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'Research and Innovation performance in the EU. Innovation Union progress at country level 2014'

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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

[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).

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.

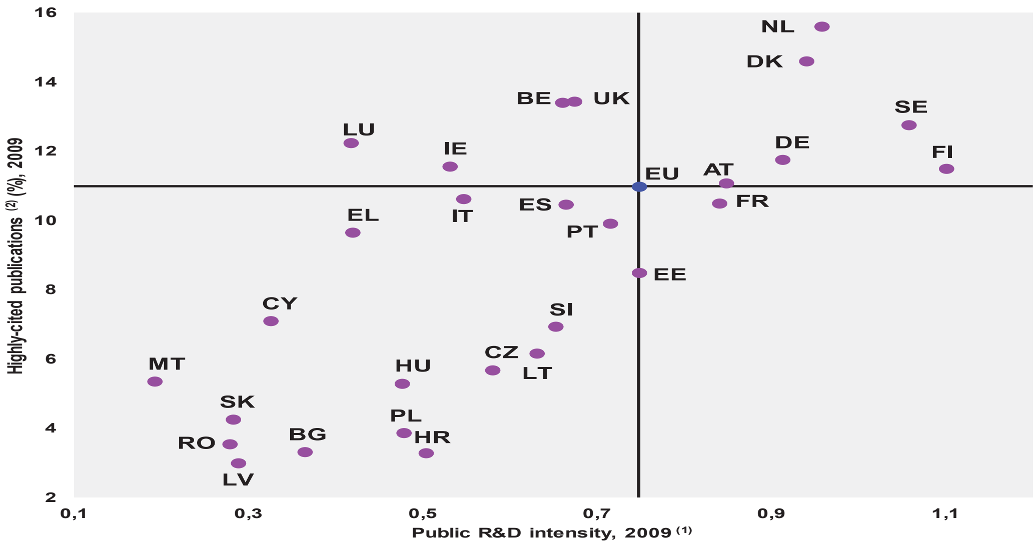
The country profiles analyse in particular the quality of Member States' knowledge base through two indicators: an indicator of the science output based on the percentage of highly cited scientific publications[13] among all national publications[14], and a composite indicator which combines this indicator 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].

[12] COM (2014) 339 final
[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.

Figure 1

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



Source: DG Research and Innovation - Analysis ans monitoring of national research policies unit
Data: Eurostat
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 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.

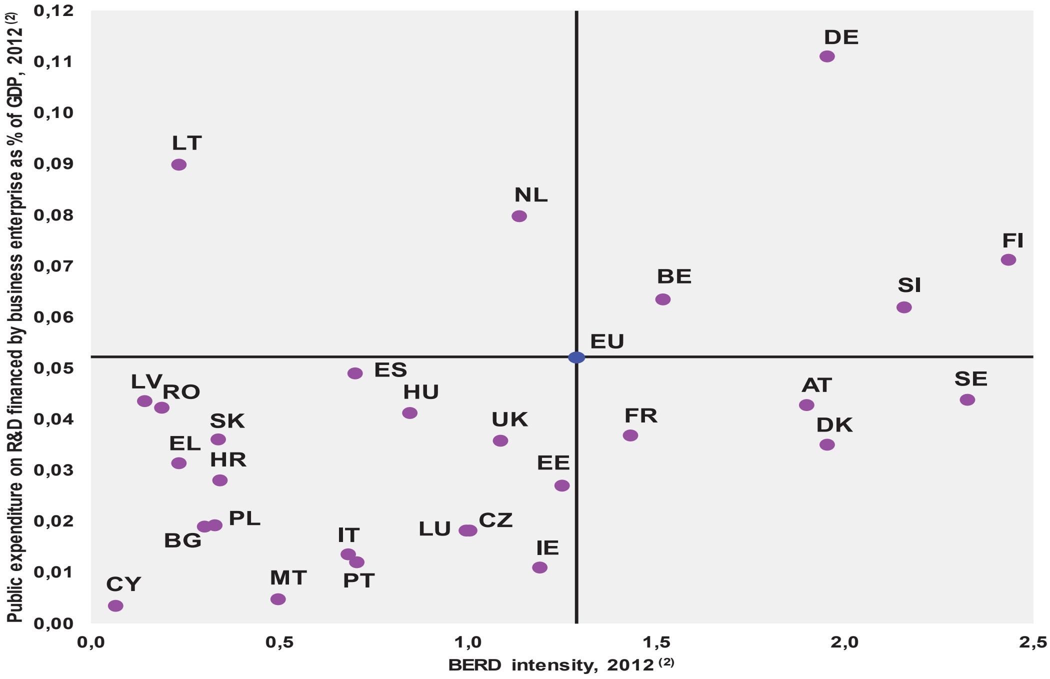
The Walloon *'pôles de compétitivité'* policy or the German comprehensive innovation-oriented strategy ('The High-Tech Strategy for Germany') are examples of policies to support the mobilisation of public research capacities around business needs. Such approaches channel significant funding into research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

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:

[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.

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.

[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).

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:

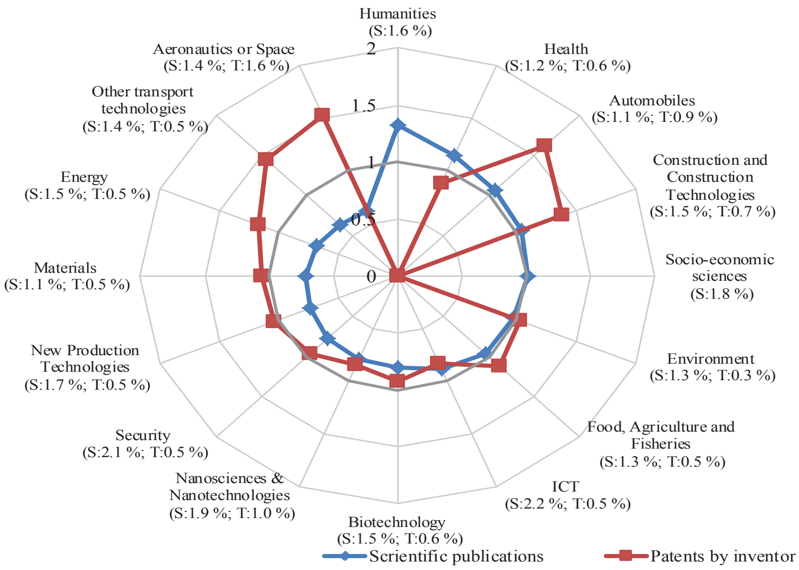
- In the areas of heath and ICT, there is a relatively strong scientific specialisation (coupled with citation rates which are slightly above average) but a weak technological specialisation. This situation compares unfavourably to the US and China where health and ICT, respectively, are areas of strong 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.

Figure 3

EU27 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)

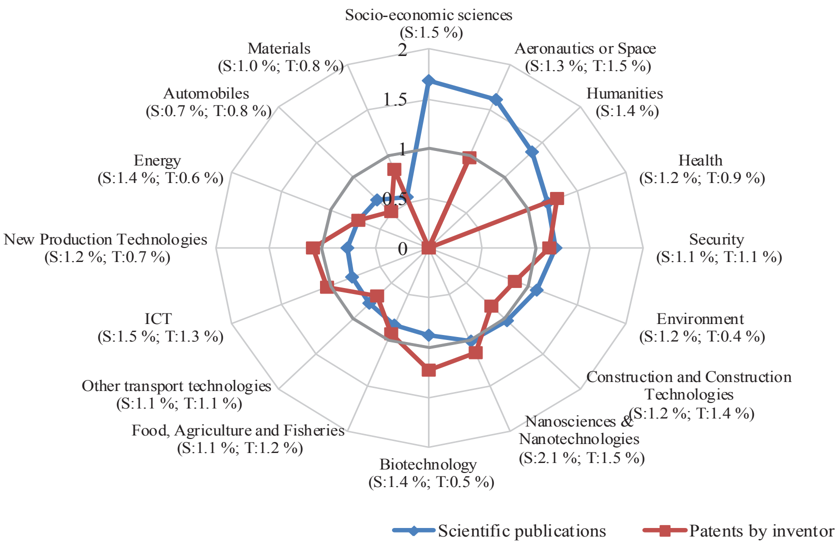


Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix - Canada, Univ. Bocconi - Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data 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 4

US 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)

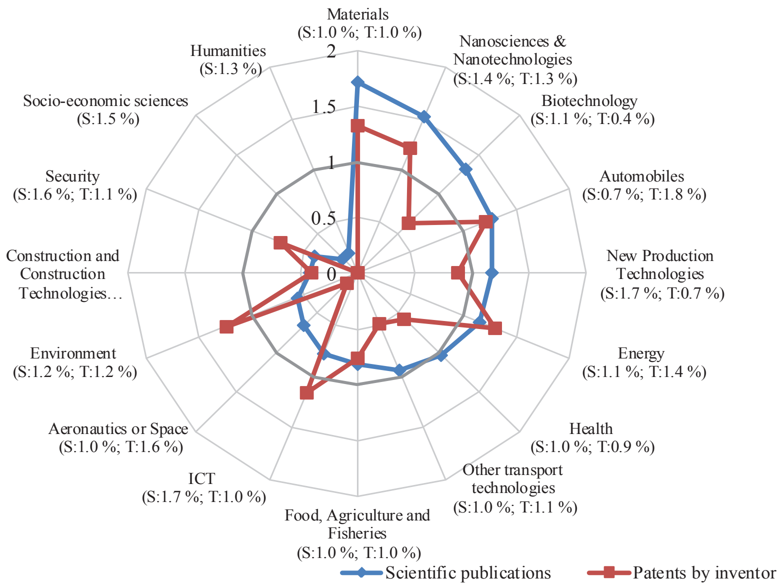


Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies
Data: Science-Metrix - Canada, Univ. Bocconi - Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data 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 5

JP 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)

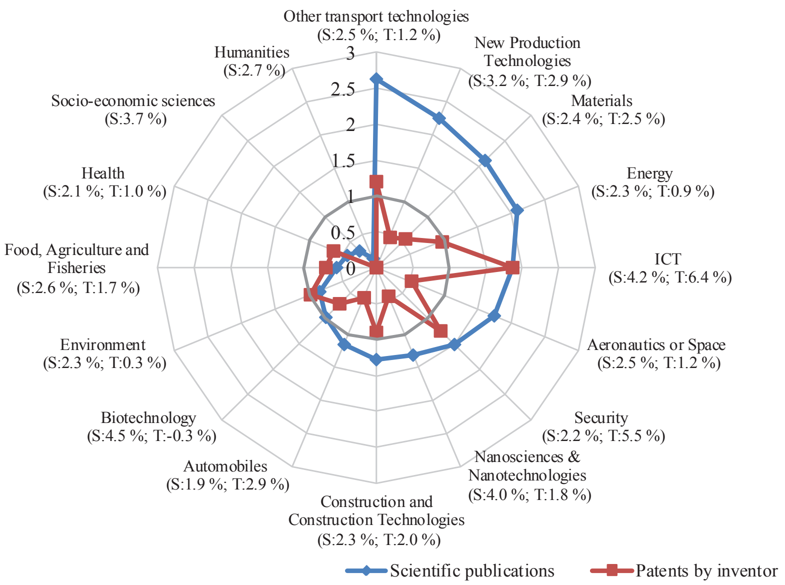


Source : DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies
Data : Science-Metrix - Canada, Univ. Bocconi - Italy
Notes : (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the 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

CN 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, Univ. Bocconi - 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.

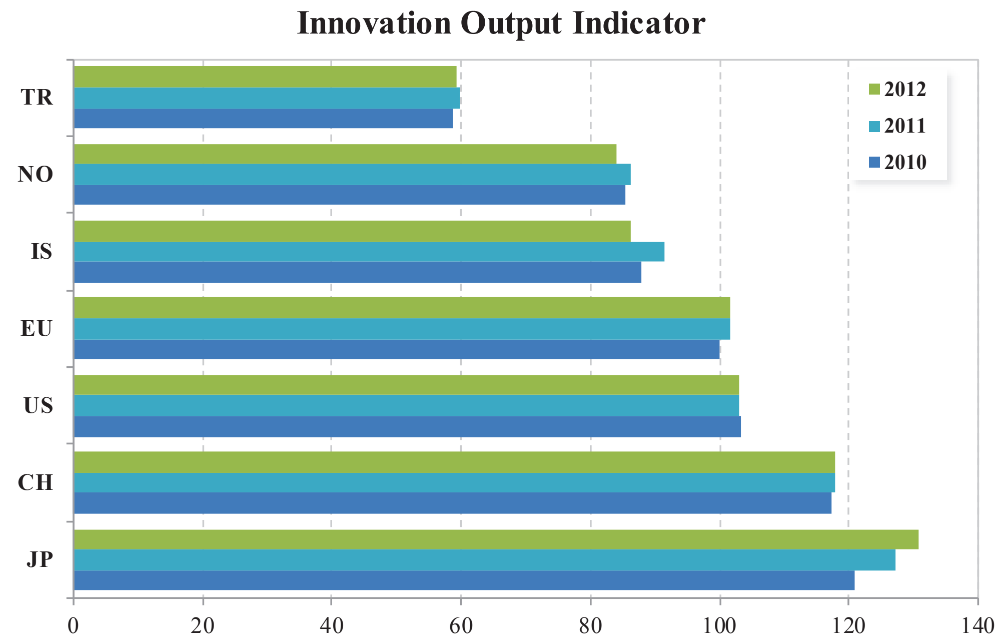
III. Innovation output: EU performance is improving slightly

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



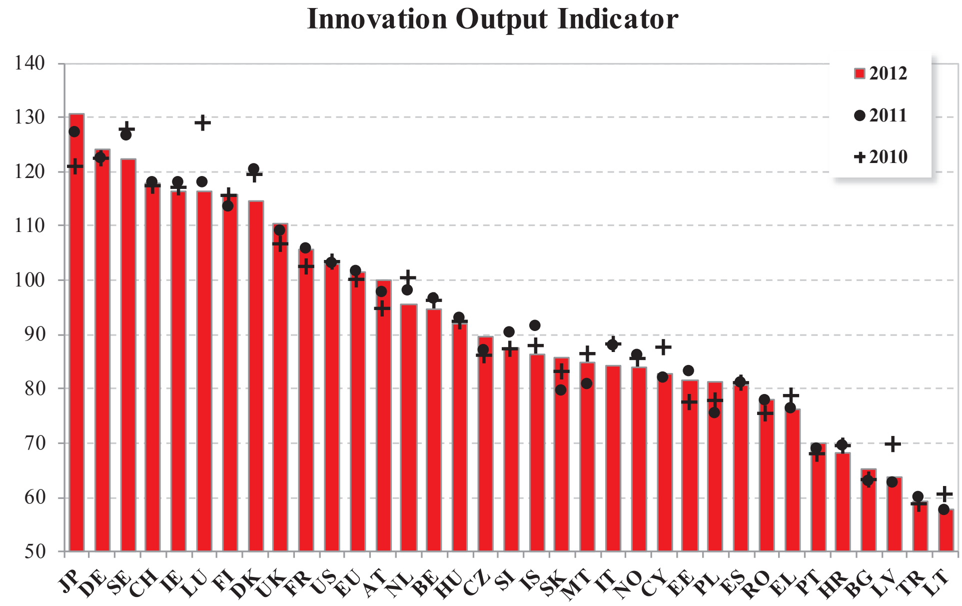
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies

Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC

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



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies

Data: Eurostat, OECD, Innovation Union Scoreboard 2014, DG JRC

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 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 %	65.2	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 %	82.7	40.7	+0.3 %	2.4 %	+31.9 %
CZ	**Czech Republic**	1.88 %	+6.6 %	26.1	+0.7 %	89.8	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 %	115.6	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 %	76.2	31.6	+0.8 %	-5.4 %	n.a.
HU	**Hungary**	1.30 %	+5.7 %	31.5	+2.4 %	92.1	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 %	63.7	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 %	95.4	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 %	70.0	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 %	86.2	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 %	83.8	40.0	+2.4 %	-17.4 %	n.a.
CH	**Switzerland**	2.87 %	+0.5 %	97.7	+2.6 %	111.6	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.

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 2012: 2.84 % (EU: 2.07 %; US: 2.79 %) 2007-2012: +2.5 % (EU: 2.4 %; US: 1.2 %)	*Excellence in S&T*[20] 2012: 51.9 (EU: 47.8; US: 58.1) 2007-2012: +3.6 % (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: 100.1 (EU: 101.6)	*Knowledge-intensity of the economy*[21] 2012: 45.3 (EU: 51.2; US: 59.9) 2007-2012: +1.7 % (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: Energy, construction, environment, automobiles, and other transport technologies	*HT + MT contribution to the trade balance* 2012: 3.5 % (EU: 4.23 %; US: 1.02 %) 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.

