.3	1.3	1.3	1.4	1.6	1.6	:	:	7.9	3.9	14
License and patent revenues from abroad as % of GDP	0.07	:	0.08	0.04	0.05	0.05	0.06	0.07	:	21.0	0.59	17
Community trademark (CTM) applications per million population	86	136	145	165	153	152	169	173	174	1.1	152	12
Community design (CD) applications per million population	:	23	22	24	22	20	23	21	19	-4.3	29	17
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	15.9	:	15.9	:	19.0	:	:	9.2	14.4	2
Knowledge-intensive services exports as % total service exports	:	:	:	24.0	22.7	22.5	21.5	21.6	:	-2.5	45.3	24
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	0.29	1.35	1.75	1.58	1.97	1.92	2.56	3.05	3.31	-	4.23 (7)	11
Growth of total factor productivity (total economy): 2007 = 100	102	100	100	100	99	99	99	100	101	1 (8)	97	2
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	34.2	:	:	:	:	38.0	2.1	51.2	20
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	11.8	11.8	11.5	11.8	11.9	0.4	13.9	19
SMEs introducing product or process innovations as % of SMEs	:	:	29.5	:	27.5	:	25.3	:	:	-4.1	33.8	21
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.05	0.09	0.10	0.10	0.09	0.14	:	:	:	19.9	0.44	15
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.16	0.28	0.23	0.22	0.22	0.23	:	:	:	2.8	0.53	15
EUROPE 2020 OBJECTIVES FOR GROWTH. JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	60.7	67.2 (9)	68.7	69.5	68.3	63.7	62.5	61.6	59.3	-3.1	68.4	26
R&D intensity (GERD as % of GDP)	0.91	1.12	1.20	1.27	1.35	1.39	1.40	1.36	1.30	0.5	*2.07*	16
Greenhouse gas emissions: 1990 = 100	135	154	151	154	143	130	125	126	:	-28 (10)	83	25 (11)
Share of renewable energy in gross final energy consumption (%)	:	8.4	9.1	9.7	10.8	13.0	13.8	15.1	:	11.7	13.0	12
Share of population aged 30–34 who have successfully completed tertiary education (%)	29.2	38.6	38.1	39.5	39.8	39.4	40.6	40.6	40.1	0.3	35.7	12
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	29.1	30.8 (9)	30.5	31.0	31.9	31.2	28.4	26.5	24.9	-4.3	12.7	28 (11)
Share of population at risk of poverty or social exclusion (%)	:	24.3	24.0	23.3	24.5	24.5	26.7	27.7	28.2	3.9	24.8	19 (11)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2008 and the previous years. Average annual growth refers to 2008–2012.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) Break in series between 2005 and the previous years.
(10) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(11) The values for this indicator were ranked from lowest to highest.
(12) Values in italics are estimated or provisional.

2014 Country-specific recommendation on R&I adopted by the Council in July 2014

"Identify sources of financing for the new national strategy for science, technology and innovation and make operational the new State Research Agency."



Sweden

World positioning in challenge-driven innovation

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Sweden. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **3.41 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **-0.2 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **87.9** (EU: 47.8; US: 58.1) 2007-2012: **+5.5 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **122.4** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **65.3** (EU: 51.2; US: 59.9) 2007-2012: **+2.0 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Health, environment, energy, ICT, materials, and security	***HT + MT contribution to the trade balance*** 2012: **1.8 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+0.5 %** (EU: +4.8 %; US: -32.3 %)

Sweden has one of the world's highest R&D intensities. The country also performs among the world leaders in terms of scientific and technological excellence, with a very positive evolution. The Swedish economy has a strong innovation output coupled with a highly knowledge-intensive structure. It has been resilient to the economic downturn, partly linked to the high and growing research excellence and knowledge-intensity.

However, despite increasing public investment in R&D, Sweden is still registering a stagnating R&D intensity, even though the trend of relative outsourcing of private R&D seems to have been reversed. Since 2002, the outflow of R&D business investment has exceeded the inflow. Sweden's good R&D position is vulnerable due to its strong dependence on a few large multinational companies, which are increasingly orienting themselves towards the global innovation system. At the same time, several larger Swedish corporations have been subject to acquisitions by foreign firms, contributing to the gradual delocalisation of strategic R&D activities.

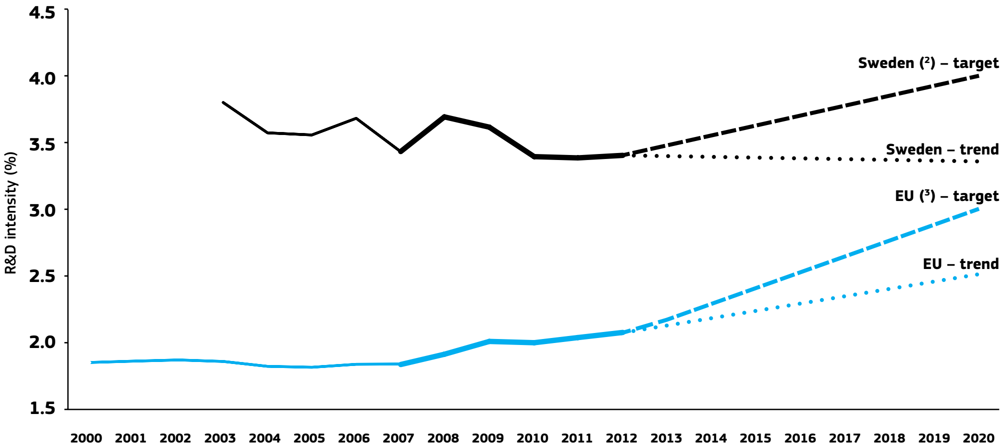
Progress is being made towards addressing these challenges. The fall in business R&D expenditure is slowing down, partly as a result of determined policies to create clusters and open innovation systems linking larger Swedish corporations to small and medium-sized enterprises (SMEs). The challenge-driven innovation approach is also being pursued, orienting innovation more closely towards global societal challenges. It aims to enhance both service and product innovations, with an increasing focus on systemic innovation. The current proposal to move towards a transport system based on non-fossil fuels by 2030 is a concrete example of such a broad innovative approach. Supply-side policies will be matched more closely with policies enhancing the demand for innovation, both from private actors and from public procurement and regulation.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

Investing in knowledge

Sweden – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, Member State
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) SE: The projection is based on a tentative R&D intensity target of 4.0 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(4) SE: There is a break in series between 2005 and the previous years.

Sweden has set an R&D intensity target of 4 % by 2020, which is more ambitious than the EU target although consistent with R&D intensity levels set by world innovation leaders such as Switzerland, Israel, the United States, Japan and South Korea. However, Sweden is not on track to meet its national target. In the period 2012-2020, the R&D intensity would need to experience an average annual growth of 2 %, which contrasts with the trend registered for 2007-2012 (-0.2 %).

The key policy for Sweden will be to continue to spur business R&D investments in the country, building on its growing clusters and the potential of lead markets. Business R&D intensity fell from 3.20 % in 2001 to 2.59 % in 2005 and to 2.31 % in 2012[3]. Within the business sector, R&D investment is highly concentrated in large, often foreign-owned companies, which makes the Swedish prima-facie good position vulnerable to change in company strategies. At the same time, R&D investment in SMEs fell almost 30 % between 2005 and 2009.

Public funding of R&D has been increasing since 2009-2016 due to investments reported in the research bills of 2008 and 2012, with a total increase of around EUR 1 billion foreseen for 2009-2016. Sweden raised its public R&D budget by 3.2 % in 2011, 4.5 % in 2012, and an additional 5.7 % in 2013. Structural Funds are an important source of funding for research and innovation (R&I) activities. Of the EUR 1.6 billion of Structural Funds allocated to Sweden over the 2007-2013 programming period, around EUR 405 million (24.9 % of the total) related to RTDI[4]. In addition, up to 2013, 4312 Swedish applications have been successful in the EU's Seventh Framework Programme (FP7), receiving a total of EUR 1.570 billion. The success rate of applicants was 23.94 % (above the EU average of 21.95 % but below comparable countries such as Switzerland, Norway and the Netherlands).

3 There is a break in series between 2005 and the previous years for both R&D intensity and business R&D intensity in Sweden.

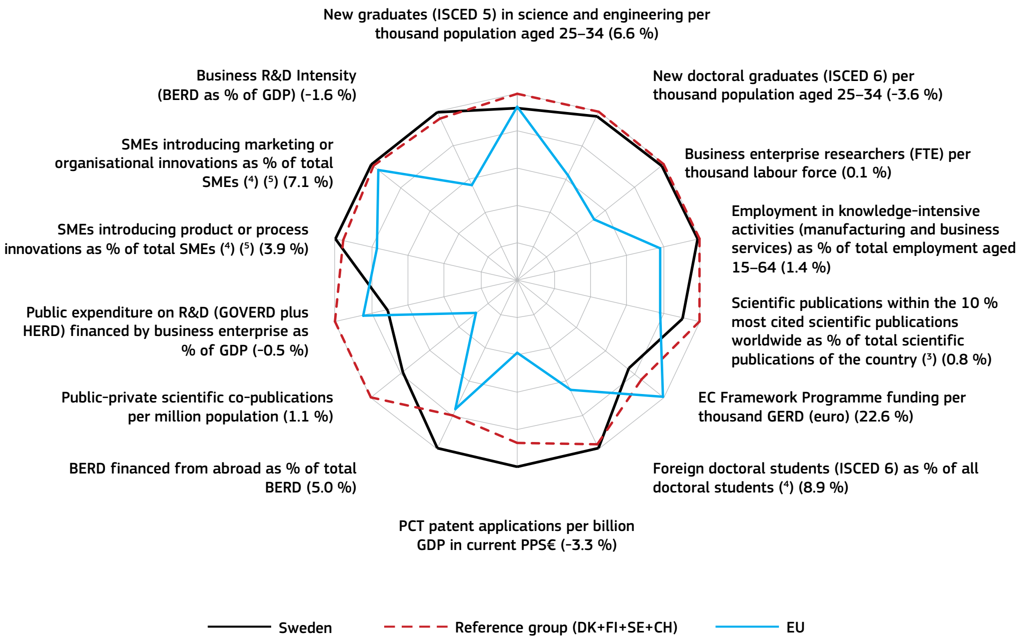
4 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Sweden's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Sweden, 2012 (1)

In brackets: average annual growth for Sweden, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.
(5) CH is not included in the reference group.

Compared to its reference group of other innovation leaders, Sweden stands out in PCT patent applications (in spite of a negative trend) and the internationalisation of its business R&D investment. Relative weaknesses are public-private cooperation, EU Framework Programme funding, the scientific impact of publications, and new graduates in science and engineering. Apart from the negative trend in business R&D intensity and new doctorate graduates, all other indicators of the Swedish R&I system point towards positive trends.

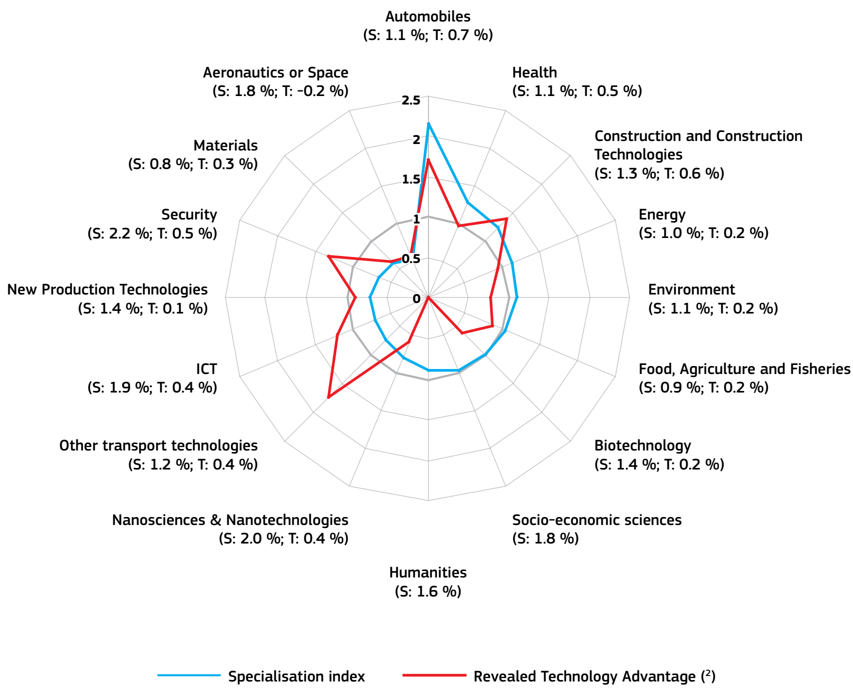
Higher education institutions perform over 26 % of R&D in Sweden. More than half of the funding for these institutions is competitive funding and part of their institutional funding is now subject to performance-based criteria. Given the small size of Sweden, the optimisation of R&I also depends on integration into the expanding European R&I system. In this context, Swedish research has become better connected to Europe in the health sector, while the second largest field of publications – in ICT – was linked more closely to European networks in 2000 compared to 2011. Currently, only the most research-intensive universities in Sweden cooperate extensively with international partners. In contrast, the business sector has developed strong co-patenting activities with firms in Germany, France and the United Kingdom.

Sweden's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Sweden shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Sweden – S&T National Specialisation (1) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)

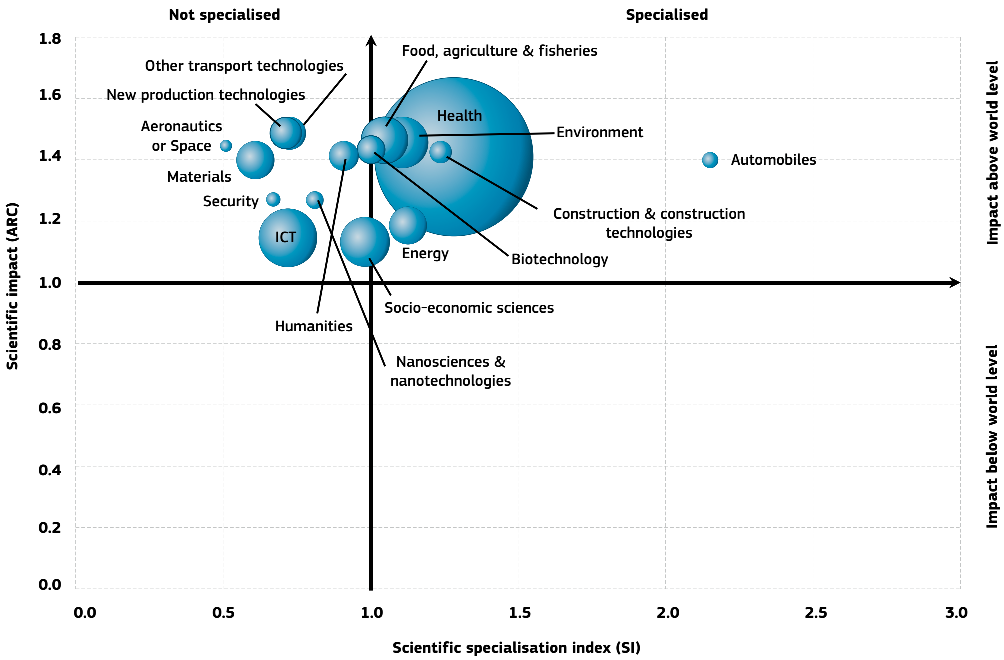


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Sweden performs well in most areas of science and technology production. In terms of specialisation profile, the automobile and construction sectors stand out as having a high specialisation in both science and technology. The country also has a scientific specialisation in health, energy, and environment research, while its technology specialisation covers security, transport, and ICT, too. In the field of automobiles, other EU Member States, such as Germany, have a similar specialisation as Sweden, while Finland, the United Kingdom, Portugal and Hungary have a scientific specialisation in this field. In the construction sector, the United Kingdom, Lithuania, Portugal and Turkey are possible cooperation partners having a similar specialisation in both science and technology.

The graph below illustrates the positional analysis of Swedish publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Sweden – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

Overall, Sweden has a very high scientific quality in almost all fields, in particular in transport technologies, new production technologies, health, environment, and research in food, agriculture and fisheries. One of Sweden's particular strengths is the good match between the fields where it produces most research (i.e. health and environment) and the fields of scientific excellence. In this context, there is room for improvement in ICT, energy, and research in socio-economic sciences. However, the Swedish scientific specialisation profile does not correspond to its technological strengths, with the exception of research for the automobiles, construction, health, energy, and environment sectors.

Policies and reforms for research and innovation

The current Swedish policy is following the 2008 and 2012 R&I bills, which stress the links between R&I. In the broad sense of innovation policy, governance issues are crucial to actively enhancing innovation in several policy areas and reinforcing comprehensive framework conditions for business innovation. In a narrower sense, the bills reinforced the funding and strategic focus of R&I. Following the 2008 bill, public funding was boosted in 24 research areas important to the Swedish business sector and society. Within the 2012 bill, strong emphasis was given to R&D in strategic innovation and in core areas for Swedish industry, such as mining, steel, wood products and the construction of a sustainable society. Also the Swedish innovation agency, Vinnova, is moving towards a challenge-driven strategy responding to business opportunities in addressing global challenges. For this reason, the agency has currently focused its international cooperation activities on four societal challenges: information society 3.0; sustainable attractive cities; future healthcare; and competitive production.

Public funding for R&D will be increased progressively and funding allocation systems for universities will be reformed progressively to enhance scientific excellence. The Swedish Research Council has an assignment to propose additional peer-review processes to evaluate the quality of Swedish universities. It is expected that 20 % of institutional funding will be allocated to universities on the basis of specific quality criteria. Moreover, Vinnova will develop and propose a model for evaluating collaboration between universities and the surrounding society, including industry, and will distribute more than EUR 20 million to the best-performing universities during 2013-2016. As regards public-private collaboration, the Swedish programmes are also supporting changes in the approach of university managers through specific training. Many initiatives are now being channelled through the management of the universities, which means they should then be able to lead and prioritise in a way that facilitates the commercialisation of research results.

Over the last five years, several initiatives have been launched to enhance the effectiveness of the Swedish R&I system, with a focus on innovation in SMEs through reinforced public-private cooperation with universities and better access to seed funding and venture capital. Industrial research institutes have been restructured and reinforced to be specific innovation intermediates and act as an interface between academic research and product development in the business sector. The model involves the private business sector buying R&D services from the institutes, while the state funds their facilities and skills development. In addition, the bill established innovation offices at each university to foster the commercialisation of research results. In recent years, Sweden has seen quite an important increase in the number of new enterprises. This is also due to improvements in the framework conditions, thanks to a dedicated focus on final users – i.e. entrepreneurs – and less red tape. The government is also promoting measures specifically addressed to women and young people. At the same time, business vouchers have been launched for the internationalisation of SMEs. The idea is to support SMEs via consultancy services before they take their first steps in foreign markets. Companies with between two and nine employees can apply for these business vouchers.

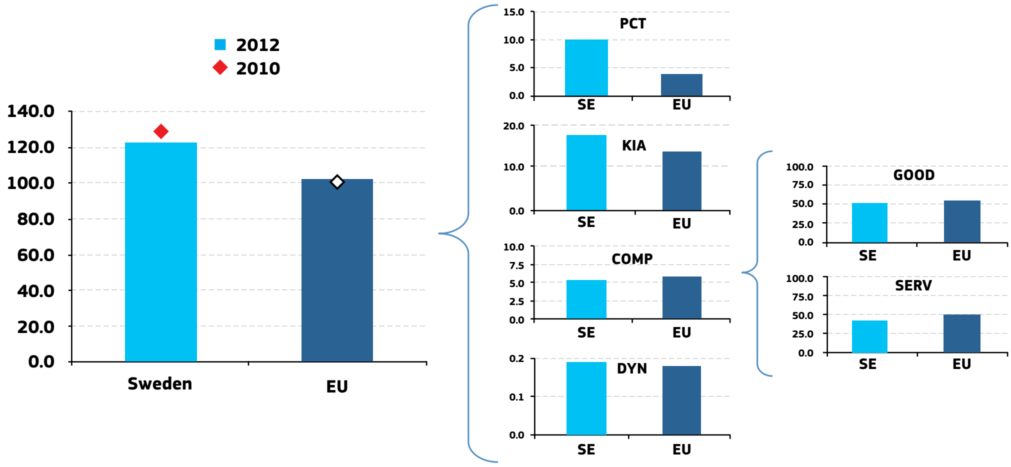
The new National Innovation Strategy, adopted at the end of 2012, comprises a holistic approach to innovation policy aimed at the year 2020. Interesting proposals have been made for both demand-side measures (i.e. introducing a new procurement law fostering innovation-friendly procurement) and supply-side measures (in particular to fund testing, demonstration infrastructure and reinforcement of incubators for new research-based products). The role of the public sector as driver of innovation is stressed. The 2011 Innovation Procurement inquiry proposed the introduction of a new law on pre-commercial procurement. Increasing importance is given to innovation in services, mobilising knowledge in the broad sense, and enhancing societal challenge-driven innovation, new business models and design-based thinking. Vinnova funds programmes which develop new knowledge and expertise within four strategic areas for Sweden: health and healthcare; transport and environment; services and ICT; and manufacturing and working life. In 2011, an Innovation Procurement programme was launched aiming to increase and extend the development of innovation procurement, mainly in the public sector. A call for proposals under this programme was issued in the same year and remained open throughout 2013.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator on innovation focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms).

The graph below enables a comprehensive comparison of Sweden's position regarding the indicator's different components:

Sweden – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Sweden is a top performer in terms of innovation output. However, its performance declined slightly between 2010 and 2012. A particularly strong performance is visible in the PCT and KIA pillars, while there is room for improvement in the share of knowledge-intensive services in the overall service trade balance. Sweden is a good EU performer as regards the innovativeness of fast-growing firms. This is the result of a high share of computer programming, scientific R&D, and architectural and engineering companies among fast-growing enterprises. The relatively lower performance on the export share of medium-/high-tech goods is due to a high share of wood and paper exports. It should be noted that these sectors do not impede the strong technology orientation in the Swedish economy, also because they are more innovative in Sweden than in most other countries.

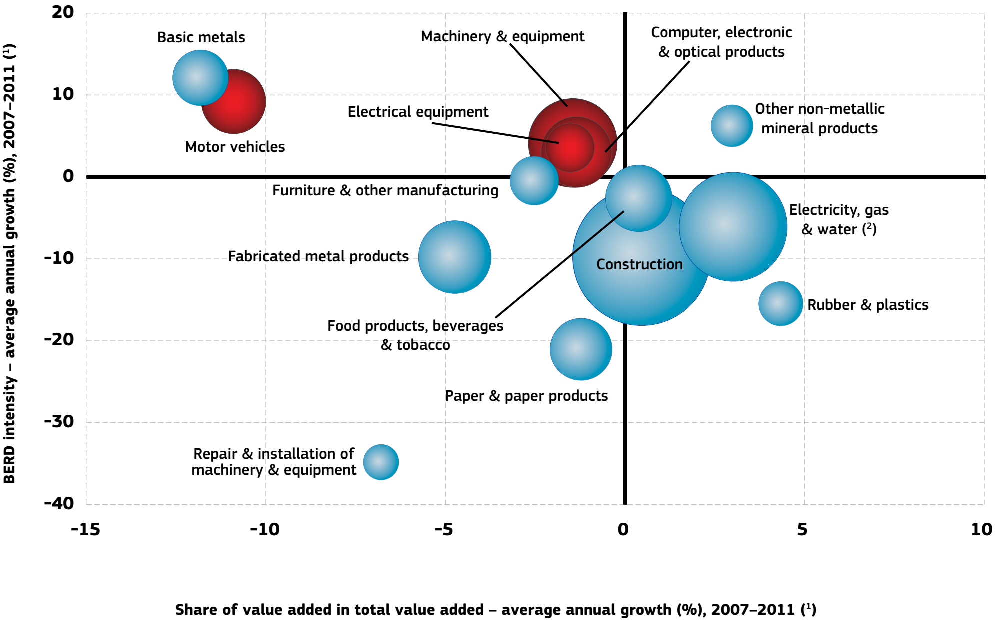
Sweden offers good framework conditions for innovation in business activities, in particular for the creation of new firms. In general, barriers to entrepreneurship are lower than in most OECD countries. The share of doctoral graduates is high (although less focused on science and technology). Clusters in some sectors (i.e. ICT, power generation, biotechnology) have grown around some of the larger research-intensive firms. Early-stage funding as a share of GDP is the highest among the EU Member States. Likewise, venture-capital investment as a share of GDP is among the highest in the OECD. However, the share of early-stage funding in total risk capital is lower than in other EU Member States and, following the financial crisis, there has been a sharp decline in risk finance.

The Swedish economy has become slightly more knowledge-intensive even during the period of economic downturn. Employment in knowledge-intensive activities as a share of total employment, both overall and in the business sector, grew between 1.0 % to 1.6 % between 2008 and 2011. Similar growth is visible in the technology sectors, measured by value added in high-tech and medium-high-tech manufacturing and knowledge-intensive services between 2008 and 2011.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries for the period 2007-2011. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Sweden – Share of value added versus BERD intensity: average annual growth, 2007–2011 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Construction', 'Furniture and other manufacturing', 'Repair and installation of machinery and equipment', 'Rubber and plastic products': 2009–2011.
(2) 'Electricity, gas and water' includes 'sewerage, waste management and remediation activities'.
(3) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

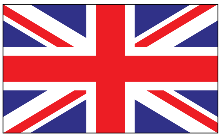
The Swedish economy has managed to maintain an important manufacturing industry since the mid- 1990s. This has also been achieved during the economic downturn. Most manufacturing sectors maintained their share of value added in the economy over the 2007-2011, with the notable exception of basic and fabricated metals and motor vehicles. In general, countries with a strong manufacturing sector have been more resilient to the economic crisis. However, over the economic downturn period, and compared to other EU Member States, the Swedish manufacturing industry presents a lower dynamic in terms of upgrading knowledge, in particular R&D. This is particularly true of the larger manufacturing sectors, such as paper and paper products, the electricity, gas and water industries, fabricated metal products, rubber and plastics, and construction – all important sectors in the Swedish economy both currently and historically. There are some promising exceptions, such as machinery and equipment, computer and electronics, electrical equipment, motor vehicles and basic metals, which all increased their R&D intensity over the period 2007-2011.

R&D-intensive firms in Sweden are found in the ICT sector (Ericsson, Axis), energy (parts of ABB), pharmaceuticals (parts of Astra Zeneca), automobiles (Volvo, Scania), industrial engineering (Alfa Laval, SKF, Husqvarna), healthcare equipment (Elektra, Getinge, Indap) and materials (Sandvik). As illustrated in the EU Industrial Scoreboard, the large Swedish R&D-intensive enterprises broadly maintained or even increased their global R&D intensities in 2011 as compared to 2009. On average, Swedish firms increased their R&D investment between 2007 and 2011, although there were exceptions – companies in the motor vehicles, software, biotechnology, and pharmaceutical sectors.

Key indicators for Sweden

SWEDEN	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	2.47	2.40	3.28	3.40	3.16	3.10	2.93	2.88	2.8	-3.6	*1.81*	1
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	502	:	:	494	:	:	478	-24.1 (3)	495 (4)	21 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	:	2.59	*2.75*	2.51	*2.74*	2.55	*2.33*	2.33	*2.31*	*-1.6*	1.31	2
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	0.96	*0.92*	0.92	*0.95*	1.06	*1.06*	1.04	*1.09*	*3.3*	0.74	1
Venture capital as % of GDP	0.86	1.01	1.34	0.89	1.00	0.45	0.90	0.56	0.48	-11.5	0.29 (6)	3 (6)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	67.4	:	:	:	:	87.9	5.5	47.8	1
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	12.5	12.8	12.5	12.6	12.7	:	:	:	0.8	11.0	5
International scientific co-publications per million population	:	1164	1224	1333	1341	1451	1533	1636	1712	5.1	343	2
Public–private scientific co-publications per million population	:	:	:	140	139	140	144	147	:	1.1	53	2
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	13.3	10.1	10.7	11.1	10.5	10.9	10.0	:	:	-3.3	3.9	2
License and patent revenues from abroad as % of GDP	0.52	0.94	1.00	1.02	0.96	1.13	1.25	1.18	1.28	4.7	0.59	5
Community trademark (CTM) applications per million population	153	128	165	200	175	200	223	248	243	4.0	152	6
Community design (CD) applications per million population	:	52	52	61	63	62	58	61	63	0.6	29	3
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	:	:	9.2	:	8.4	:	:	-4.4	14.4	21
Knowledge-intensive services exports as % total service exports	:	41.2	41.2	40.4	40.7	42.3	39.9	39.8	:	-0.4	45.3	10
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	2.51	1.89	2.41	1.76	1.97	2.30	1.83	1.95	1.80	-	4.23 (7)	15
Growth of total factor productivity (total economy): 2007 = 100	88	97	99	100	98	94	99	100	100	0 (8)	97	4
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	59.0	:	:	:	:	65.3	2.0	51.2	3
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	16.6	16.8	16.9	17.2	17.6	1.4	13.9	4
SMEs introducing product or process innovations as % of SMEs	:	:	40.7	:	40.6	:	43.8	:	:	3.9	33.8	6
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.56	0.57	0.64	0.66	0.64	0.85	:	:	:	13.6	0.44	3
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	1.94	1.78	1.71	1.50	1.03	1.25	:	:	:	-8.6	0.53	2
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	77.7	78.1 (5)	78.8	80.1	80.4	78.3	78.1	79.4	79.4	-0.2	68.4	1
R&D intensity (GERD as % of GDP)	:	3.56	*3.68*	3.43	*3.70*	3.62	*3.39*	3.39	*3.41*	*-0.2*	*2.07*	2
Greenhouse gas emissions: 1990 = 100	96	93	93	91	89	83	91	86	:	-5 (9)	83	13 (10)
Share of renewable energy in gross final energy consumption (%)	:	40.4	42.4	43.9	45.0	47.7	47.9	46.8	:	1.6	13.0	1
Share of population aged 30–34 who have successfully completed tertiary education (%)	31.8	37.6	39.5	41.0	42.0	43.9	45.3	46.8	47.9	3.2	35.7	5
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	7.3	10.8	8.6 (11)	8.0	7.9	7.0	6.5	6.6	7.5	-1.3	12.7	7 (10)
Share of population at risk of poverty or social exclusion (%)	:	14.4	16.3	13.9	14.9	15.9	15.0	16.1	*18.2*	5.5	24.8	4 (10)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Break in series between 2005 and the previous years.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK, These Member States were not included in the EU ranking.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(10) The values for this indicator were ranked from lowest to highest.
(11) Break in series between 2006 and the previous years.
(12) Values in italics are estimated or provisional.



