An Analysis of the Portuguese Research and Innovation System

Challenges, strengths and weaknesses towards 2020

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

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Title **An Analysis of the Portuguese Research and Innovation System: Challenges, strengths and weaknesses towards 2020**

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Opening Remarks

As the national funding agency for science and technology, the Fundação para a Ciência e a Tecnologia (FCT) is a key actor in the national Research and Innovation System (R&I). It is currently the main source of funding not only for the public research sector, but also for the most basic and strategic forms of R&I activities in the business sector. The FCT also plays a crucial role in promoting the visibility and integration of national science into the European Research Area, while also contributing to the formulation of policies and programmes at European and transnational levels, and with the countries with which we have agreements. These crucial functions of the FCT are supported by the quality and professionalism of its staff, the ample coverage and remit of its work and the active role it plays in constructing both European and transnational R&D policy agendas. This work builds on the collective efforts of several decades, while adapting it to the current needs of the system.

It is in this context that our vision for the FCT includes a return to a once prominent role as an organiser of forums for collective discussion of national strategies for research and innovation. Additionally the FCT embraces the challenge of defining future directions, together with the scientific and business communities and, as of now, with the national and regional organisations responsible for the formulation and implementation of research and innovation policies. This report is the first small step in that direction, helping to provide the foundations for a productive dialogue between all the relevant actors. This work encourages increased strategic collaboration and interconnection across key players in the run up to 2020, building upon an R&D and innovation system growing in strength and competitiveness at an international level.

Miguel Seabra
President of the Fundação para a Ciência e a Tecnologia (FCT)
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Executive Summary

An Analysis of the Portuguese Research and Innovation System as part of a Strategy for Smart Specialisation for Portugal and its Regions

This work presents an Analysis of the National Research and Innovation System (NRIS), with a view to helping define a Smart Specialisation Strategy for the country and its regions in a more general way. The analysis carried out was driven by the need to provide a supporting basis for the Strategy given the existing specialisation profile, namely at a regional and national level, associated with Research and Development (R&D) and with Innovation. To achieve this goal, an in-depth analysis of the evolution of the NRIS was carried out, placing particular focus on identifying the system dynamics associated with the production and exploitation of scientific or technological knowledge.

A structural description was produced, identifying a typology of agents as well as the main ways in which they interact, thus allowing an analysis of the system evolution dynamics. In a previous step, the socioeconomic context of the NRIS was analysed so as to identify those aspects critical to an understanding of the profile and performance of the system in question.

An attempt has been made throughout the report to contextualise the various factors under analysis using a Group of more than 10 countries chosen for comparison, while also taking into account the EU average, where applicable.

Another central aspect of the study carried out relates to the identification and analysis of the internal strengths and weaknesses of the R&I system as well as the external threats and opportunities that can impinge on it with respect to delivering the 2020 Strategy of the European Union within the expected timeframe.

Portugal has maintained its commitment to mobilise resources for R&D activities

The fact that Portugal has not been able to keep on a path of convergence with the EU over the decade from 2000 to 2010 has not meant that the country has not maintained and reinforced its commitment to accelerate its R&D efforts, namely when it comes to allocating resources.

While the efforts noted above have, in particular, led to an increased involvement of enterprises in R&D and Innovation activities, it is also true that the resultant economic activity, for example, from industrial exporters and services in high-tech areas does not yet reflect the transformation observed in the System over recent decades.

The growth of the NRIS over the last decade has been decidedly driven by its most dynamic participants

Over the last decade, the Portuguese System for Research and Innovation has benefited from changes focusing on the mechanisms for mobilising resources, allowing a significant increase in its scientific and technological base. This process was to a great extent driven by the most dynamic participants of the NRIS, namely semi-public organisations. On the other hand, the configuration of the public and semi-public sector experienced major changes to its structure: activities carried out by the organisations known as National Laboratories reduced its weight notably, while universities and a significant number of units, centres and institutes underwent consolidation and growth. In contrast, the business sector became a more decisive sector, gaining a significant weight in terms of performance and funding of R&D activities, although by the end of the decade its efforts mobilising system resources continued to be underdeveloped.