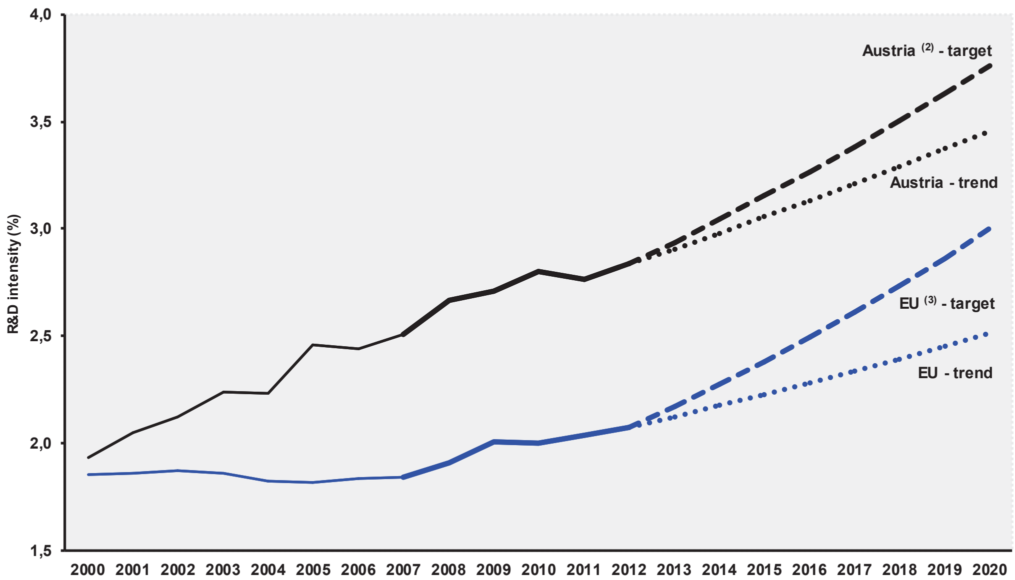
Austria's R&I policies are addressing these challenges by means of educational reform, improved governance of the R&D sector, establishing new research centres of excellence, setting up a more

[20] 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.
[21] Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

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.

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.

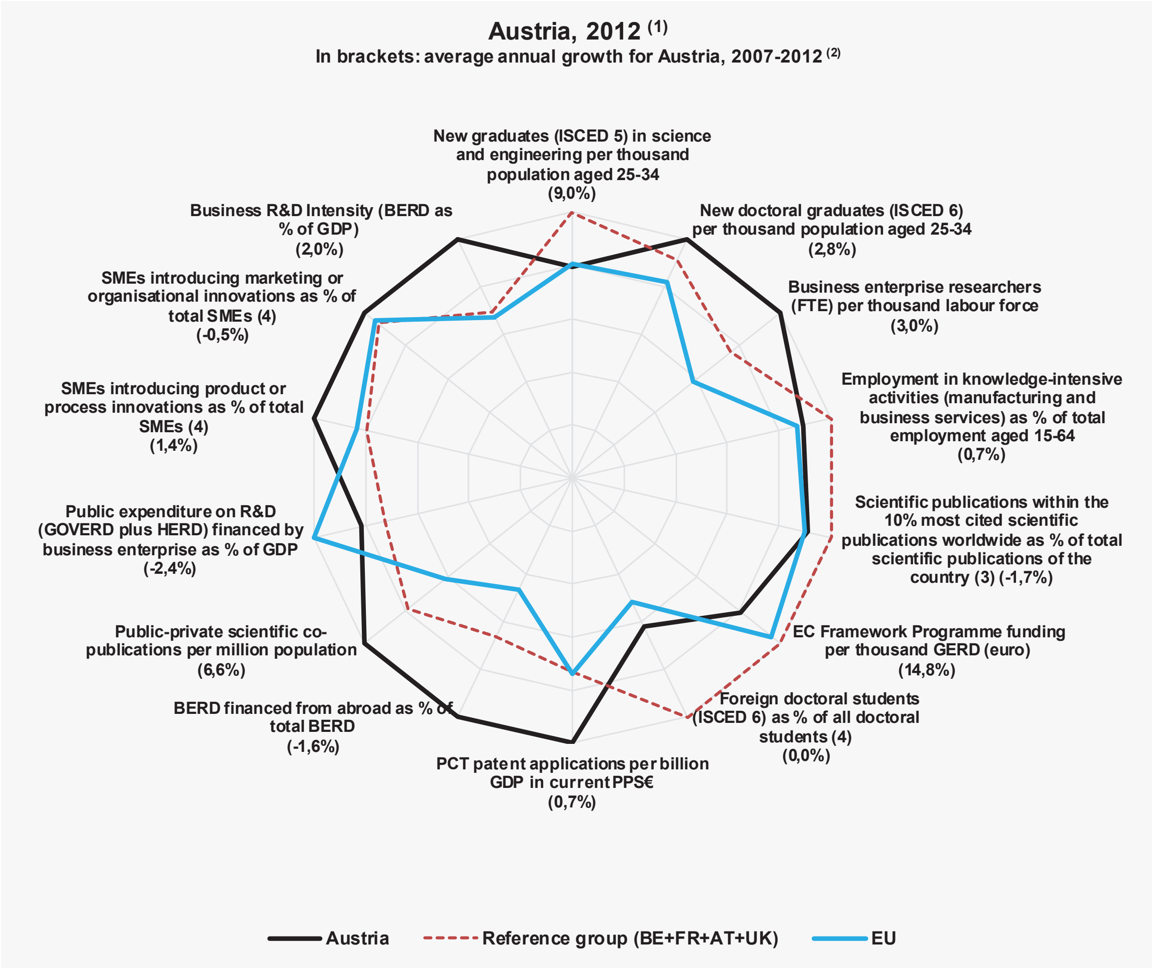
A key instrument in recent years has been the Seventh Framework Programme for Research (FP7). At 22.5 %, Austrian applicants' success rate in FP7 is close to the EU average success rate of 22 %. Until mid-2013, over 3300 Austrian participants had been partners in an FP7 project, with a total EU financial 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)[22], whilst EUR 530 million has been spent on innovation in a broad sense (including entrepreneurship, innovative ICT, and human capital).

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.

[22] 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.



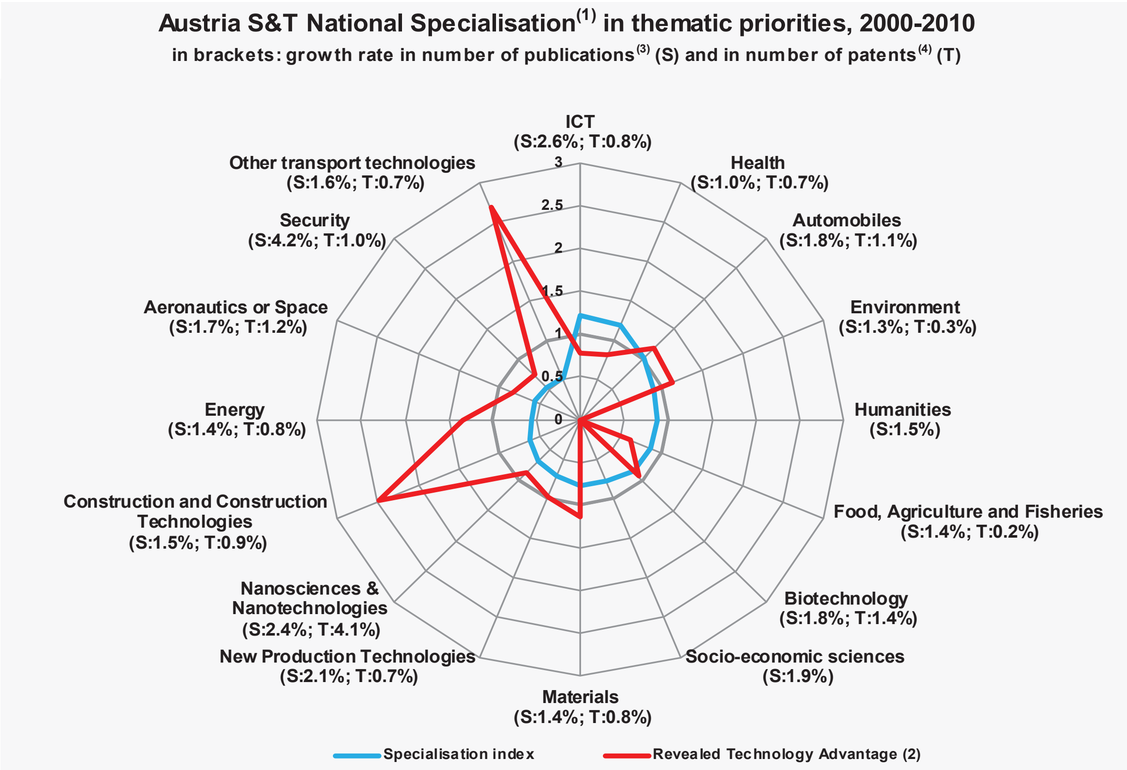
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates 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.

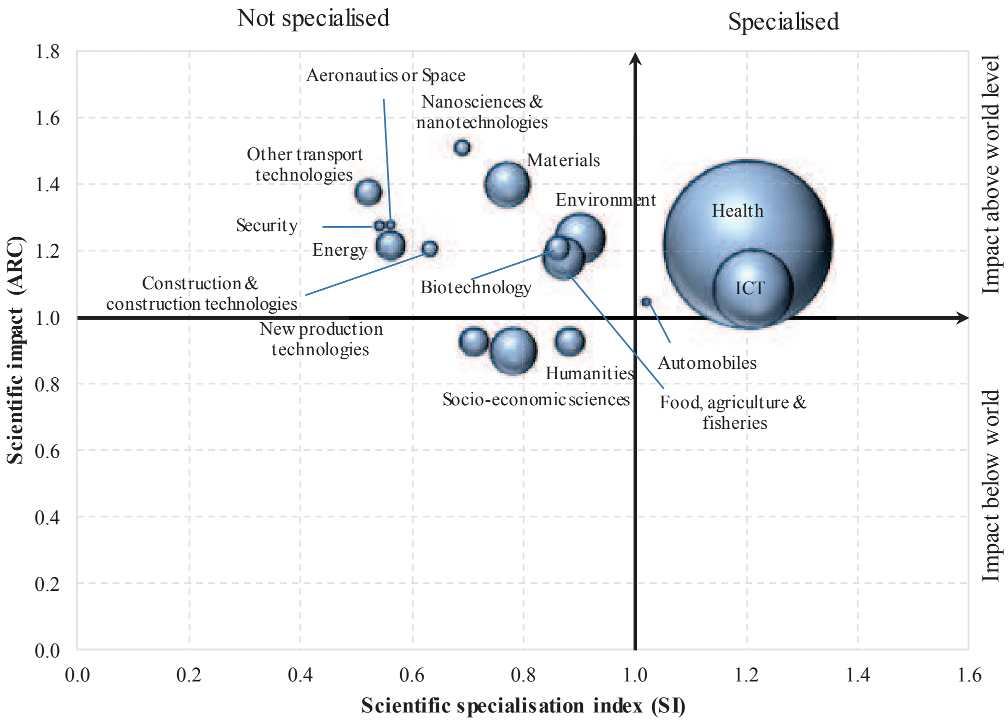


Source: DG Research and Innovation - Analysis and monitoring of national research policies
Data: Science Metrix - Canada, Univ. Bocconi - Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data corresponding to the WIPO-PCT 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.

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.

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



Source: DG Research and Innovation - Analysis and monitoring of national research policies unit
Data: Science Metrix - Canada, based on Scopus
Notes: Scientific specialisation include 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.

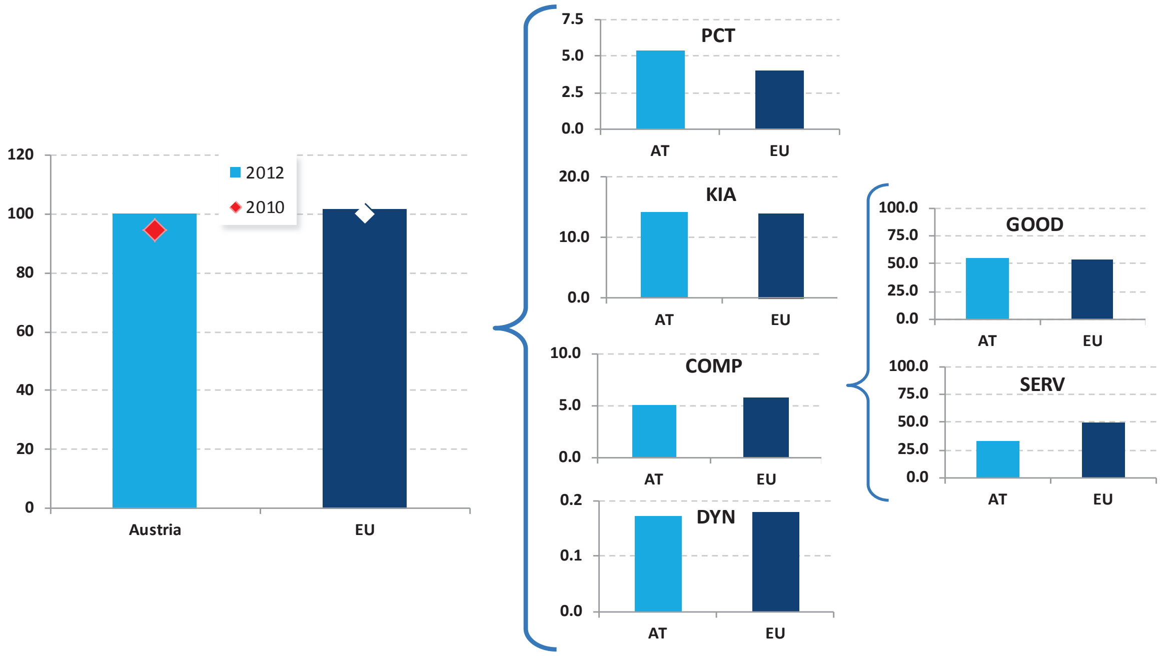
The Austrian government has set up a task force to implement the RTDI strategy. A key measure to stimulate private investment concerns the simplification of the tax regime for R&D activities to a single tax credit raised from 8 % to 10 %. In addition, the cap on the amount which can be subcontracted 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.

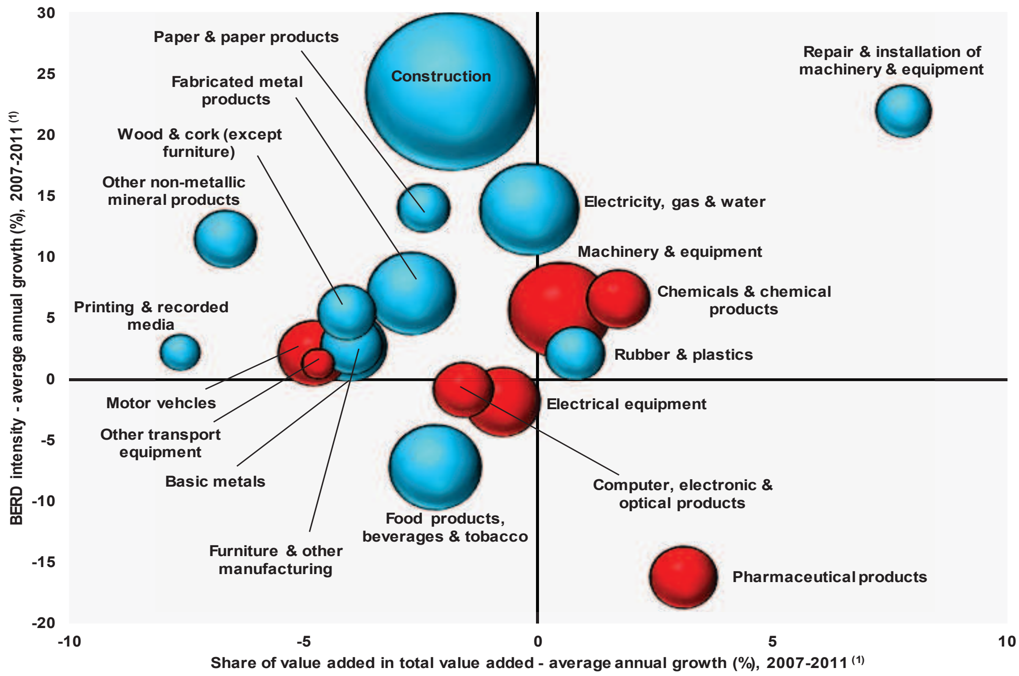
Tourism is an important economic sector in Austria, which is a leading winter tourism destination. It contributes to both a low share of employment in knowledge-intensive activities and, together with the export of services such as road and rail transport, which are not classified as knowledge-intensive, 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 - Analysis and monitoring of national research policies unit
Data: Eurostat
Notes: (1) 'Food products; beverages and tobacco products': 2009-2011.
(2) High-Tech and Medium-High-Tech sectors (NACE Rev. 2 - 2 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€	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€	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€	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 trainng (%)	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, 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 2012: 2.24 % (EU: 2.07 %; US: 2.79 %) 2007-2012: +3.4 % (EU: 2.4 %; US: 1.2 %)	*Excellence in S&T*[23] 2012: 61.1 (EU: 47.8; US: 58.1) 2007-2012: +3.2 % (EU: +2.9 %; US: -0.2)
Innovation Output Indicator 2012: 94.8 (EU: 101.6)	*Knowledge-intensity of the economy*[24] 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: Biotechnology, food and agriculture	*HT + MT contribution to the trade balance* 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.