United Kingdom

Delivering an effective innovation system

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in the United Kingdom (UK). They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.72 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **-0.3 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **63.5** (EU: 47.8; US: 58.1) 2007-2012: **+5.2 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **110.3** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **60.7** (EU: 51.2; US: 59.9) 2007-2012: **+0.6 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Construction, health, environment, security	***HT + MT contribution to the trade balance*** 2012: **4.2 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+9.2 %** (EU: +4.8 %; US: -32.3 %)

The UK's overall innovation performance is above the EU average. There are particular strengths in human resources, venture capital, business angels, entrepreneurship, and international co-publications (although the number of academic-corporate co-authored publications is low). The number of collaborations by innovative small and medium-sized enterprises (SMEs) with other entities continues to increase (albeit that SME/university collaboration is limited), while rates of improvement in human resources and international co-publications are well above average. The presence of several world-class universities, a significant proportion of young doctoral graduates, and competitive strengths in sectors such as pharmaceuticals and digital technologies have helped achieve this strong performance. However, there are relative weaknesses in RDI investments by firms, the creation of intellectual assets, and SMEs introducing innovations. In addition, the UK suffers from a relatively low level of basic skills, insufficient domestic human capital to exploit research and innovation (R&I), a dearth of management skills, the concentration of R&D in a small number of sectors and firms, and a low proportion of medium-sized growth firms.

The economy has several distinctive characteristics that give it competitive advantages in the innovation sphere: a world-leading science base and information infrastructure; a prominent financial sector (although this could be better incentivised to support company creation and growth); a rich supply of high-level skills plus a proven attractiveness to globally mobile talents; strong performance by business in creating intangible assets; and a relatively large role played by the service sector for industry and export performance. These characteristics, highlighted by the UK government in its strategy for innovation published at the end of 2011, underpin the four priority areas identified for

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

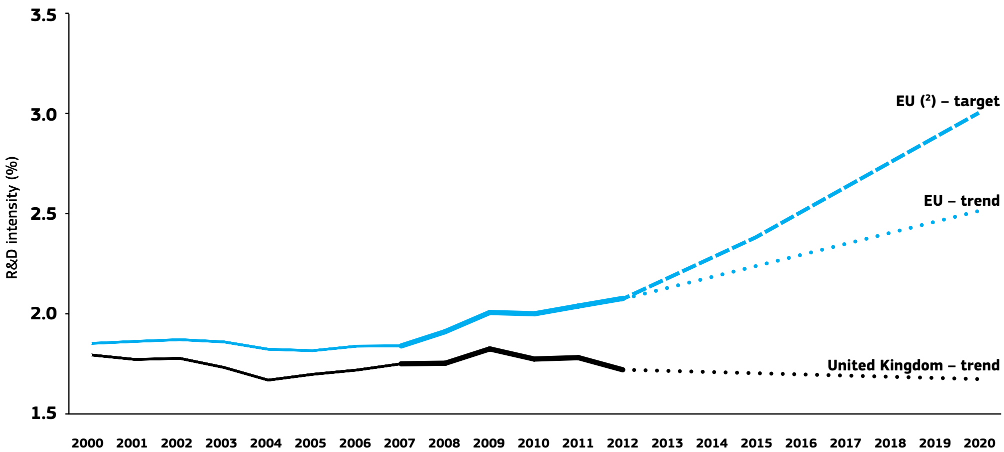
2 Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

policy development: strengthening the sharing and dissemination of knowledge; fostering the development and use of a more coherent innovation infrastructure; driving business innovation in all sectors of the economy; and transforming the public sector into a major driver of innovation.

The UK continues to benefit from a key strength of its innovation policy governance system: a long-term, strategic perspective informed by an extensive process of review and evaluation and benefiting from a relative absence of dramatic shifts in priorities, instruments or structures.

Investing in knowledge

United Kingdom – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) UK: An R&D intensity target for 2020 is not available.

In 2012, the higher education sector was responsible for EUR 8.81 billion of R&D activities, representing 26.5 % of total R&D performed. This share increased from 20.6 % in 2000 at an average annual growth rate of 2.1 %. Business enterprise finances 45.6 % of R&D and performs around 63.4 % of R&D. Expenditure by business enterprise on R&D amounted to EUR 21.1 billion in 2012, close to the 2006 level. Government finances around 28.9 % of R&D. An important characteristic of the UK research system is the significant R&D investment financed from abroad – some 19.7 % (9 % of the EU average) – and from the non-profit sector – about 4.6 %. In 2012, the UK's gross domestic expenditure on R&D was some EUR 33.3 billion, declining by 3.1 % in real terms from the 2011 figure. UK institutions benefited from EUR 6.1 billion from the EU's Seventh Framework Programme (FP7) (15.4 % of the total, which is the second-highest share among Member States). The success rate of UK applicants in FP7 is 23.1 %, well above the average EU rate of 21.9 %. Of the EUR 9891 billion of Structural Funds allocated to the UK over the 2007-2013 programming period, around EUR 1922 billion (19.4 % of the total) related to RTDI[3].

R&D intensity (2012) was 1.72 % of GDP, down from 1.78 % in 2011and lower than the EU average of 2.06 %. The trend since 2000 shows an initial fall, a mild recovery from 2005 (peaking in 2009), and a recent decline. Public expenditure on R&D accounted for 34.7 % of the total. Albeit with ups and downs, growth was negative overall between 2000 and 2012 (averaging out at -0.3 % per year), and business R&D intensity fell from 1.16 % in 2001 to 1.09 % in 2012. In spite of this negative trend, the UK has not set a national R&D intensity target corresponding to the European Council's request regarding Europe 2020 headline targets. As part of the government's 2010 fiscal consolidation strategy, the science budget was frozen in cash terms at just

3 RTDI includes the following sectors: (01) RTD activities in research centres, (02) RTD infrastructures and centres of competence, (03) Technology transfer and improvement of cooperation of networks, (04) Assistance to RTD, particularly in SMEs (and RTD services in research centres), (06) Assistance to SMEs for the promotion of environmentally friendly products and processes, (07) Investment in firms directly linked to research and innovation, (09) Other methods to stimulate research and innovation and entrepreneurship in SMEs, and (74) Developing human potential in the field of research and innovation.

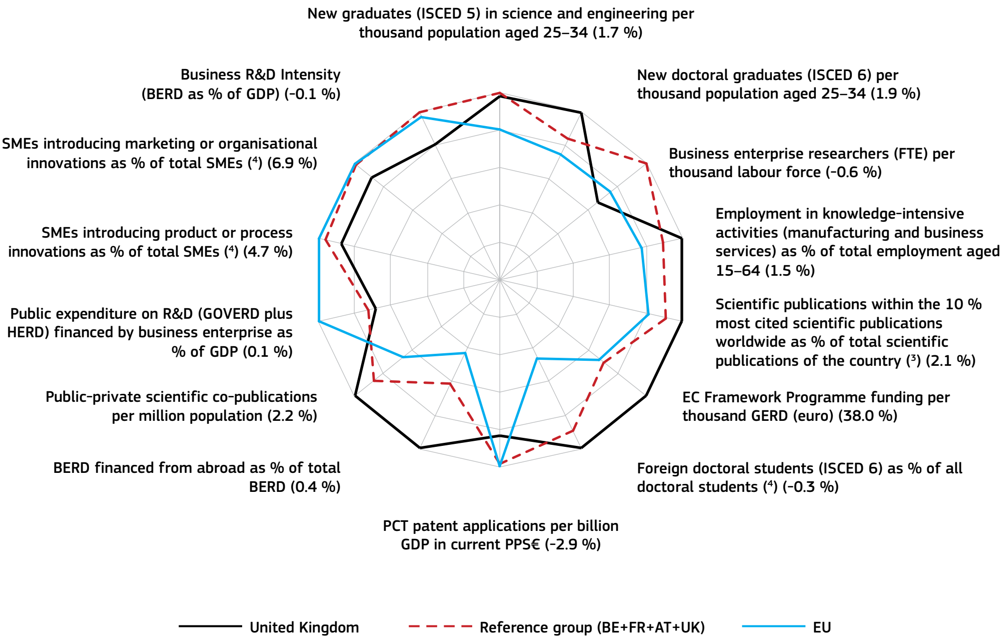
over £4.6 billion (EUR 5.4 billion) for the next four years, amounting to a cut of some 10 % in real terms over the period. The capital expenditure budget for science was not protected. However, in its 2013 spending review, the government announced that it was increasing science capital funding in real terms from £0.6 billion (EUR 7.5 billion) in 2012-13 to £1.1 billion (EUR 1.3 billion) in 2015-16, and in line with inflation to 2016-2017. The government will also set a long-term capital budget for science in the next parliament, increasing in line with inflation to 2020-21. Announcements in the March 2014 budget saw further commitments of £0.22 billion (EUR 0.27 billion) to research programmes.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the UK research and innovation (R&I) system. Reading clockwise, it gives information on human resources, scientific production, technology exploitation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.

United Kingdom, 2012 (1)

In brackets: average annual growth for United Kingdom, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies

Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.

Notes: (1) The values refer to 2012 or to the latest available year.

(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.

(3) Fractional counting method.

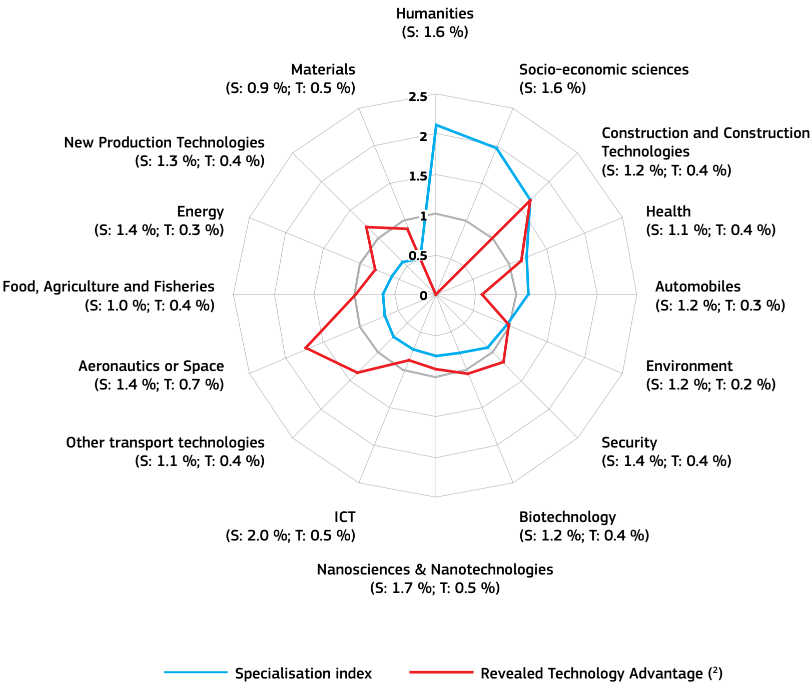
(4) EU does not include EL.

As a whole, the UK R&I system performs above the EU average, with strengths in the quality of research, but weaknesses in the introduction of innovations to the market. The proportion of human resources in science and technology as a share of the UK labour force is above the EU average, and has risen since 2006. High numbers of highly qualified UK-educated researchers are resident in other OECD countries, associated with the circulation of high-level human resources. On research infrastructures, the UK recognises that investment in world-class infrastructure is a prerequisite for world-class research: it hosts a large number of national and international facilities and is involved in many facilities in Europe and the rest of the world. As regards universities, greater emphasis has been placed recently on stimulating their engagement with businesses and local communities, with a Higher Education Investment Fund as the main policy stimulus. Knowledge transfer from research to business is a UK policy priority, with several initiatives providing funding to stimulate collaborative research and inter-sectorial mobility or supporting the creation of university and public-sector spin-outs. Sectorial support is strongly focused on advanced manufacturing, covering vocational skills education, apprenticeships, high-value manufacturing technology innovation accelerators ('catapults'), incentive prizes, fellowships and advisory services. Life sciences also attract particular support.

UK's scientific and technological strengths

The spider graph below illustrates the areas, based on the Framework Programme thematic priorities, where the UK shows potential in science and technology areas in a European context. Both the specialisation index (SI) and the revealed technological advantage (RTA) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

United Kingdom – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

The UK performs well in most areas of technology production. Apart from the sectors highlighted above, current patent activity suggests that the UK is also relatively strong in the areas of organic chemistry, pharmaceuticals and medical technology. It has a world-class reputation in aerospace and nanotechnology research, and particularly significant R&D capabilities in renewables, especially offshore wind power and marine energy. However, compared to its competitors, UK R&D is concentrated in a relatively small number of sectors and is carried out by relatively few businesses. Greater business investment in R&D would be helpful across all sectors of the UK economy.

Regarding specialisation (see the graph above), there is a good match between the scientific and technological performance at the country level in the fields of construction, health, environment, and security, reflecting a particularly good absorption of science into technological products for these fields. Three out of the four fields are also among the most successful in FP7, namely health, environment, and security. The same goes for the overall research field of social sciences and humanities, where there is a strong specialisation in publications at a national level coupled with a high success rate in FP7.

The coherence among S&T co-specialisation at home and participation in FP7 shows that the UK successfully builds on its national S&T capabilities when participating in the EU's Framework Programme.

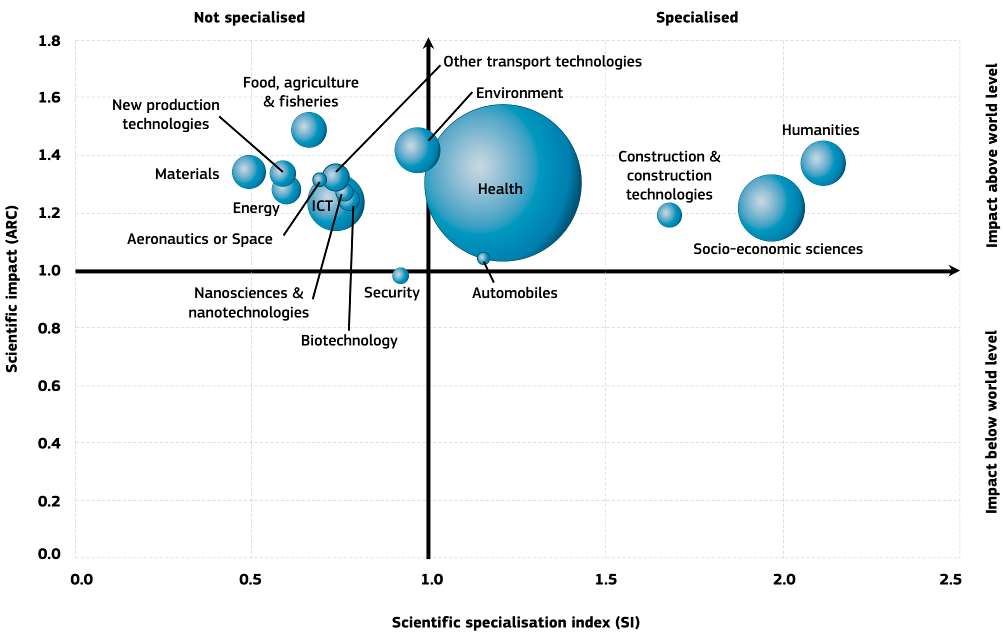
Going deeper into the analysis, the UK's greatest technological specialisation appears to be in the field of aeronautics. This is not matched by a similar specialisation in science, although there has been a sufficiently high growth in both publications and patents over the last 10 years, and the quality of science is very good. High growth rates are also noted in the fields of ICT, and nanosciences and nanotechnologies, showing the potential for increasing specialisation in these fields in the future.

One specific case is the automobiles sector where the science created in this field is not sufficiently translated into technology. In addition, the field appears to be quite static, without spectacular growth rates in S&T over the last decade and with a rather linear quality of science.

Finally, the food, agriculture and biotech sector is among the fields where the UK is most successful in FP7. However, this is not matched by a specialisation here at the national level, so this field could be looked at more closely when evaluating the strengths of research performed at national level.

The graph below illustrates the positional analysis of the UK publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

United Kingdom – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

Overall, as shown in the graph above, the UK has a very high scientific quality (with an impact above world level) in almost all fields, independently from the specialisation level.

In terms of scientific production, the UK research base is the most productive in the G8, generating more papers and citations per unit of investment than any other large country.[4]

Policies and reforms for research and innovation

The government has stated its commitment to prioritising, to a certain extent, spending on science and innovation while pursuing fiscal consolidation. Overall, RDI policy focuses on increasing the UK's ability to innovate and commercialise new technologies as a means for driving economic growth and creating jobs. The aim is to encourage greater levels of innovation in all sectors of the economy, supported by a better-integrated and more cohesive innovation system. The updated version of the National Infrastructure Plan, published in December 2013, brings investments related to science and innovation into the list of priority investments for the first time.

RDI policies are managed at the national level by the Department for Business, Innovation and Skills (BIS), which sponsors the seven UK Research Councils, the Higher Education Funding Council for England (HEFCE), and the Technology Strategy Board (TSB). The TSB is responsible for funding innovation and technology development within business and acts as the national innovation agency for the UK. The devolved administrations of Northern Ireland, Scotland and Wales are responsible for certain elements of funding, specifically for higher education research and for enterprise agencies.

The government has decided that all programmes for and funding linked to R&I should be delivered by national organisations. Consequently, regional development agencies, which had previously played a role in innovation funding, were dissolved in mid-2012. New Local Enterprise Partnerships are being introduced at sub-national level, although without dedicated budgets for R&I, and with no role in delivering innovation support programmes.

Funding for research in the UK is provided in two ways: competitive, project-based funding delivered through the Research Councils, for which researchers in UK universities or public-sector research can apply, with each Research Council allocating resources within its field between institutes, facilities, research studentships and projects; or via HEFCE in England and its counterparts in Northern Ireland, Scotland and Wales, covering research, knowledge transfer and infrastructure.

The TSB is the UK's prime channel for supporting business-led technology innovation. It is responsible for a range of innovation programmes, including knowledge-transfer partnerships, which embed new graduates mostly in SMEs; knowledge-transfer networks, to help industry access knowledge and information; collaborative R&D, which supports the business and research communities working together on projects; funding for proof of concept, market validation studies and the development of prototypes (the 'Smart' initiative); and the new network of 'catapult' innovation accelerators.

Tax credits are the biggest single funding mechanism provided by the UK government for incentivising investment in business R&D. The SME scheme gives companies a deduction in corporate tax of 125 % of qualifying expenditure and the possibility of a payable credit. The large-company scheme offers a deduction of 30 %.

The government has also put considerable emphasis on using public procurement to stimulate innovation capacity. The Small Business Research Initiative encourages innovative firms to tackle RDI challenges facing government departments, while the Forward Commitment Procurement programme helps public-sector organisations to develop new products and services to meet demand.

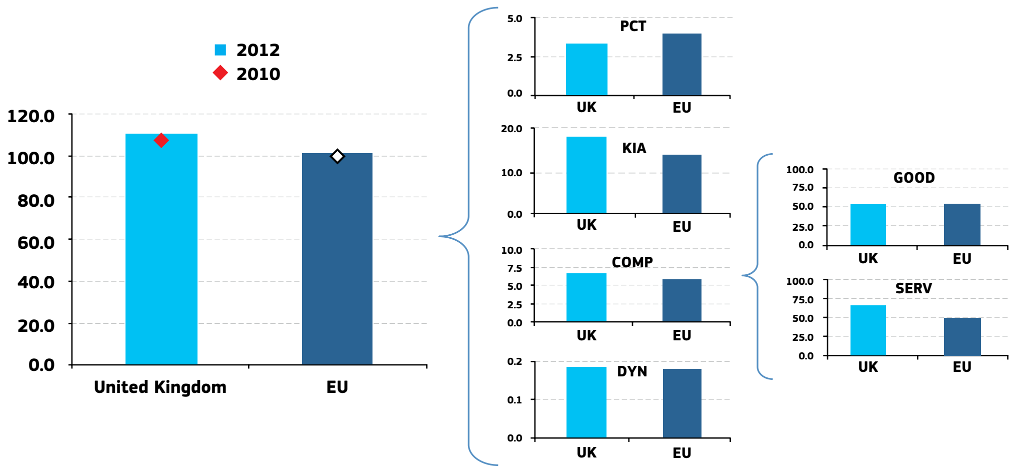
A 'Patent Box' scheme, launched in 2013, applies a reduced rate of tax to profits from patents and certain other types of intellectual property. The hypothesis is that this will encourage firms to retain existing patents, develop new, innovative technologies and patent them, and to locate jobs and activities associated with patentable activities in the UK.

4 International Comparative Performance of the UK Research Base, Elsevier, 2011.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of the UK's position regarding the indicator's different components:

United Kingdom – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

The UK is a very good performer in terms of the European innovation indicator. This is the result of good performance in all components of the indicator, except patent applications, where the UK's performance is below the EU average.

With its service-based economy (both agriculture and manufacturing have a low employment share), the country performs particularly well in employment in knowledge-intensive activities, and in the export share of knowledge-intensive services. The relatively low score in patents is partly explained by the UK's economic structure, in which the patent-intensive manufacturing sector has a relatively low share of economic activities.

The relatively good performance in knowledge-intensive activities and in the export share of knowledge-intensive services stems from the relative importance of financial and information services. The UK has relatively large financial services exports, but is also an important exporter of computer services and of other professional and technical services, including public relations, accounting, consultancy, engineering, and research. Furthermore, a high share of employment in education (the UK receives a high number of foreign tertiary students) and health also contributes to a high share of employment in knowledge-intensive services.

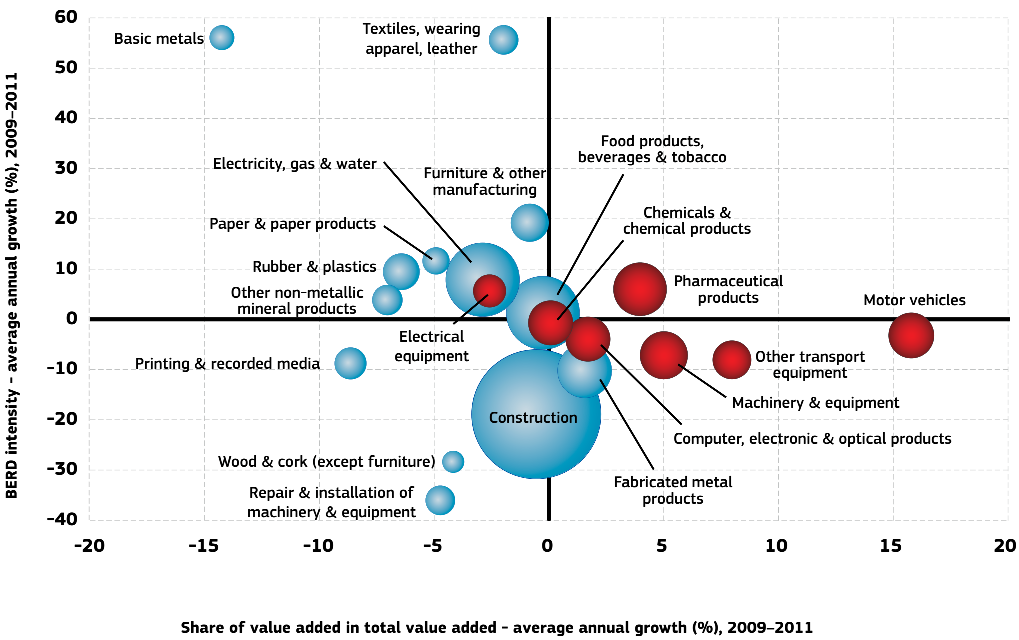
The UK also scores slightly above the EU average for the share of medium-/high-tech goods in total goods exports, a result of strong exports of machinery and pharmaceutical products.

Despite a high general level of enterprise dynamism, in recent years the high growth of enterprises has occurred in sectors, such as retail, which do not have high innovation coefficients. To some extent this explains the average score attained for the innovativeness of growing firms.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis shows the changing weight of each industry sector in value added over the period 1995-2007. The general trend of moving to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the horizontal axis are those whose research intensity has increased over time. The size of a bubble represents the sector share (in value added) in manufacturing (all sectors shown). The red sectors are those that are already high-tech or medium-to-high-tech.

United Kingdom – Share of value added versus BERD intensity: average annual growth, 2009–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Note: (1) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

Manufacturing is the third largest sector of the UK economy in terms of share of GDP, after business services and the wholesale and retail sectors. In common with other leading manufacturing countries, the UK has specialised increasingly in higher-technology manufacturing industries such as medical or chemical products, and precision machinery and equipment.

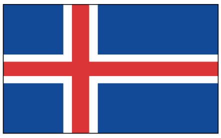
Furthermore, there has been a shift in employment in manufacturing away from production towards support services, logistics and distribution, sales and marketing, and R&D activities. Current patent activity suggests that the UK is relatively strong in the areas of organic chemistry, biotechnology, pharmaceuticals and medical technology, but relatively weak in the electronics, optics, nanotechnology, and information technology sectors. In addition, the proportion of firms that are exporting is increasing in many manufacturing industries.

The graph shows that while a significant proportion of medium-tech and high-tech sectors have increased their research intensity, they have not increased their share of value added. However, the research intensity of some sectors has stagnated, or in several cases fallen, which could endanger their long-term competitiveness.

Key indicators for the United Kingdom

UNITED KINGDOM	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)	Rank within EU
ENABLERS												
Investment in knowledge												
New doctoral graduates (ISCED 6) per thousand population aged 25–34	1.33	1.97	2.05	2.18	2.05	2.16	2.27	2.39	2.40	1.9	*1.81*	5
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	495	:	:	492	:	:	494	-1.5 (3)	495 (4)	13 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	1.17	1.04	1.06	1.09	1.09	1.10	1.08	1.13	1.09	-0.1	1.31	12
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.60	0.62	0.62	0.62	0.63	0.68	0.65	0.62	*0.60*	*-0.6*	*0.74*	15
Venture capital as % of GDP	0.81	1.28	2.07	1.61	1.24	0.60	1.12	1.18	0.81	-12.8	0.29 (5)	1 (5)
S&T excellence and cooperation												
Composite indicator on research excellence	:	:	:	49.3	:	:	:	:	63.5	5.2	47.8	5
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	12.9	12.9	12.8	13.2	13.4	:	:	:	2.1	11.0	4
International scientific co-publications per million population	:	719	768	826	867	916	954	999	1021	4.3	343	11
Public–private scientific co-publications per million population	:	:	:	73	70	70	76	79	:	2.2	53	8
FIRM ACTIVITIES AND IMPACT												
Innovation contributing to international competitiveness												
PCT patent applications per billion GDP in current PPS (EUR)	4.3	3.6	3.7	3.6	3.4	3.5	3.3	:	:	-2.9	3.9	9
License and patent revenues from abroad as % of GDP	0.55	0.57	0.59	0.57	0.55	0.62	0.62	0.57	0.51	-2.2	0.59	9
Community trademark (CTM) applications per million population	132	115	136	151	138	129	141	152	163	1.5	152	13
Community design (CD) applications per million population	:	24	23	29	23	22	26	26	27	-0.7	29	12
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	8.5	:	7.3	:	:	:	:	-7.4	14.4	26
Knowledge-intensive services exports as % total service exports	:	57.7	58.6	60.5	62.5	64.2	61.1	61.2	:	0.3	45.3	4
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	1.86	4.46	6.86	2.74	3.12	3.82	3.05	3.16	4.25	-	4.23 (6)	6
Growth of total factor productivity (total economy): 2007 = 100	90	97	98	100	98	93	94	94	94	-6 (7)	97	19
Factors for structural change and addressing societal challenges												
Composite indicator on structural change	:	:	:	59.0	:	:	:	:	60.7	0.6	51.2	6
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	16.8	17.5	17.0	17.4	17.8	1.5	13.9	3
SMEs introducing product or process innovations as % of SMEs	:	:	25.1	:	27.0	:	29.6	:	:	4.7	33.8	18
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.21	0.18	0.21	0.20	0.21	0.25	:	:	:	12.2	0.44	9
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.94	0.68	0.61	0.54	0.51	0.50	:	:	:	-3.8	0.53	11
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES												
Employment rate of the population aged 20–64 (%)	74.0	75.2	75.2	75.2	75.2	73.9	73.6	73.6	74.2	-0.3	68.4	6
R&D intensity (GERD as % of GDP)	1.79	1.70	1.72	1.75	*1.75*	*1.82*	*1.77*	1.78	*1.72*	*-0.3*	*2.07*	13
Greenhouse gas emissions: 1990 = 100	90	89	88	87	85	78	80	75	:	-12 (8)	83	10 (9)
Share of renewable energy in gross final energy consumption (%)	:	1.4	1.6	1.8	2.4	3.0	3.3	3.8	:	20.5	13.0	26
Share of population aged 30–34 who have successfully completed tertiary education (%)	29.0	34.6	36.5	38.5	39.7	41.5	43.0	45.8	47.1	4.1	35.7	6
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	18.2	11.6	11.3	16.6 (10)	17.0	15.7	14.9	15.0	13.6	-3.9	12.7	23 (9)
Share of population at risk of poverty or social exclusion (%)	:	24.8	23.7	22.6	23.2	22.0	23.2	22.7	24.1 (11)	0.1	24.8	15 (9)

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT. These Member States were not included in the EU ranking.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK. These Member States were not included in the EU ranking.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(9) The values for this indicator were ranked from lowest to highest.
(10) Break in series between 2007 and the previous years.
(11) Break in series between 2012 and the previous years. Average annual growth refers to 2007–2011.
(12) Values in italics are estimated or provisional.