R&D investment is concentrated on four main socio-economic objectives

Engineering and Technology, particularly enabling technologies, stand out given their relevance for mobilising human and financial resources. On the other hand, R&D investment in the country is mainly concentrated on four socioeconomic objectives: (i) Industrial production and technology; (ii) General advancement of knowledge; (iii) Transport, Telecommunications and Other Infrastructures; and (iv) Health.

Even though there has been a notable rise in scientific production, Portugal remains below its potential

Portugal had the highest growth rate in scientific production within the group of countries studied over the period 2000–2010. Within the group of countries used for comparison, Portugal is ranked 9th both in terms relative to world production and in terms of production volume on a per capita basis. The country was also in 9th place within the group in relation to its productivity. As such, Portugal continues at a level below its potential (when accounting for the number of Full-time Equivalent Researchers).

The number of publications produced with international collaboration tripled between 2000 and 2010; however, these are concentrated on a limited number of countries.

The most significant change to the structure of Portuguese scientific production by area for the period between 2000 and 2010 – when measured by number of publications – is Medical and Health Sciences gaining first place in 2010 (exchanging place with Exact Sciences that occupied first place in 2000). Engineering and Technology, Natural Sciences (excluding Exact Sciences), Social Sciences, Agricultural Sciences, and the Humanities, in this order, then follow up by number of publications.

Portuguese scientific production has a diverse profile by region

The distribution of Portuguese scientific production over the NUTS 2 regions is diverse, with each region contributing in a specific way to the national production as a whole. In the North, Materials Science is responsible for the most publications; in the Centre and Lisbon regions, Electrical and Electronic Engineering; in the Alentejo region, Environmental Sciences; in the Algarve and Azores regions, Marine and Freshwater Biology; and, lastly, in the region of Madeira, Applied Physics.

Comparing the profile given by the specialisation of Portuguese scientific production with that of other comparable countries shows a higher degree of specialisation and particularities

Portugal specialised particularly in Marine Sciences over the 2000–2010 period (namely in Fisheries and Marine and Freshwater Biology, Oceanography and Ocean Engineering, where the country has increased its specialisation). In addition, Portugal has also shown notable specialisation in the Environment and Biology, which have more potential for national clusters of a technological or economic nature. These clusters can be related to sciences studying the Sea, Biotechnology, Health, and engineering in areas such as Manufacturing, Construction, Materials and Transports.

The following areas were identified as being the most relevant in terms of scientific impact: Space Science, Physics, Agricultural Sciences, Plant and Animal Sciences, Neurosciences and Clinical Medicine, having an impact over and above the world average.

The intensity of patenting continues to be low relative to the average for Europe, despite significant growth

A sizeable rise was observable in the level of patents filed for Europe by Portuguese residents between 2000 and 2009, which subsequently diminished in 2010 and 2011. However, the extremely low level of patents issued for the country at the start of the decade under study meant that the growth that occurred in the number of patent applications did not lead to significantly higher levels by the end of the decade.

Pharmaceutical Products, Civil Engineering and Fine Chemicals were responsible for the largest number of patent applications in 2010. A significant increase was visible in the number of European patent applications coming from the Higher Education sector, even though the total number of patents granted was very low. Over the period 2000–2008, the distribution of the total number of European patent applications by technological area was concentrated in Information Technology, Pharmaceutical Products, Biotechnology, Medical Technologies, Renewable Energies and Environmental Management.

In 2010, Portugal continued to show little impetus to submit patent applications in high-technology areas, even though it was the country that grew most among the group used for comparison.

The most common areas of innovation in Portugal and the factors that drive them can be seen as reflecting the characteristics of the specialisation profile for the economic activities in the different regions

Compared with the average in the European Union, Portuguese enterprises are more active in service and process innovation and less active in the innovation of manufactured goods and bringing new products to market.

The most common innovation activities in Portugal are the acquisition of machinery, equipment and software; training for activities related to innovation; and the execution of in-house R&D activities. It is also notable that a relatively low percentage of enterprises externally source either their R&D or other knowledge, be it in Portugal or the European Union.

The main obstacles to developing innovation activities are related to the associated costs, funding and financing, and to market conditions, such as uncertainty and the power of leading companies.