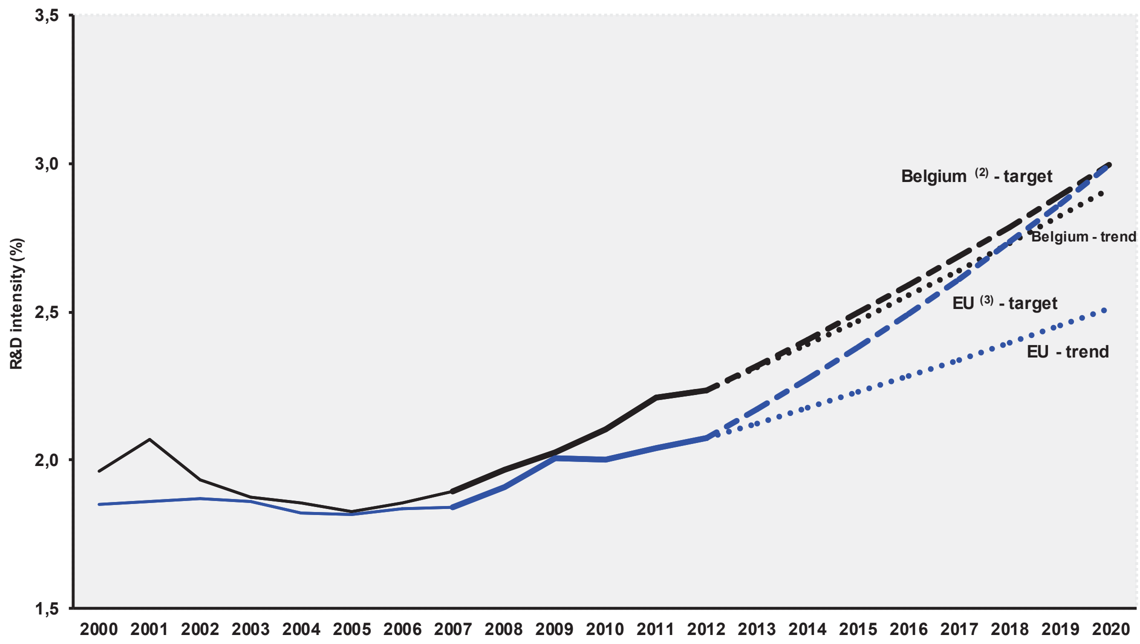
There is a consensus in Belgium about the critical importance of fostering the innovation-based competiveness of Belgian businesses. This has been reflected by all political entities in the development of sophisticated and comprehensive policy mixes at national and regional levels and in significant budgetary efforts in favour of R&D. At federal level, tax incentives for R&D are an

[23] 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.
[24] Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

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.

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.

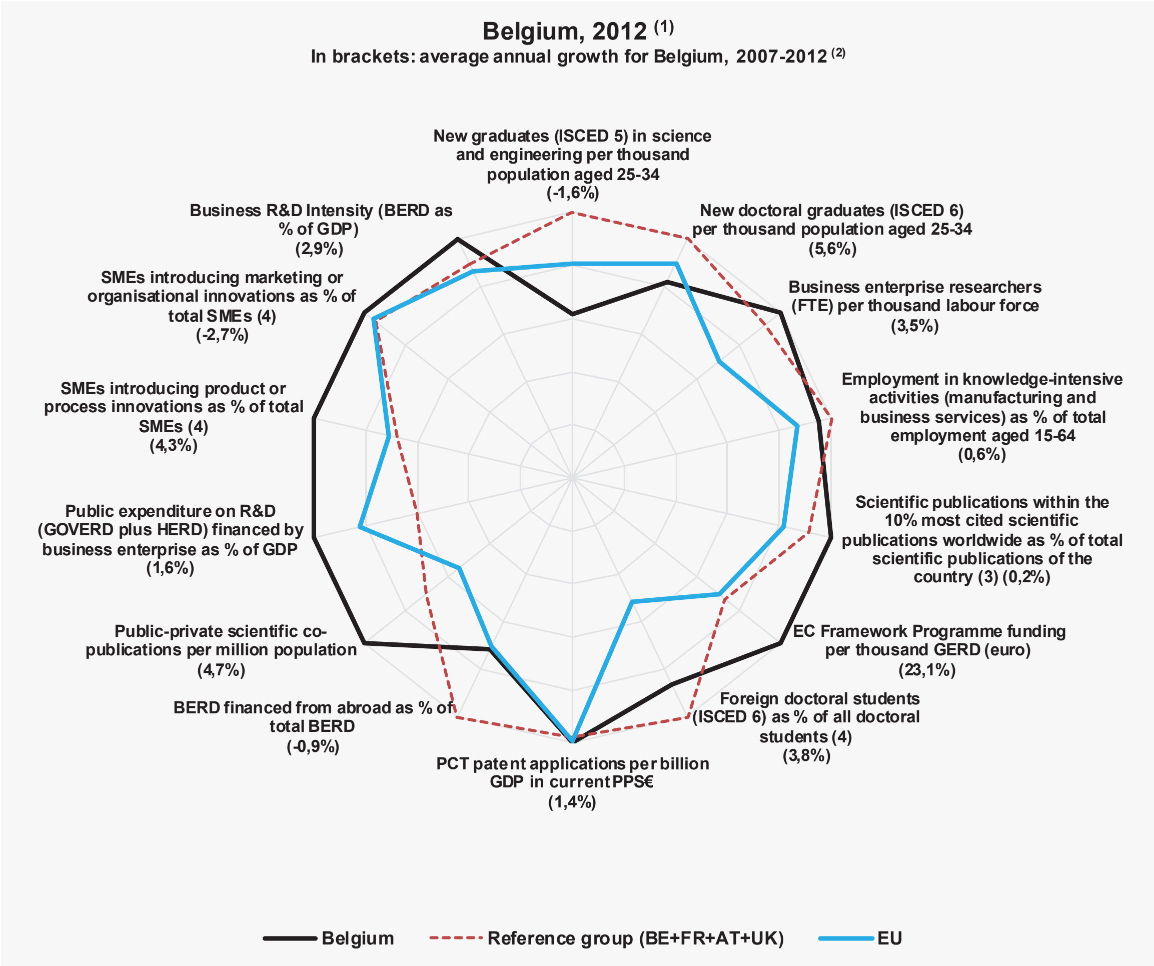
With reference to the breakdown of business R&D expenditure (BERD) by product fields, the increase in Belgian business R&D intensity since 2005 has been driven by the very strong growth of R&D expenditure related to pharmaceuticals (accounting for 31 % of BERD in 2011 vs. 25 % in 2005) and to services (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 288 million (14 % of the total) relate to RTDI[25].

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.



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.

[25] 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.

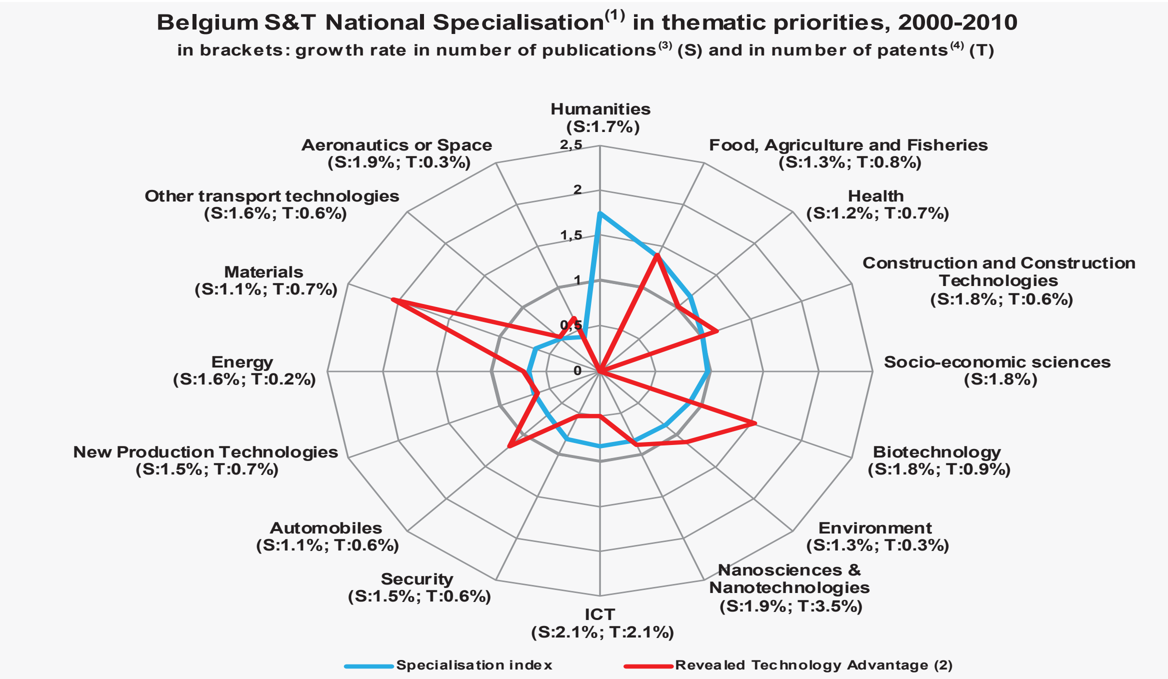
The overall shape of the graph highlights the strong performance of the Belgian research and innovation system. Belgium scores higher than the EU average for the vast majority of the indicators. In particular, it has a high-quality public research and higher education system, characterised by a strong 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[26], 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'[27] 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.

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.

[26] 13. 4 %, well above the EU average of 10. 9 % – this is the third best EU performance.
[27] Index calculated by Science-Metrix, based on the number of co-publications while taking into account the size of national scientific output.



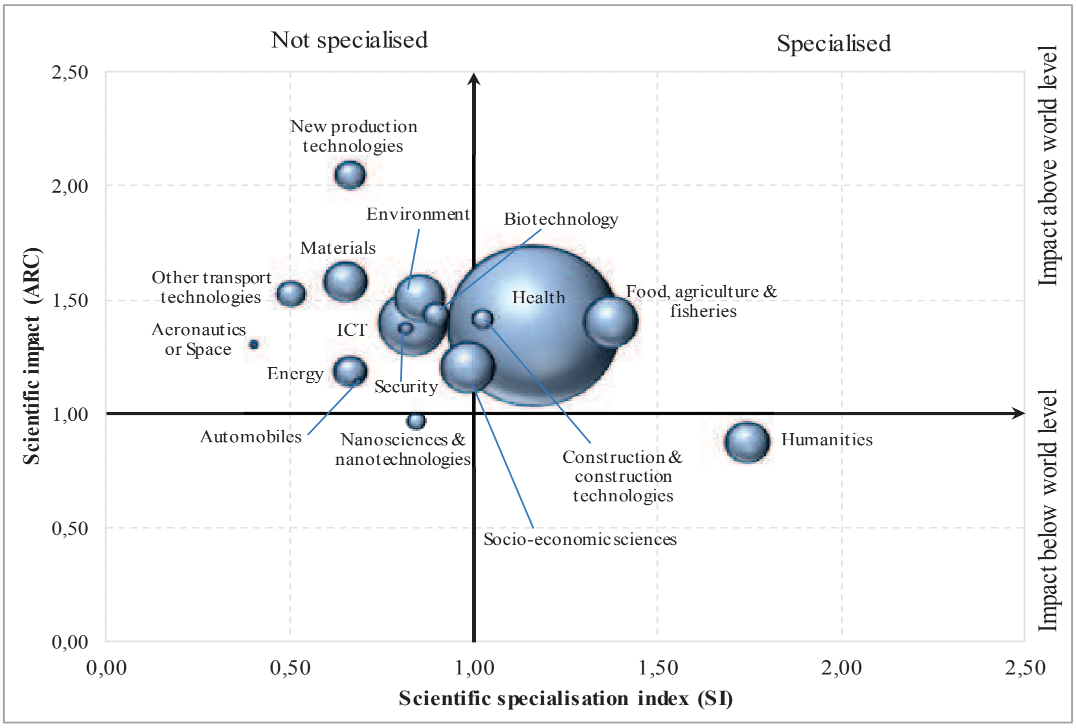
Source: DG Research and Innovation - Analysis and monitoring of national research policies
Data: Science Metrix - Canada, Univ. Bocconi - Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data corresponding 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.

The graph above shows Belgium's strong technological specialisations (as measured by the number of patents) in materials, biotechnology[28] 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.

[28] 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.

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



Source: DG Research and Innovation - Economic Analysis Unit

Data: Science Metrix - Canada, based on Scopus

Notes: Scientific specialisation include 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[29] 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.

[29] 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).

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.

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[30] 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.

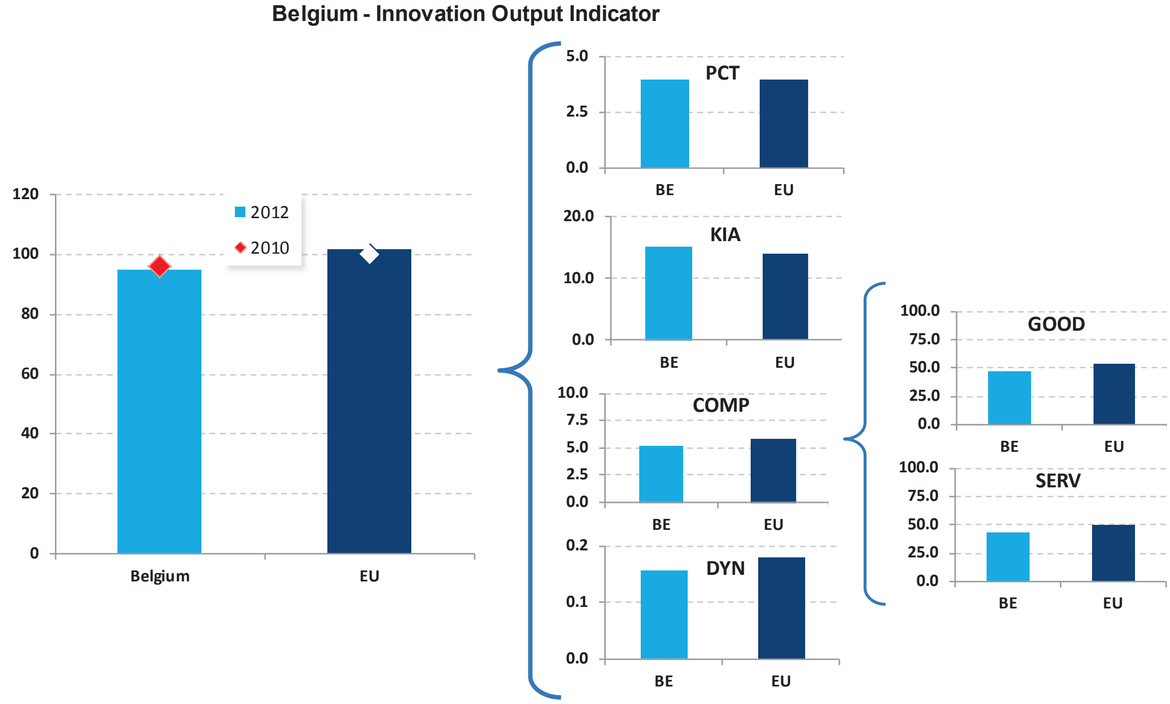
While budgetary efforts by all federated entities to support R&D led to an increase of GBAORD (government budget appropriations for research and development) of 23 % in real terms between 2005 and 2008, Belgian's GBAORD has stagnated since then (-4.5 % in real terms between 2008 and 2012). However, this has to be seen in the context of the development of powerful R&D tax

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

incentives[31] 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[32].

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:



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 %).

[31] Foregone tax revenues due to such incentives are not included in GBAORD.

[32] 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.

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.

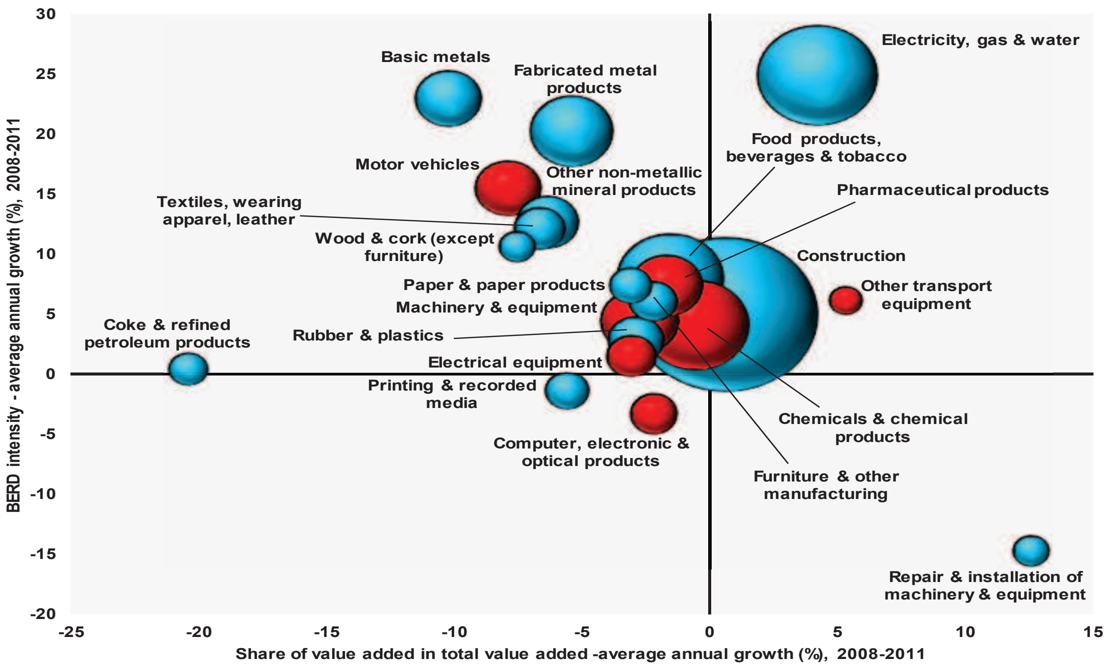
Its composite score is dragged down by its share of MHT exports and the share of knowledge-intensive services in services exports, which are both below the EU average. The latter is explained in particular by the high volume of exports in some logistics-, transport- and trade-related services, which 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 - Economic Analysis Unit
Data: Eurostat
Note: (1) High-Tech and Medium-High-Tech sectors (NACE Rev. 2 - 2 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[33]. 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.