Iceland

More innovation for a more competitive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Iceland. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **2.40 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **-2.8 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **38.7** (EU: 47.8; US: 58.1) 2007-2012: **+8.8 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **86.4** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **n.a.** (EU: 51.2; US: 59.9) 2007-2012: **n.a.** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Food, agriculture and fisheries, and health	***HT + MT contribution to the trade balance*** 2012: **-15.0 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

Iceland has one of the highest R&D intensities in Europe and an excellent science base. However, a main challenge for the country is to transform this into economic competitiveness. Prioritisation and thematic-oriented funding would help Iceland, as a small country in a globalised world, to build a more effective R&I strategy.

According to the Innovation Union Scoreboard 2014, which classifies Iceland among the innovation followers, it is the only country in which innovation has not improved over the 2006-2013 period. Evidence shows that Iceland's competitiveness in high-tech and medium-tech products and services is low, with a negative trade balance for high-tech and medium-tech products since 2000. In the Global Competitiveness Index (GCI) 2013-2014, Iceland ranks 31 (out of 148 countries), maintaining its position from previous years. Despite significant difficulties in recent post-crisis years, Icelandic competitive strengths include the country's high-level educational system coupled with a relatively innovative business sector (27^{th}). The country's strengths are its scientific outputs (high scores for the international co-publications and public-private co-publications).

R&I were part of Iceland's recovery package for economic growth. However, in the years since the economic collapse, the higher education and research institutions have experienced budget cuts that amount to about a quarter of their pre-crisis budget, in real terms. In 2003, the establishment of the Science and Technology Policy Council (STPC), a key body giving core strategic advice on S&T policy developments, headed by the prime minister, centralised R&I governance at a high political level. The Ministry of Science, Higher education and Culture is responsible for the implementation of R&D policy in Iceland while the Ministry of Industries and Innovation deals with innovation policy. The Icelandic Centre for Research (Rannis) allocates most of the competitive funds and the Innovation Centre Iceland (ICI) deals with support services for innovation- and entrepreneurship-related activities. The fragmented R&I system and insufficient focus on the implementation of policies and objectives

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

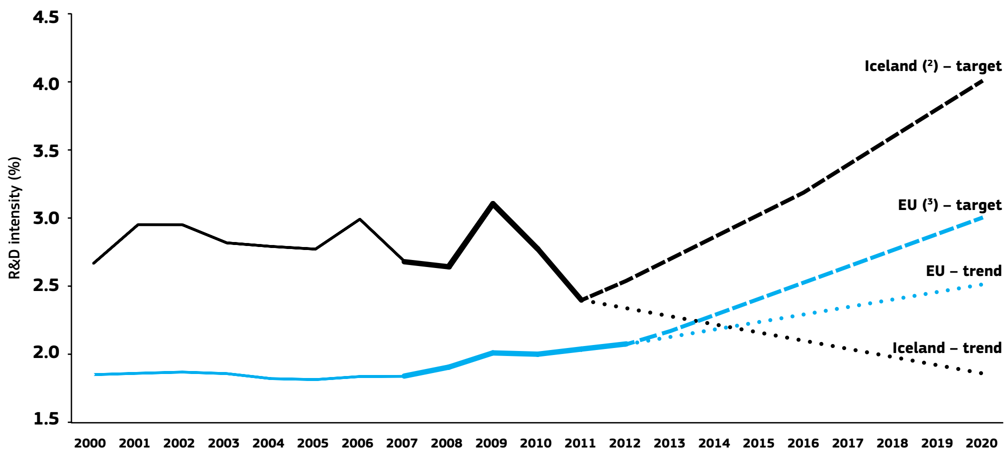
2 Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

has long been conceived as Icelandic structural weakness. Two external evaluations of the system have been conducted since the STPC was set up, and a focused international peer review of the Icelandic R&I system is currently being conducted in the context of the European Research Area and Innovation Committee (ERAC).

In November 2013, the STPC adopted a new policy for the years 2013-2016 which focuses on the following priorities: increased efforts in building up human resources in science and innovation, more cooperation between universities, research institutions and companies aimed at increasing the system's efficiency, more public and private investment in R&I, and a strong focus on the quality and value creation of R&I (emphasis on evaluation and quality control). For the first time, the Council will follow up the policy with a single action plan which is currently being finalised.

Investing in knowledge

Iceland – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2007–2011 in the case of Iceland.
(2) IS: The projection is based on a tentative R&D intensity target of 4.0 % for 2020.
(3) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(4) IS: The values for 2004 and 2010 were interpolated by DG Research and Innovation.

Iceland had an R&D intensity of 3.11 % in 2009, a relatively high level compared to the EU average of 2.07 % (2012). However, following the financial crisis that hit Iceland in 2008, R&D intensity went down to 2.4 % in 2011. In January 2011, ('Iceland 2020' policy statement), Iceland set an R&D intensity target of 4 %, to be reached by 2020, with the private sector contributing 70 % of the total and the public sector contributing 30 %. The new STPC policy is setting a target of 3 % R&D intensity by 2016. Taking into consideration the cuts in R&D spending, achieving this target would appear to be difficult. Icelandic R&D intensity experienced an average annual growth of -2.8 % in 2007-2011 while the growth required to reach the 2020 target is much higher at 5.8 %.

A significant share of total R&D investment in Iceland comes from the public sector. In 2011, the public sector accounted for 42 % of total R&D investment. The business sector accounted for 48 %, which shows a decline from 2007 when the share was 54.6 %. Business R&D expenditure experienced a negative average annual growth of -3.7 % in 2007-2011, reaching 1.26 % in 2011. Insufficient business enterprise expenditure on R&D is one of the key weaknesses of the Icelandic R&I system. Therefore, the new STPC policy (2013-2016) is putting emphasis on increasing funding for and supporting business expenditure on R&D (for example, tax incentives for start-ups). Since 2010, the year tax deductions for companies investing in R&D projects (up to 20 % of costs) were introduced, indirect government support to R&D has been increasing.

3 Investment Plan for Iceland 2013-2015

The STPC policy also addresses another challenge in the Icelandic R&D system and proposes increasing the level of competitive research funding, which accounted for only 15-20 % before the increase in 2013[3], to around 25 % of competitive funding. However, by 2016, the Icelandic government intends to withdraw all the proposed increases in funding to competitive R&D funds. With the new act on public finances proposing a five-year budgetary plan, focused government planning should be introduced which would create more financial stability for the users of R&D, too.

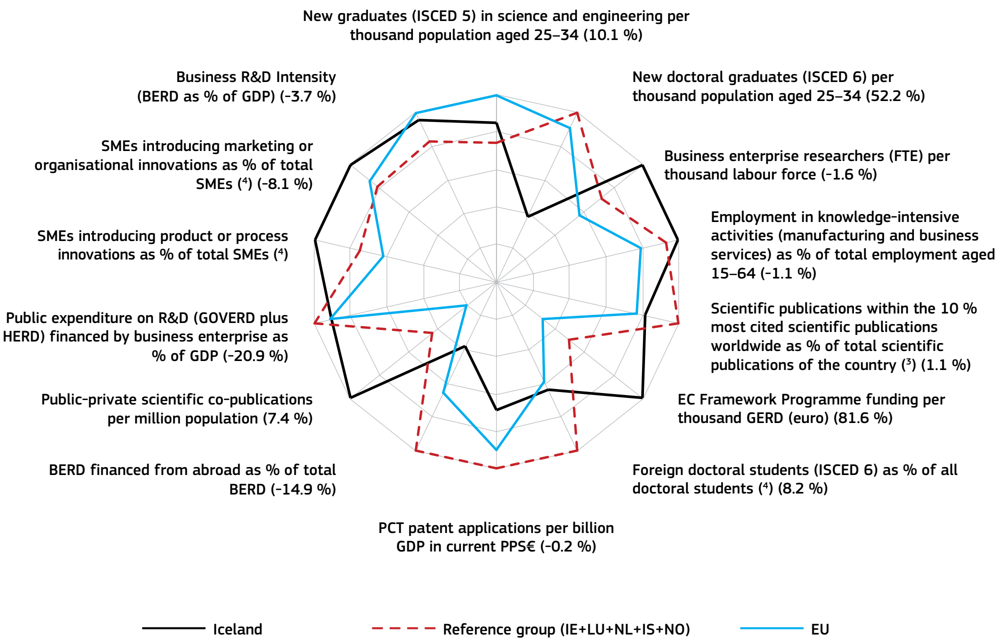
Public expenditure on R&D (GOVERD +HERD) as a % of GDP experienced a negative average annual growth between 2007 and 2012 (-2 %). Mobilising private R&D funding in times of economic crisis is another challenge: the level of private-sector funding of R&D in Iceland is low and has declined since 2007.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Iceland's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year are given in brackets.

Iceland, 2012 (1)

In brackets: average annual growth for Iceland, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The European Economic Area (EEA) agreement, signed in 1994, is the main pillar on which political and economic relations between Iceland and the European Union rests. It gives Iceland the right to participate in a range of EU programmes in areas such as research and education. The Icelandic Centre for Research (Rannis) coordinates and promotes Icelandic participation in collaborative international science and technology projects inside the European Research Area. In particular, Iceland places great emphasis on integration in Nordic R&D cooperation programmes, including the Nordic Research and Innovation Area.

As a whole, the Icelandic R&I system performs above the EU average for most of the indicators, with strengths in scientific production (public-private scientific co-publications and the high impact of the international co-publications) and very good results in terms of participation in the EU Framework Programmes. As of February 2014, 852 eligible proposals were submitted in response to 478 FP7 calls for proposals involving 1170 applicants from Iceland and requesting EUR 344 million in EU contributions. Iceland has the closest collaborative links in FP7 with the UK, Germany, Spain, the Netherlands and France.

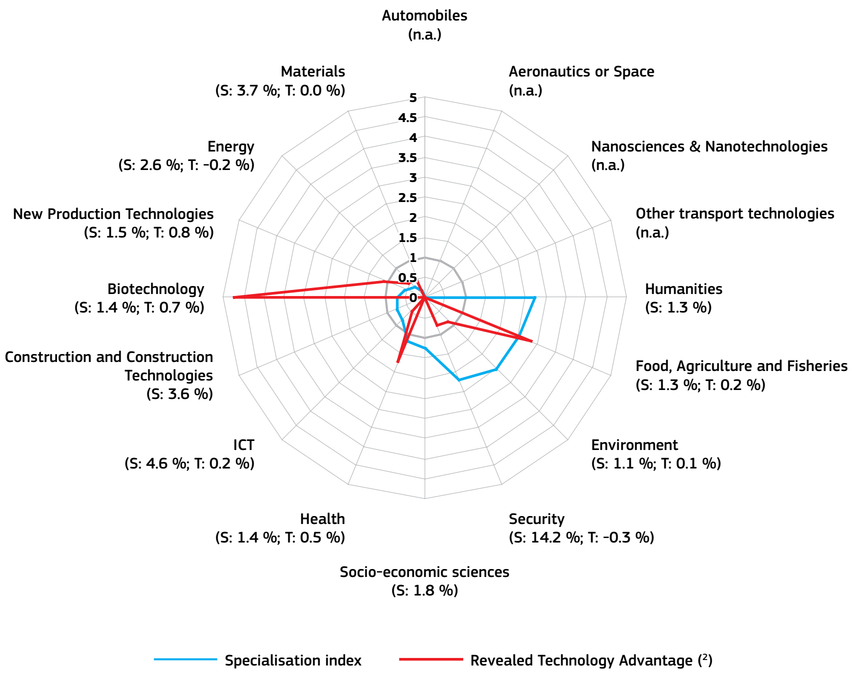
The Icelandic economy is very knowledge-intensive, as illustrated by both the level of employment in knowledge-intensive activities and the high number of business researchers per thousand of the labour force. A challenge for Iceland is to increase the numbers of students participating in science, engineering and doctoral studies. The impressive growth observed in new doctoral graduates indicates that Iceland is on track to address this challenge. The number of foreign doctoral students and scientific publications within the 10 % most cited worldwide is above the EU average but below the average of the reference group countries.

The biggest decrease was observed in the average annual growth of public expenditure on R&D and in the BERD financed from abroad. Iceland scores high in innovative SMEs, but it is important to note that business R&D intensity has been falling since 2007.

Iceland's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Iceland shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Iceland – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



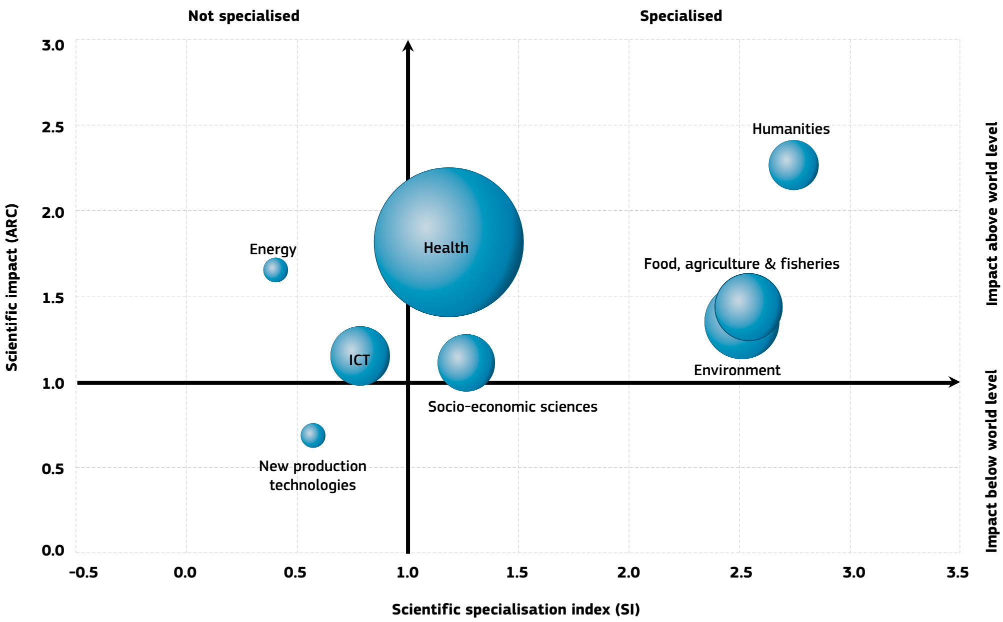
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

Comparison of the scientific and technological specialisation in selected thematic priorities shows a mixed situation with some co-specialisations as well as some mismatches. Technology production is strongly specialised in biotechnology, food, agriculture, fisheries, and health. Iceland, together with Switzerland and the Netherlands, is among the countries with the highest scientific impact for health. In the case of health, and food, agriculture and fisheries, the co-specialisation in S&T over the last decade shows that Iceland has been successful in transferring knowledge from science to technology in those fields. However, there is no corresponding scientific specialisation for a strong technological performance in the field of biotechnology. On the other hand, the science created in the fields of security, and environment is not translated into technology. High growth rates of patenting in security, ICT, materials, and construction show the potential for increasing specialisation in those fields in the future. It is interesting to note that biotechnology and environment are among the fields in which Iceland is the most successful in FP7. However, this is not matched by S&T co-specialisation in those fields at the national level. Therefore, these sectors could be scrutinised more closely when evaluating the strengths of research performed at national level.

Iceland is among those European countries with the highest scientific impact and has a high ratio of highly cited publications per total publications. Excellence in science is noted for most of the fields. As illustrated in the graph below, Iceland's strong scientific specialisation in the fields of environment, humanities, food, agriculture and fisheries, health, and socio-economic sciences matches the high impact of those fields above the world level.

The graph below illustrates the positional analysis of Icelandic publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Iceland – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

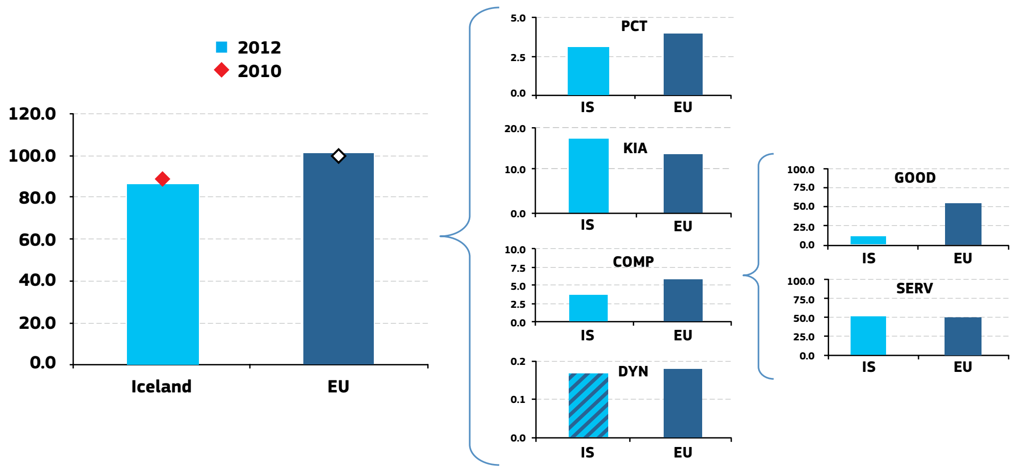
Icelandic excellence in research is correlated to important cooperation with researchers from other European countries and beyond. In general, the smaller countries, like Iceland and Luxembourg, are forced to specialise more and make strategic choices regarding their collaborative links.

In the fields where Iceland is specialised in both science and technology, the ERA offers good opportunities for cooperation, in particular with Denmark, Latvia, Switzerland and Croatia in the field of health, and with Norway, Denmark, Lithuania, the Netherlands, Switzerland, Slovakia, Spain and Portugal in the food and agriculture sector.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Iceland's position regarding the indicator's different components.

Iceland – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average); estimated value.
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

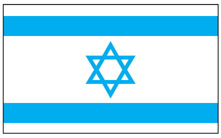
The indicator places Iceland among medium-low performers. This is the result of low performance in the export share of medium-/high-tech goods where the country's performance is very low. Historically, Iceland is a resource-based economy with its fishing industry and energy being the main drivers of its economy. With no sizeable high-tech industry and a high share of food exports (fish), Iceland scores at a low level as regards the share of medium-/high-tech goods in total goods exports. As a result of its high share of air-transport services, the country scores better (slightly above the EU average) in knowledge-intensive service exports.

Together with Switzerland, Luxembourg, Ireland, Sweden and Belgium, Iceland has the most knowledge-intensive economy in terms of employment. An above-EU-average share of employment in information and communication, financial services, education, health, and the arts explains the country's high share of employment in knowledge-intensive activities which, despite having dropped slightly since 2009, is still well above the EU average. Iceland is among those European countries which registered a fall in international co-patenting as a significant drop in PCT patent applications was observed in the country in the period 2009-2011.

Key indicators for Iceland

ICELAND	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (¹) (%)	EU average (²)
ENABLERS Investment in knowledge											
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.05	0.34	0.34	0.22	0.48	0.67	0.77	:	:	52.2	*1.81*
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	506	:	:	507	:	:	493	-12.7 (³)	495 (⁴)
Business enterprise expenditure on R&D (BERD) as % of GDP	*1.50*	1.43	1.59	1.46	1.44	1.64	1.39	1.26	:	-3.7	1.31
Public expenditure on R&D (GOVERD + HERD) as % of GDP	*1.11*	1.26	1.32	1.15	1.14	1.39	:	1.06	:	*-2.0*	*0.74*
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation											
Composite indicator on research excellence	:	:	:	25.3	:	:	:	:	38.7	8.8	47.8
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	10.8	11.4	11.3	11.5	11.5	:	:	:	1.1	11.0
International scientific co-publications per million population	:	1376	1387	1737	1862	2302	2662	2648	2725	9.4	343
Public–private scientific co-publications per million population	:	:	:	192	200	216	239	255	:	7.4	53
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness											
PCT patent applications per billion GDP in current PPS (EUR)	4.7	4.7	4.2	3.0	2.7	3.9	3.0	:	:	-0.2	3.9
License and patent revenues from abroad as % of GDP	0.00	:	0.00	0.00	0.00	1.80	1.60	1.55	:	-7.1 (⁵)	0.59
Community trademark (CTM) applications per million population	14	41	167	319	399	178	126	97	147	-14.3	152
Community design (CD) applications per million population	:	14	7	10	13	6	22	9	13	5.1	29
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	:	:	:	:	6.1	:	:	:	14.4
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	53.1	51.6	51.0	:	-2.0	45.3
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-19.65	-16.81	-17.67	-13.22	-12.93	-11.96	-12.69	-13.57	-14.98	-	4.23 (⁶)
Growth of total factor productivity (total economy): 2007 = 100	94	102	100	100	99	97	94	96	97	-3 (⁷)	97
Factors for structural change and addressing societal challenges											
Composite indicator on structural change	:	:	:	54.9	:	:	:	:	55.8	0.3	51.2
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	18.2	18.8	18.3	18.2	17.4	-1.1	13.9
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	:	:	54.2	:	:	:	33.8
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.57	0.02	0.00	0.00	0.00	0.11	:	:	:	46.8	0.44
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	1.65	2.40	1.51	0.47	0.87	0.65	:	:	:	17.5	0.53
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES											
Employment rate of the population aged 20–64 (%)	:	85.5	86.3	86.7	85.3	80.6	80.4	80.6	81.8	-1.2	68.4
R&D intensity (GERD as % of GDP)	*2.67*	2.77	2.99	2.68	2.65	3.11	:	2.40	:	-2.8	*2.07*
Greenhouse gas emissions: 1990 = 100	110	109	124	131	142	134	130	:	:	-1 (⁸)	83
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	:	:	:	:	:	:	:
Share of population aged 30–34 who have successfully completed tertiary education (%)	32.6	41.1	36.4	36.3	38.3	41.7	40.9	44.6	42.8	3.3	35.7
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	29.8	24.9	25.6	23.2	24.4	21.3	22.6	19.7	20.1	-2.8	12.7
Share of population at risk of poverty or social exclusion (%)	:	13.3	12.5	13.0	11.8	11.6	13.7	13.7	12.7	-0.5	24.8

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (¹) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(²) EU average for the latest available year.
(³) The value is the difference between 2012 and 2006.
(⁴) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT.
(⁵) Average annual growth refers to 2009–2011.
(⁶) EU is the weighted average of the values for the Member States.
(⁷) The value is the difference between 2012 and 2007.
(⁸) The value is the difference between 2011 and 2007. A negative value means lower emissions.
(⁹) Values in italics are estimated or provisional.



Israel

The challenge of attracting foreign funding for innovation

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Israel. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **4.20 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **-2.5 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **64.5** (EU: 47.8; US: 58.1) 2007-2012: **-2.1 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **n.a.** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **n.a.** (EU: 51.2; US: 59.9) 2007-2012: **n.a.** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: ICT, biotechnology, security, and health	***HT + MT contribution to the trade balance*** 2012: **5.9 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+8.7 %** (EU: +4.8 %; US: -32.3 %)

Israel is a very knowledge-intensive country. It has a strong and dynamic business sector and has achieved excellence in scientific and technical education and research. This has led to high levels of technological entrepreneurship and start-ups. The economy is very knowledge-intensive with high-tech and medium-tech products contributing significantly to the trade balance. The country's main strengths are its high research intensity, mainly due to a very high business expenditure on R&D, and its patenting activity.

Nevertheless, in spite of this high performance in the field of R&I, Israel faces some structural challenges that have created a certain degree of stagnation over the last decade. Budgets for Israeli universities have not increased in line with the growth of student numbers, resulting in a decline in scientific production and the outward mobility of students. Venture capital (VC) has fallen due to the low returns on VC investments. As a consequence, the total funds available for investment are at a lower level than in previous years. Israeli fund-management firms need to raise new funds if they are to continue their important role in supporting Israeli start-ups.

Recently, the governance of the public R&I system has been reformed, and a six-year plan to revive higher education and university-based research was launched in 2011. The plan calls for a 30 % increase in budgets, a doubling of funding for competitive grants, and a 9 % increase in the number of researchers. The plan provides for the creation of 20 new CORE centres of research, four of which are already operational.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

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Investing in knowledge

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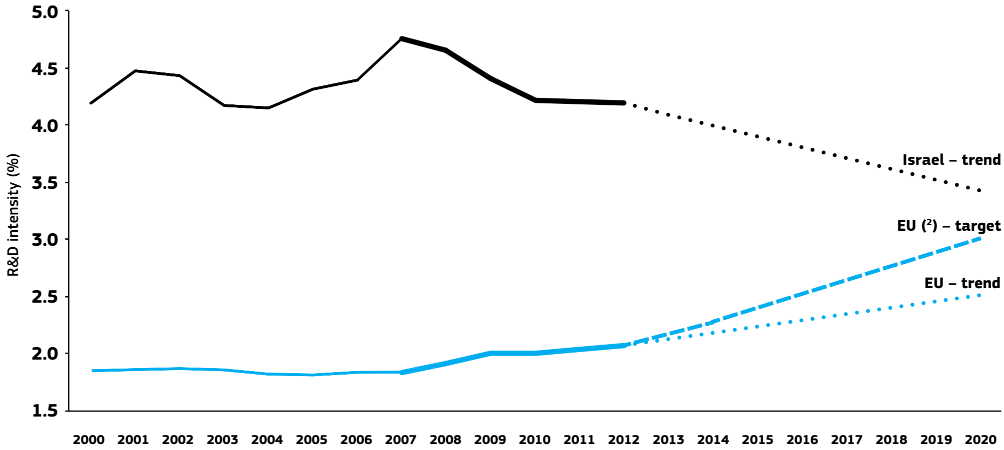

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Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) IL: An R&D intensity target for 2020 is not available.

In 2000, Israel's R&D intensity was already higher than 4 % and continued to increase until 2007, when it reached 4.84 %. It then fell to 4.20 % in 2012, a value which is more than double the EU average. The business sector accounts for around 80 % of total R&D expenditure. Although Israel was less affected by the global economic and financial crisis than other countries, business R&D intensity decreased from 3.9 % in 2007 to 3.54 % in 2012.

Foreign-owned firms are contributing to increasing the country's R&D intensity through inward investment in R&D. The level of this investment is an indicator of the degree of internationalisation of business R&D as well as the country's attractiveness for foreign investors. The BERD finance from abroad is 50 % of the total BERD, while the EU average is around 10 %.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Israel's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.

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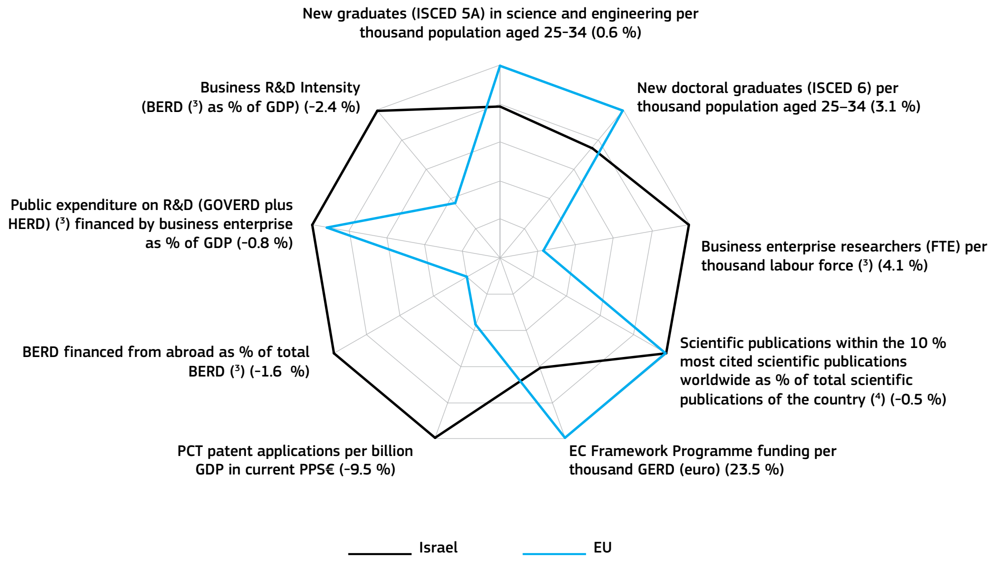

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Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) IL: Defence is not included.
(4) Fractional counting method.