Those information sources considered of great importance to the majority of enterprises in Portugal and the European Union are “Information which is held within the company or group”, “Customers or consumers” and “Suppliers of equipment, materials, components or software”.

The most common partners in innovation projects developed by enterprises in Portugal and the European Union are: “Suppliers of equipment, materials, components or software”, “Customers or consumers”, “Universities or other higher-education institutions” and “Consultants, laboratories or private R&D institutions” – the percentage of enterprises involved in partnerships is lower than the European average for each form of partnership.

Portugal has a greater percentage of enterprises than the European average developing service and process innovations, both autonomously and in collaboration with other enterprises and institutions. However, Portugal’s profile is less innovative with respect to product innovation, either carried out autonomously or in cooperation with other enterprises or institutions.

The profile of the Portuguese economy shows a clear international specialisation in activities of low or medium-low technological intensity, with a particular concentration in the North and Centre of the country. The four sectors: i. Food products and Beverages; ii. Non-metallic mineral products; iii. Forestry based products; and iv. Metal products, are characterised by a combination of economic activities in which Portugal is specialised and where productivity can be seen to be above or below the average of the other European Union countries. The potential for gains from significant economies of scale, economies of scope/ related variety and knowledge spillovers in each sector, is enhanced by the regional concentration of these activities in the North and Centre of the country, by the national scientific specialisation in the areas of each sector, and by those employed in Research and Development. These sectors have shown a significant dynamism of firm growth in terms of employment.

The Textile, Clothing and Footwear sector is the most specialised in terms of employment and value added, representing a significant part of the Portuguese economy. Although the economic activities of this sector are characterised by below average productivity compared to the European Union, the sector has shown itself to have an important dynamism in terms of the number of high growth companies, in particular gazelles. It has also benefitted from a high degree of national scientific specialisation in Materials Science – Textiles, as well as other highly relevant scientific areas, and from a significant number of people employed in R&D.

The Automotive Sector, including electrical and electronic equipment, stands out for being internationally specialised in technology-intensive activities.

Manufacturing industry has benefitted from a high degree of national scientific specialisation in various areas, such as Materials Science - Composites; Materials Science - Biomaterials; Chemical Engineering; Manufacturing Engineering; Industrial Engineering; Operations Research and Management Science, among others.

The profile of economic specialisation shows a concentration of manufacturing industry in the North and Centre regions of the country. Lisbon also has a significant number of companies in different areas of economic activity, particularly those which make significant use of technology and/or knowledge, including a higher concentration of services.

The large diversity and the significant size of the Clusters that characterise the North of the country present significant potential to benefit from economies of agglomeration. The variety of the activities and the relationships between their producers open the way to various types of positive externalities and synergies.

The Related Variety Index is designed to measure the variety of related activities, taking into account the weight of employment in each of them. In 2011, the Centre had the highest Index level in the country, followed by Lisbon and the Tagus Valley, the North and the Alentejo, which shows an upward trend.

The research and innovation system evolved across the different dimensions, in particular reinforcing its links and approaching the established targets

At the beginning of the last decade, Portuguese public policy explicitly adopted the concept of a national innovation system. Public intervention has been largely centred on the creation and reinforcement of links between producers and users of knowledge, as well as its circulation, reinforcing the density and completeness of the system. Links were mainly promoted by support for public research and company partnerships and the creation of intermediary organisations.

An analysis of the Government Planning Options between 2000 and 2013 allowed a systematization of the key issues that have characterised the planning of RTD and innovation public policies. The strengthening of the innovation system, the reinforcing of capabilities and competencies, the reorganisation of the institutional fabric and the promotion of networking, as well as the fostering of knowledge exploration and of the structural capabilities of the system environment.

The mobilisation of the international research organisations, namely the intergovernmental research organisations and the foreign research institutions, was crucial for stimulating the R&D system. Such involvement is a key feature of the process of national research growth.

Generally speaking, the research and innovation system has reached the targets defined by public policies in terms of the tertiary education and the research publication outputs, as well as the increase in the human resources linked to the system. However, the goals set for the outputs related to the technological objectives and for the technological intensification of the economy were not reached.