[33] 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€	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€	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€	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 trainng (%)	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, 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 in 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*[34] 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*[35] 2012: 33.5 (EU: 51.2; US: 59.9) 2007-2012: +2.8 % (EU: +1.0 %; US: +0.5 %)
Areas of marked S&T specialisations: 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.

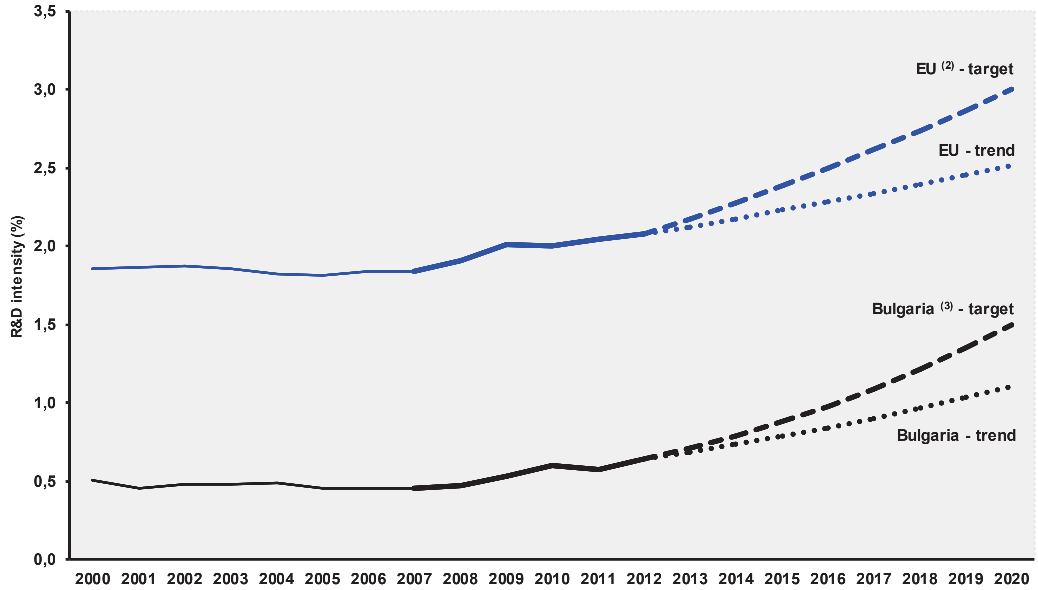
Bulgaria's research and innovation systems face serious challenges. Inefficiencies and fragmentation in the allocation of funds for R&I, coupled with insufficient and falling public funding, impede any build-up of R&I capacities in Bulgaria. Low salary levels and outdated research infrastructures fail 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.

[34] 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.
[35] Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

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.

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.

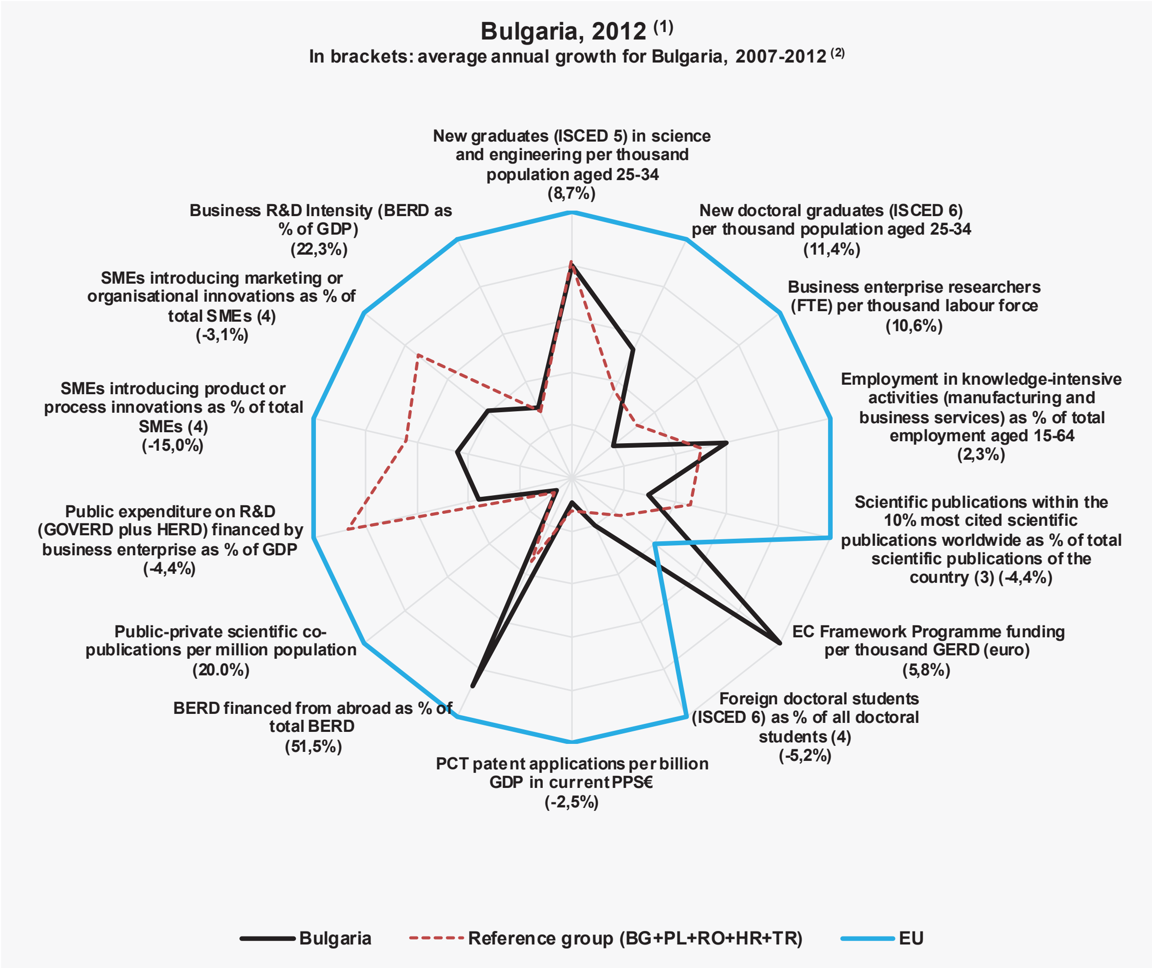
The share of R&D financed from abroad, which ranged from 5-8 % for the 2000-2009 period, increased to 43.9 % in 2011. Structural Funds are an important source of funding for research and innovation activities. However, of the EUR 6.7 billion of Structural Funds allocated to Bulgaria over the 2007-2013 programming period, only EUR 293 million (4.4 % of the total, which is the lowest share in the EU) relate to RTDI[36].

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.

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.

[36] 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.



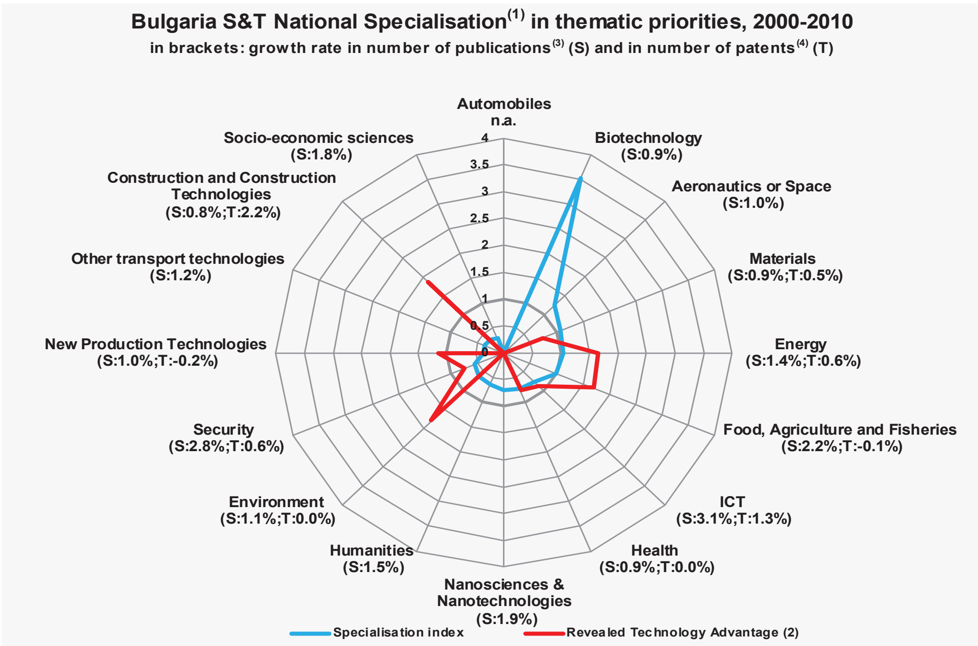
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates 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.



Source: DG Research and Innovation - Analysis and monitoring of national research policies
Data: Science Metrix - Canada, Univ. Bocconi - 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 WIPO-PCT 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.

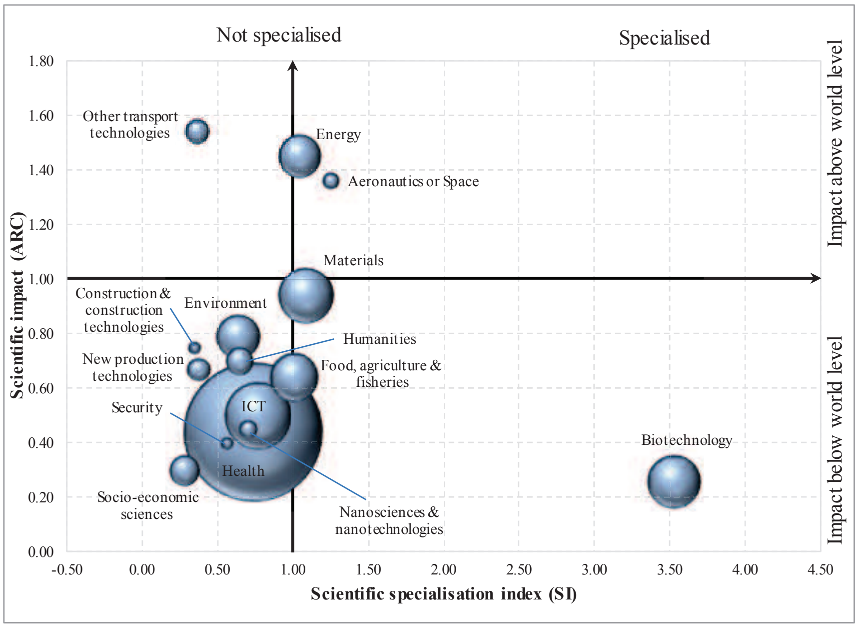
According to the RTA definition and the FP thematic classification, Bulgaria demonstrates RTA in construction and construction technologies; environment (highest participation rate of national researchers/companies in FP7); new production technologies; food, agriculture and fisheries; energy; and ICT, 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.

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



Source: DG Research and Innovation - Analysis and monitoring of national research policies unit

Data: Science Metrix - Canada, based on Scopus

Notes: Scientific specialisation include 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.

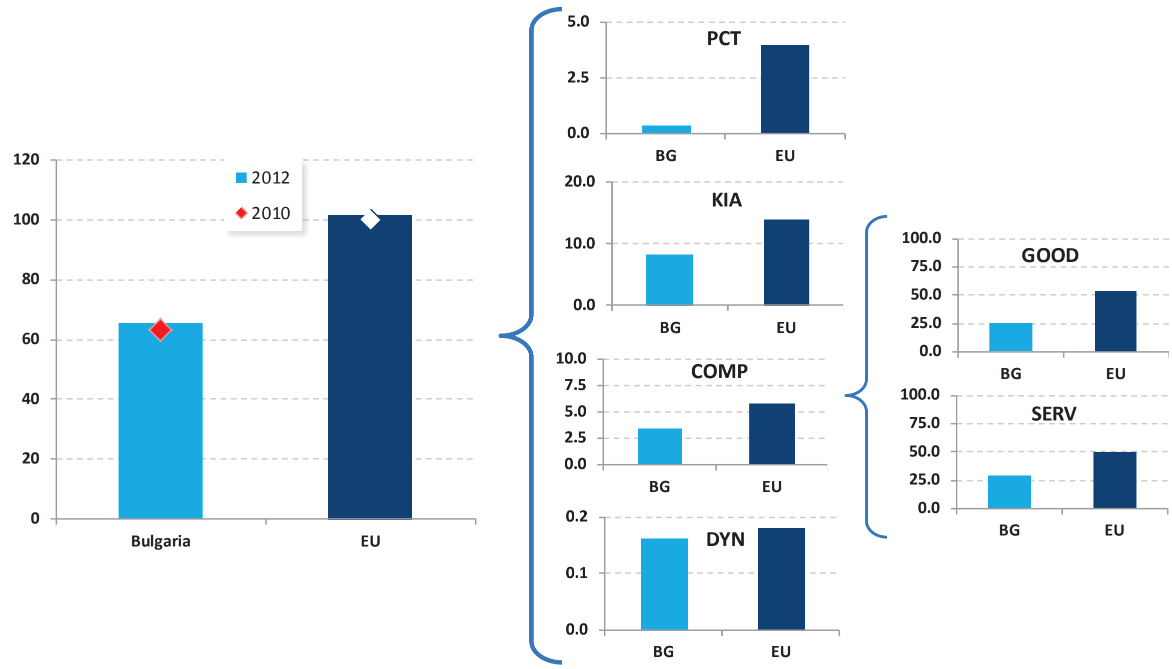
Bulgarian legislation on intellectual property is in line with EU directives, but it has failed to spur indigenous innovative activity due to problems with enforcement and the capacity of the judiciary.

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, w hich refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in know ledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-grow th enterprises (employment-w eighted average).
COMP = Combination of sub-components GOOD and SERV, using equal w eights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Know ledge-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[37]. 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

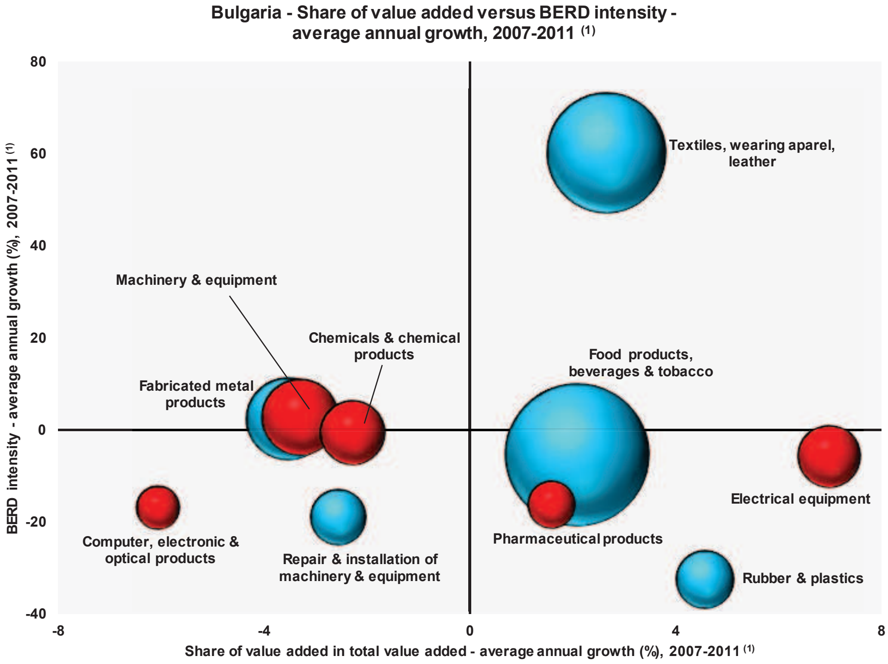
[37] As regards other IPR-related innovation outputs, such as Community trademarks and designs, Bulgaria performs near the EU average, if measured per unit of GDP, and at about half the EU level, if measured on a per-capita basis.

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. 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.



Source: DG Research and Innovation - Analysis and monitoring of national research policies unit
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 - 2 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[38]. 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 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.

[38] Source: Innovation Union Competitiveness report 2013.

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€	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€	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€	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 trainng (%)	:	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, 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*[39] 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*[40] 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.

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[39] 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.
[40] Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation 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.