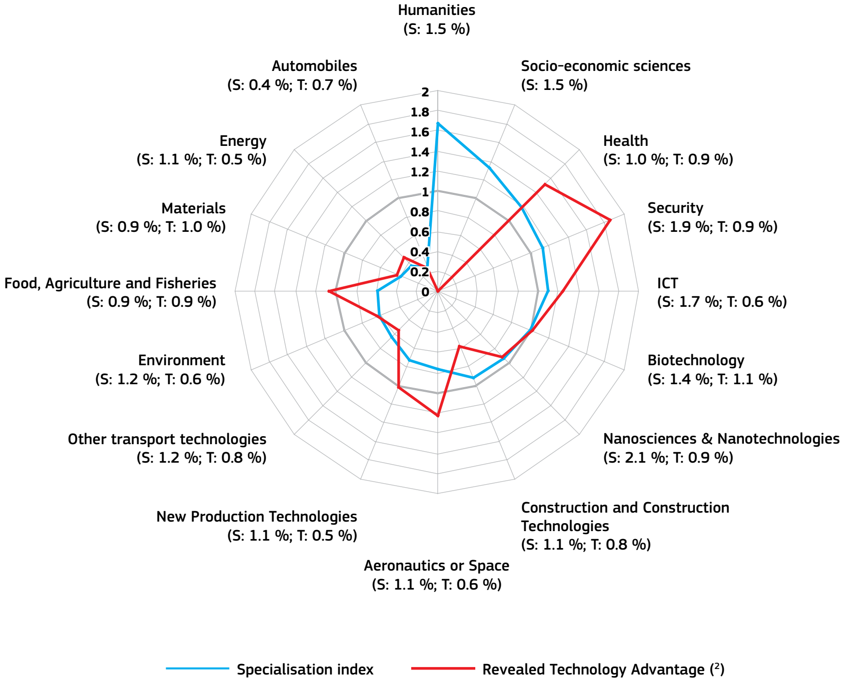
The graph shows that Israel is well above the EU average for the majority of the R&I indicators. Indeed, the country's overall level of innovation performance places it among the group of European 'innovation leaders'. Only Sweden, Switzerland and Finland show higher levels of innovation performance. PCT patent applications per billion GDP are three times higher than the EU average, which is a considerable difference.

Although the supply of human resources for science and technology is below the EU average for new science and technology graduates and new doctoral graduates per thousand population aged 25-34 years, knowledge production – as evidenced by highly cited scientific publications – is at the same level as the EU average, indicating a good scientific base. This is confirmed by Israel's remarkable level of participation as an Associated Country in the EU's Seventh Framework Programme (FP7). The total number of participants is 1816 (out of 8602), receiving more than EUR 747 million. The success rate of the participants is 21.1 %, which is above the EU average.

Israel's scientific and technological strengths

The spider graph below illustrates the areas, based on the Framework Programme thematic priorities, where Israel shows potential in science and technology areas in a European context. Both the specialisation index (SI) and the revealed technological advantage (RTA) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Israel – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)

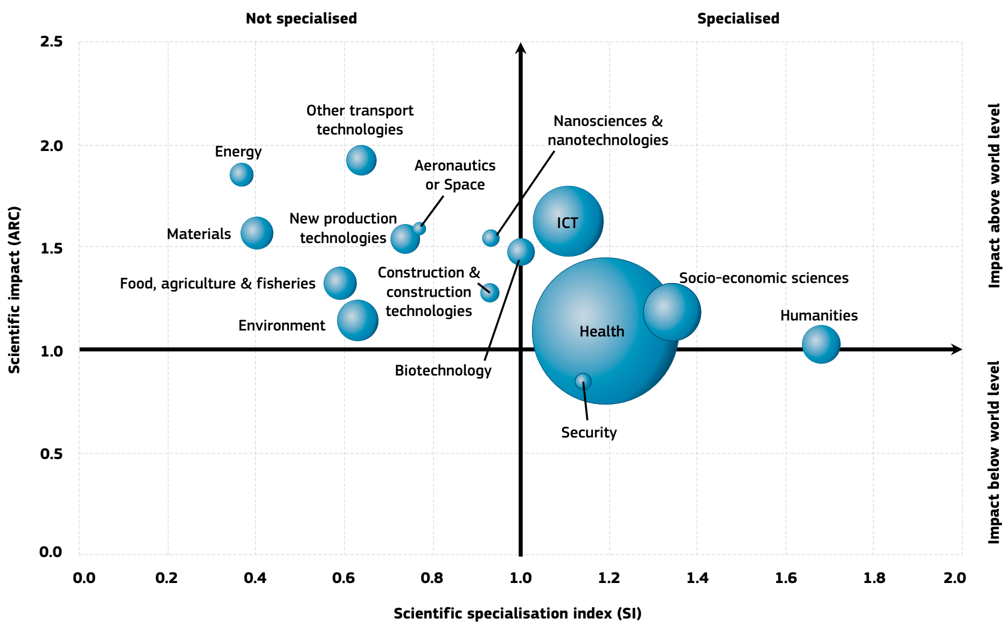


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

The figures show that overall Israel is successful in transferring knowledge from science to technology in most of the analysed fields. In addition, there has been a general coherence in the dynamics of co-specialisation in S&T over the last decade, whereby a simultaneous growth in both publications and patents can be observed in various fields (except for socio-economic sciences and humanities, where there are no patents). Another positive aspect is reflected by the general higher level of specialisation in technology compared to science, which can be interpreted in the sense that the technological performance of the country is based on national science – with an overall excellent quality – as well as on science coming from abroad.

The graph below illustrates the positional analysis of Israeli publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Israel – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



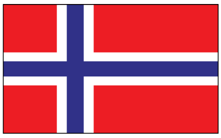
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

As regards scientific quality (see graph above) Israel performs well in all the scientific priorities. It is worth noting that there is a good match between scientific quality and technological specialisation at country level in the fields of ICT, biotechnology, and health.

Key indicators for Israel

ISRAEL	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)
ENABLERS Investment in knowledge											
New doctoral graduates (ISCED 6) per thousand population aged 25–34	:	1.15	1.14	1.20	1.32	1.25	1.37	1.36	:	3.1	*1.81*
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	442	:	:	447	:	:	466	24.6 (3)	495 (4)
Business enterprise expenditure on R&D (BERD (5)) as % of GDP	3.37	3.52	3.60	4.00	3.87	3.68	3.51	3.54	3.54	-2.4	*1.31*
Public expenditure on R&D (GOVERD + HERD) (6) as % of GDP	0.79	0.76	0.73	0.70	0.73	0.67	0.66	0.63	0.60	-2.8	*0.74*
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation											
Composite indicator on research excellence	:	:	:	71.7	:	:	:	:	64.5	-2.1	47.8
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	11.0	11.0	11.0	11.0	:	:	:	:	-0.5	11.0
International scientific co-publications per million population	573	774	800	828	836	820	860	896	:	2.0	343
Public–private scientific co-publications per million population	:	:	:	:	:	:	:	:	:	:	:
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness											
PCT patent applications per billion GDP in current PPS (EUR)	11.9	14.1	14.8	14.2	12.3	11.7	10.5	:	:	-9.5	3.9
License and patent revenues from abroad as % of GDP	:	:	:	:	:	:	:	:	:	:	:
Community trademark (CTM) applications per million population	:	:	:	:	:	:	:	:	:	:	:
Community design (CD) applications per million population	:	:	:	:	:	:	:	:	:	:	:
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	:	:	:	:	:	:	:	:	:
Knowledge-intensive services exports as % total service exports	:	:	:	:	:	:	:	:	:	:	:
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-4.67	-3.08	-2.29	-5.06	4.23	6.86	6.48	5.42	5.92	-	4,23 (7)
Growth of total factor productivity (total economy): 2000 = 100	:	:	:	:	:	:	:	:	:	:	:
Factors for structural change and addressing societal challenges											
Composite indicator on structural change	:	:	:	67.8	:	:	:	:	67.8	-0.01	51.2
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	:	:	:	:	:	:	:
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	:	:	:	:	:	:	:
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.16	0.27	0.37	0.31	0.55	0.44	:	:	:	19.8	0.44
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	2.86	3.81	3.19	3.06	2.93	2.75	:	:	:	-5.3	0.53
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES											
Employment rate of the population aged 15–64 (%)	56.1	56.7	57.6	58.9	59.8	59.2	60.2	60.9	66.5	2.4	64.1
R&D intensity (GERD (5) as % of GDP)	4.19	4.32	4.39	4.76	4.66	4.40	4.22	4.21	4.20	*-2.5*	*2.07*
Greenhouse gas emissions: 1990 = 100	:	:	:	:	:	:	:	:	:	:	:
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	:	:	:	:	:	:	:
Share of population aged 25–34 who have successfully completed tertiary education (%)	:	:	:	:	:	:	44.2	:	:	:	34.6
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	:	:	:	:	:	:	:	:	:	:
Share of population at risk of poverty or social exclusion (%)	:	:	:	:	:	:	:	:	:	:	:

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT.
(5) Defence is not included.
(6) Defence is not included in GOVERD; Social Sciences and Humanities is not included in HERD.
(7) EU is the weighted average of the values for the Member States.
(8) Values in italics are estimated or provisional.



Norway

The challenge of structural change towards a more diversified economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Norway. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **1.65 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+0.7 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **67.6** (EU: 47.8; US: 58.1) 2007-2012: **+15.7 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **83.9** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **40.0** (EU: 51.2; US: 59.9) 2007-2012: **+2.4 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Energy, environment, food, agriculture and fisheries, and other transport technologies	***HT + MT contribution to the trade balance*** 2012: **-17.4 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

Norway has the second highest GDP per capita in Europe. This partly explains the low R&D intensity level, which was only 1.65 % in 2012, well below the EU average (2.07 %). Nevertheless, Norway maintains one of the highest spending levels on R&D per capita. The country's R&D intensity fluctuated slightly over the period 2007-2012, reaching a high of 1.76 % in 2009 but remaining almost stable between 2010 and 2012, with an average annual growth rate of 0.7 %.

To a large extent the Norwegian economy is based on traditional industrial activities related to the extraction of raw materials and natural resources (i.e. oil and natural gas, fish, minerals) and to their industrial processing into bulk products and semi-finished goods. High shares of public R&D financing have been allocated to these activities to improve their efficiency. However, a forward-looking distribution of R&D investments should be considered in order to reduce Norway's dependence on raw materials and facilitate a gradual change towards a more diversified economy.

The knowledge-intensity of the Norwegian economy remains below the EU average although it has been growing at a faster rate in recent years (+2.4 % instead of +1.0 % at the European level). Internationalisation has become an overall priority of the government's R&I policy in recent years in order to improve the quality of research. The new White Paper on research entitled 'Long-term perspectives – Knowledge provides opportunity', which was presented in March 2013, states that Norway should commit to strengthening the internationalisation of its research system. Following this line, it has been requested that all activities of the Research Council of Norway (RCN) include clearly defined objectives and plans for international cooperation. Moreover, in terms of funding, there has been a shift from instruments dedicated to internationalisation towards including the internationalisation dimension in all activities.

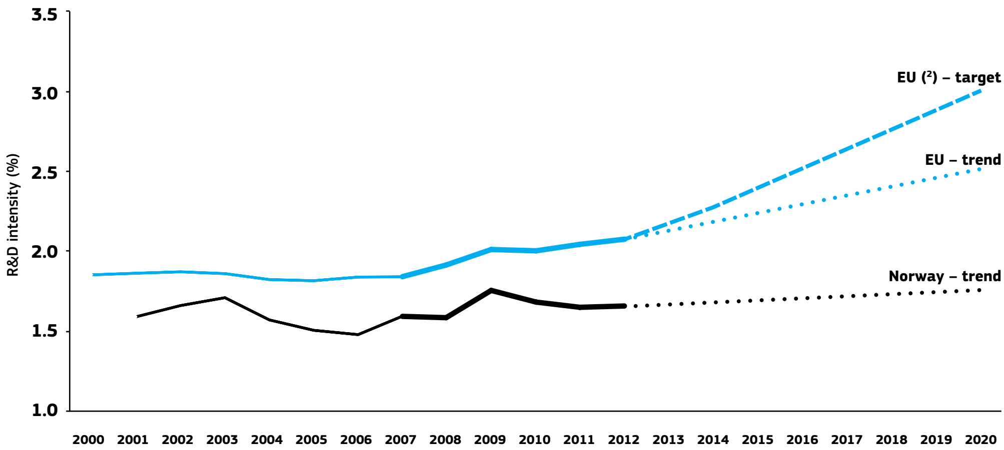
The Norwegian system also shows a high level of S&T excellence (67.6 in 2012 compared to an EU average of 47.8), which is expected to increase further in the following years, thanks to its significant growth rate (+15.7 % between 2007 and 2012).

[1] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

[2] Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

Investing in knowledge

Norway – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) NO: An R&D intensity target for 2020 is not available.

Norway's R&D intensity was 1.65 % in 2012, which is still a long way from the EU average. This is partly due to the particular nature of the Norwegian economy – which is characterised by traditional industrial activities related to the extraction and processing of natural resources – and partly to its high level of GDP. Nevertheless, following its election in October 2013, the new government has committed to achieving a 3 % target by 2030.

While in 2012 Norway's public R&D intensity was slightly higher than the EU average (0.79 % vs. 0.74 %), the 0.87 % business R&D intensity was much lower than the EU value of 1.31 %, and a long way below the level of the other Nordic countries. However, it is important to mention that the BERD value does not include any form of indirect support, such as tax credits, which is still the largest R&D support scheme for business in Norway. In recent years, Norwegian policy-makers have increasingly recognised that the low level of industrial R&D should be seen against the backdrop of the country's industrial structure, and the new government has already declared its intention to put more emphasis on stimulating R&D investments in the private sector.

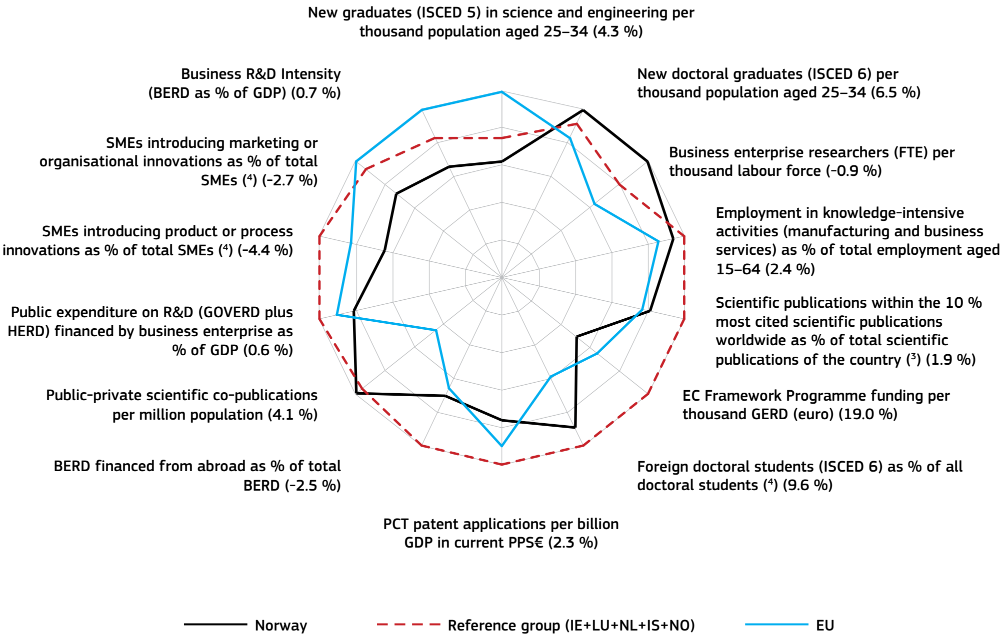
The EU's Seventh Framework Programme is the most important international research programme in which Norway participates. Norwegian institutions and researchers have been participating in EU FPs since 1987. The success rate of Norwegian participants in FP7 is 24.49 %, which means that one in four applicants eventually receives funding. To date, the successful participants have received a total EU financial contribution of EUR 675 million.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the Norwegian innovation system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.

Norway, 2012 ([1])

In brackets: average annual growth for Norway, 2007–2012 ([2])



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: ([1]) The values refer to 2012 or to the latest available year.
([2]) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
([3]) Fractional counting method.
([4]) EU does not include EL.

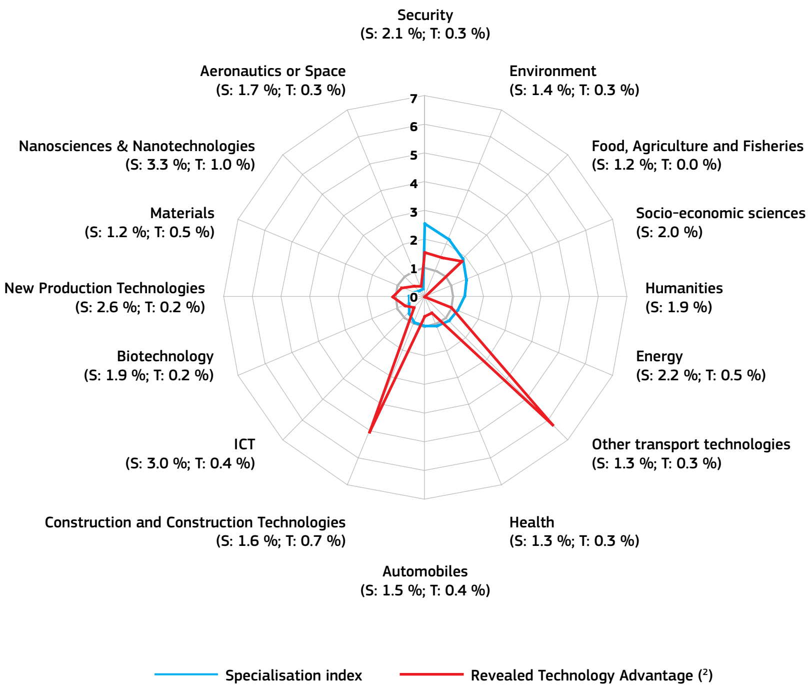
Norway's main strengths are its human resources, public-private cooperation, and the attractiveness of its research system. Although the share of new graduates in science and engineering is lower than the EU average, Norway has a very high number of full-time researchers in the labour force and a strong dynamic of new doctoral graduates. At the same time, it is among the OECD countries with the highest education level, revealing a wide range of employees with higher-education qualifications in both the public and private sectors. Furthermore, the Norwegian higher education system is considered attractive by foreign doctoral students, with numbers continuing to rise since 2000 (+9.6 % annual growth). As regards public-private collaboration, the number of co-publications is much higher in Norway than in other European countries.

Areas of relative weakness are private investments in R&D, the low levels of patenting, and the modest level of business innovation among small and medium-sized enterprises (SMEs). While both the BERD intensity and the number of PCT patent applications have increased slightly in recent years, the share of SMEs introducing marketing/organisational or product/process innovation has decreased even further. A variety of measures targetting SMEs exist in Norway, such as the Skattefunn and the BIA schemes. The first is a tax-credit scheme aiming to leverage R&D activities in businesses, whereas the second one is a funding scheme for business innovative projects without any thematic restriction. Norwegian authorities have also tried to simplify rules and reduce the administrative burden on SMEs in a wide range of fields, such as competition, tax and auditing.

Norway's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Norway shows scientific and technological specialisations[3]. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to the one existing at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Norway – S&T National Specialisation (1) in thematic priorities, 2000–2010
in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



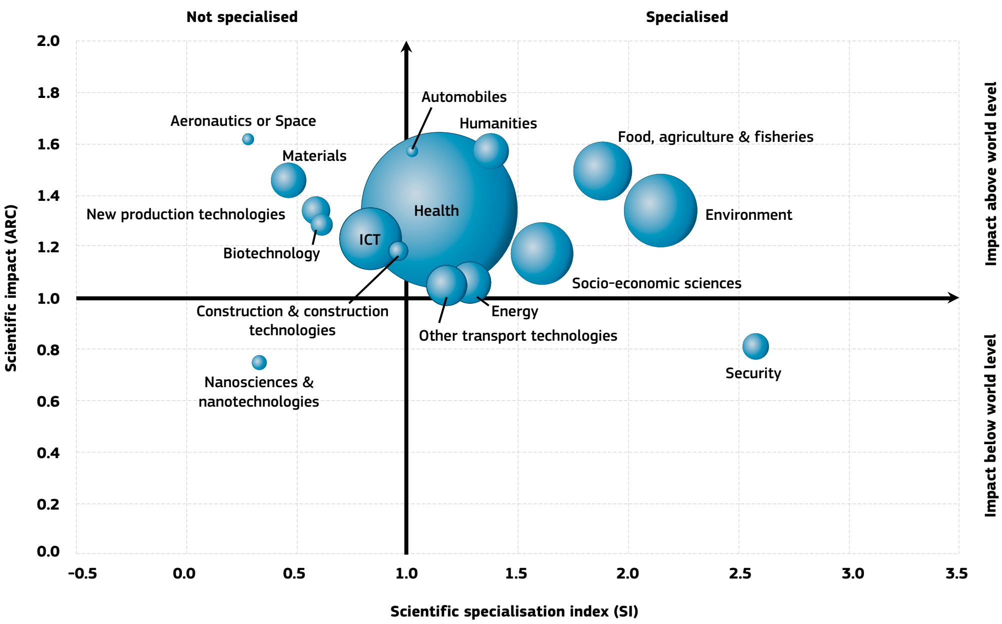
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

The annual report on the condition and evolution of Norway's higher-education sector published in May 2013 shows that the number of scientific publications has registered a 60 % increase since 2003. Norwegian S&T activities present substantial scientific specialisations in almost all FP7 thematic priorities, the only exceptions being aeronautics, nanotechnologies, materials, new product technologies, and biotechnologies. This scientific activity follows the country's R&D policy priorities closely.

At the same time, Norway's technology production is quite well in line with the scientific specialisation patterns, showing relative strengths in patenting in many sectors, such as other transport technologies, construction technologies, energy, food, agriculture and fisheries, and environment. This alignment between scientific publications and revealed technology advantages reflects smooth knowledge transfer between academia and private companies, although the level of Norwegian patenting remains below the EU average for both PCT and European Patent Office applications.

[3] Please note that Norway only became an EPO member state in 2008.

Norway – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The graph above illustrates the positional analysis of Norwegian publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

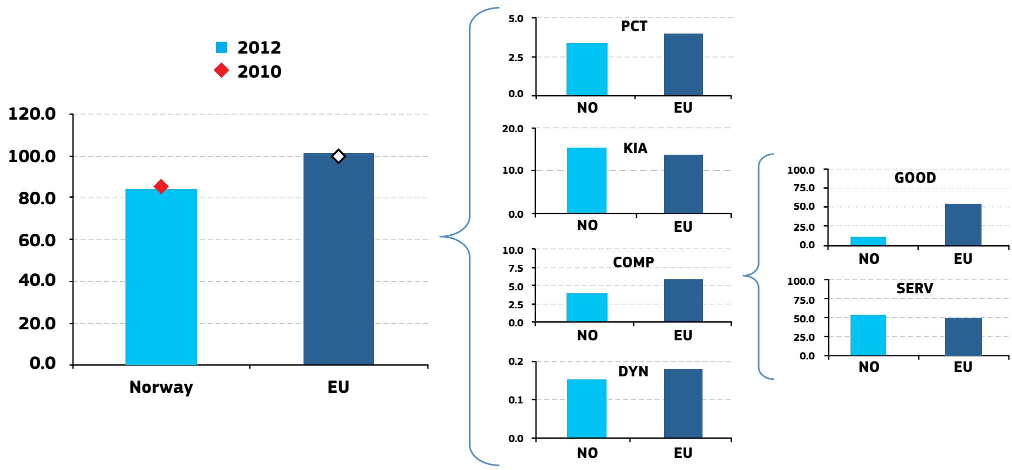
The country is mainly specialised in security, environment, food, agriculture and fisheries, and socio-economic sciences and humanities. In almost all sectors, the scientific impact of publications is above the world level, with the exception of nanotechnology and security. As in almost all countries, the health bubble dominates strongly. Since the mid-1990s, Norway has seen the most significant rise in scientific impact, and today the proportion of highly cited Norwegian scientific publications is greater than the EU average.

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator on innovation focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms).

The graph below enables a comprehensive comparison of Norway's position regarding the indicator's different components:

Norway – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average).
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Norway is a medium-low performer in the European innovation indicator. This is mainly due to a very low performance in the export share of medium-/high-tech goods. All other areas are almost in line with or above the EU average, and Norway's performance is improving slightly.

With mineral fuels (oil, natural gas) representing two-thirds of exports, and fish representing another 6 %, the share of medium-/high-tech goods in total good exports is relatively low in Norway (at the lowest position in Europe). Norway performs better (i.e. slightly above the EU average) in knowledge-intensive services exports, mainly as a result of its maritime freight transport sector.

The country performs below EU average in the innovativeness of fast-growing firms because of high shares of employment in the mining and quarrying, and construction sectors. However, the share of employment in knowledge-intensive activities is well above the EU average, showing that the quality of Norway's human capital remains one of its greatest strengths.

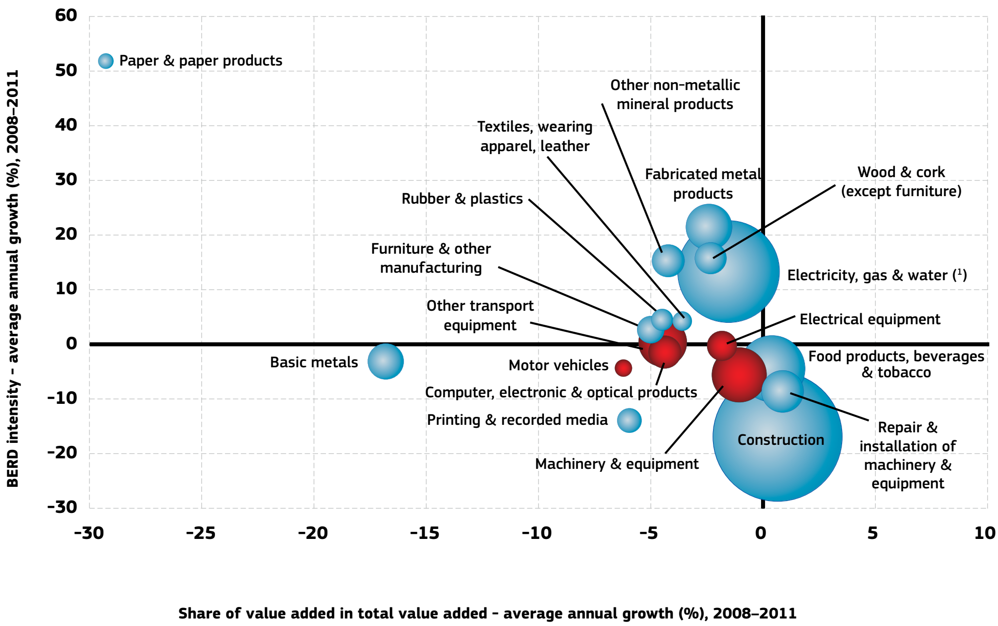
The production in services accounts for around 76 % of employment (man hours) and 52 % of value added in the Norwegian economy (2010). The construction sector is not included in the figures. The share of services in total value added is lower in Norway compared to many other advanced economies, mainly as the result of a dominant oil sector in the country. In its Review of Innovation Policy in Norway (OECD, 2008) the OECD notes that "Non-R&D based innovation, for instance in the service sector, seems to underlie the exceptional productivity performance of the private service sector".

Innovation Norway and the Research Council of Norway manage several schemes and instruments promoting innovation. Policies aiming to strengthen the framework conditions for innovation and targeted programmes aiming to enhance innovation in enterprises are open to all industry sectors, but there are no schemes exclusively for service innovation.

Upgrading the manufacturing sector through research and technologies

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend to the left-hand side reflects the decline in manufacturing in the overall economy. The sectors above the x-axis are those where research intensity has increased over time. The size of the bubble represents the sector share (in value added) in manufacturing (for all sectors presented on the graph). The red sectors are high-tech or medium-high-tech sectors.

Norway – Share of value added versus BERD intensity: average annual growth, 2008–2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat
Notes: (1) 'Electricity, gas and water' includes 'sewerage, waste management and remediation activities'.
(2) High-tech and medium-high-tech sectors (NACE Rev. 2 – two-digit level) are shown in red.

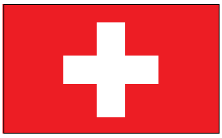
The above graph shows that there were only small changes in R&D investments in the manufacturing sectors over the period 2008-2011. Very few sectors have significantly increased their R&D intensities (i.e. paper and paper products, fabricated metal products, other non-metallic mineral products, wood and cork, electricity, gas and water), and manufacturing in general has continued to lose its weight in the overall economy. Most of the sectors are grouped near the intersection point of the axes, meaning that small variations in levels of R&D intensity are usually accompanied by small or no variations in shares of value added. In this context, the paper and paper products sector represents a negative exception as its business R&D intensity registered a significant increase (+51.8 %) while the share of value added decreased drastically (- 29.3 %).

In recent years, R&D policies and innovation strategies have focused on specific and representative areas of Norway's economy. These include the strategies for oil and gas, energy, climate, green growth, biotechnologies, nanotechnologies, and the maritime sector. At the national level, there is also a broad political consensus on the need to foster R&D-intensive and knowledge-intensive manufacturing industries and services by exploiting both renewable and non-renewable energy technologies.