Global SWOT Analysis

Global Swot

Strengths

Context

1. A competitive advantage in natural resources arising from a continental shelf which is 18 times the size of the Portuguese territory.
2. Half of the activities in the service sector are knowledge-intensive.
3. Rising trend in the technological balance of payments level, representative of an emerging national capacity to sell R&D services overseas.

Research and innovation system

4. The national potential for research and innovation has been on a converging path with the average of the EU27 over the last decade.
5. A research and innovation system with all essential components in place – R&I performers, intermediaries and disseminators, funding agents / investors and a legal and political framework – and with network connections between components.
6. Improvements in the workings of those structures that implement the policy-making functions of government and central administration.
7. Institutional flexibility which exists as a result of a layer of institutions which mediate between the traditional actors.
8. The region of Lisbon is classified as a leader, and the Centre is classified as a follower by the EU Regional Innovation Scoreboard.
9. Universities with academic and scientific quality, located midway in the world rankings.
10. A significant number of R&D units and institutions that are classified as excellent by international evaluation.

11. Growing (although still insufficient) focus by companies on R&D activities with some large companies part of the EU Industrial R&D Investment Scoreboard.

12. A growing number of companies active in service innovation and process innovation.

13. Enabling technologies that are important for R&D, namely ICT, in particular in companies.

14. An increase in the number of cooperative ventures between companies, universities and research institutes, even though they are largely driven by public programs.

15. An intensification of the knowledge flows at a national and international level, both via a growing mobility of people with doctorates and an increase in the number of academic publications produced in co-authorship.

16. Good R&D infrastructures.

Scientific and technological production

17. A sustained growth in national scientific production in all scientific and technological areas.

18. Scientific and technological areas with the most publications in the last decade: **i.** Pharmacology and Pharmacy; **ii.** Physical Chemistry; **iii.** Materials Science - Multidisciplinary; **iv.** Environmental Sciences; v. Food Science and Technology; and **vi.** Economics.

19. Scientific and technological areas that reached a citation impact level above the world average: **i.** Space Science; **ii.** Physics; **iii.** Agricultural Sciences; **iv.** Neurosciences; **v.** Behavioural Sciences; **vi.** Plant and Animal Sciences; and **vii.** Clinical Medicine.

20. Scientific and technological areas with the highest average annual rate of growth (number of publications) in the last five years: by descending order **i.** Medical and Health Sciences (Respiratory System – 78%; Multidisciplinary Psychology – 46%; General & Internal Medicine – 41%; Rheumatology – 40%; Sports Sciences – 38%); **ii.** Exact Sciences (Mathematics – 12%; Applied Mathematics – 12%; Multidisciplinary Chemistry – 12%; Astronomy and Astrophysics – 11%); **iii**. Engineering and Technology

(Civil Engineering – 24%; Energy and Fuels – 24%; Biomedical Engineering – 23%; Instruments and Instrumentation – 22%; Telecommunications – 21%; Food Science and Technology – 20%); **iv.** Natural Sciences, other than Exact Sciences (Biology – 40%; Multidisciplinary Geosciences -25%; Ecology – 19%; Atmospheric Sciences and Meteorology - 19%; Biochemical Research Methods – 18%); **v.** Agricultural Sciences (Multidisciplinary Agriculture - 26%; Food Science and Technology – 20% - also included in Engineering and Technology; Forestry – 18%; Veterinary Sciences – 18%; Animal and Milk Product Sciences – 17%; and with less growth, Fisheries – 7%); **vi.** Social Sciences (Management and Operational Research – 19%; Economics – 18%).

21. Scientific Specialisation (index >2) for the following areas: **i.** Fisheries; **ii.** Marine and Freshwater Biology; **iii.** Materials Science - Composites; **iv.** Ocean Engineering; v. Agricultural Engineering; **vi.** Applied Chemistry; vii. Oceanography; **viii.** Ceramic Materials; **ix.** Biomaterials; **x.** Thermodynamics; **xi.** Civil Engineering; **xii.** Chemical Engineering; **xiii.** Textile Materials Science; **xiv.** Construction and Building Technologies.