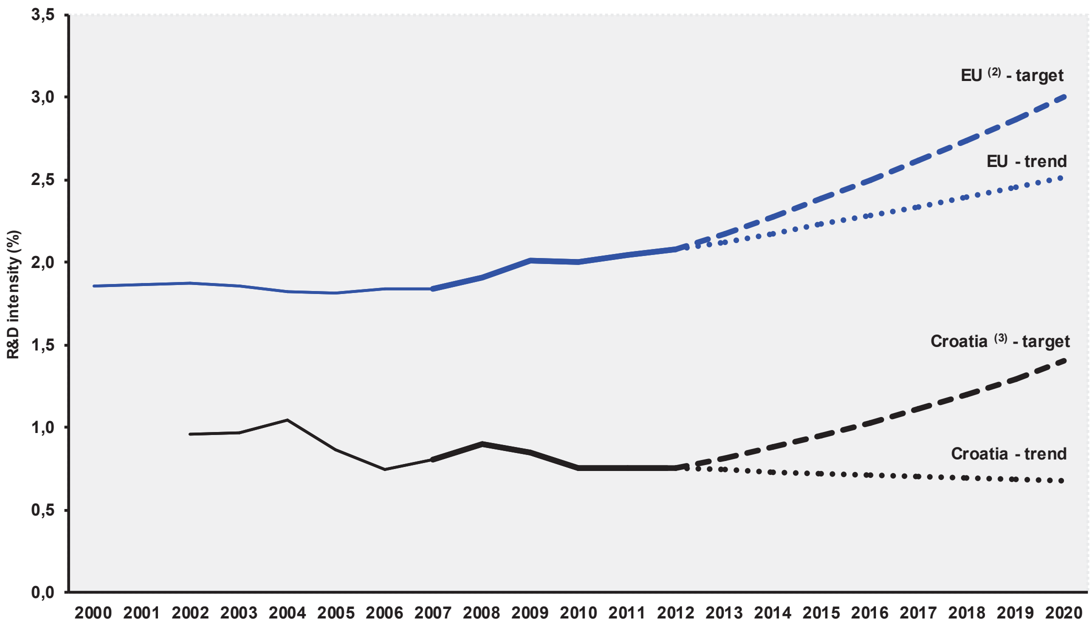
Although the new government, elected in November 2011, has started significant economic reforms and has taken initiatives to spur competitiveness and growth, Croatia is lagging behind on important issues such as protection of investment in order to stimulate private investment; decrease of regulatory 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.

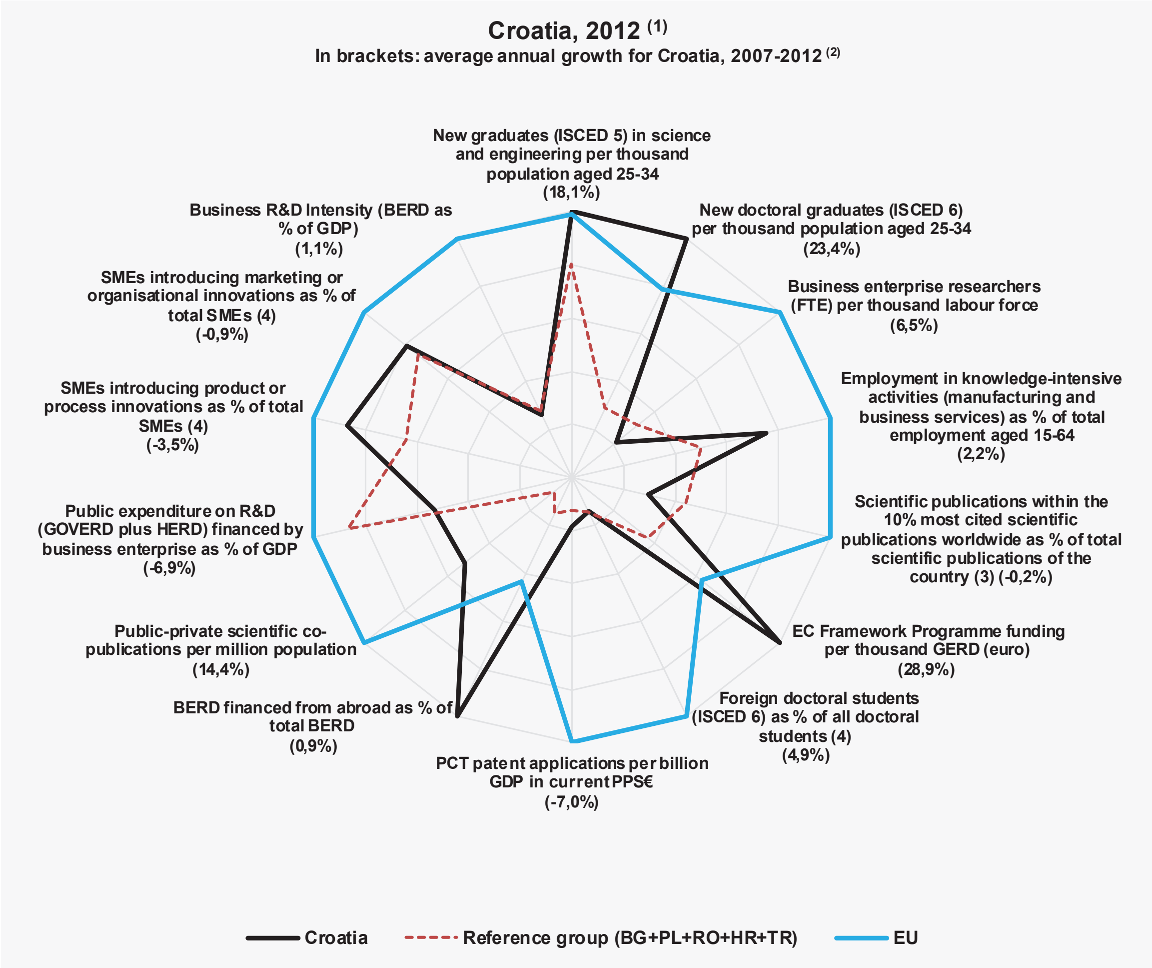
As a Candidate and later Accession Country, Croatia was able to deploy substantial funding (in the order of EUR 24 million) in support of its R&I capacity under the Pre-Accession Instrument (IPA) and, for the last six months of 2013, under the European Regional Development Fund. Combined with a loan 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.



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[41], 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

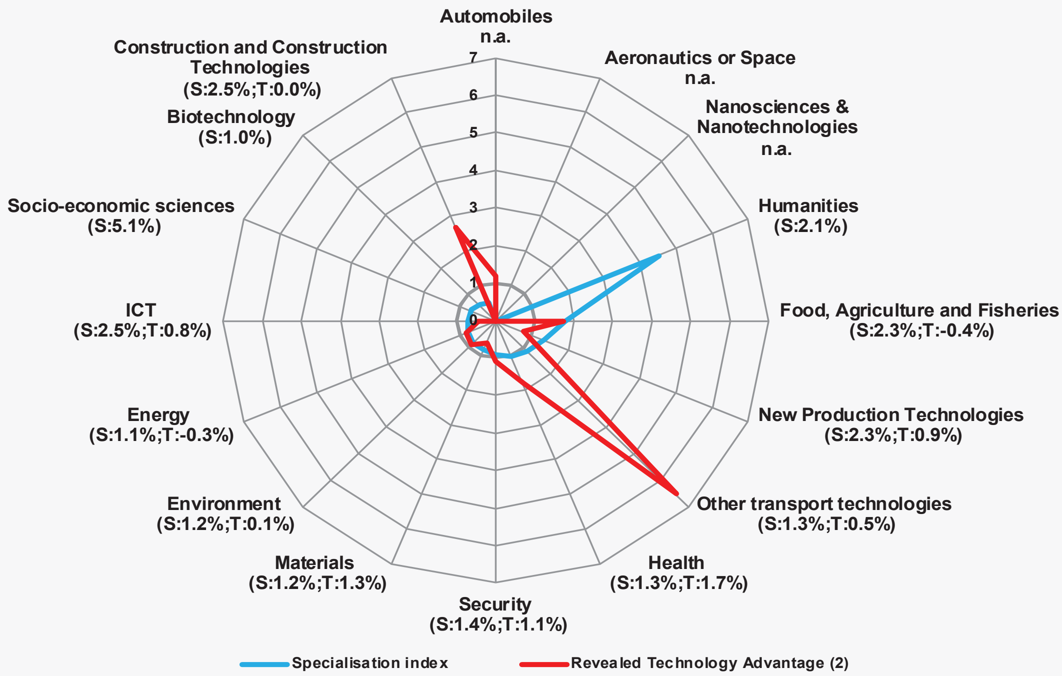
The graph below illustrates the areas, based on the Framework Programme thematic priorities, where Croatia shows scientific and technological specialisations. Both the specialisation index (SI, based on the number of publications) and the revealed technological advantage (RTA, based on the number of 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.

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

10

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 - Analysis and monitoring of national research policies
Data: Science Metrix - Canada, Univ. Bocconi - 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 WIPO-PCT 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.

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.

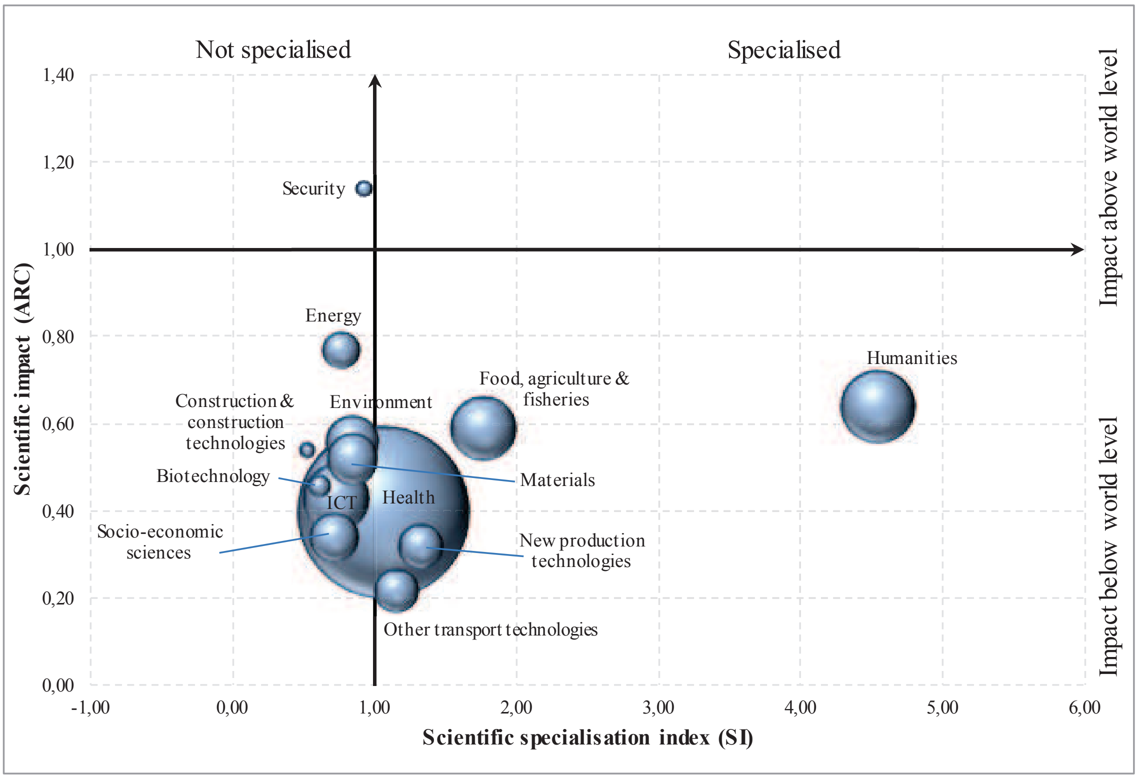
The lack of specialisation also reflects the funding policy in Croatia which does not highlight thematic areas or set national priorities but is based on a horizontal approach. One of the objectives of the announced national strategy for science is precisely to set priorities.

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.

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



Source: DG Research and Innovation - Analysis and monitoring of national research policies unit

Data: Science Metrix - Canada, based on Scopus

Notes: Scientific specialisation include 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

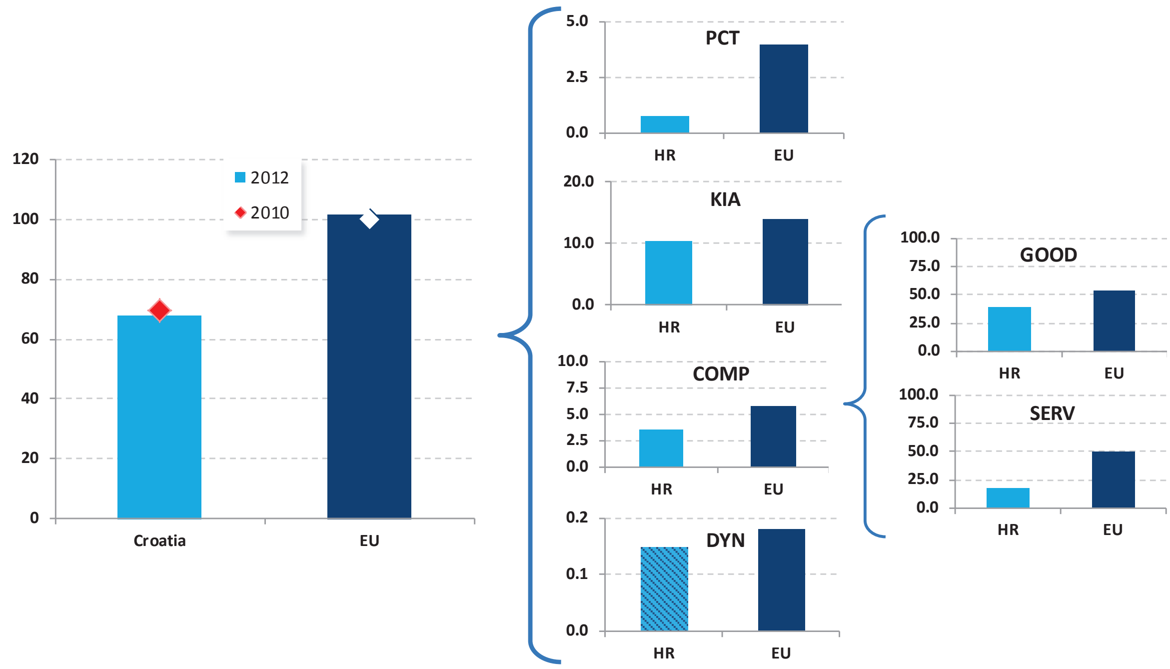
April 2014, the adoption of a Roadmap on Infrastructures according to the European Strategic Forum on Research Infrastructures (ESFRI) is to be welcomed.

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, w hich refer to 2010.
PCT = Number of PCT patent applications per billion GDP, PPS.
KIA = Employment in know ledge-intensive activities in business industries as % of total employment.
DYN = Innovativeness of high-grow th enterprises (employment-w eighted average); estimated value.
COMP = Combination of sub-components GOOD and SERV, using equal w eights.
GOOD = High-tech and medium-high-tech products exports as % total exports. EU value refers to EU-28 average (extra-EU = 59.7 %).
SERV = Know ledge-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[42]. 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.

[42] 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€	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	0.7	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€	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€	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 trainng (%)	:	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*[43] 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*[44] 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

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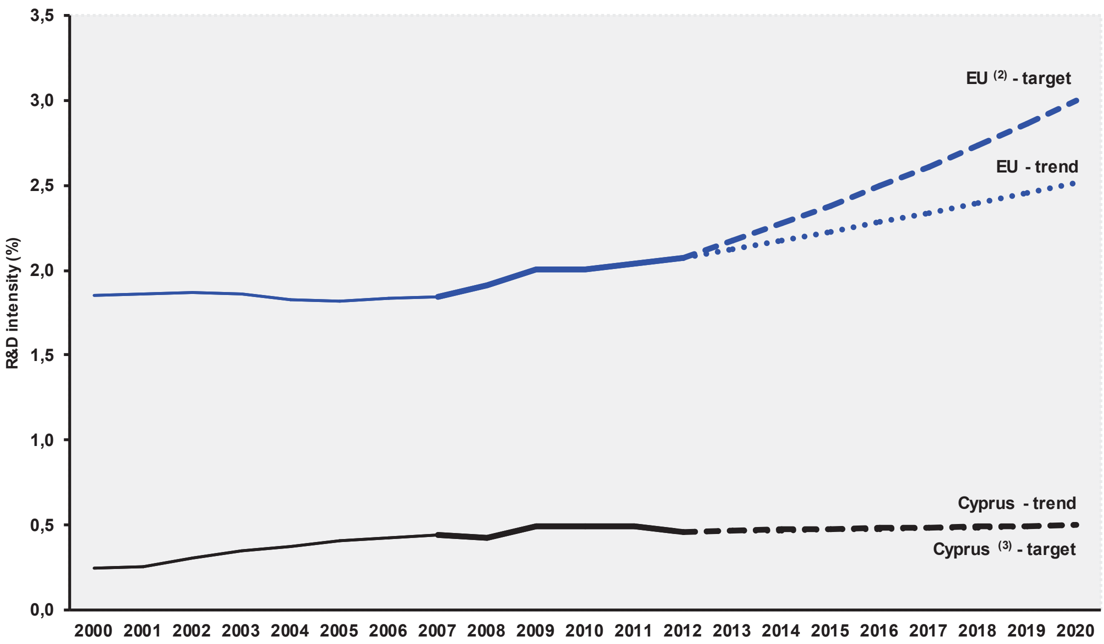
[43] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.

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

imposed as part of the country's economic adjustment programme. At the same time, opportunities could be created by following 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[45]. 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 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.