Key indicators for Norway

NORWAY	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)
ENABLERS Investment in knowledge											
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.96	1.33	1.41	1.59	1.99	1.74	1.92	2.05	2.17	6.5	*1.81*
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	490	:	:	498	:	:	489	-0.5 (3)	495 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	:	0.81	0.79	0.84	0.84	0.91	0.86	0.86	0.87	0.7	1.31
Public expenditure on R&D (GOVERD + HERD) as % of GDP	:	0.70	0.69	0.76 (5)	0.74	0.85	0.82	0.79	0.79	*0.8*	*0.74*
Venture capital as % of GDP	0.16	0.17	0.17	0.24	0.25	0.23	0.29	0.20	0.22	-2.1	0.29 (6)
S&T excellence and cooperation											
Composite indicator on research excellence	:	:	:	32.6	:	:	:	:	67.6	15.7	47.8
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	11.3	11.7	11.1	12.1	11.5	:	:	:	1.9	11.0
International scientific co-publications per million population	:	938	1078	1191	1293	1440	1539	1638	1767	8.2	343
Public–private scientific co-publications per million population	:	:	:	98	102	114	119	116	:	4.1	53
FIRM ACTIVITIES AND IMPACT Innovation contributing to international competitiveness											
PCT patent applications per billion GDP in current PPS (EUR)	4.3	3.5	3.2	3.1	2.9	3.7	3.3	:	:	2.3	3.9
License and patent revenues from abroad as % of GDP	0.10	0.17	0.20	0.18	0.15	0.17	:	:	:	-3.3	0.59
Community trademark (CTM) applications per million population	28	35	44	48	59	70	68	70	72	8.3	152
Community design (CD) applications per million population	:	15	16	18	14	16	13	9	10	-10.8	29
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	4.8	:	3.3	:	6.1	:	:	35.2	14.4
Knowledge-intensive services exports as % total service exports	:	47.7	50.1	46.9	48.9	49.4	:	:	:	2.6	45.3
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-19.77	-18.39	-18.26	-17.52	-17.73	-16.74	-16.46	-17.38	-17.42	-	4.23 (7)
Growth of total factor productivity (total economy): 2007 = 100	96	102	101	100	97	94	94	94	94	-6 (8)	97
Factors for structural change and addressing societal challenges											
Composite indicator on structural change	:	:	:	35.4	:	:	:	:	40.0	2.4	51.2
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	13.8	14.9	14.2	15.1	15.2	2.4	13.9
SMEs introducing product or process innovations as % of SMEs	:	:	29.8	:	28.9	:	26.4	:	:	-4.4	33.8
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.22	0.24	0.22	0.30	0.24	0.39	:	:	:	14.0	0.44
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.55	0.29	0.34	0.29	0.24	0.31	:	:	:	3.3	0.53
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES											
Employment rate of the population aged 20–64 (%)	80.3	78.2	79.5	80.9	81.8	80.6	79.6	79.6	79.9	-0.2	68.4
R&D intensity (GERD as % of GDP)	:	1.51	1.48	1.59	1.58	1.76	1.68	1.65	1.65	0.7	*2.07*
Greenhouse gas emissions: 1990 = 100	107	108	108	111	108	103	108	:	:	-3 (9)	83
Share of renewable energy in gross final energy consumption (%)	:	60.2	60.7	60.5	62.1	65.2	61.4	65.0	:	1.8	13.0
Share of population aged 30–34 who have successfully completed tertiary education (%)	37.3	39.4	41.9 (10)	43.7	46.2	47.0	47.3	48.8	47.6	1.7	35.7
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	12.9	4.6	17.8 (10)	18.4	17.0	17.6	17.4	16.6	14.8	-4.3	12.7
Share of population at risk of poverty or social exclusion (%)	:	16.2	16.9	16.5	15.0	15.2	14.9	14.5	13.8	-3.5	24.8

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT.
(5) Break in series between 2007 and the previous years.
(6) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK.
(7) EU is the weighted average of the values for the Member States.
(8) The value is the difference between 2012 and 2007.
(9) The value is the difference between 2010 and 2007. A negative value means lower emissions.
(10) Break in series between 2006 and the previous years.
(11) Values in italics are estimated or provisional.



Switzerland

The challenge of structural change maintaining a leading competitive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Switzerland. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **2.87 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+0.5 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **97.7** (EU: 47.8; US: 58.1) 2007-2012: **+2.6 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **117.8** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **73.4** (EU: 51.2; US: 59.9) 2007-2012: **+0.8 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Energy, environment, biotechnology, ICT, nanoscience and nanotechnology	***HT + MT contribution to the trade balance*** 2012: **8.1 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **+1.3 %** (EU: +4.8 %; US: -32.3 %)

Switzerland's level of economic development is amongst the highest in Europe. Swiss research policy is characterised by continuity and stability and the country performs better in R&D than both the EU (average) and the United States. Switzerland had an R&D intensity of 2.87 % in 2008 (the latest available year) with an R&D intensity average annual growth rate of 1.9 % in the period 2000-2008, both of which are higher than the corresponding values for the EU (2.03 % and 0.8 %) and the US (2.75 % and 0.2 %).

The high level of R&D performance is accompanied by a high level of S&T excellence with Switzerland performing at a level twice the EU average. It is one of the most advanced countries in terms of the knowledge-intensity of its economy, and made even further progress over the years 2007-2012.

The country performs well in all indicators relating to the size of the knowledge economy. There is also a high performance on the cumulative inward and outward FDI stock as a share of GDP, relative specialisation in the exports of medium-high-tech and high-tech products (Revealed Competitive Advantage) and the share of value added in knowledge-intensive activities within the country's total value added.

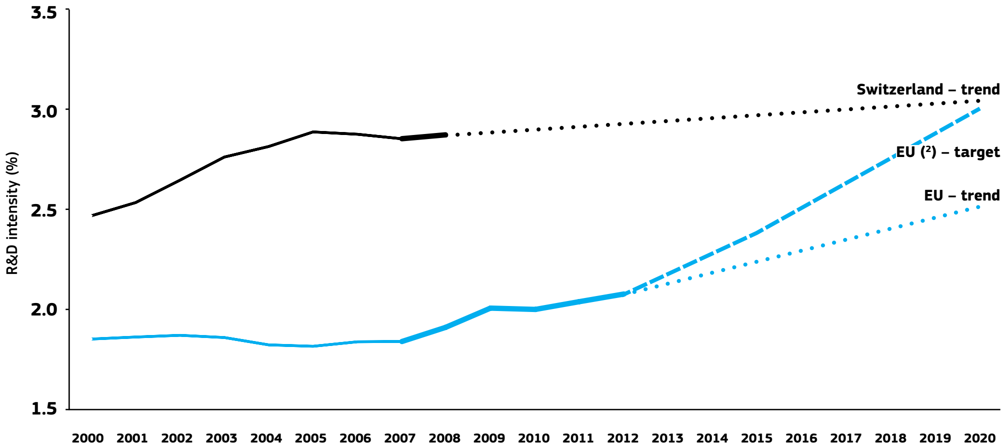
The contribution of high-tech (HT) and medium-high-tech (MT) products to the country's trade balance is much higher than the corresponding contributions in the EU as a whole and the US. It is based on a very good performance by the knowledge-intensive sectors of the economy and includes sectors such as medicaments and vaccines, watches, and orthopaedic appliances.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

Investing in knowledge

Switzerland – R&D intensity projections: 2000–2020 ([1])



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat
Notes: ([1]) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2004–2008 in the case of Switzerland.
([2]) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
([3]) CH: An R&D intensity target for 2020 is not available.
([4]) CH: The values for 2001, 2002, 2003, 2005, 2006 and 2007 were interpolated by DG Research and Innovation.

The Swiss research system is of high quality and based on a clear-cut separation between the public sector, which is centred on very-research-intensive universities, and the private sector, which is focused on the large research units within multinational companies. The main priority for Swiss national R&I policies is to provide excellent framework conditions by fostering basic as well as applied research and technology transfer.

Switzerland has one of the highest R&D intensities both in Europe and in the world, with a value of 2.87 % in 2008. Over the last decade, R&D intensity grew at an average annual rate of 1.9 %, well above the EU rate of 0.8 % and, if this trend continues, will reach 3.60 % in 2020. Almost 74 % of R&D is performed by the private sector. This is due to the specific structure of the Swiss economy which is dominated by large multinational companies with their own global strategies. Swiss research policy focuses mainly on the quality of the public research sector and on the training of skilled researchers. An important trend in public R&D expenditure is the increasing R&D expenditure for universities. As a result, over the period 2000-2010, total higher education expenditure on R&D increased in real terms at an average annual rate of 5 %. In 2008, higher education expenditure on R&D as a percentage of total expenditure on R&D in Switzerland was approximately the same as the EU average (CH: 24.2 % vs. EU: 23.0 %).

The share of new doctoral graduates per thousand population aged 25-34 years increased from 2.7 % in 2002 to 3.5 % in 2011, a value which is more than twice the EU average. Switzerland's competitive R&I system is maintained by intensive and successful scientific activity, as shown by a high share of scientific publications within the 10 % most-cited scientific publication worldwide (16.4 % in 2009), a high number of international scientific co-publications per million population (2894 in 2012), a high level of PCT patent applications per billion GDP (7.9 in 2010) and a high level of licensing and patent revenues from abroad as a % of GDP (3.24 % in 2012).

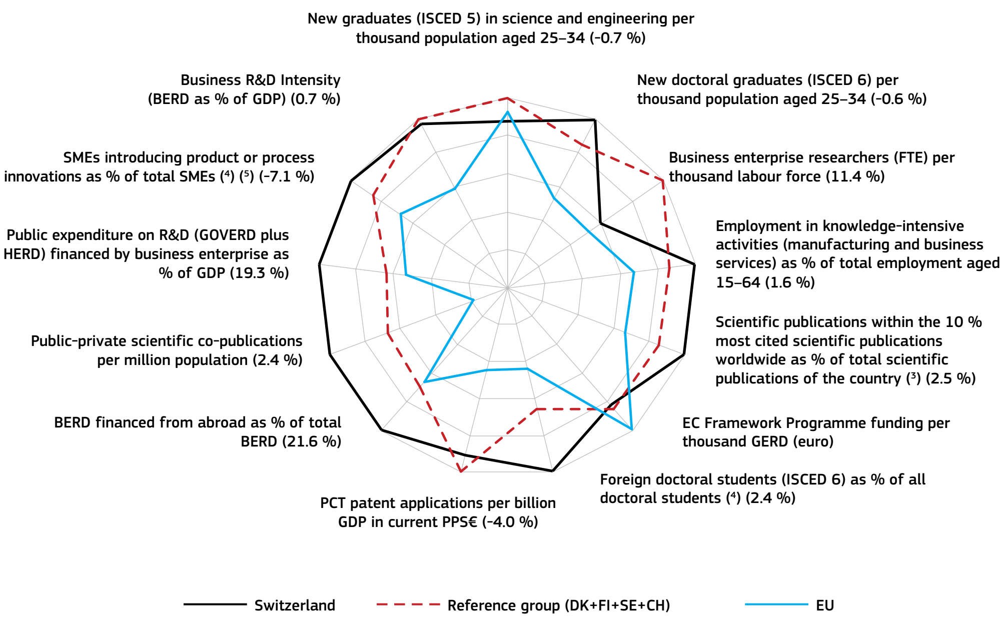
Switzerland has a good tradition of participating in international research programmes at the European level. Its success rate for participants in the EU's Seventh Framework Programme (FP7) was 25 %. The successful participants received a total financial contribution from the EU of EUR 1.7 billion.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Switzerland's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2007 to the latest available year (2012) are given in brackets.

Switzerland, 2012 (1)

In brackets: average annual growth for Switzerland, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.
(5) CH is not included in the reference group.

The Swiss R&I system is characterised by very strong scientific and technological production that outperforms the EU on almost all the indicators analysed in the graph above, making Switzerland an innovation leader.

One weakness in Switzerland's R&I system, compared to the group of reference countries, is in the field of researchers employed by business enterprises. However, this number has increased significantly in recent years. However, the number of graduates in the fields of science and engineering per thousand population aged 25-34 years has declined over the period 2007-2012, creating a growing gap in the supply of graduates in these fields. Another challenge facing the Swiss R&I system is improving the curricula for education and training in relation to entrepreneurial education and the teaching of intercultural and communication skills.

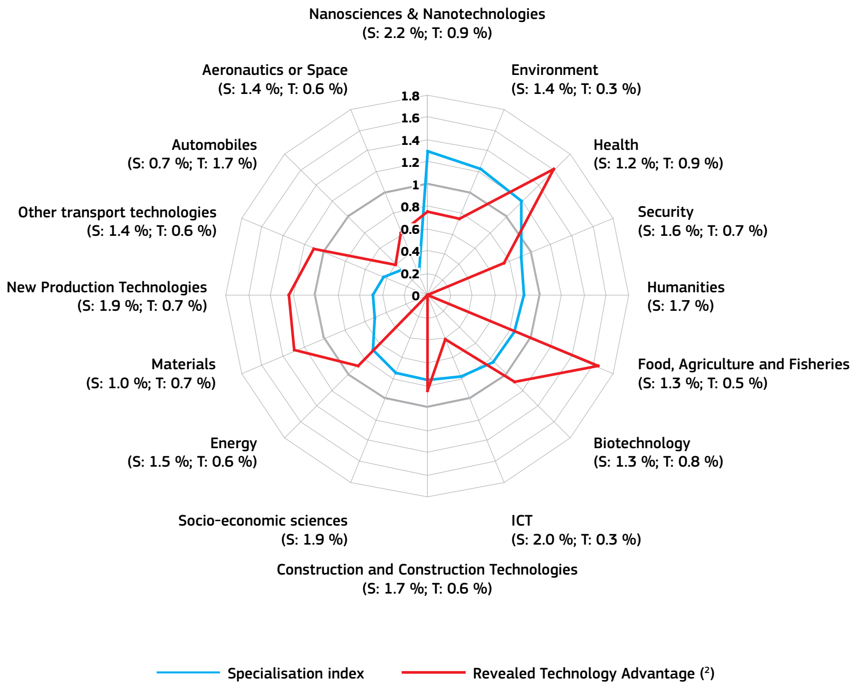
Although business expenditure on R&D (BERD) as a percentage of total expenditure on R&D is very high in Switzerland (73.5 %), the share of business expenditure financed from abroad is lower than both the EU average and Switzerland's reference group of countries, probably as a result of the abundance of financial resources within the country. Switzerland outperforms both the EU and its reference group of countries in terms of production of scientific publications, public-private scientific co-publications, share of foreign doctoral students among all doctoral students, and its share of employment in knowledge-intensive activities in total employment aged 15-64 years.

Switzerland's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Switzerland shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Switzerland – S&T National Specialisation (1) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)

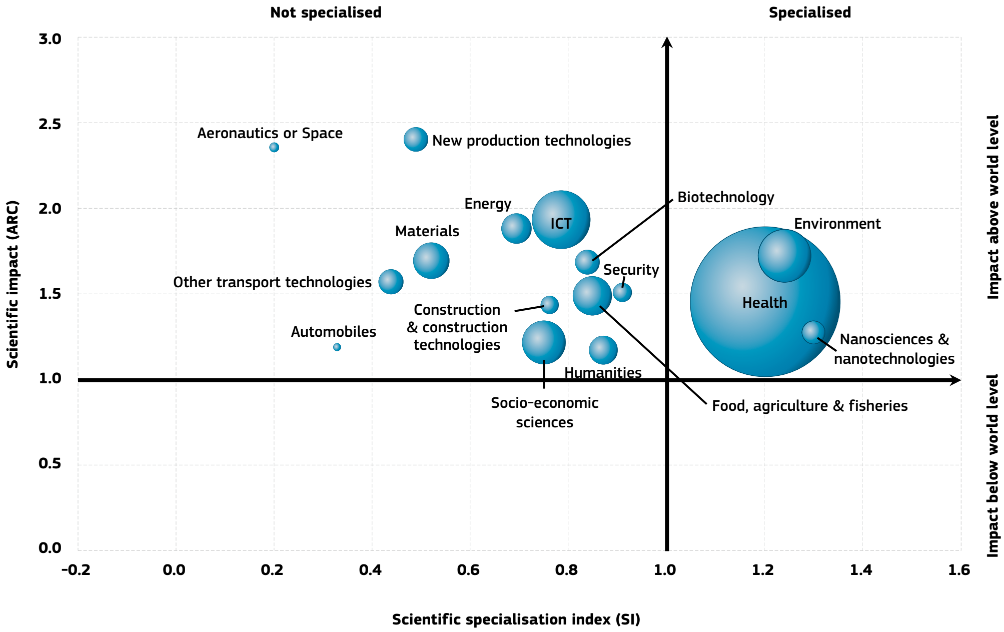


Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

As illustrated in the graph above, there is a notable difference in performance between scientific production (publications) and technological production (patents) in Switzerland. As regards publications, the country shows specialisation in the fields of nanoscience and nanotechnologies, environment, and health. With reference to revealed technological advantage as measured by patents (technological output), Switzerland has obvious strengths in health and food and, to a lesser extent, biotechnology, materials, new production technologies, and other transport technologies.

The graph above illustrates the positional analysis of Swiss publications showing the country's situation in terms of scientific specialisation and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Switzerland – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



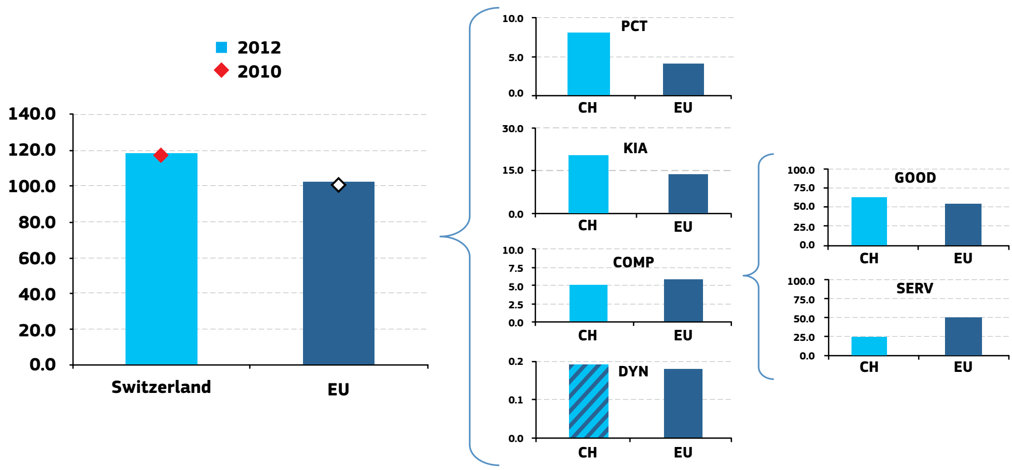
Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The country shows a high specialisation in publications in the field of health, environment, and nanoscience and nanotechnologies. In these areas, as well as in all the other areas, scientific impact is above the world average

Innovation Output Indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid-/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms). The graph below enables a comprehensive comparison of Switzerland's position regarding the indicator's different components.

Switzerland– Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average); estimated value.
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Switzerland is a very good performer in the European innovation indicator. This is the result of a good performance in all components except knowledge-intensive service exports. However, recently its performance has not improved further.

Good performance in patents is explained by the above-average share of patent-intensive industries (pharmaceuticals, medical technology, biotechnology, ICT) and the relatively high number of large manufacturing companies headquartered in Switzerland and carrying out research and patenting in the country as a result of a well-performing research system.

Switzerland's good performance in knowledge-intensive activities is explained by the importance of its financial, insurance, and legal and accounting services, as well as activities performed by head offices, consultancies and other professional, scientific and technical activities in its economy.

As a result of strong exports of pharmaceutical products, watches and machinery, Switzerland performs above the EU average as regards the share of medium-high and/high-tech goods in total goods exports. Figures for services exports are incomplete and the Swiss performance in this area must be analysed carefully. Switzerland has high financial and insurance services exports, but also has a high share of trade-related services, royalties and licence fees, which are classified as non-KIS.

Key indicators for Switzerland

SWITZERLAND	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)
ENABLERS											
Investment in knowledge											
New doctoral graduates (ISCED 6) per thousand population aged 25–34	:	3.31	3.42	3.49	3.44	3.58	3.68	3.51	3.39	-0.6	*1.81*
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	530	:	:	534	:	:	531	1.3 (3)	495 (4)
Business enterprise expenditure on R&D (BERD) as % of GDP	1.82	:	:	:	2.11	:	:	:	2.17	0.7	1.31
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.60	:	0.66	:	0.71	:	0.80	:	0.90	6.0	*0.74*
Venture capital as % of GDP	0.23	0.12	0.26	0.29	0.30	0.18	0.37	0.13	0.13	-14.6	0.29 (5)
S&T excellence and cooperation											
Composite indicator on research excellence	:	:	:	85.9	:	:	:	:	97.7	2.6	47.8
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	15.6	15.9	15.6	15.8	16.4	:	:	:	2.5	11.0
International scientific co-publications per million population	:	1763	1919	2132	2225	2376	2532	2738	2894	6.3	343
Public–private scientific co-publications per million population	:	:	:	253	254	269	281	278	:	2.4	53
FIRM ACTIVITIES AND IMPACT											
Innovation contributing to international competitiveness											
PCT patent applications per billion GDP in current PPS (EUR)	7.4	9.0	8.6	8.9	7.9	8.1	7.9	:	:	-4.0	3.9
License and patent revenues from abroad as % of GDP	:	2.24	1.97	2.07	2.17	2.93	3.01	2.98	3.24	9.4	0.59
Community trademark (CTM) applications per million population	165	273	338	376	388	371	462	482	428	2.6	152
Community design (CD) applications per million population	:	55	57	76	51	38	37	43	34	-15.0	29
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	:	:	24.9	:	16.1	:	:	-19.6	14.4
Knowledge-intensive services exports as % total service exports	:	37.4	37.3	38.4	34.2	30.5	26.6	25.1	:	-10.0	45.3
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	6.30	6.98	7.56	7.58	8.28	8.17	8.02	8.44	8.08	-	4.23 (6)
Growth of total factor productivity (total economy): 2007 = 100	93	97	98	100	100	98	100	100	100	0 (7)	97
Factors for structural change and addressing societal challenges											
Composite indicator on structural change	:	:	:	70.4	:	:	:	:	73.4	0.8	51.2
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	19.5	19.9	19.8 (8)	19.9	20.5	1.6	13.9
SMEs introducing product or process innovations as % of SMEs	:	:	:	:	57.0	:	49.2	:	:	-7.1	33.8
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.42	0.54	0.48	0.68	0.55	0.76	:	:	:	5.7	0.44
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	2.30	2.79	2.63	2.52	2.23	2.25	:	:	:	-5.5	0.53
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES											
Employment rate of the population aged 20–64 (%)	80.9	79.9	80.5	81.3	82.3	81.7	81.1 (8)	81.8	82.0	0.6	68.4
R&D intensity (GERD as % of GDP)	2.47	:	:	:	2.87	:	:	:	:	0.5 (9)	*2.07*
Greenhouse gas emissions: 1990 = 100	98	103	102	98	101	99	102	:	:	4 (10)	83
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	:	:	:	:	:	:	:
Share of population aged 30–34 who have successfully completed tertiary education (%)	27.3	33.4	35.0	36.5	41.3	43.4	44.2	43.8	43.8	3.7	35.7
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	7.3	9.7	9.6	7.6	7.7	9.1	6.6	6.3	5.5	-6.3	12.7
Share of population at risk of poverty or social exclusion (%)	:	:	:	17.9	18.6	17.2	17.2	17.2	17.5	-0.5	24.8

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT.
(5) Venture capital: EU does not include EE, HR, CY, LV, LT, MT, SI and SK.
(6) EU is the weighted average of the values for the Member States.
(7) The value is the difference between 2012 and 2007.
(8) Break in series between 2010 and the previous years. Average annual growth refers to 2010–2012.
(9) Average annual growth refers to 2004-2008.
(10) The value is the difference between 2010 and 2007. A negative value means lower emissions.
(11) Values in italics are estimated or provisional.

Turkey

The challenge of structural change for a more competitive economy

Summary: Performance in research and innovation

The indicators in the table below present a synthesis of research and innovation (R&I) performance in Turkey. They relate knowledge investment and input to performance and economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The indicator on excellence in science and technology takes into consideration the quality of scientific production as well as technological development. The Innovation Output Indicator covers technological innovation, skills in knowledge-intensive activities, the competitiveness of knowledge-intensive goods and services, and the innovativeness of fast-growing enterprises, focusing on innovation output. The indicator on knowledge-intensity of the economy focuses on the economy's sectoral composition and specialisation and shows the evolution of the weight of knowledge-intensive sectors and products.

Key indicators of research and innovation performance	
R&D intensity 2012: **0.86 %** (EU: 2.07 %; US: 2.79 %) 2007-2012: **+4.4 %** (EU: 2.4 %; US: 1.2 %)	***Excellence in S&T***[1] 2012: **17.6** (EU: 47.8; US: 58.1) 2007-2012: **+6.7 %** (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: **59.2** (EU: 101.6)	***Knowledge-intensity of the economy***[2] 2012: **19.5** (EU: 51.2; US: 59.9) 2007-2012: **+5.3 %** (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Energy, construction and construction technologies, and automobiles	***HT + MT contribution to the trade balance*** 2012: **-3.1 %** (EU: 4.23 %; US: 1.02 %) 2007-2012: **n.a.** (EU: +4.8 %; US: -32.3 %)

Since the early 2000s, Turkey has devoted increasing importance to investment in science, technology and innovation, as shown by the continuing rise in government funding for R&D and innovation activities. The growing political commitment to science, technology and innovation is also reflected in the Tenth Development Plan (2014-2018) adopted by the Parliamentary General Assembly on 2 July 2013. It establishes a long-term perspective and identifies improving science, technology and innovation as one of the building blocks for innovative production and steady growth.

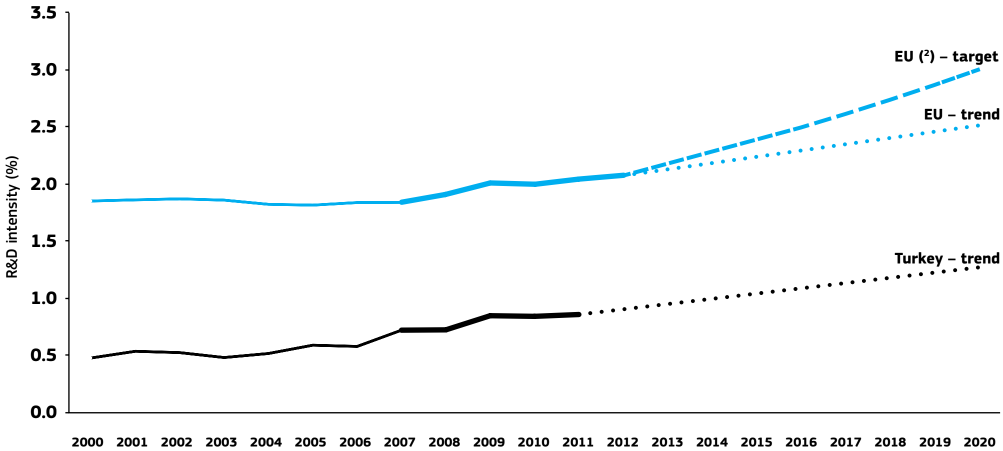
The new science, technology and innovation strategy document, National Science, Technology and Innovation Strategy (UBTYS), covering the period 2011-2016, was approved by the Supreme Council for Science and Technology (BTYK) in December 2010. It aims to create more output from existing research capacity, to enhance needs-oriented research capacity, and defines strategic focus areas for increased science, technology and innovation performance. Target-oriented approaches are identified in the areas where Turkey has R&D and innovation capacities, demand-oriented approaches where further R&D and innovation efforts are needed, while bottom-up approaches (including basic, applied and frontier research) are also an option.

1 Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

2 Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

Investing in knowledge

Turkey – R&D intensity projections: 2000–2020 (1)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat
Notes: (1) The R&D intensity projections based on trends are derived from the average annual growth in R&D intensity for 2007–2012 in the case of the EU, and for 2007–2011 in the case of Turkey.
(2) EU: The projection is based on the R&D intensity target of 3.0 % for 2020.
(3) TR: An R&D intensity target for 2020 is not available.

R&D intensity in Turkey increased progressively from 0.48 % in 2000 to 0.86 % in 2011, experiencing an average annual growth rate of 4.4 % during this period. If this trend continues, Turkey will have an R&D intensity of 1.27 % in 2020, which would be a very good achievement although still below the projected EU average for 2020.

Turkey's R&D intensity decreased slightly from 0.85 % in 2009 to 0.84 % in 2010 due to a corresponding decrease in public R&D intensity from 0.51 % to 0.48 %. Despite the decline in public R&D intensity and the economic crisis, R&D expenditure has increased across all sectors while business R&D intensity grew from 0.34 % in 2009 to 0.37 % in 2011.

Although Turkey's business R&D intensity is still well below the EU average of 1.30 %, it is involved in a positive catching-up process with an average annual growth rate of 2.0 %[3].

Turkish R&I also benefit from support from the EU budget, the main funding instrument being the EU's Framework Programmes for research and development. The total number of participants in the Seventh Framework Programme (FP7) in Turkey is 1201 (out of 7844 applicants), who are receiving more than EUR 200 million. Although the success rate among the participants rose to 16.56 %, it remains below the EU average success rate of 23.72 %.