Weaknesses

1. Low rate of labour productivity.
2. Low educational level of the labour force mainly associated with the older age ranges.
3. A low level of employment in technology-intensive manufacturing industries.
4. Relative unattractiveness for foreign direct investment.
5. Barriers to innovation identified by companies: costs, funding, financing and access to markets.

Research and innovation system

6. Limited evaluation activity (ex-ante, interim, ex-post) of policies and national programmes.

7. Limited use of organised forums for debate and insufficient involvement of stakeholders in supporting the design of policies and programmes.

8. The Government sector is mainly focused on funding, with a limited role in performing research and development which has been decreasing over the last decade.

9. Companies contract only a small amount of R&D services from other institutional sectors.

10. Only a small proportion of enterprises consider academic publications to be important sources of information for innovation.

11. The interaction that occurs between the actors of the research and innovation system does not influence the mobility of qualified personnel (particularly people with doctorates) for companies.

12. Companies are not inclined to contract qualified human resources; Portugal is the country where the least number of people with doctorates are employed by companies for the countries under comparison.

13. Portuguese companies collaborate only weakly with system actors other than those companies that are part of international R&D projects (FP7). National companies collaborate in a limited fashion with other actors within the national scientific system.

Scientific and technological production

14. 1The productivity of the Portuguese scientific community is still below that of benchmark countries.

15. Portuguese scientific production has only limited world impact.

16. The number of patent applications is insufficient.

Opportunities

Context

1. A growing specialisation in knowledge-intensive services.

Research and innovation system

2. A growing percentage of companies with innovation activity.

3. Emerging trend for increased in-house technological capacity in firms.

4. The business sector increased its share of R&D expenditures, namely in the North, Centre and Lisbon regions.

5. Research actors are showing a growing capability to compete internationally in research projects, or as service providers, and have technological solutions for the European market.

6. Collaboration across the European research area can foster the participation of companies in R&D projects.

7. The geographical areas of international collaboration overlap for both "knowledge producers" and companies.

Scientific and technological production

8. By becoming part of the "open access" movement, Portuguese scientific production potentially will become more visible internationally.

9. High-technology patents represent a significant proportion of all patent applications.

Economic specialisation

10. Regional clusters exist that have significant potential for benefiting from both economies of scale and scope, as well as synergies and positive externalities. This favours knowledge transfer and technological upgrades involving manufacturing industry in sectors of lower technological intensity, such as those associated with **i.** Food products and Beverages; **ii.** Textiles, Clothing and Footwear; **iii.** Mineral products; **iv.** Metal products; and **v.** Forestry based products; as well as of higher technological intensity, such as those associated with **vi.** Chemical products (except pharmaceutical); and **vii.** Electronic, Electrical and Transportation Equipment, particularly related to the Automotive Industry.

11. Technology-intensive industries that show significant growth potential: **i.** Automotive Industry, including Electrical, Electronic and Transportation equipment; **ii.** Telecommunications; **iii.** Research and security (activities related to security systems); **iv.** Pharmaceutical industry; **v.** Chemical industry; **vi.** Computers, Electronics and Optics; **vii.** Information Technology; **viii.** Media, Radio and Television; **ix.** Information; and **x.** Machinery and Equipment.

12. Scientific specialisation which coincides with areas of economic specialisation, occurring in the following clusters: **i.** Food Products cluster / the fields of Food Science and Technology and of Agronomic Engineering; **ii.** Textiles cluster / the field of Materials Science - Textiles; **iii.** Ceramics cluster / the field of Materials Science - Ceramics; **iv.** Paper, Furniture, Wood and Cork cluster (forestry based industries) / the fields of Materials Science – Paper and Wood and of Forestry and Logging.

Threats

Context

1. The economy is for the large part specialised in activities of low or medium-low technological intensity, in competition with high-growth emerging economies.

2. The existing imbalance in the population between the coastal and inland regions is at risk of exacerbation.

3. An ageing population and increase in the dependence ratio.

Research and innovation system

4. The decrease in the R&D performed by the National Laboratories over the last decade might jeopardize the government's ability to fulfil its missions of providing public goods and useful information to support the formulation of public policy and to address the societal challenges.

5. The FCT and the Agency for Competitiveness and Innovation (IAPMEI) are the only public and private funding sources of a thematic or sectorial nature.