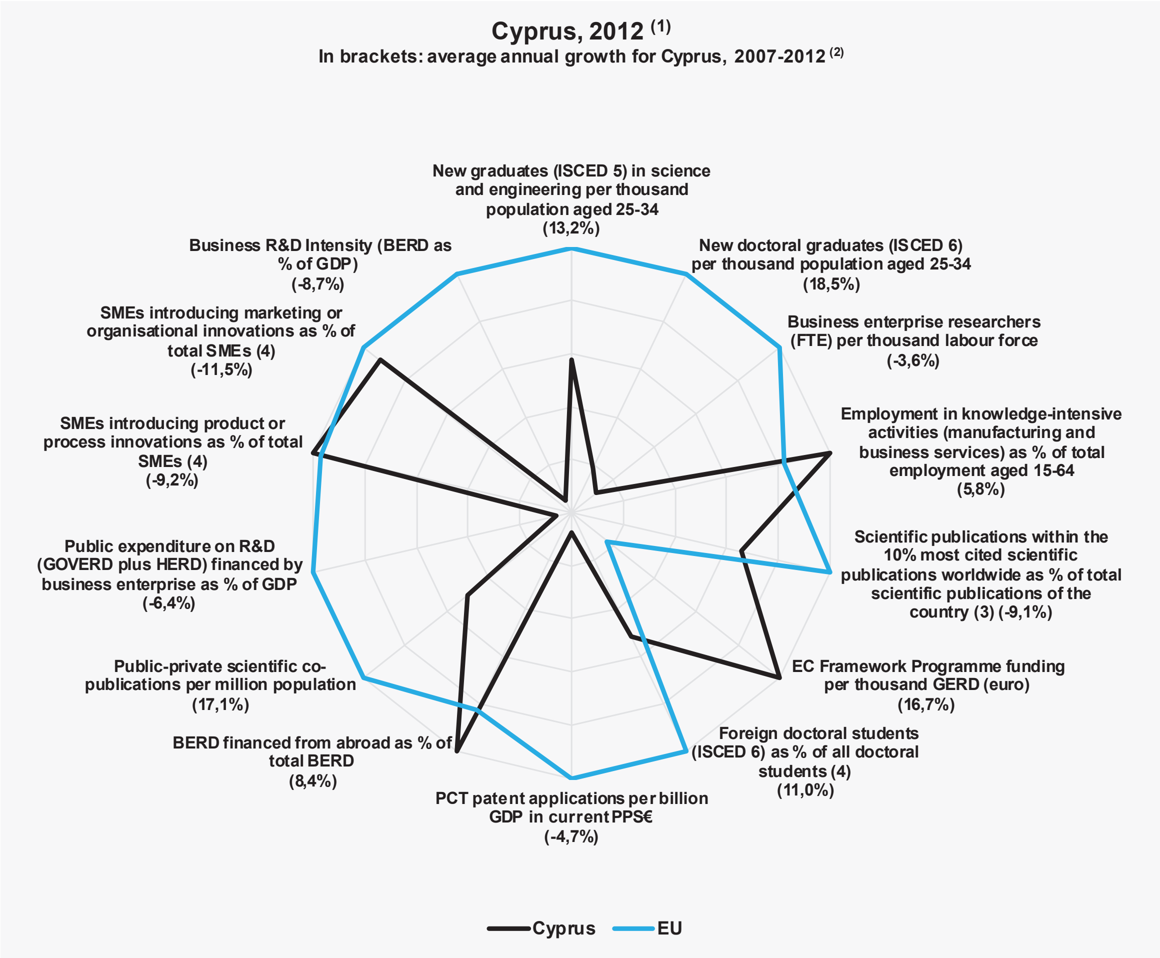
The main source of external funding for R&I in Cyprus has been the EU's Seventh Framework Programme for Research and Technological Development (FP7). Until March 2014, 435 participants from Cyprus benefited from FP7, benefitting from a total of EUR 87.8 million, with around one-third of that funding 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.

[45] 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.



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.

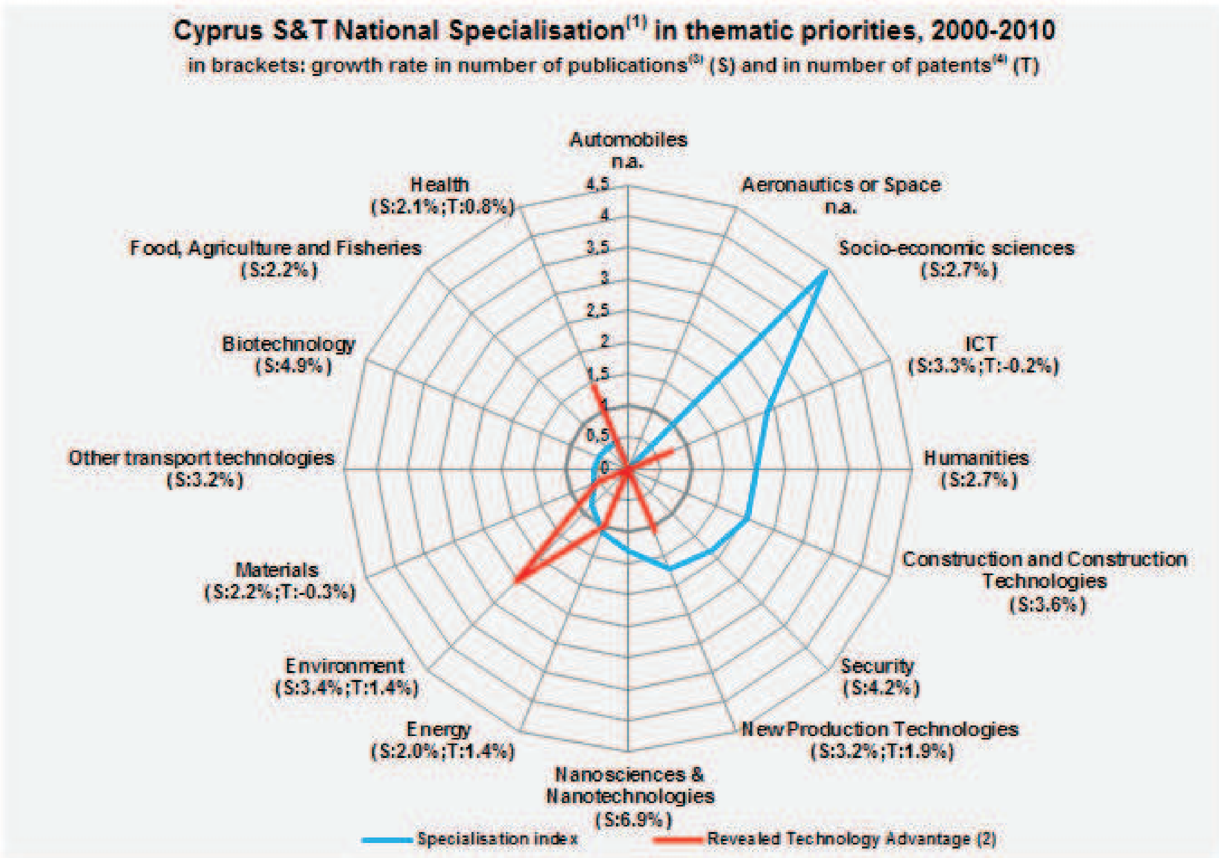
(4) EU does not include EL.

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.



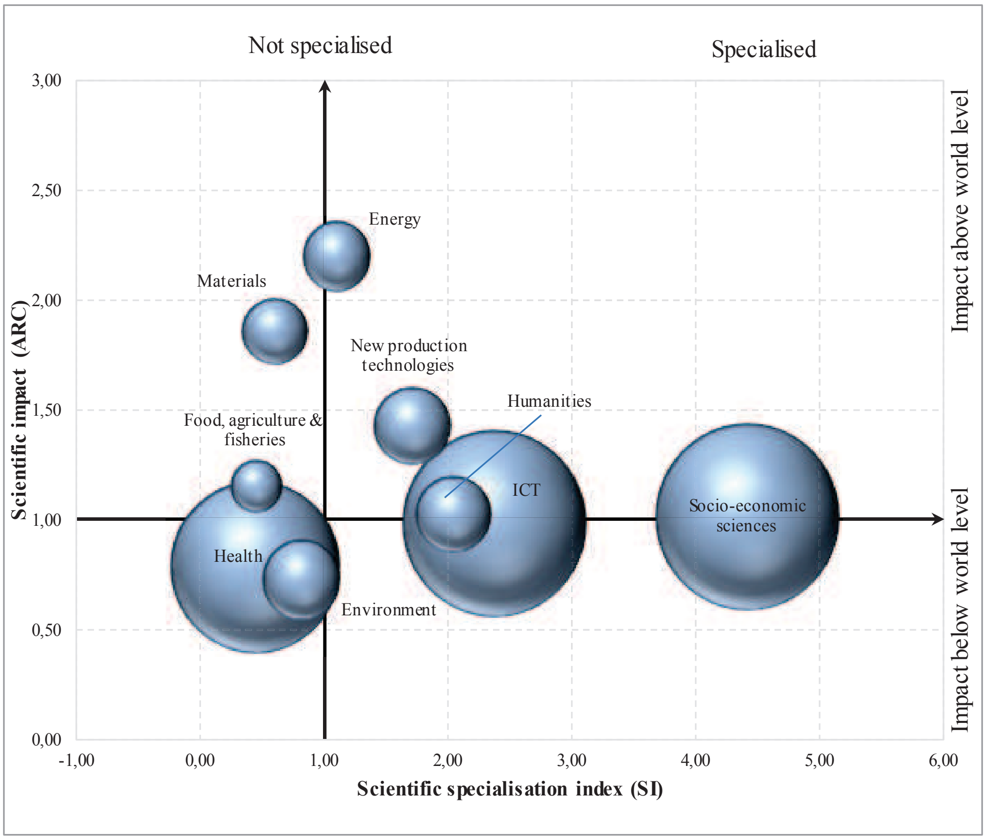
Source: DG Research and Innovation - Analysis and monitoring of national research policies
Data: Science Metrix - Canada, Univ. Bocconi - Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data corresponding 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.

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.

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



Source: DG Research and Innovation - Analysis and monitoring of national research policies unit

Data: Science Metrix - Canada, based on Scopus

Notes: Scientific specialisation include 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.

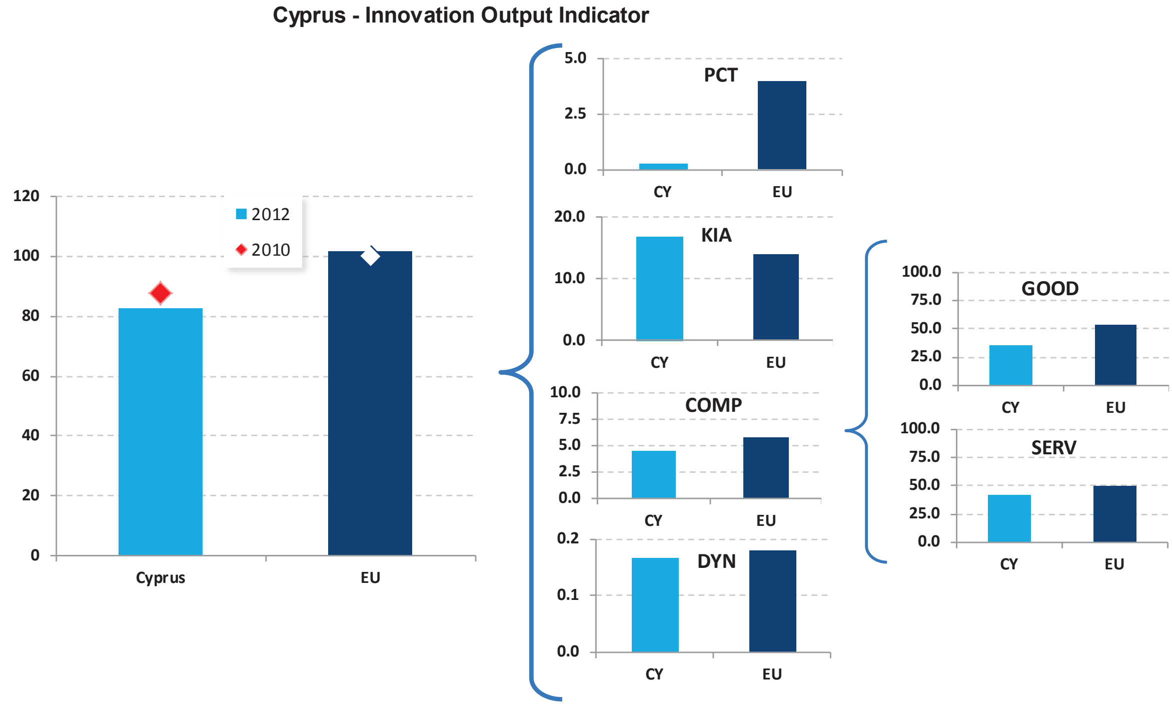
Furthermore, the Smart Specialisation Strategy for R&I, an *ex-ante* conditionality for the use of European Structural and Investment Funds (ESIF) for R&I in Cyprus is expected to be finalised in spring 2014. The sectors identified through this process are: tourism, energy, construction, shipping, health,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



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.

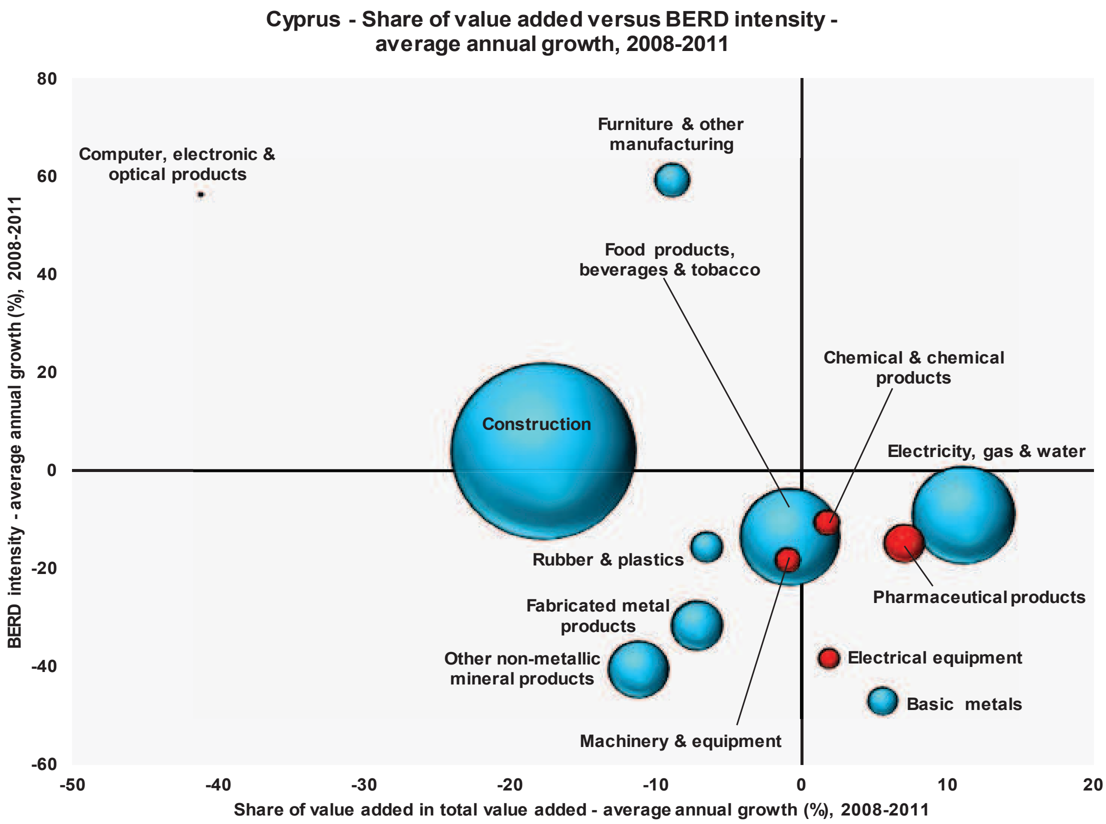
Low performance in patents is linked to the country's economic structure with a very small capital goods sector and a lack of large manufacturing companies, which typically show high patenting activities when headquartered in the respective country and if linked to a well-performing research system.

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.



Source: DG Research and Innovation - Analysis and monitoring of national research policies unit
Data: Eurostat
Note: (1) High-Tech and Medium-High-Tech sectors (NACE Rev. 2 - 2 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€	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€	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€	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 trainng (%)	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.

The 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*[46] 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*[47] 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

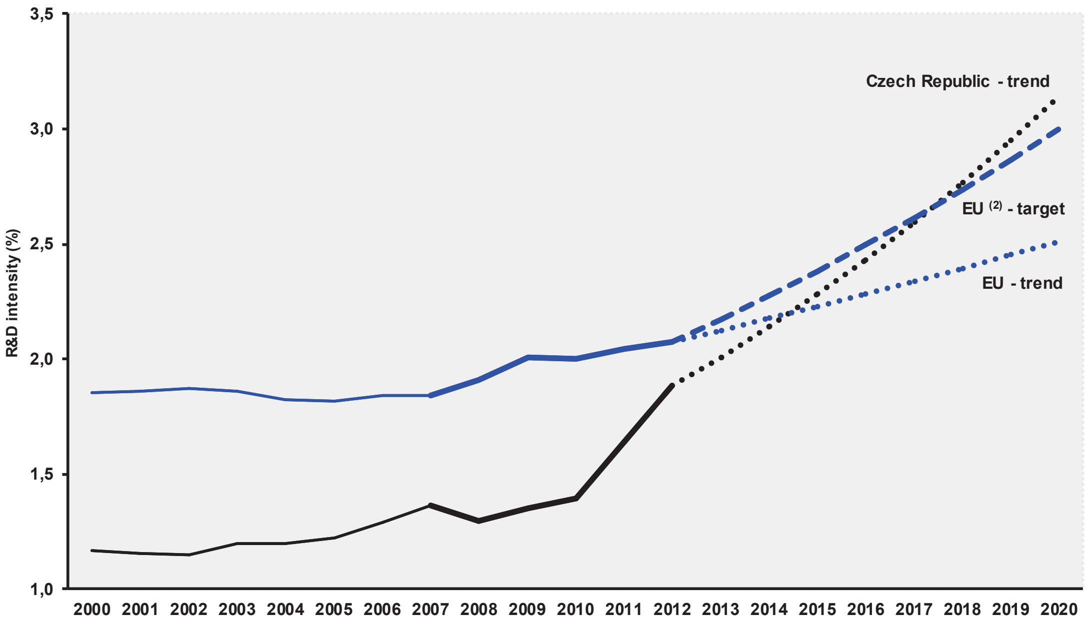
[46] Composite indicator that includes PCT per population, ERC grants per public R&D, top universities and research institutes per GERD and highly cited publications per total publications.
[47] Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.

emergence and development of domestic innovation leaders actively supported by public research institutions.