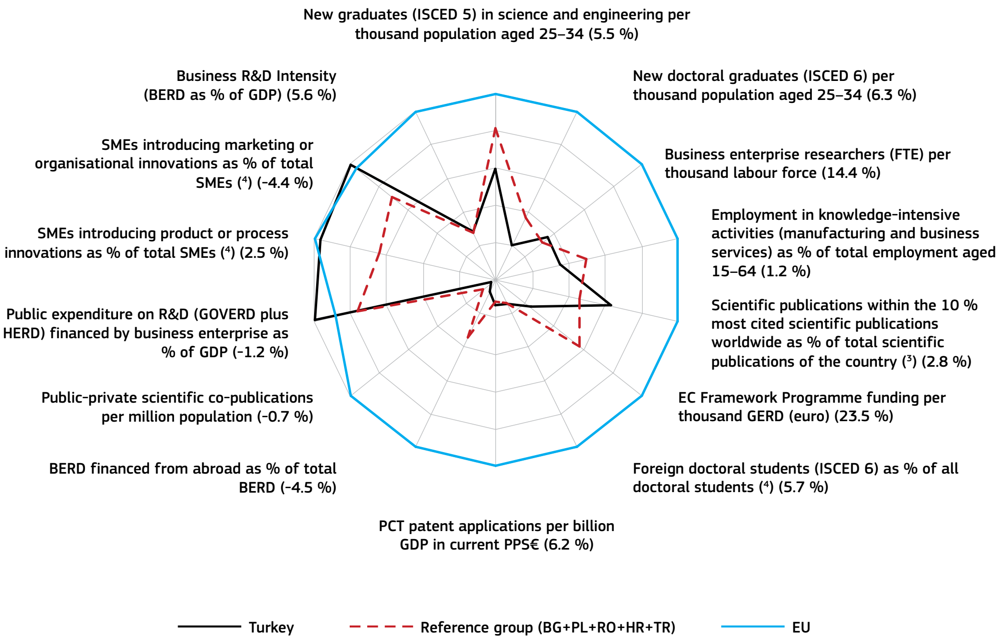
3 Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007-2012.

An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of Turkey's R&I system. Reading clockwise, it provides information on human resources, scientific production, technology valorisation and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.

Turkey, 2012 (1)

In brackets: average annual growth for Turkey, 2007–2012 (2)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science-Metrix/Scopus (Elsevier), Innovation Union Scoreboard.
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates which do not refer to 2007–2012 refer to growth between the earliest available year and the latest available year for which comparable data are available over the period 2007–2012.
(3) Fractional counting method.
(4) EU does not include EL.

The graph above shows that the Turkish R&I system is still weaker than the EU average in all areas except innovation in small and medium-sized enterprises (SMEs) and public expenditure on R&D financed by business enterprise as a % of GDP. On the other hand, the average annual growth rates for most of the indicators are increasing progressively.

The most vulnerable areas include human resources, patents and public-private scientific co- publications. In particular, Turkey is behind countries with similar knowledge capacity and economic structure in human resources, with new graduates in science and engineering and new doctoral graduates showing especially low averages. The relative strength of Turkey's R&I system has declined in the quality of its scientific production, lowering its average annual growth to 2.8 % in the share of its scientific publications among the top 10 % most cited worldwide.

A new policy tool has been designed to improve the quality and impact of scientific publications; it is based on arranging the incentives for scientific publications according to their impact factors. In view of Turkey's commitment to achieve 2023 targets, it shows great potential for catching up.

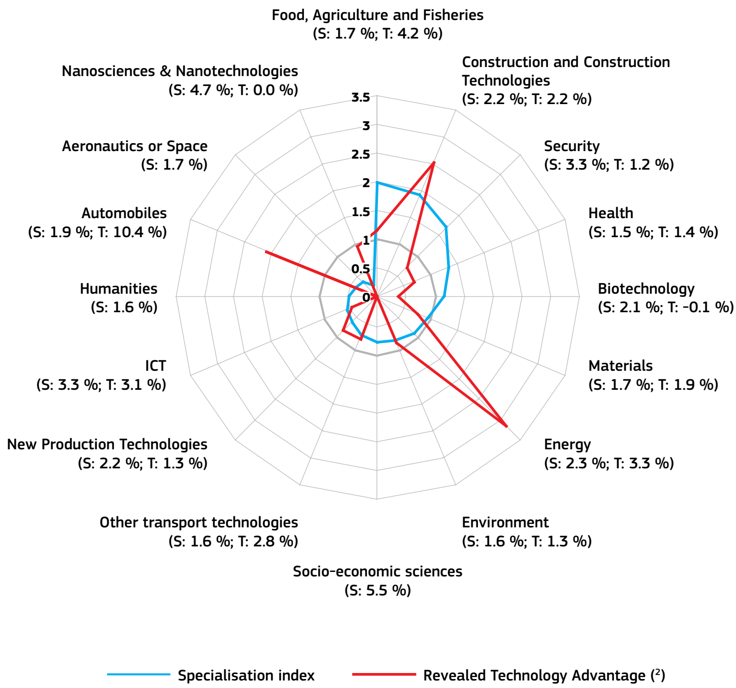
The decrees adopted at the 24th meeting of the Supreme Council for Science and Technology (BTYK), which focus on furthering the development of human resources for STI, can be considered as complementary initiatives to the National Science and Technology Human Resources Strategy and Action Plan (2011-2016). These decrees strengthen the linkage between the Action Plan and education policies, their main purpose being to improve the quality of Turkey's education system.

Turkey's scientific and technological strengths

The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Turkey shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of patents) measure the country's scientific (SI) and technological (RTA) capacity compared to that at the world level. For each specialisation field it provides information on the growth rate in the number of publications and patents.

Turkey – S&T National Specialisation (1) in thematic priorities, 2000–2010

in brackets: growth rate in number of publications (3) (S) and in number of patents (4) (T)



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada; Bocconi University, Italy
Notes: (1) Values over 1 show specialisation; values under 1 show a lack of specialisation.
(2) The Revealed Technology Advantage (RTA) is calculated based on the data corresponding to the WIPO-PCT number of patent applications by country of inventors. For the thematic priorities with fewer than 5 patent applications over 2000–2010, the RTA is not taken into account. Patent applications in 'Aeronautics or Space' refer only to 'Aeronautics' data.
(3) The growth rate index of the publications (S) refers to the periods 2000–2004 and 2005–2009.
(4) The growth rate in number of patents (T) refers to the periods 2000–2002 and 2003–2006.

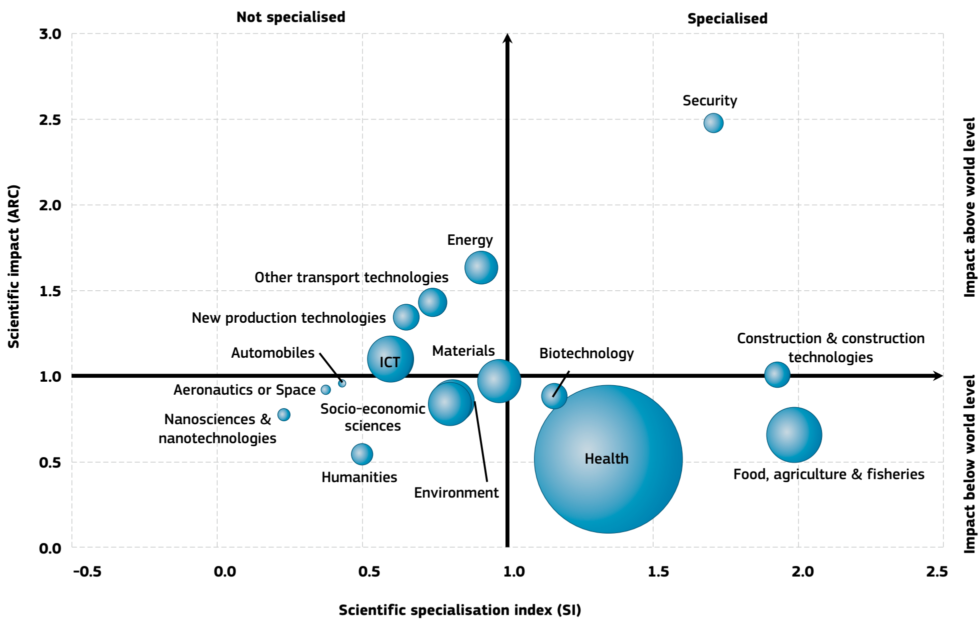
The graph above shows Turkey's strong technological specialisations (measured by the number of patents) in energy, construction and construction technologies, and automobiles, as well as scientific specialisation in food, agriculture and fisheries, construction, security, health and biotechnology. Co-specialisation in science and technology can be noted for food, agriculture and fisheries, construction and, to some extent, energy.

The relatively limited correlation between specialisation in science and specialisation in technologies suggests that the knowledge transfer towards industry through technologies is limited while, at the same time, the country has yet to benefit from sufficient inflows of foreign direct investment for technological activities, which would help shape a more coherent industrial specialisation.

Like Bulgaria, Romania, Poland and Croatia, Turkey has a low knowledge-intensive economy and a rather modest participation in FP7. Turkish participation in FP7 is highest in food, agriculture and biotechnologies.

The graph below illustrates the positional analysis of Turkish publications showing the country's situation in terms of scientific specialization and scientific impact over the period 2000-2010. The scientific production of the country is reflected by the size of bubbles, which corresponds to the share of scientific publications from a science field in the country's total publications.

Turkey – Positional analysis of publications in Scopus (specialisation versus impact), 2000–2010



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus
Note: Scientific specialisation includes 2000–2010 data; the impact is calculated for publications of 2000–2006, citation window 2007–2009.

The graph above shows the results of a positional analysis of scientific publications in Turkey. The highest numbers of scientific articles are produced in the field of health, followed by food, agriculture and fisheries, ICT, materials and socio-economic sciences. Scientific excellence can be found in particular in the field of security, energy, other transport technologies, new production technologies, ICT, and construction and materials. However, those areas of greatest impact are still underdeveloped in terms of the number of publications.

Policies and reforms for research and innovation

Since 2013, Turkey has adopted an even more bottom-up strategic approach to formulating and implementing STI policy, which enables the wide and active participation of non-state actors. Through this process, both the private sector and academia have identified their R&D needs in a detailed and more efficient way, and support mechanisms have acquired a more targetted structure.

In addition, in 2013 the Scientific and Technological Research Council of Turkey (TÜBİTAK) developed call-based measures to improve R&D performance in the priority research areas. 'The Support Programme for Research, Technological Development and Innovation Projects in Priority Areas (TÜBİTAK-1511)' targetted private-sector companies whereas 'The Support Programme for Research, Technological Development and Innovation Projects in Priority Areas (TÜBİTAK-1003)' was directed towards researchers from both academia and private/public research centres. Within the last two years, around 60 calls have been opened within the scope of TÜBİTAK-1511 and TÜBİTAK-1003 covering all the priority fields, and new calls will be opened in the near future.

The most recent STI priorities include the decisions adopted in meetings of the Supreme Council for Science and Technology (BTYK) which set new targets for Turkey's national innovation and entrepreneurship system. The BTYK's 26th meeting was held on 11 June 2013. The resulting seven new decisions, directly or indirectly related to the energy sector.

The national innovation and entrepreneurship system targets have been renewed and new ones set for 2023, the aim being for Turkey to become of the top 10 economies in the world by 2023. The targets are: to increase R&D intensity to 3 %; to increase business R&D intensity to 2 %; to raise the number of full-time equivalent (FTE) researchers to 300 000; to raise the number of FTE researchers in business to 180 000.

On the other hand, The Support Programme for National New Opinions and Products (TÜBİTAK 1005) aims to support much-needed projects in Turkey in order to reduce foreign technology dependency and/or increase the country's competitiveness. The development of applied research or experimental research projects at the national/international level for new products, processes, methods and modelling is also supported.

Another example is the decree which aims to develop policy tools to trigger innovation and entrepreneurship in the universities.

In line with this decree, a university index was developed in 2012 to evaluate universities' entrepreneurship and innovativeness performance, based on such criteria as R&D projects, university-industry collaborations, international collaborations, articles, licences and spin-offs. The 50 most entrepreneurial universities in Turkey were listed for the first time, and this list will be renewed and published annually.

The Ministry of Science, Industry and Technology (MoSIT) has also adopted the evaluation-based approach by conducting a performance index work and impact assessment. The first task was preparation of the index for the Technology Development Zones operating in Turkey. The results were announced at a summit held by the ministry in March 2013. The new index is under preparation and indicators are being reviewed for better results.

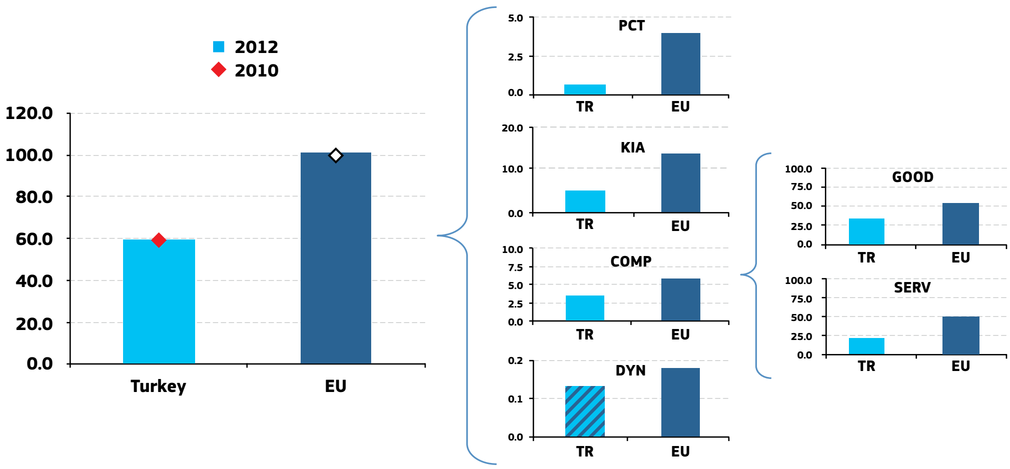
To coordinate the R&I policies and supporting tools, a temporary interministerial coordination board has been set up, including participation of the relevant governmental bodies, to review all R&D, innovation and entrepreneurship support mechanisms in Turkey with a view to ensuring a target-oriented approach.

Innovation Output indicator

The Innovation Output Indicator, launched by the European Commission in 2013, was developed at the request of the European Council to benchmark national innovation policies and to monitor the EU's performance against its main trading partners. It measures the extent to which ideas stemming from innovative sectors are capable of reaching the market, providing better jobs and making Europe more competitive. The indicator on innovation focuses on four policy axes: growth via technology – (patents); jobs (knowledge-intensive employment); long-term global competitiveness (trade in mid-/high-tech commodities); and future business opportunities (jobs in innovative fast-growing firms).

The graph below enables a comprehensive comparison of Turkey's position regarding the indicator's different components:

Turkey – Innovation Output Indicator



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC
Notes: All data refer to 2012 except PCT data, which refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in knowledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-growth enterprises (employment-weighted average); .
COMP = Combination of sub-components GOOD and SERV, using equal weights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Knowledge-intensive services exports as % of total service exports. EU value refers to EU-28 average (extra-EU = 56 %).

Turkey is a low performer in the European innovation indicator. This is the result of low performance in most components of the innovation indicator, whilst the country has no areas of strong performance. Furthermore, its performance is stagnating.

The relatively low performance in patents is linked to Turkey's economic structure, with a relatively large agricultural and low-tech sector (textiles), a limited number of large Turkish multinational manufacturing companies, and the division of work within international companies, including motor vehicle producers, which have production facilities in Turkey but tend to do research and patenting in the headquarter country[4].

Turkey has a very low share in knowledge-intensive activities, partly explained by the importance of employment in the agriculture, construction and tourism sectors.

As regards the exports of goods, low- and medium-low-tech sectors, such as food and textiles, are over-represented, which explains the low performance in the share of medium-high/high-tech exports.

The low share of knowledge-intensive service exports is explained by the importance of tourism (personal and business travel represent nearly 60 % of service exports) and of transport services (road freight transport) which are not classified as knowledge intensive.

However, Turkey is committed to improving its innovative capacity through smart policies and more investment in RDI activities.

4 Turkey also performs at a low level in Community designs and trademarks.

Key indicators for Turkey[5]

TURKEY	2000	2005	2006	2007	2008	2009	2010	2011	2012	Average annual growth 2007–2012 (1) (%)	EU average (2)
ENABLERS											
Investment in knowledge											
New doctoral graduates (ISCED 6) per thousand population aged 25–34	0.19	0.22	0.20	:	0.31	0.34	0.38	0.37	:	**6.3**	***1.81***
Performance in mathematics of 15-year-old students: mean score (PISA study)	:	:	424	:	:	445	:	:	448	**24.0 (3)**	**495 (4)**
Business enterprise expenditure on R&D (BERD) as % of GDP	0.16	0.20	0.21	0.30	0.32	0.34	0.36	0.37	:	**5.6**	***1.31***
Public expenditure on R&D (GOVERD + HERD) as % of GDP	0.32	0.39	0.37	0.42	0.40	0.51	0.48	0.49	:	**3.6**	***0.74***
Venture capital as % of GDP	:	:	:	:	:	:	:	:	:	:	:
S&T excellence and cooperation											
Composite indicator on research excellence	:	:	:	12.7	:	:	:	:	17.6	**6.7**	**47.8**
Scientific publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country	:	5.1	5.5	6.6	6.8	7.0	:	:	:	**2.8**	**11.0**
International scientific co-publications per million population	:	43	48	53	58	66	70	76	85	**9.8**	**343**
Public–private scientific co-publications per million population	:	:	:	2	2	2	2	2	:	**-0.7**	**53**
FIRM ACTIVITIES AND IMPACT											
Innovation contributing to international competitiveness											
PCT patent applications per billion GDP in current PPS (EUR)	0.2	0.4	0.4	0.5	0.5	0.6	0.6	:	:	**6.2**	**3.9**
License and patent revenues from abroad as % of GDP	0.00	:	:	0.00	0.00	0.00	0.00	0.00	:	:	**0.59**
Community trademark (CTM) applications per million population	0.7	1.5	2.1	2.0	2.2	2.1	3.0	4.7	5.5	**22.4**	**152**
Community design (CD) applications per million population	:	0.8	0.7	1.2	1.4	0.8	0.7	1.0	0.9	**-5.3**	**29**
Sales of new-to-market and new-to-firm innovations as % of turnover	:	:	15.8	:	:	:	:	:	:	:	**14.4**
Knowledge-intensive services exports as % total service exports	:	:	:	16.6	18.7	18.5	21.0	21.9	:	**7.1**	**45.3**
Contribution of high-tech and medium-tech products to the trade balance as % of total exports plus imports of products	-10.66	-4.79	-2.94	-1.95	-0.82	-3.88	-2.83	-2.22	-3.13	**-**	**4.23 (5)**
Growth of total factor productivity (total economy): 2005 = 100	100	117	120	:	:	:	:	:	:	**3 (6)**	**103**
Factors for structural change and addressing societal challenges											
Composite indicator on structural change	:	:	:	15.1	:	:	:	:	19.5	**5.3**	**51.2**
Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15–64	:	:	:	:	:	4.8	4.8	4.7	5.0	**1.2**	**13.9**
SMEs introducing product or process innovations as % of SMEs	:	:	29.5	:	:	:	32.5	:	:	**2.5**	**33.8**
Environment-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.004	0.01	0.01	0.01	0.01	0.01	:	:	:	**-2.6**	**0.44**
Health-related technologies: patent applications to the EPO per billion GDP in current PPS (EUR)	0.01	0.01	0.01	0.01	0.02	0.10	:	:	:	**158.1**	**0.53**
EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES											
Employment rate of the population aged 20–64 (%)	:	:	48.2	48.2	48.4	47.8	50.0	52.2	52.8	**1.8**	**68.4**
R&D intensity (GERD as % of GDP)	0.48	0.59	0.58	0.72	0.73	0.85	0.84	0.86	:	**4.4**	***2.07***
Greenhouse gas emissions: 1990 = 100	159	176	187	203	196	198	:	:	:	**-6 (7)**	**83**
Share of renewable energy in gross final energy consumption (%)	:	:	:	:	:	:	:	:	:	:	:
Share of population aged 30–34 who have successfully completed tertiary education (%)	:	:	11.9	12.3	13.0	14.7	15.5	16.3	18.0	**7.9**	**35.7**
Share of population aged 18–24 with at most lower secondary education and not in further education or training (%)	:	:	48.8	46.9	45.5	44.3	43.1	41.9	39.6	**-3.3**	**12.7**
Share of population at risk of poverty or social exclusion (%)	:	:	72.4	:	:	:	:	:	:	**-**	**24.8**

Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Eurostat, DG JRC – Ispra, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2007–2012.
(2) EU average for the latest available year.
(3) The value is the difference between 2012 and 2006.
(4) PISA (Programme for Internatonal Student Assessment) score for EU does not include CY and MT.
(5) EU is the weighted average of the values for the Member States.
(6) The value is the difference between 2006 and 2005.
(7) The value is the difference between 2009 and 2007. A negative value means lower emissions.
(8) Values in italics are estimated or provisional.

5 According to data provide by the Turkish government, values for some indicators are as follows:
- BERD as % of GDP increased from 0.16 in 2000 to 0.36 in 2010 with an average annual growth rate of 10.7.
- GERD as % of GDP increased from 0.48 in 2000 to 0.84 in 2010 with an average annual growth rate of 6.2.
- In 2010, the average number of SMEs introducing products or process innovations was 32.6 %.

Methodological Annex

Symbols and abbreviations

Country codes

AT	Austria	**IE**	Ireland	**SW**	Sweden
BE	Belgium	**IT**	Italy	**UK**	United Kingdom
BG	Bulgaria	**LV**	Latvia	**EU**	European Union
HR	Croatia	**LT**	Lithuania		
CY	Cyprus	**LU**	Luxembourg	**CN**	China
CZ	Czech Republic	**MT**	Malta	**IS**	Iceland
DK	Denmark	**NL**	Netherlands	**IL**	Israel
EE	Estonia	**PL**	Poland	**JP**	Japan
FI	Finland	**PT**	Portugal	**NO**	Norway
FR	France	**RO**	Romania	**KR**	South Korea
DE	Germany	**SK**	Slovakia	**CH**	Switzerland
EL	Greece	**SI**	Slovenia	**TR**	Turkey
HU	Hungary	**ES**	Spain	**US**	United States

Other abbreviations

:	'not available'
-	'not applicable' or 'real zero' or 'zero by default'

Overall performance in research and innovation

R&D intensity

Definition: Gross Domestic Expenditure on R&D (GERD) as % of Gross Domestic Product (GDP)

Sources: Eurostat, OECD

Gross Domestic Product (GDP)

Definition: Gross Domestic Product (GDP) data have been compiled in accordance with the European System of Accounts (ESA 1995). Since 2005, GDP has been revised upwards for the majority of EU Member States following the allocation of FISIM (Financial Intermediation Services Indirectly Measured) to user sectors. This has resulted in a downward revision of R&D intensity for individual Member States and for the EU.

Source: Eurostat

Gross Domestic Expenditure on R&D

Definition: Gross domestic expenditure on R&D (GERD) is defined according to the OECD Frascati Manual definition. GERD can be broken down by four sectors of performance:

(i) Business Enterprise expenditure on R&D (BERD);
(ii) Government intramural expenditure on R&D (GOVERD);
(iii) Higher Education expenditure on R&D (HERD);
(iv) Private Non-Profit expenditure on R&D (PNPRD).

GERD can also be broken down by four sources of funding:

(i) Business enterprise;
(ii) Government;
(iii) Other national sources (higher education and private non-profit);
(iv) Abroad.

Sources: Eurostat, OECD

Innovation Output Indicator

$$I = w_1 \times PCT + w_2 \times KIA + w_3 \times COMP + w_4 \times DYN$$

where

PCT = Number of patent applications filed under the Patent Cooperation Treaty per billion GDP
Patent counts are based on the priority date, the inventor's country of residence and fractional counts (Eurostat/OECD)

KIA = Employment in knowledge-intensive activities in business industries (including financial services) as % of total employment.
Knowledge-intensive activities are defined, based on EU Labour Force Survey data, as all NACE Rev.2 industries at 2-digit level where at least 33 % of employment has a higher education degree (ISCED5 or ISCED6) (Eurostat).

COMP = 0.5 × *GOOD* + 0.5 × *SERV*

GOOD = High-tech and medium-high-tech products exports as % of total goods exports (Eurostat (COMEXP)/UN (Comtrade)).

SERV = Knowledge-intensive services exports as % of total service exports
(exports of knowledge-intensive services are measured by the sum of credits in EBOPS (Extended Balance of Payments Services Classification) 207, 208, 211, 212, 218, 228, 229, 245, 253, 260, 263, 272, 274, 278, 279, 280 and 284 (UN/Eurostat)).

DYN = Employment in fast-growing firms in innovative business industries, including financial services

$$\sum_s (CIS^{score} \times KIA^{score})_s \frac{E_{sC}^{HG}}{E_C^{HG}}$$

where

$(CIS^{score} \times KIA^{score})_s$ = Innovation coefficient of sector *s*, resulting from the product of Community Innovation Survey and Labour Force Survey scores for each sector at EU level.

E_C^{HG} = The employment in fast-growing firms in sector *s* and country *C*.

E_C^{HG} = The employment in fast-growing firms in country *C*.

w_1, w_2, w_3, w_4 = The weights of the component indicators, fixed over time, and statistically computed in such a way that the component indicators are equally balanced.
The current values are (34, 15, 37, 14).

Source: DG Research and Innovation (*Commission Staff Working Document - Developing an indicator of innovation output*) – Unit for the Analysis and Monitoring of National Research Policies

Excellence in research (S&T)

Definition: This composite indicator was developed to measure research excellence in Europe – i.e. the effects of European and national policies on the modernisation of research institutions, the vitality of the research environment, and the quality of research outputs in both basic and applied research. This core indicator is a composite of four variables:

- The share of highly cited publications in all publications where at least one of the authors has an affiliation in a given country (10 % of the most highly cited publications considered, full counting method; source: Science-Metrix calculations using Scopus data).

- Number of top scientific universities and public research organisations in a country divided by million population (world top 250 scientific universities and top 50 public research organisations considered; source: Leiden Ranking and SCImago Institutions Ranking).

- Patent applications per million population (PCT patent applications by country of inventor, three-year moving average; source: OECD, Eurostat).

- Total value of ERC grants received divided by public R&D performed by higher education and government sectors (transformed by using the natural logarithm, multi-year projects divided equally over time; source: DG-RTD, ERC).

The value of the composite indicator (a country score) is a geometric average of the four variables normalised between 10 and 100 using the min-max method and taking into consideration the two time points simultaneously.

Source: Group of Research and Innovation Union Impact, RTD-JRC (Ispra): Composite Indicator of Research Excellence, 2012.

Knowledge-intensity of the economy (structural change of economy)

Definition: Compositional structural change indicators measure changes in the actual sectoral composition of the economy in terms of production and employment, business research and development (R&D), high-tech exports and technological specialisation, and foreign direct investments. Changes may affect the linkages among sectors and technologies, and influence the changes to countries' international advantages.

Eight compositional structural change indicators have been identified and organised into five dimensions:

- The R&D dimension measures the size of business R&D (as a % of GDP) and the size of the R&D services sector in the economy (in terms of total value added; source: wiiw calculations using OECD, Eurostat, WIOD and national sources).

- The skills dimension measures changing skills and occupations in terms of the share of people employed in knowledge-intensive activities (both manufacturing and service sectors considered where on average at least a third of the employees are tertiary graduates; source: Eurostat).

- The sectoral specialisation dimension captures the relative share of knowledge-intensive activities (in terms of value added; source wiiw calculations using OECD, Eurostat, WIOD and national sources).

- The international specialisation dimension captures the share of the knowledge economy through technological (patents) and export specialisation (revealed technological and competitive advantage).

- The internationalisation dimension refers to the changing international competitiveness of a country in terms of attracting and diffusing foreign direct investment (inward and outward foreign direct investments).

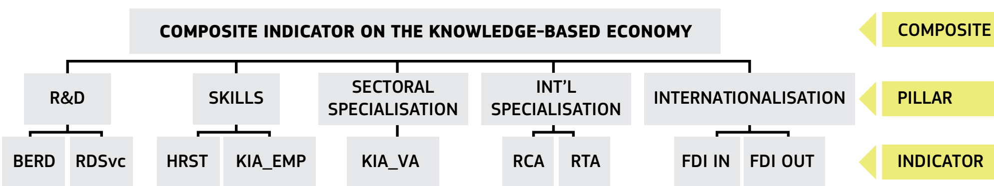
The eight indicators in the five pillars have been normalised between 10 and 100 using the min-max method and taking into consideration three time points simultaneously. The five pillars have also been aggregated into a single composite indicator of structural change using the geometric average to provide an overall measure of country progress in this area.

Source: Group of Research on the impact of the Innovation Union (GRIU), RTD-JRC/IPSC Ispra): Composite indicators measuring structural change, monitoring the progress towards a more knowledge-intensive economy in Europe, 2011.