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.

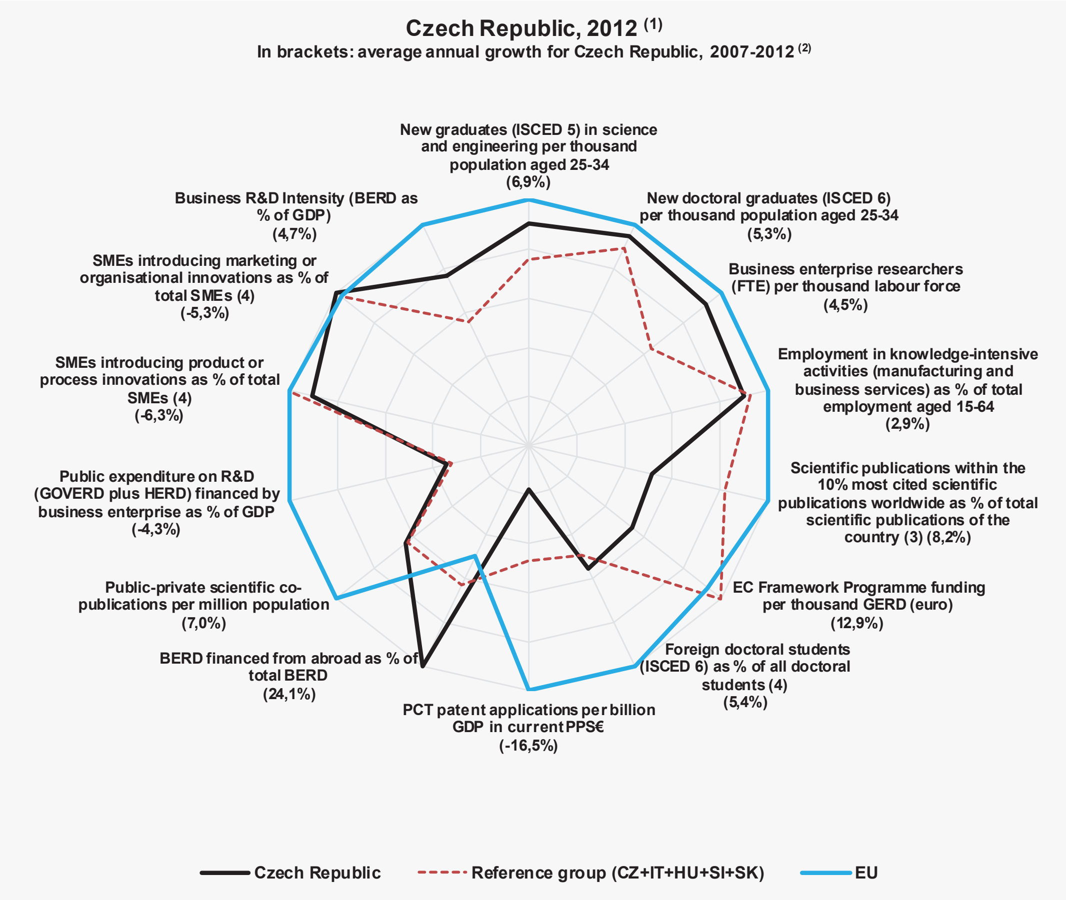
About EUR 4.1 billion of Structural Funds were earmarked for RTDI[48] in the Czech Republic in the programming period 2007-2013 (representing 15.5 % of the total). Around 84 % of these funds had been absorbed by August 2013. Structural Funds are therefore one of the largest sources of public funding 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 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.

[48] 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 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.



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[49] 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 scientific co-publications has surged over the last decade, in particular in partnerships with Germany, the United Kingdom, France, Italy and Slovakia.

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

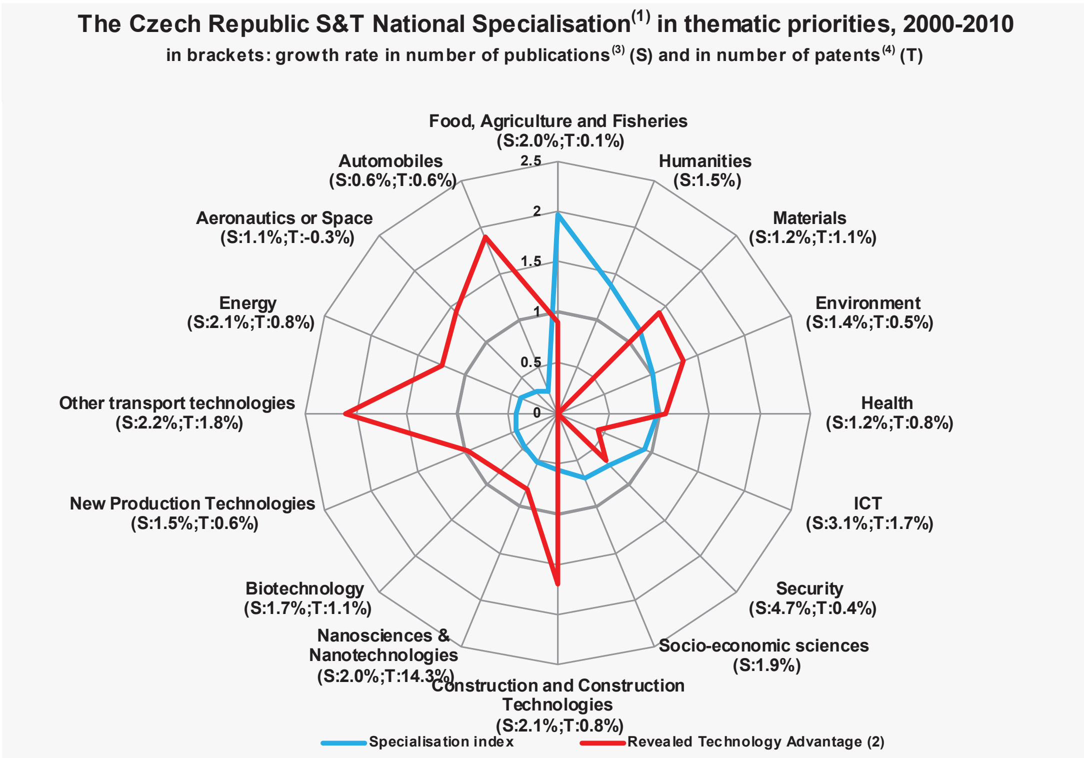
In addition, the success rate of Czech entities in FP7 (20.56 %) is approaching the EU average (22 %), which is evidence of enhanced scientific quality and networking within the ERA. However, Czech participants in FP7 still receive a share of the total EC funding (0.67 %) which is markedly lower than 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[50].

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.



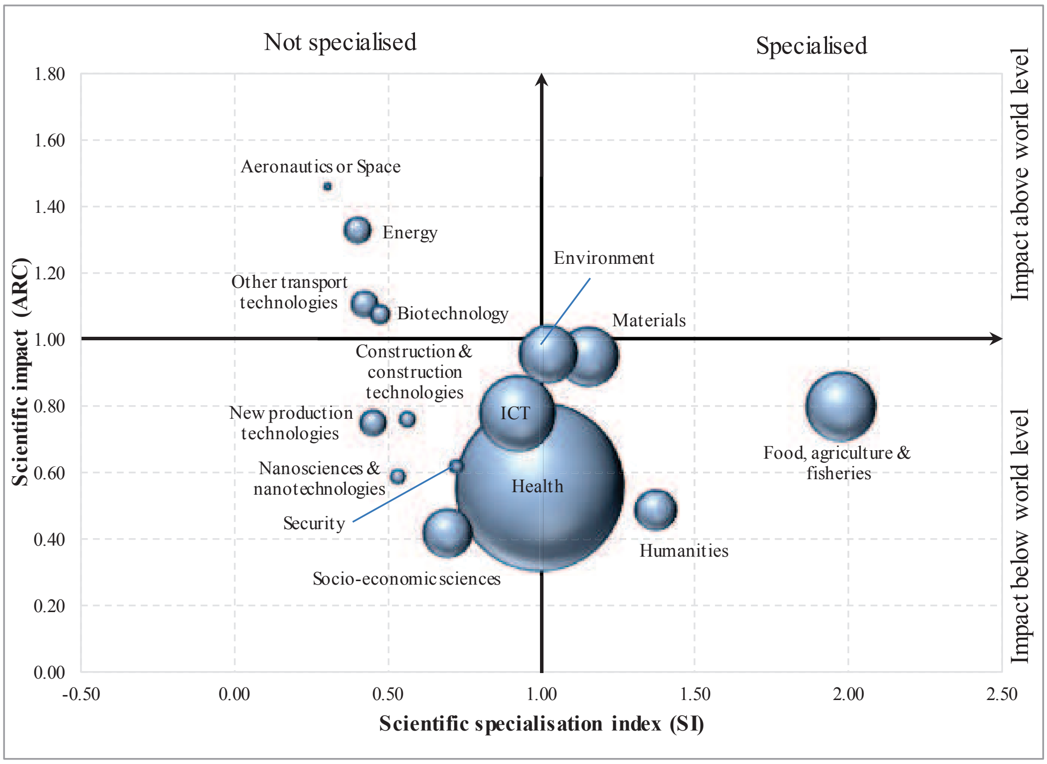
Source: DG Research and Innovation - Analysis and monitoring of national research policies
Data: Science Metrix - Canada, Univ. Bocconi - Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data corresponding to the WIPO-PCT 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.

[50] 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.

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



Source: DG Research and Innovation - Analysis and monitoring of national research policies unit

Data: Science Metrix - Canada, based on Scopus

Notes: Scientific specialisation include 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[51]. 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

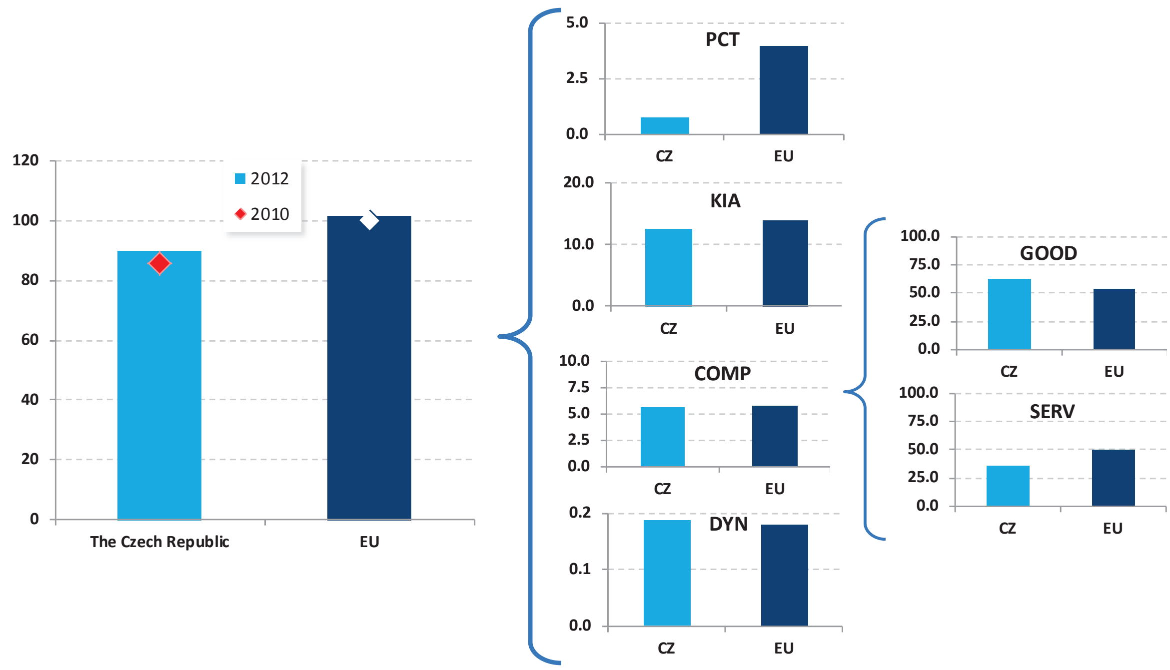
[51] As part of the Czech Republic International Competitiveness Strategy for 2012-2020.

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.

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.

The 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.

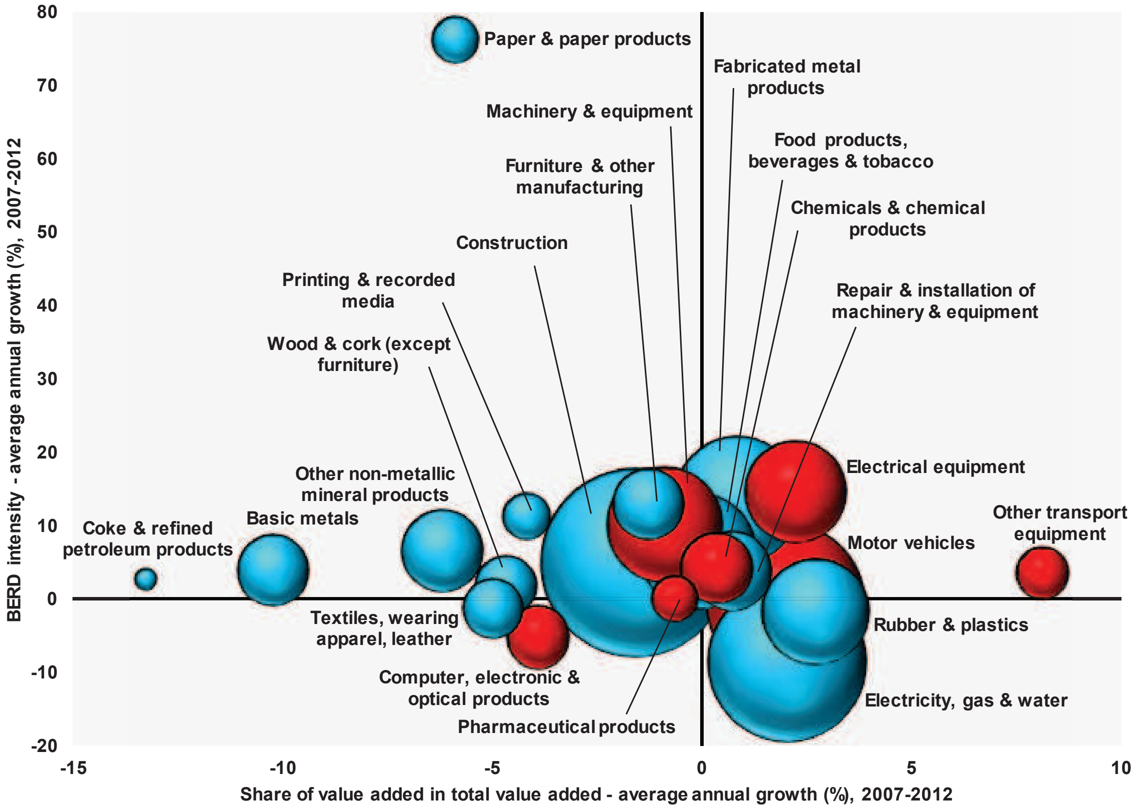
Even compared to other Central and Eastern European countries, the Czech Republic has a very low level of patenting activity relative to GDP. A large part of the innovative economy, especially the automobile sector, is foreign owned and research and patenting is mostly done in the headquarter countries of these multinational companies[52]. 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.

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

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



Source: DG Research and Innovation - Analysis and monitoring of national research policies unit
Data: Eurostat
Note: (1) High-Tech and Medium-High-Tech sectors (NACE Rev. 2 - 2 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[53].

[53] 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€	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€	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€	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 trainng (%)	:	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, 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 in 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*[54] 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*[55] 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[56]. 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.

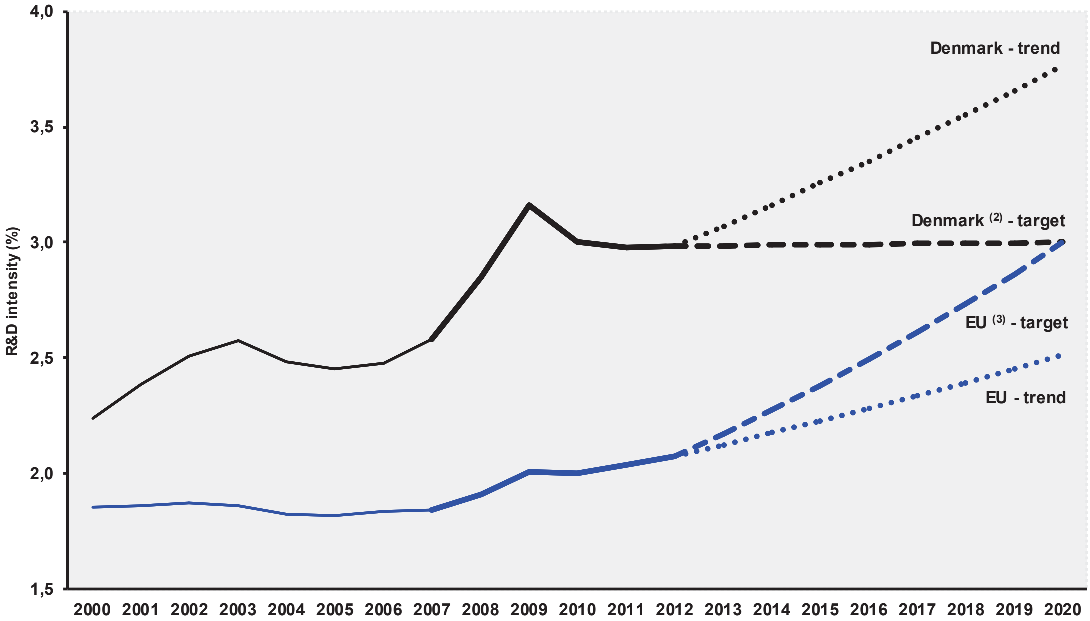
In December 2013, the Productivity Commission issued a report on education and innovation. As regards innovation, the report puts forward the idea that the greatest potential for increasing the return on public research effort is probably in raising the quality of training. It also stresses that an important

[54] 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.
[55] Composite indicator that includes R&D, skills, sectoral specialisation, international specialisation and internationalisation sub-indicators.
[56] Measured as change in GDP per person employed.

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 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 European country to reach this level, after Finland and Sweden in 2011.

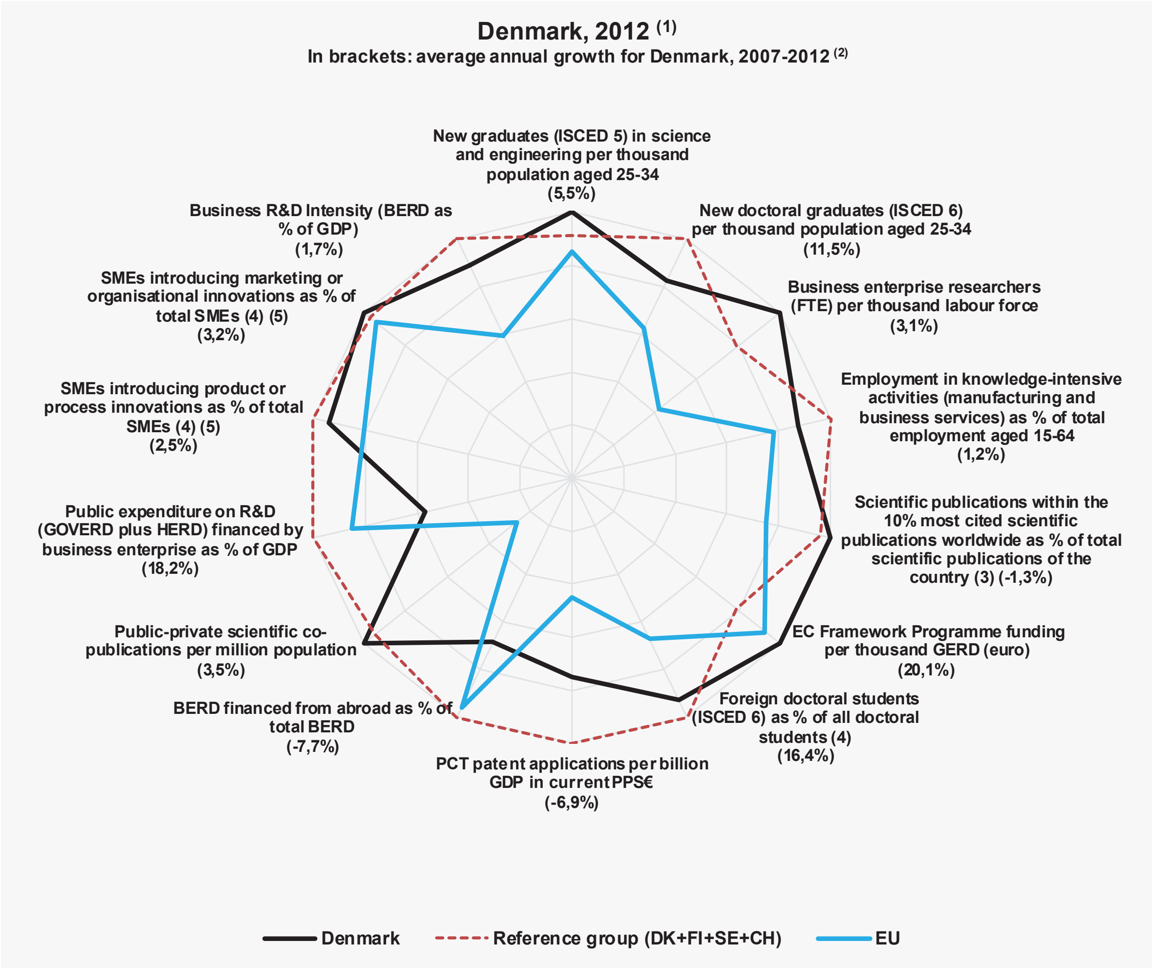
Over the last decade, business R&D intensity has increased in Denmark to reach the US level. Having reached its peak in 2009-2010, business expenditure on R&D has declined slightly since 2011 (2.01 % in 2010; 1.96 % in 2012), but remains at the third highest level in the EU. Denmark is behind Finland 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[57]. Almost 2616 partners from Denmark have been participating in FP7, receiving financial contributions of over EUR 952 million from the European Commission.

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.

[57] 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.



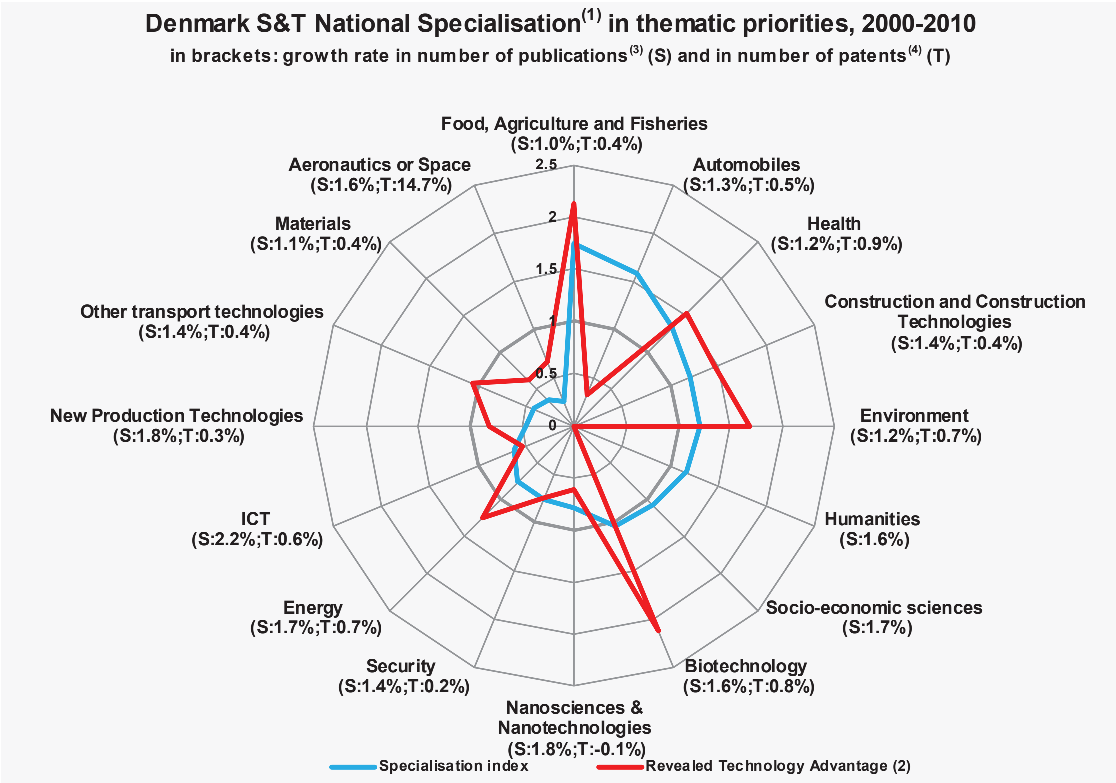
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research Policies
Data: DG Research and Innovation, Eurostat, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard
Notes: (1) The values refer to 2012 or to the latest available year.
(2) Growth rates 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.



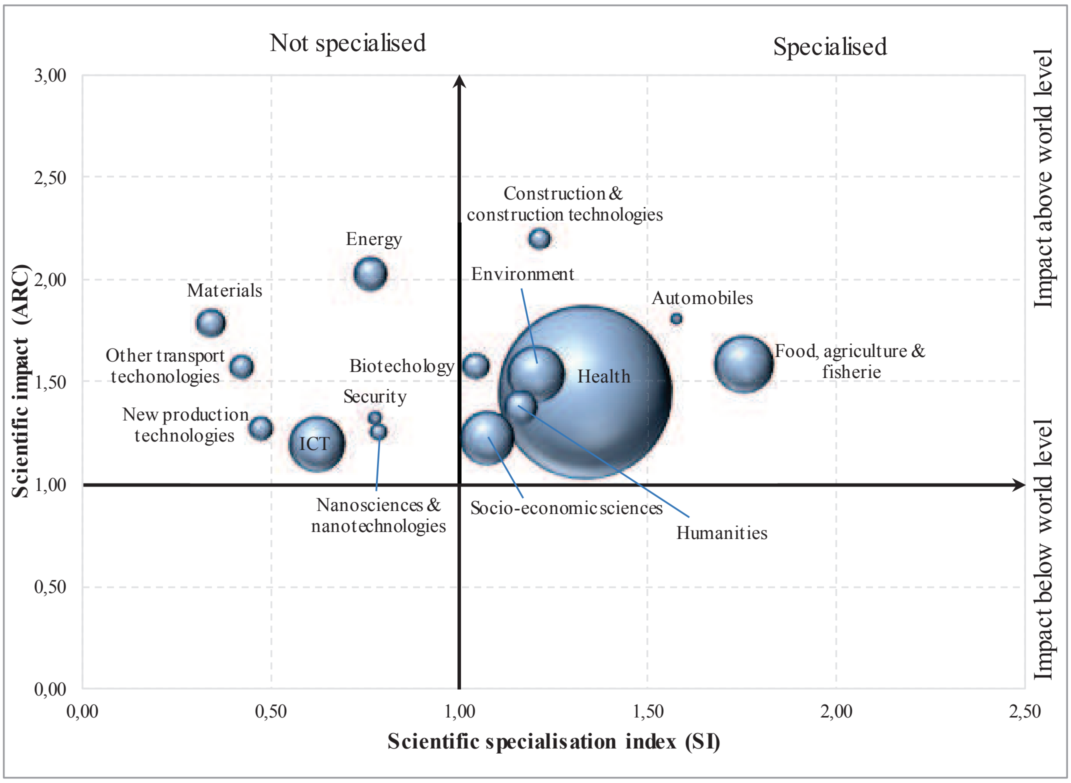
Source: DG Research and Innovation - Analysis and monitoring of national research policies
Data: Science Metrix - Canada, Univ. Bocconi - Italy
Notes: (1) Values over 1 show specialisation, under 1 lack of specialisation.
(2) The Revealed Technology Advantage is calculated based on the data corresponding to the WIPO-PCT 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.

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.

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



Source: DG Research and Innovation - Economic Analysis Unit

Data: Science Metrix - Canada, based on Scopus

Notes: Scientific specialisation include 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.

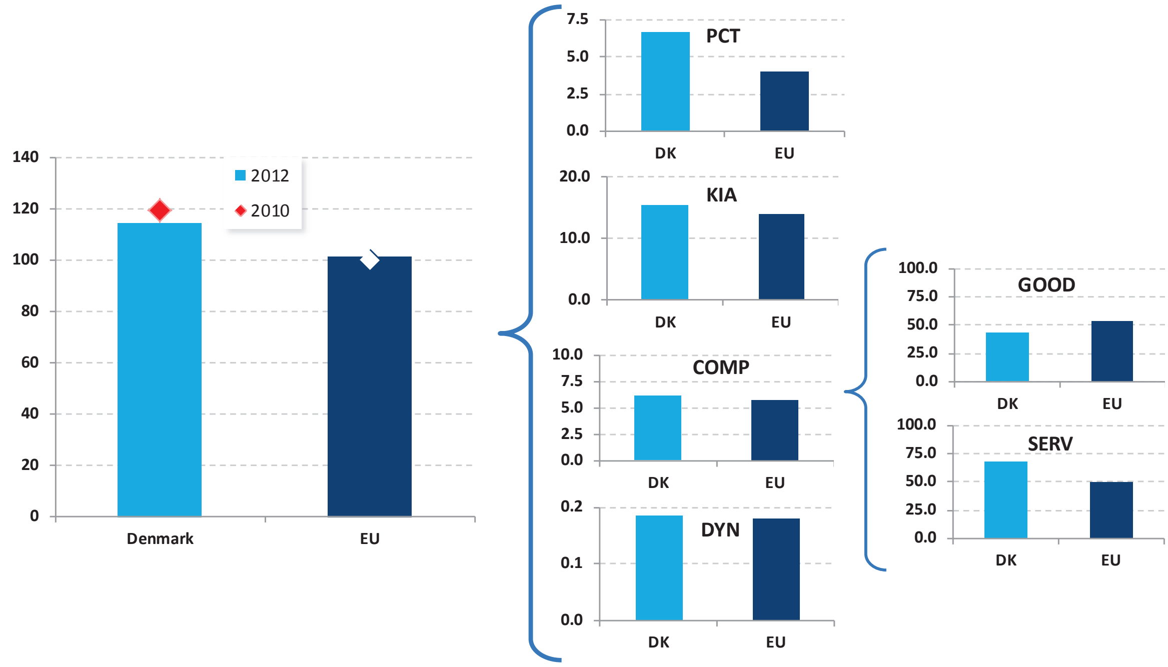
With reference to the new innovation strategy, the Danish government started a process that led to the creation of the first INNO+ catalogue presented in September 2013. Based on the involvement of a multitude of actors from the innovation system, INNO+ defines 21 concrete areas for research and innovation 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.

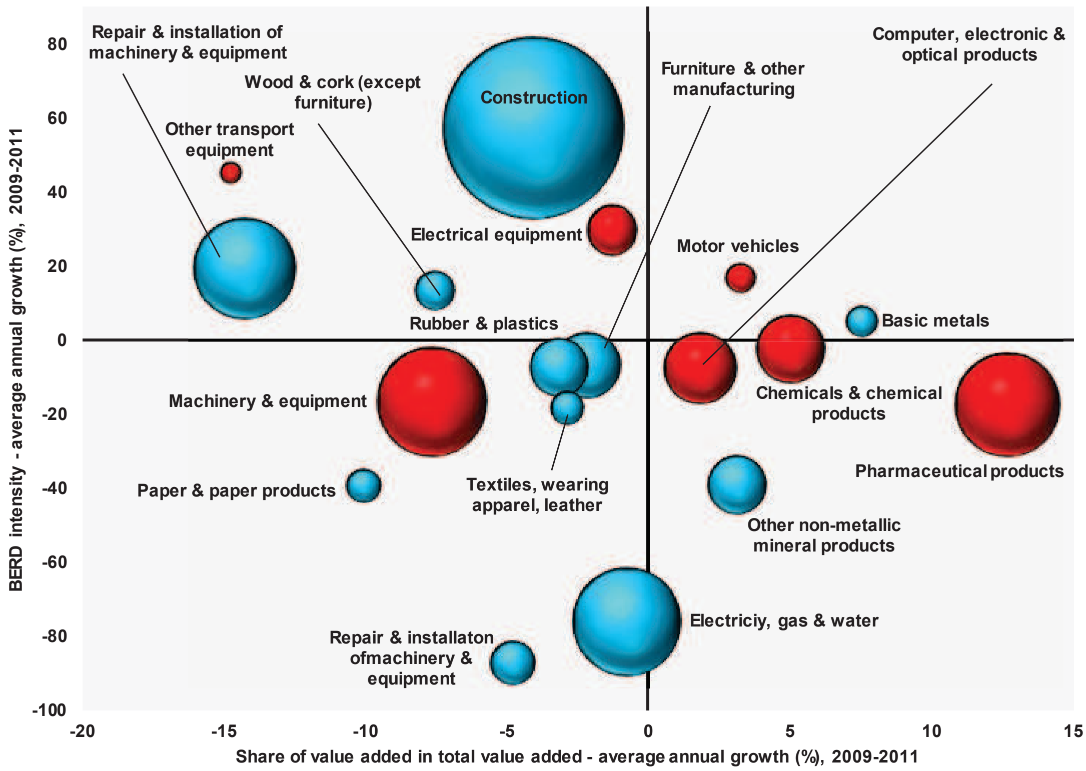
The poor performance in the contribution of high-tech and medium-high-tech goods to the trade balance is explained by the high level of exports of agricultural products (notably pork and dairy products) and, to a lesser extent, mineral fuels.

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 - Analysis and monitoring of national research policies unit
Data: Eurostat
Note: (1) High-Tech and Medium-High-Tech sectors (NACE Rev. 2 - 2 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€	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€	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€	1.87	2.33	1.98	1.88	1.45	1.31	:	:	:	-16.6	0.53	1
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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 trainng (%)	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, 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.