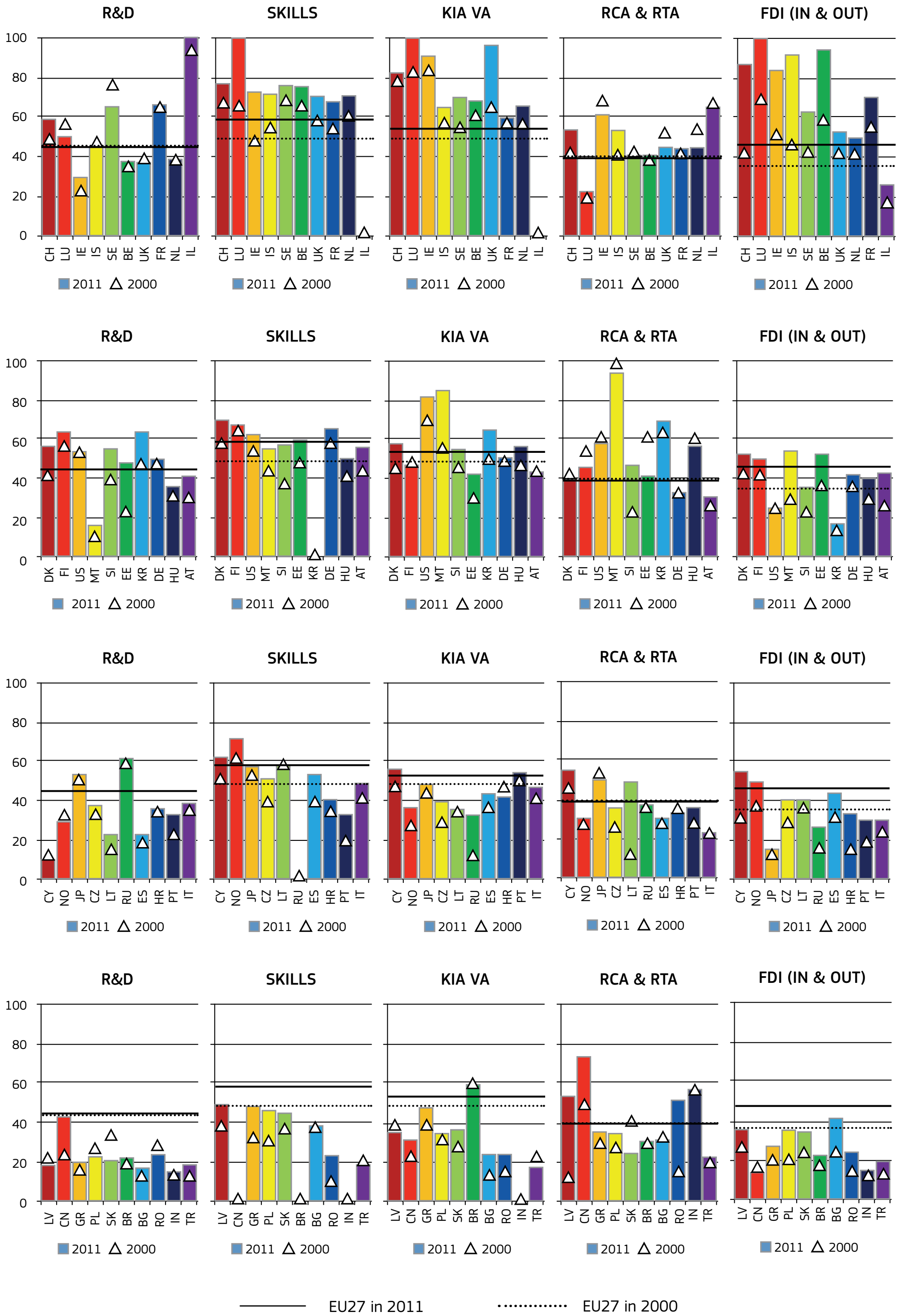
Indicators on the size of the knowledge economy

Indicator	Definition	Source
	R&D indicators	
BERD	Total R&D expenditure as a share of GDP (%)	Eurostat/OECD
RDSvc	The share of R&D services in the economy (the value added share of sector NACE Rev 2 code K72 in the total economy)	Eurostat/OECD EUKLEMS/WIOD (wiiw)
	Skills indicators	
HRST	Share of human resources in science and technology (HRST) as a share of the active population (15–74 years old) (%)	Eurostat
KIA_EMP	Share of people employed in knowledge-intensive activities (KIAs) as a percentage of total employment	Eurostat
	Sectoral specialisation indicator	
KIA_VA	The share of value added in knowledge-intensive activities within the total value added in a country	Eurostat/OECD EUKLEMS/WIOD (wiiw)
	International specialisation indicators	
RTA	Relative specialisation in holding PCT patents in selected technology classes (Revealed Technological Advantage – RTA)	OECD
RCA	Relative specialisation in the export of medium-high-tech and high-tech products (Revealed Competitive Advantage – RCA)	Eurostat
	Internationalisation indicators	
FDI_IN	Cumulative inward FDI stock as a share of GDP	UNCTAD
FDI_OUT	Cumulative outward FDI stock as a share of GDP	UNCTAD

The architecture of the composite indicator on the knowledge-based economy



Comparison of pillar-level structural dynamics for 40 countries, at 2000 and 2011



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies; DG JRC-Ispra

Note: Bars indicate pillar composite scores for 2011; triangles indicate pillar scores for 2000.

For reference, EU-27 scores are shown with a continuous line in 2011 and a dotted line in 2000.

Contribution of high-tech and medium-high-tech manufacturing to trade balance

Definition: The “contribution to the trade balance” is the difference between the observed industry trade balance and the theoretical trade balance.

Trade balance means the difference between the level of exports and the level of imports in a particular industry/sector.

The contribution to the trade balance is calculated by the formula:

$$\left[(X_i - M_i) - (X - M)\frac{(X_i + M_i)}{(X + M)}\right] / (X + M) * 100$$

where

$(X_i - M_i)$	=	observed industry trade balance
$(X - M)\frac{(X_i + M_i)}{(X + M)}$	=	theoretical trade balance

If there is no comparative advantage or disadvantage for any industry, a country’s total trade balance (surplus or deficit) should be distributed across industries according to their share in total trade. A positive value for an industry indicates structural surplus and a negative value a structural deficit.

The HT & MHT trade balance include the following SITC Rev.3 products: 266, 267, 512, 513, 525, 533, 54, 553, 554, 562, 57, 58, 591, 593, 597, 598, 629, 653, 671, 672, 679, 71, 72, 731, 733, 737, 74, 751, 752, 759, 76, 77, 78, 79, 812, 87, 88, 891.

Sources: OECD (*Moving Up the Value Chain: Staying Competitive in the Global Economy*, 2007), UN (Comtrade), RTD - Unit for the Analysis and Monitoring of National Research Policies

High-tech trade

Definition: High-tech trade covers exports and imports of products the manufacture of which involved a high intensity of R&D. They are defined in accordance with the OECD’s high-tech product list (see OECD (1997) - Revision of the High-Technology Sector and Product Classification (1997), STI *Working Papers* 2/1997, OECD, Paris. The indicators used in this report use the so-called ‘product approach’, i.e. they measure the world market share of exports of high-tech products.

Sources: Eurostat (Comext), UN (Comtrade)

Investing in knowledge

Public expenditure on R&D

Definition: For the purposes of this publication, public expenditure on R&D is defined as Government intramural expenditure on R&D (GOVERD) plus Higher Education expenditure on R&D (HERD).

Sources: Eurostat, OECD

BERD intensity

Definition: Business Enterprise expenditure on R&D (BERD) as % of Gross Domestic Product (GDP).

Sources: Eurostat, OECD

Public sector R&D intensity

Definition: Public expenditure on R&D (GOVERD plus HERD) as % of GDP.

Sources: Eurostat, OECD

Government budget for R&D

Definition: The government budget for R&D is defined as government budget appropriations or outlays for R&D (GBAORD), according to the OECD Frascati Manual definition. The data are broken down by socio-economic objectives in accordance with the nomenclature for the analysis and comparison of scientific programmes and budgets (NABS).

Source: Eurostat

Structural Funds

Definition: Structural Funds are funds intended to facilitate the structural adjustment of specific sectors or regions, or combinations of both, in the European Union. Structural Funds for RTDI include data from sectors involving research and development, technological innovation, entrepreneurship, innovative ICT and human capital.

Source: DG REGIO

Purchasing Power Standards (PPS)

Definition: Financial aggregates are sometimes expressed in Purchasing Power Standards (PPS), rather than in euro based on exchange rates. PPS are based on a comparison of the prices of representative and comparable goods or services in different countries in different currencies on a specific date. The calculations of R&D investments in real terms are based on constant 2000 PPS.

Source: Eurostat

Value added

Definition: Value added is current gross value added measured at producer prices or at basic prices, depending on the valuation used in the national accounts. It represents each industry's contribution to GDP.

Sources: Eurostat, OECD

Venture capital

Definition: Venture capital investment is defined as private equity being raised for investment in companies. Management buyouts, management buy-ins, and venture purchase of quoted shares are excluded. Venture capital includes early stage (seed + start-up), expansion and replacement capital.

Source: Eurostat

Average Annual Growth Rate

Definition: Average annual growth rate (AAGR) refers to the compound annual growth rate (CAGR) and is the geometric progression ratio that provides a constant rate of return over the time period.

$$AAGR = CAGR = \left[\left(\frac{v_f}{v_i} \right)^{\frac{1}{(y_f - y_i)}} - 1 \right] * 100$$

where

v_f	=	final value
v_i	=	initial value
$y_f - y_i$	=	number of years

An effective research and innovation system building on the European Research Area

Framework Programme

Definition: The Framework Programmes for Research and Technological Development are the EU's main instruments for supporting collaborative research, development and innovation in science, engineering and technology. Participation is on an internationally collaborative basis and must involve European partners. The First Framework Programme was launched in 1984. The Seventh Framework Programme (FP7) covers the period 2007–2013.

Source: DG Research and Innovation

Higher education

ISCED (International Standard Classification of Education);

ISCED 5: Tertiary education (first stage) not leading directly to an advanced research qualification;

ISCED 5A: Tertiary education programmes with academic orientation;

ISCED 5B: Tertiary education programmes with occupation orientation;

ISCED 6: Tertiary education (second stage) leading to an advanced research qualification (PhD or doctorate).

Human Resources for Science and Technology (HRST), R&D personnel and researchers

The Canberra Manual proposes a definition of HRST as people who either have higher education or are employed in positions that normally require such education. HRST applies to people who fulfil one or other of the following conditions:

a) Have successfully completed education at the tertiary level in an S&T field of study (HRSTE - Education);

b) Not formally qualified as above, but employed in an S&T occupation where the above qualifications are normally required (HRSTO - Occupation).

HRST Core (HRSTC) refers to people with both tertiary-level education and an S&T occupation. Scientists and engineers are defined as ISCO (International Standard Classification of Occupations) categories 21 (physical, mathematical and engineering science professionals) and 22 (life science and health professionals).

The Frascati Manual proposes the following definitions of R&D personnel and researchers:

- R&D personnel: "All persons employed directly on R&D should be counted, as well as those providing direct services such as R&D managers, administrators, and clerical staff." (p.92);

- Researchers: "Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned." (p.93). R&D may be either the primary function or a secondary function. It may also be a significant part-time activity.

Therefore, the measurement of personnel employed in R&D involves two exercises:

- Measuring their number in headcounts (HC) whereby the total number of people who are mainly or partially employed in R&D are counted;

- Measuring their R&D activities in full-time equivalence (FTE): the number of people engaged in R&D is expressed in full-time equivalents on R&D activities (= person-years).

Source: Eurostat

Public- and private-sector researchers

Definition: For the purposes of this publication, public-sector researchers are researchers in the government and higher-education sectors. Private-sector researchers are researchers in the business-enterprise and private non-profit sectors.

Sources: Eurostat, OECD

Small and medium-sized enterprises (SMEs)

Definition: Small and medium-sized enterprises (SMEs) are defined as enterprises having fewer than 250 employees.

Sources: Eurostat, OECD

Licence and patent revenues from abroad

Definition: This refers to the export part of international transactions in royalties and licence fees.

Source: Eurostat

Patent Cooperation Treaty (PCT) patents

Definitions: The Patent Cooperation Treaty (PCT) is an international treaty administered by the World Intellectual Property Organization (WIPO) and signed by 133 Paris Convention countries. The PCT makes it possible to seek patent protection for an invention simultaneously in each of a large number of countries by filing a single 'international' patent application instead of filing several separate national or regional applications. Indicators based on PCT applications are relatively free from the 'home advantage' bias (proportionate to their inventive activity, domestic applicants tend to file more patents in their home country than non-resident applicants). The granting of patents remains under the control of the national or regional patent offices. The PCT patents considered are 'PCT patents, at international phase, designating the European Patent Office'. The country of origin is defined as the country of the inventor.

The timeliness (at the international phase of the PCT procedure) is much better than for Triadic patents. However, the relatively low cost of a patent application on an international basis prevents the PCT procedure from being very selective. Many PCT applications will cover inventions whose value is known *a posteriori* to be low, while few will cover inventions of very high value. A high share of patent applications invented in a given country might result in a limited impact on its economy if they all turn out to be of little or no use.

Patents dealing with societal challenges comprise climate-change-mitigation patents and health-technology patents. Climate-change-mitigation patents comprise patents for renewable energy, electric and hybrid vehicles, and energy efficiency in buildings and lighting. Health-technology patents comprise patents for medical technologies and pharmaceuticals.

Environment-related technologies

Definition: Patent applications to EPO per billion GDP in current EUR PPS.

Environment-related technologies refer to the following thematic areas:

a) General environmental management;

b) Energy generation from renewable and non-fossil sources;

c) Combustion technologies with mitigation potential;

d) Technologies specific to climate-change mitigation;

e) Technologies with potential or indirect contribution to emissions mitigation;

f) Emissions abatement and fuel efficiency in transportation;

g) Energy efficiency in buildings and lighting.

Source: OECD

Health-related technologies

Definition: Patent applications to the EPO per billion GDP in current EUR PPS.

Health-related technologies refer to medical technologies and pharmaceuticals: surgery, dentistry, prostheses, transport/accommodation for patients, physical therapy devices, containers, medical preparations, sterilisation, media devices, electrotherapy, and chemical compounds.

Source: OECD

Community trademark

Definition: A Community trademark is any trademark which is pending registration or has been registered in the EU as a whole (rather than on a national level within the EU).

Sources: OHIM, Eurostat

Country groupings – methodology

In order to create homogeneous groups of similar research and innovation systems in the European Research Area, a Principal Component Analysis (PCA) was carried out on 19 variables characterising research and innovation systems. The values of the variables were obtained for 2008 or the latest available year from Eurostat and the OECD and included data for the then 27 EU Member States as well as for Norway, Switzerland, Croatia, Turkey and Israel. Table 1 presents the main values of the different factors accruing from the PCA. The first principal component explains 49.7 % of the variance. The second principal component explains 12.4 % of the variance, and together the two principal components are able to explain over 62 % of the total variance.

Table 1: Results of the PCA

	Eigenvalue	Proportion	Cumulative
Factor 1	9.44203858	0.4969	0.4969
Factor 2	2.35266703	0.1238	0.6208
Factor 3	1.96210394	0.1033	0.724
Factor 4	1.23153877	0.0648	0.7889
Factor 5	1.01292575	0.0533	0.8422

Table 2 presents the correlation matrix between the main components and the individual variables that can help in interpreting the nature of these factors. To a large extent, the first component corresponds to a country's economic and technological development. As shown by the correlation matrix, this factor is closely related to per capita GDP, investments in R&D, HRST, research excellence, patents and levels of skills and employment. The second component represents the sectoral specialisation, as shown by the coordinates of industrial employment and employment in medium-high and high-tech manufacturing.

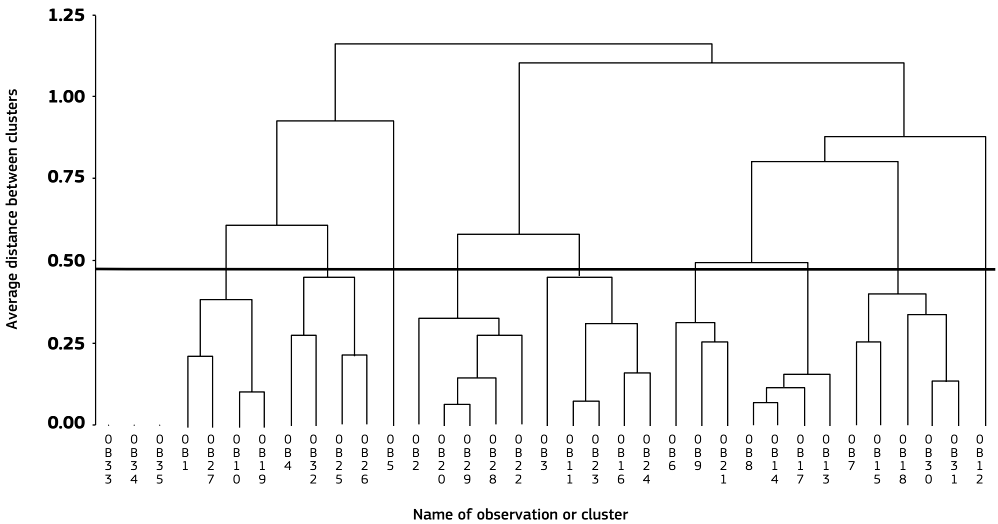
Table 2: Correlation matrix between the principal components and the individual variables

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
GERD as % GDP	**0.88045**	0.34761	0.1694	0.09631	-0.06329
BERD as % GDP	**0.86653**	0.37803	0.0769	0.10575	-0.03081
GOVERD as % GDP	0.07583	0.26135	0.55564	-0.44498	0.49791
HERD as % GDP	**0.77148**	0.08173	0.20893	0.25351	-0.41071
HRST as % total population	**0.84051**	-0.32415	0.24602	-0.09118	0.16476
EPO patent applications per million population	**0.85114**	0.24681	-0.1413	0.04174	-0.02927
EPO high-tech patents per million population	**0.82359**	0.28775	-0.08296	0.01004	-0.02086
Population aged 25–64 having completed tertiary education	**0.76955**	-0.39397	0.23008	-0.10595	0.04449
Participation in lifelong learning	**0.8845**	-0.00273	0.21098	0.24563	-0.03637
Employment in primary sectors	-0.63319	0.01507	0.40398	-0.07697	-0.32419
Employment in industrial sectors	-0.5726	**0.60788**	0.22957	0.32484	0.2158
Employment in business and financial sectors	0.59243	0.03313	-0.52275	-0.38809	0.16055

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Employment in high-tech and medium-high-tech manufacturing	-0.07533	**0.88354**	0.0989	0.10371	0.24159
Employment in knowledge-intensive services (KIS)	**0.90799**	-0.08451	-0.00034	0.15404	0.08702
Population density	-0.05817	-0.08058	**-0.69541**	0.49535	0.29596
Employment rate	**0.70931**	-0.29551	**0.44466**	0.10663	0.07883
GDP per capita	**0.75882**	-0.09803	-0.28462	-0.27672	0.20282
GDP natural logarithm	0.17245	0.584	-0.29413	-0.48494	-0.41219
Research excellence (highly cited scientific publications)	**0.89965**	0.08266	-0.2061	0.04531	-0.10682

Based on the findings of the PCA, a hierarchical cluster analysis has been carried out to gather the regions into homogeneous groups. Figure 1 presents the dendrogram showing the different groups as well as a bar separating the different country groups.

Figure 1: Cluster analysis – dendrogram



Source: DG Research and Innovation

Scientific and technological strengths

The NUTS classification

Definition: The Nomenclature of Statistical Territorial Units (NUTS) is a single coherent for dividing up the European Union's territory in order to produce regional statistics for the Community. NUTS subdivides each Member State into a whole number of regions at NUTS level 1. Each of these is then subdivided again into regions at NUTS level 2 and, in turn, subdivided into regions at NUTS level 3.

Source: Eurostat

Scientific publications

Definition: Publications refer to research articles, reviews, notes and letters published in referenced journals which are included in the Elsevier Scopus database. The counting method used at the country level for publications was the full-counting method. However, for the EU aggregate, double counts of multiple occurrences of EU Member States in the same record were excluded.

Source: Scopus (Elsevier); treatments and calculations: Science-Metrix

Average of Relative Citations (ARC)

The ARC is an indicator of the scientific impact of papers produced by a given entity (e.g. the world, a country, a NUTS 2 region, an institution) relative to the world average (i.e. the expected number of citations). The number of citations received by each publication is counted for the year in which it was published and for the three subsequent years. For papers published in 2000, for example, citations received in 2000, 2001, 2002 and 2003 are counted.

To account for different citation patterns across scientific fields and sub-fields (e.g. there are more citations in biomedical research than in mathematics), each publication's citation count is divided by the average citation count of all publications of the corresponding document type (i.e. a review would be compared to other reviews, whereas an article would be compared to other articles) that were published the same year in the same sub-field to obtain a Relative Citation count (RC). The ARC of a given entity is the average of the RCs of the papers belonging to it. An ARC value above one means that a given entity is cited more frequently than the world average, while a value below one means the opposite. The ARC is computed for the 2000–2006 period only, since publications in 2007, 2008 and 2009 have incomplete citation windows.

Methodology of co-publication analysis

The methodology used for co-publication analysis involved three types of analysis:

a) Single country publications cover co-publications that involve domestic partners only; this is the sum of all papers written by one or more authors from a given country (and non-nationals resident in that country). Although the literature usually distinguishes between domestic single publications (including one or more authors belonging to the same institution) and domestic co-publications (i.e. authors within the same country but from different main organisations), for the purpose of the current analysis the sum of the two categories has been used under the heading "single country publications".

b) EU transnational co-publications refer to international co-publications which involve at least one author from an EU country. This category includes both co-publications by authors from at least two different EU Member States (as defined by research papers containing the addresses of at least two authors in different countries) and co-publications by one or several authors from the EU together with at least one author from a country outside the EU.

c) Extra-EU co-publications is a subcategory of the broader EU transnational co-publications. It refers exclusively to international co-publications involving at least one EU author and at least one non-EU author, as defined by the authors' addresses in different countries.

Another important methodological issue concerns the way in which a co-publication is quantified. The full counting method has been used in this report, meaning that a single international co-published paper is assigned to more than one country of scientific origin. If, for example, the authors' addresses indicate three different countries in the EU, the publication is counted three times – once for each country mentioned. Therefore, in a matrix of co-publications between countries, the number of publications mentioned is not a completely accurate indicator of the number of publications being co-authored, but rather how often a country or region is involved in co-publications.

Public-private co-publications

Definition: The number of public-private co-authored research publications. The private sector excludes the private medical and health sector.

Sources: Scopus (Elsevier); Science-Metrix

Specialisation Index (SI)

Definition: This is an indicator of the research intensity for a given economic sector, as defined by a sample of representative companies, in a given research area (sub-field) relative to the intensity of the reference entity (world, entire output as measured by the database) in the same research area. In other words, when a sector is specialised in a sub-field, it places more emphasis on that field at the expense of other research areas. The SI formula is the following:

$$SI = \frac{\left(X_s / X_T\right)}{\left(N_s / N_T\right)}$$

where

X_s = Papers from sector X in a given research area s (e.g. NACE 15&29.53 in food sciences)

X_T = Papers from entity X in a reference set of papers T (e.g. NACE 15&29.53 in Scopus)

N_s = Papers from the reference entity N in a given research area s (e.g. world in food sciences)

N_T = Papers from the reference entity N in a reference set of papers (e.g. world in Scopus)

A given sector is specialised relative to the reference entity if the index value is above one, and the reverse if the index value is below one. This indicator's value is directly related to the relevance of the sub-field for the sector (the higher the value of the indicator, the greater relevance of the sub-field for the sector).

Source: Science-Metrix/Scopus (Elsevier)

Revealed Technological Advantage index (RTA)

Definition: The Revealed Technological Advantage (RTA) index provides information about the technological specialisation of areas and countries. The formula used to calculate the RTA index is the following:

$$RTA_{ij} = \left(\frac{X_{ij}}{\sum_j X_{ij}}\right) / \left(\frac{\sum_i X_{ij}}{\sum_i \sum_j X_{ij}}\right)$$

where

X_{ij} = The number of patents for an area (or country) *i* in technology *j*

$\sum_j X_{ij}$ = Total number of patents for the area (or country) *i*

$\sum_i X_{ij}$ = Total number of patents for the technology *j*

$\sum_i \sum_j X_{ij}$ = Total number of patents worldwide

The expression's numerator represents the share of technology *j* among all patents in an area (or country) *i*. In other words, it represents the relative importance of technology *j* in the patenting activity of the area (or country) *i*.

The denominator represents the share of all patents in all areas (countries) accounted for by technology *j* – i.e. it represents the relative importance of technology *j* in patenting activities worldwide.

A zero value for the RTA indicates that area *i* has not patented in technology *j* and thus it is fully de-specialised in that technology. The RTA takes value one when the weight of technology *j* in the patenting activities of area *i* is exactly equal to the weight that this technology has in patenting at the world level. This implies that an RTA value greater than one indicates that area *i* is relatively specialised in technology *j*. On the contrary, an RTA value lower than one indicates that area *i* is relatively de-specialised in that technology. Comparison of the different specialisation levels across the various technological and economic fields enables conclusions to be drawn about the relative strengths and weaknesses of different areas and countries (although the RTA index must be interpreted with caution for those areas and countries which have registered a relatively small number of patents).

Source: University Bocconi (Italy)

Innovation and growth in firms

Innovative enterprises

Definition: Enterprises that introduce new or significantly improved products (goods or services) to the market, or enterprises that implement new or significantly improved processes or a new organisational or marketing method, which has not been used before. Innovations are based on the results of new technological developments, new combinations of existing technology or the utilisation of other knowledge acquired by the enterprise.

Source: Eurostat

Fast-growing enterprises/ High-Growth Enterprises

Definition: High-Growth Enterprises (HGEs) are defined as enterprises with an average annual growth in employees greater than 10 % a year, over a three-year period, and with 10 or more employees at the beginning of the observation period.

Source: Eurostat

EU Industrial R&D Investment Scoreboard

Definition: The EU Industrial R&D Investment Scoreboard presents information on the top 1000 EU companies and 1000 non-EU companies. The Scoreboard includes data on R&D investment along with other economic and financial data. It is the source for the ICT Scoreboard which provides data on the ICT companies with the largest R&D budgets globally.

Source: DG JRC

Upgrading the manufacturing sector through research and technologies

Knowledge-Intensive Activities (KIAs)

Definition: Knowledge-Intensive Activities (KIAs) are defined as economic sectors in which more than 33 % of the employed labour force has completed academic-oriented tertiary education (i.e. at ISCED 5 and 6 levels). They cover all sectors in the economy, including manufacturing and services, and can be defined at two- and three-digit levels in the statistical classification of economic activities.

Source: Eurostat

Knowledge-Intensive Services (KIS)

Definition: Knowledge-Intensive Services (KIS) include the following sectors (NACE Rev.2 codes are given in brackets): water transport (50), air transport (51), publishing activities (58), motion picture, video and television programme production, sound recording and music publishing activities (59), programming and broadcasting activities (60), telecommunications (61), computer programming, consultancy and related activities (62), information service activities (63), financial service activities, except insurance and pension funding (64), insurance, reinsurance and pension funding, except compulsory social security (65), activities auxiliary to financial services and insurance activities (66), legal and accounting activities (69), activities of head offices; management consultancy activities (70), architectural and engineering activities; technical testing and analysis (71), scientific research and development (72), advertising and market research (73), other professional, scientific and technical activities (74), veterinary activities (75), security and investigation activities (80), public administration and defence; compulsory social security (84), education (85), human health and social work activities (86 to 88), arts, entertainment and recreation (90 to 93).

Source: Eurostat

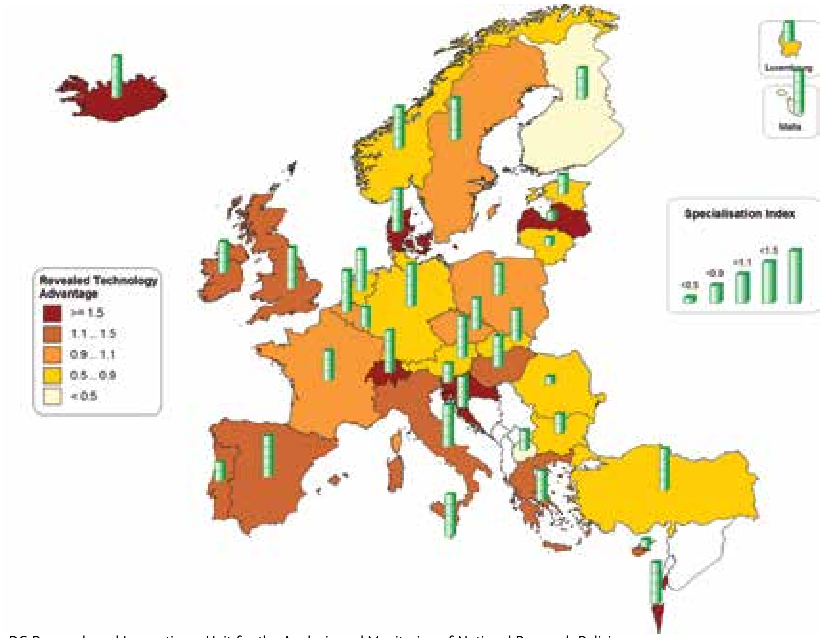
Knowledge-Intensive Services exports

Definition: KIS exports are measured by the sum of credits in EBOPS (Extended Balance of Payments Services Classification) 207, 208, 211, 212, 218, 228, 229, 245, 253, 260, 263, 272, 274, 278, 279, 280, 284.

Sources: UN, Eurostat

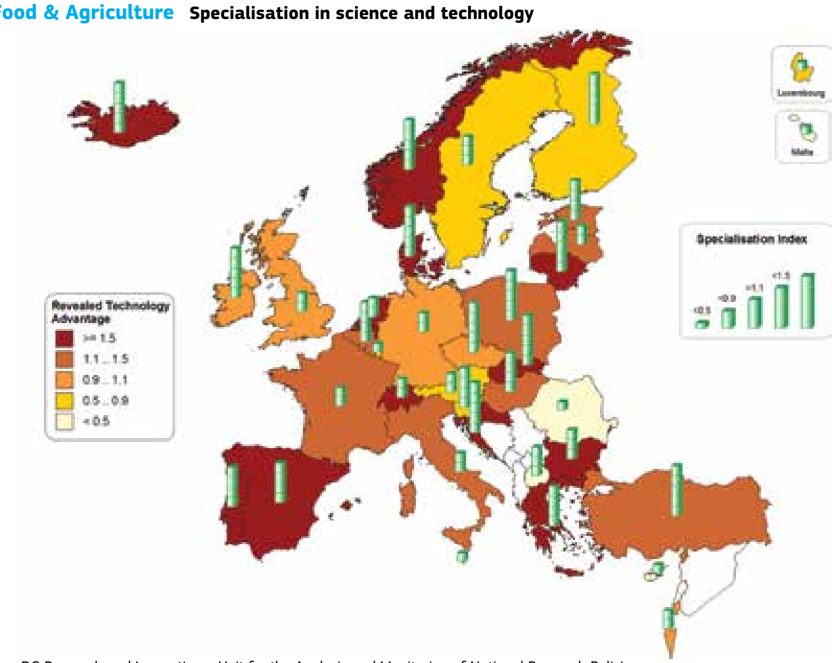
Maps on Science and Technology specialisation in Framework programme thematic priorities

Health Specialisation in science and technology



Source: DG Research and Innovation – Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix Canada, based on Scopus data; Bocconi University, Italy, based on WIPO-PCT applications
Notes: Revealed Technological Advantage (RTA) index is calculated for the period 2000–2010, based on the number of WIPO-PCT applications by country of inventor. For the countries with fewer than five patent applications for the period 2000–2010, RTA is not considered. Specialisation index (SI) is calculated for the period 2000–2011, based on Scopus data on publications.

Food & Agriculture Specialisation in science and technology



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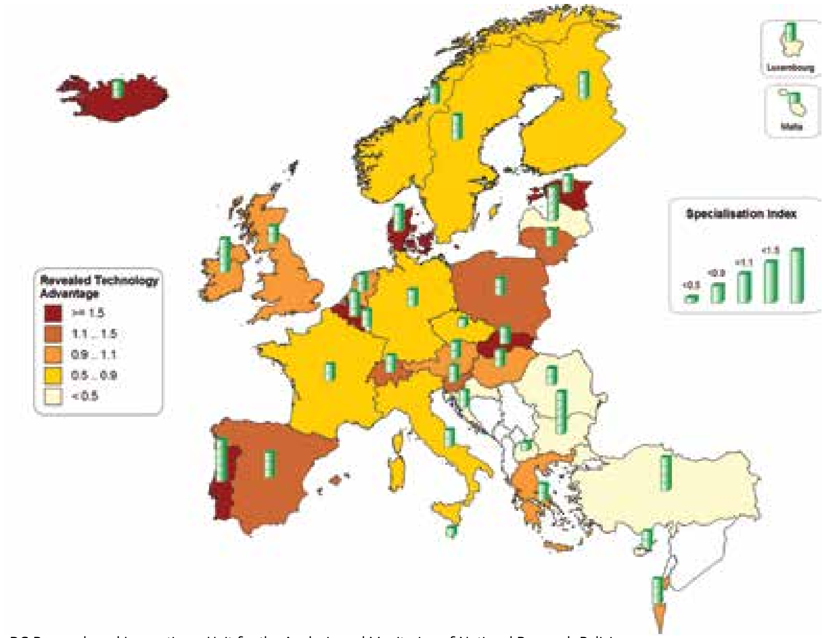
Biotechnology Specialisation in science and technology



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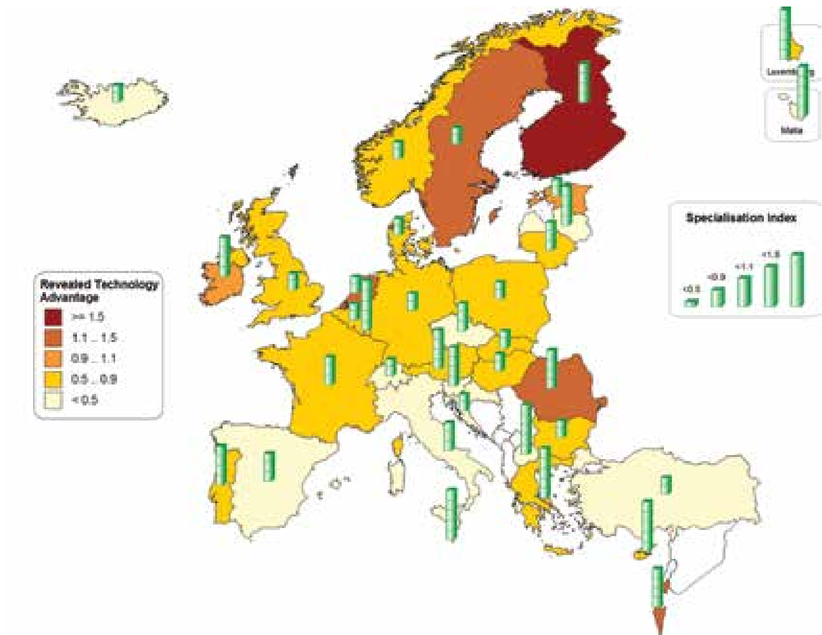
ICT Specialisation in science and technology



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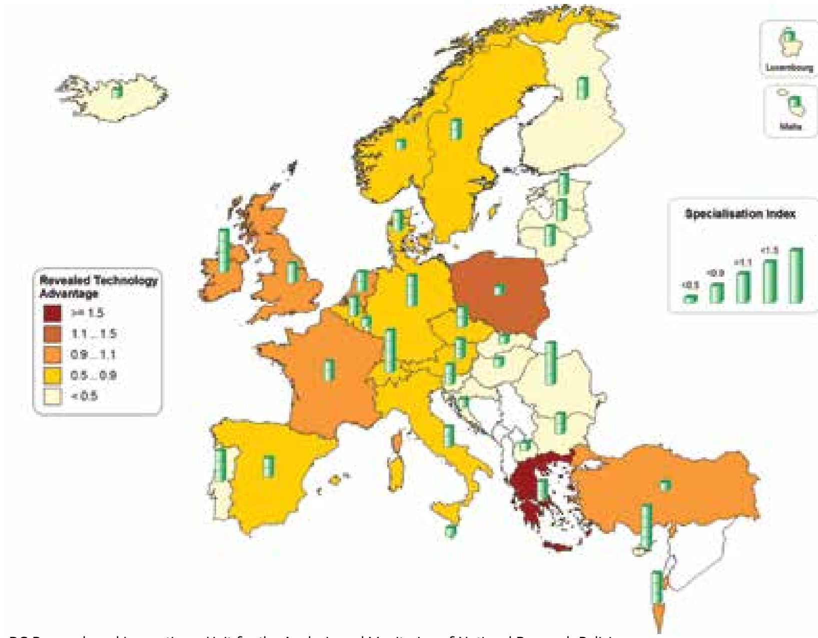
Nanosciences & Nanotechnologies **Specialisation in science and technology**



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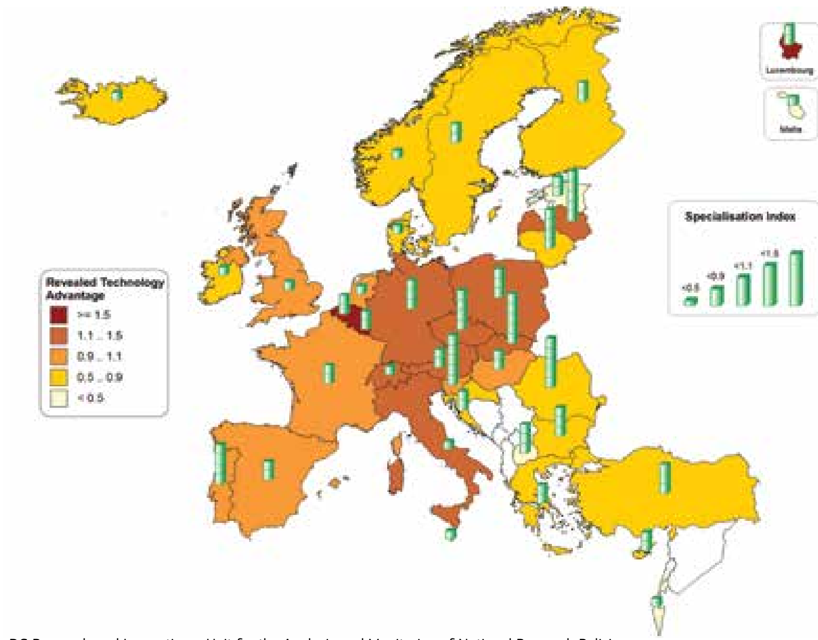
Materials (excl. Nanotechnologies) **Specialisation in science and technology**



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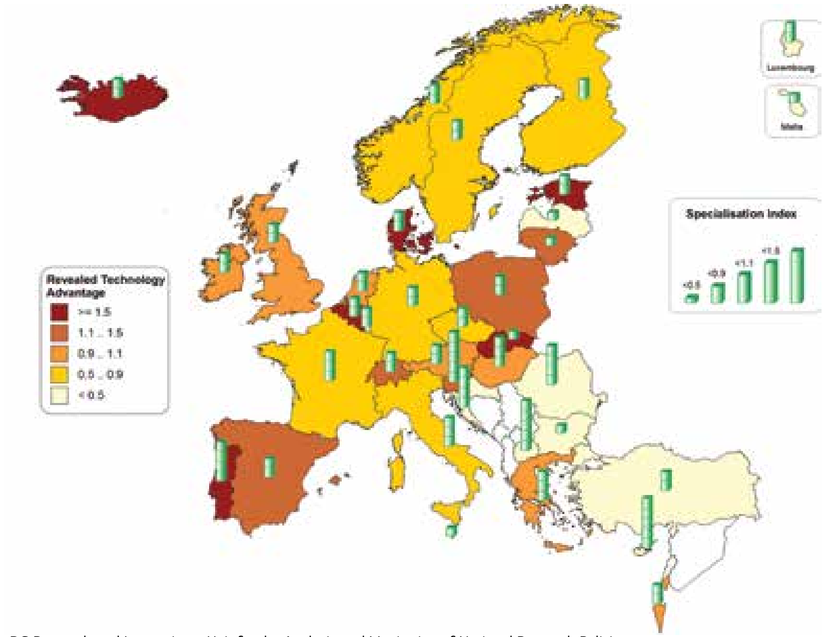
New Production Technologies **Specialisation in science and technology**



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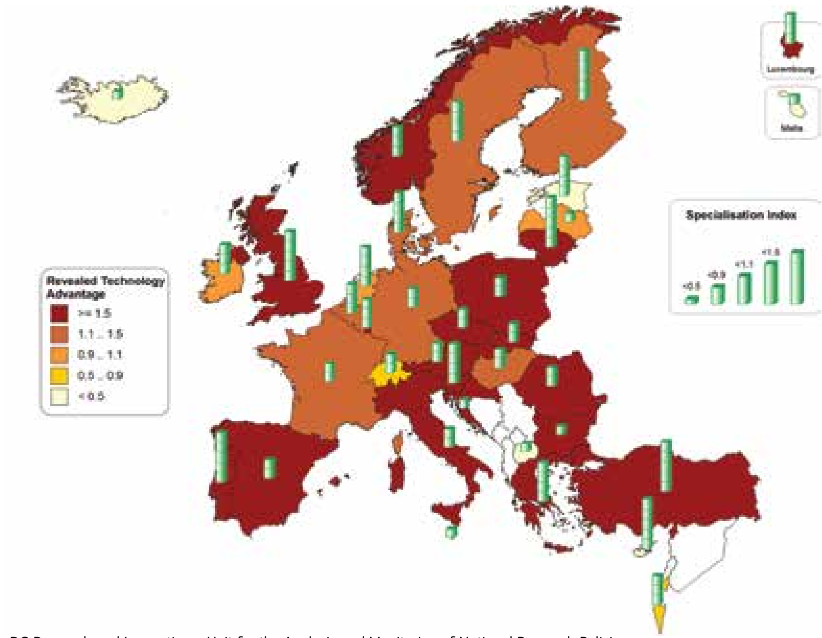
Construction & Construction Technologies **Specialisation in science and technology**



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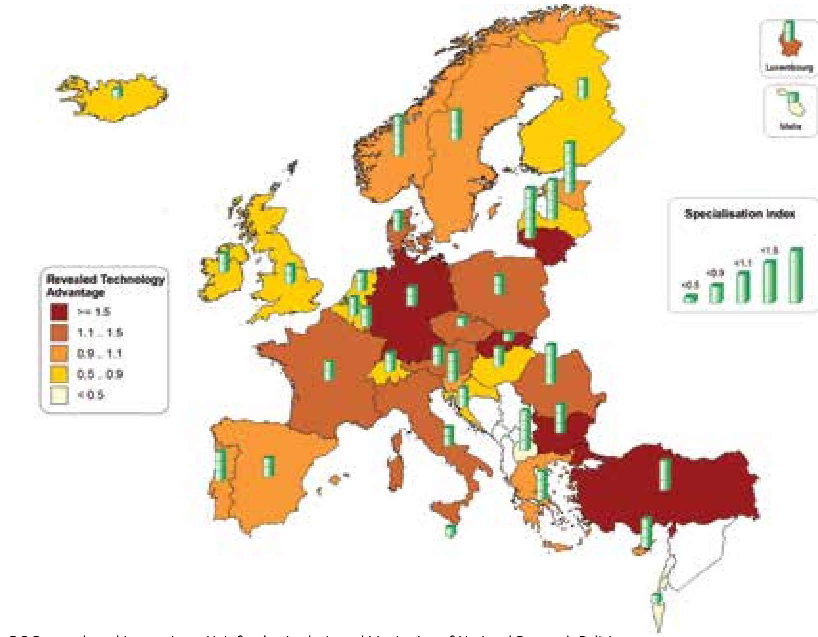
Energy Specialisation in science and technology



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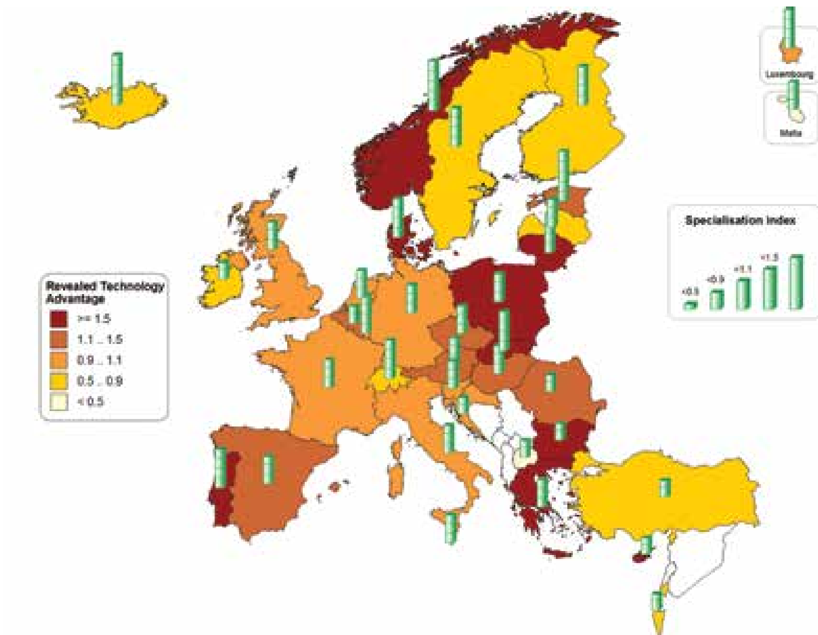
Environment Specialisation in science and technology



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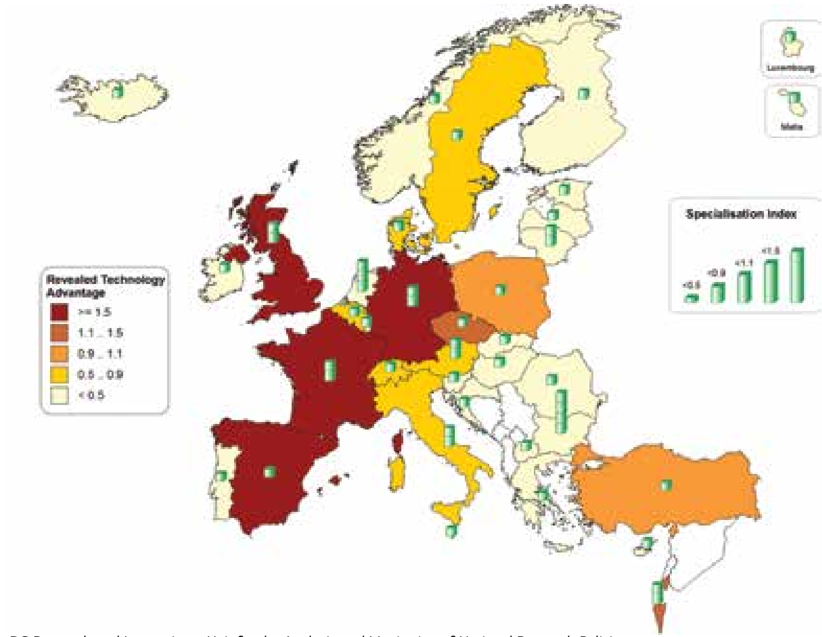
Aeronautics **Specialisation in science and technology**



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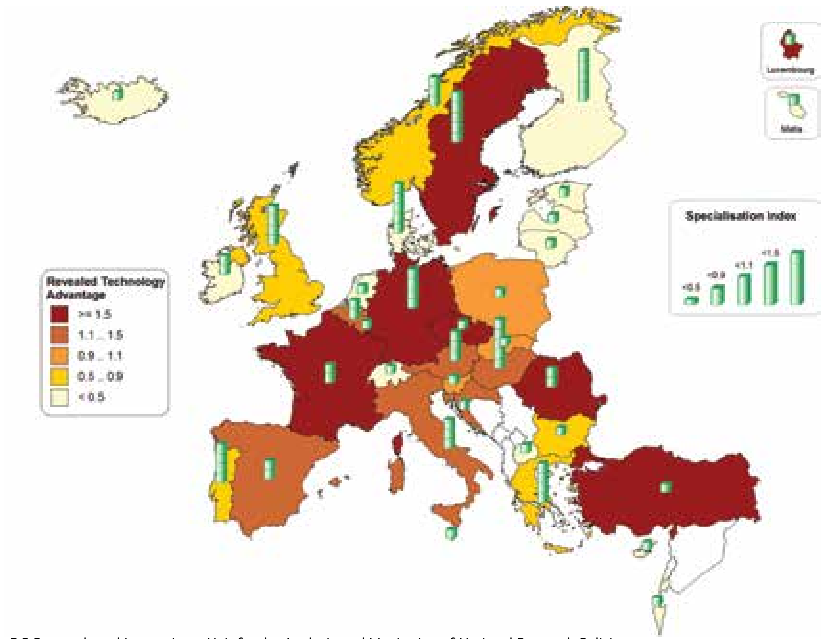
Automobiles **Specialisation in science and technology**



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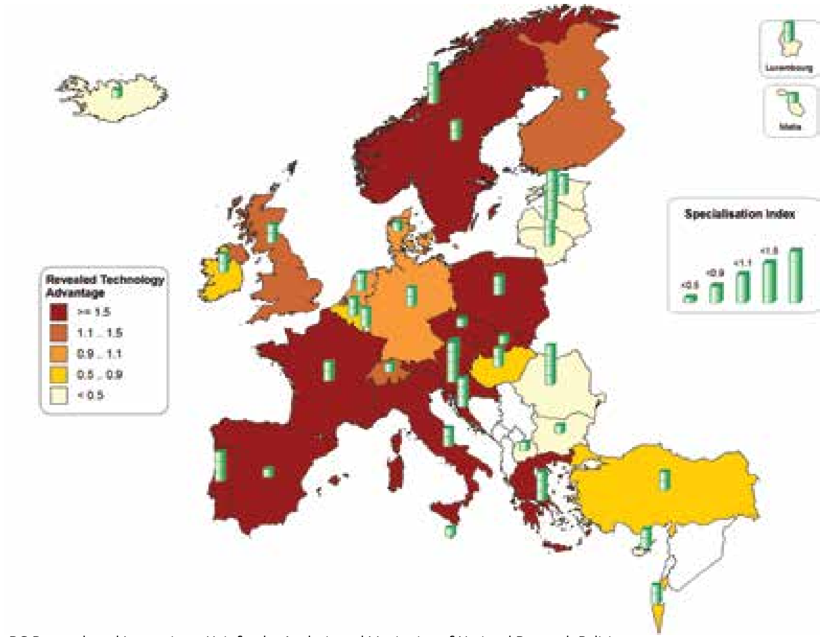
Other Transport Technologies **Specialisation in science and technology**



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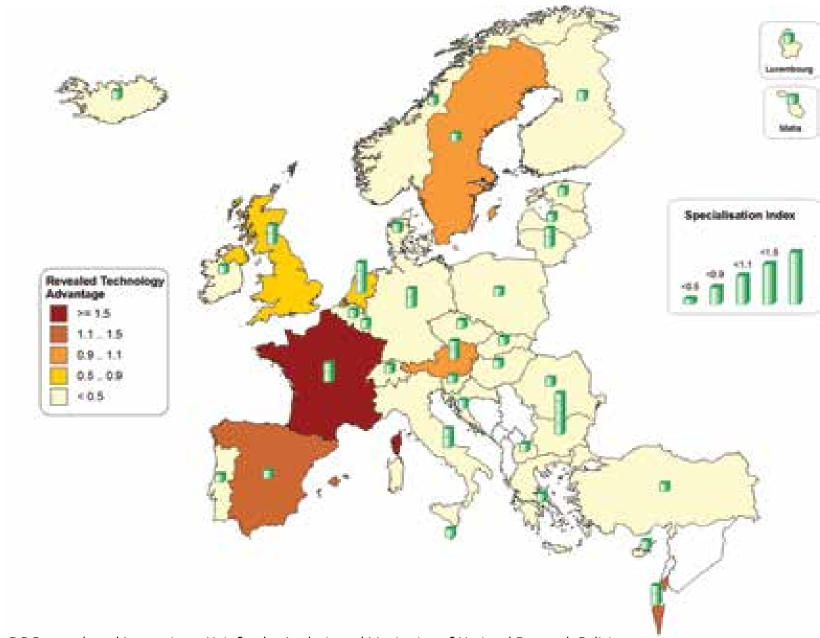
Space **Specialisation in science and technology**



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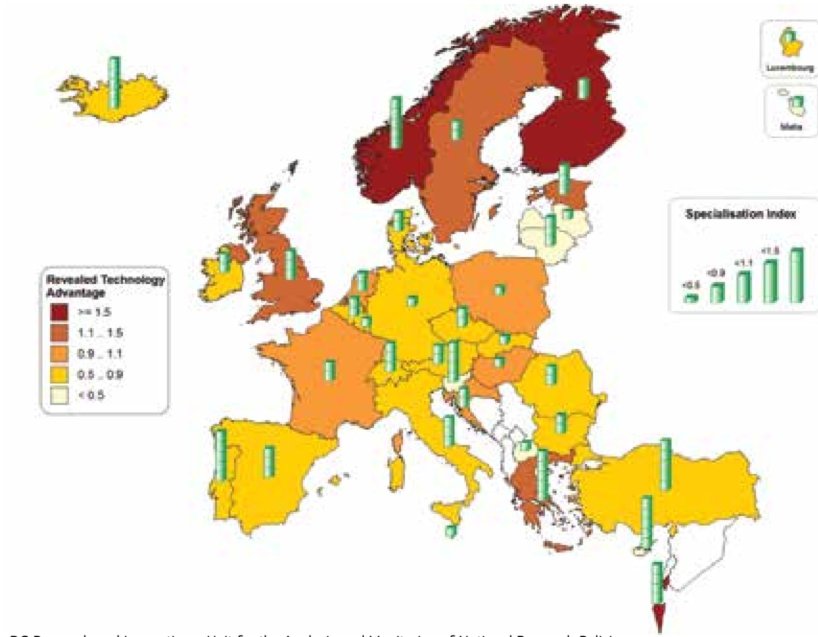
Security **Specialisation in science and technology**



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List of Acronyms / Abbreviations

AdI	Innovation Agency, Portugal
AEI	National Research Agency, Spain
ANVUR	National Agency for the Evaluation of University System and Research, Italy
ARC	Average of relative citations
BERD	Total R&D expenditure as a share of GDP (%)
BICRO	Business Innovation Centre of Croatia
BIF	Baltic Innovation Fund
BIS	Department for Business, Innovation and Skills, UK
BMBF	Federal Ministry for Education and Research, Germany
BMWi	Federal Ministry for Economic Affairs, Germany
BRIC	Brazil, Russia, India and China
BTYK	Supreme Council for Science and Technology, Turkey
CD	Community design
CDTI	Centre for Industrial Technological Development, Spain
CIR	Research tax credit, France
COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
COTEC	Foundation for Technological Innovation, Spain
CUE	Communities of Universities and Institutions, France
CTM	Community trademark
EBOPS	Extended Balance of Payments Services classification
ECB	European Central Bank
E-CORDA	External Common Research Data Warehouse
EEA	European Economic Area
ENA	National School of Administration, France
EPO	European Patent Office
ERA	European Research Area
ERAC	European Research Area and Innovation Committee
ERA-NET	Strengthening coordination of national and regional research programmes under FP7
ERC	European Research Council
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Fund
ESFRI	European Strategy Forum on Research Infrastructures
EU – EU-28	European Union
EUR	Euro
FCT	Foundation for Science and Technology, Portugal
FDI	Foreign direct investment
FiDiPro	Finland Distinguished Professor Programme
FISIM	Financial intermediation services indirectly measured
FNR	National Research Fund, Luxembourg
FP7	Seventh Framework Programme for Research
FTE	Full-time equivalent
GBAORD	Government budget appropriations or outlays for R&D
GCI	Global competitiveness index
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
GOVERD	Government intramural expenditure on R&D
GSRT	General Secretariat for Research and Technology, Greece
HEFCE	Higher Education Funding Council for England
HERD	Higher Education expenditure on R&D
HEI	Higher education institutes
HGE	High-growth enterprise
HRST	Human resources in science and technology
HT	High-tech
ICI	Innovation Centre Iceland
ICT	Information and communication technologies
IMF	International Monetary Fund
INNO+	Platform for strategic investments in innovation, Denmark
IP	Intellectual property
IPA	Pre-Accession Instrument
ISCED	International Standard Classification of Education
JRC	Joint Research Centre (of the European Commission)
KEJN	Committee for Evaluation of Scientific Institutions, Poland

KETs	Key enabling technologies
KIA	Knowledge-intensive activities
KIS	Knowledge-intensive services
KNOW	National Leading Scientific Centres, Poland
KTI	Knowledge Transfer Ireland
ME	Ministry of Economy, Slovakia
MESRS	Ministry of Education, Science, Research and Sport, Slovakia
MNCs	Multinational companies
MIUR	Ministry for Education, University and Research, Italy
MISE	Ministry for Economic Development, Italy
MIT-MKB	Encouraging SME innovation top sectors, the Netherlands
MoSIT	Ministry of Science, Industry and Technology, Turkey
MTA	Hungarian Academy of Sciences
MT/MHT	Medium high-technology/Medium high-technology and high technology
n.a.	not available
NACE	Statistical Classification of Economic Activities
NCBiR	National Centre for Research and Development, Poland
NCN	National Science Centre, Poland
NCRITD	National Committee on Research, Innovation and Technological Development, Cyprus
NIH	National Innovation Office, Hungary
NIS	National Innovation Strategy, Czech Republic
NRP	National Reform Programme
NSRF	National Strategy for Research, Technological Development and Innovation, Greece
NTIT	National Science Policy and Innovation Board, Hungary
NUTS	Nomenclature of Statistical Territorial Units
OECD	Organisation for Economic Co-operation and Development
OHIM	Office for Harmonization in the Internal Market
OP	Operational Programme
PCT	Patent Cooperation Treaty
PISA	Programme for International Student Assessment
PONREC	National Operational Programme for Research and Competitiveness, Italy
PPS	Purchasing Power Standards
PRC	Public Research Centre, Luxembourg
PRES	Higher education research institutions clusters, France
PRP	Enterprise Development Programme, Poland
RANNIS	Icelandic Centre for Research
R&D	Research and development
R&I	Research and innovation
RCA	Revealed comparative advantage
RIS3	Research and Innovation Strategies for Smart Specialisation
RISS	Research and Innovation Strategy 2011-2020, Slovenia
RPF	Framework Programme for R&I, Cyprus
RTA	Revealed technological advantage Index
RTDI	Research, technological development and innovation
S&E	Science and engineering
S&T	Science and technology
SGCSTI	Slovak Government's Council for Science, Technology and Innovation
SERV	Knowledge-intensive service exports
SFI	Science Foundation Ireland
SHOK	Strategic Centre for Science, Technology and innovation
SI	Specialisation Index
SIEG	Strategy for Innovation and Effectiveness of the Economy 2020, Poland
SIFIDE	System of tax investments for companies investment in R&D, Portugal
SME	Small and medium-sized enterprise
S3	Smart Specialisation Strategy
STI	Science, technology and industry
STPC	Science and Technology Policy Council, Iceland
TFP	Total factor productivity
TSB	Technology Strategy Board, UK
TKI	Top Consortia for Knowledge and Innovation, the Netherlands
TÜBİTAK	Scientific and Technological Research Council of Turkey
UBTYS	National Science, Technology and Innovation Strategy, Turkey
VC	Venture capital
VTT	Technical Research Centre of Finland
WEF	World Economic Forum
WBSO	R&D promotional law, the Netherlands
WIPO	World Intellectual Property Organization

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