Thematic SWOT Analysis

1.

The National Research and Innovation System in Context

Strengths

1. Continental shelf 18 times the size of the land mass.
2. Number of graduates in Maths and Science and Technology, aged 20–29, above the EU27 average.
3. Knowledge-intensive services have a significant share of the total employment in the services sector.
4. The Technological Balance of Payments shows an upward trend.
5. R&D services and technical support services have good potential for sale overseas.

Weaknesses

1. Investment (GFCF) has been falling since 2007.
2. Low labour productivity.
3. The educational level of the population (aged 25-64) is one of the lowest in the EU27.
4. A low share of employment in medium- and high-technology manufacturing activities (as % of total employment).
5. Exports of high-technology products are fragile.
6. The level of coverage is unfavourable for acquisition rights/usage of licences, brands and the like.
7. Difficulties exist in attracting foreign direct investment (FDI).

Opportunities

1. Specialisation in knowledge-intensive services.

Threats

1. A risk of exacerbating the imbalance in the population distribution between the coastal and inland regions.

2. A persistent divergence from the trajectory of economic convergence with the European Union since the beginning of the first decade of this century.

3. An ageing population and an increase in the dependency ratio.

4. The possible impact of the economic and financial crisis for a fall in investment and financing of R&D and innovation.

2.
Characterising the National Research and Innovation System

Strengths

1. Universities with academic and scientific merit, some of which appear in world rankings.
2. A significant number of R&D units are classified as excellent by international peer review panels in all scientific areas.
3. The business sector attributes growing importance to R&D.
4. Some large companies conduct R&D investment on a European scale, namely in the ICT, Financial, Engineering, Energy and Pharmaceutical Industry sectors.
5. Lisbon is classified as part of the group of leaders in the EU Regional Innovation Scoreboard.

Weaknesses

1. A limited amount of R&D services is contracted by companies from other institutional sectors.
2. The Government sector is mainly focused on funding and has little to do with performing research and development.

Opportunities

1. A growing percentage of companies have innovation activities.

2. There is an increasing trend for companies to develop in-house technological capabilities.

3. Financial and human resources are being increasingly allocated to S&T by companies, especially in the regions of the North, Centre and Lisbon.

Threats

1. The decrease in the R&D performed by the National Laboratories over the last decade might jeopardize the government's ability to fulfil its missions of providing public goods and useful information to support the formulation of public policy and to address the societal challenges.

3.
Mobilising Financial and Human Resources and Infrastructures

Strengths

1. Expansion and transformation of the scientific and technological base of the Portuguese system for R&I over the last decade.

2. A continual growth in the human resources, namely researchers, compared to the European average.

3. Growth in R&D funding, namely by the Government, in convergence with the European average.

4. Strengthening R&D capacity in companies, in convergence with the European average, and with significant growth in the last decade (5% per year).

5. ICT areas are important for mobilising R&D resources, namely in the business sector.

6. Indirect funding by the Government for R&D, through tax incentives, which is comparable with the most advanced European systems.

7. The R&D infrastructures and research platforms in Portugal are of good quality.

Weaknesses

1. The research intensity of the economy (R&D expenditure/GDP) is still below the European average despite good progress over the last few years.

2. The total number of personnel associated with R&D is still below the European average.

3. Low capacity for attracting foreign investment, which is below that of comparable countries.

4. Companies concentrate their investment on their own R&D activities and do not embrace open innovation.

5. There is limited direct funding of companies by the Government.

6. The existing information about the R&D infrastructures in Portugal is not exhaustive and is out of date.

Opportunities

1. ICTs have the potential for research relating to societal challenges.

2. Electronic infrastructure for S&T is of increasing relevance.

Threats

1. Companies are key players in the system, although there are fears their central position is unsustainable due to the economic crisis.

2. Funding by the Government is mainly directed at the higher education sector.

4.
Knowledge Production

Strengths

1. The growth in the number of publications is sizable compared to the benchmark group of countries.

2. Diverse institutions are responsible for the growth in scientific publications, including universities, polytechnics, National Laboratories, research institutes and hospitals.

3. The scientific and technological areas with the largest number of publications over the last decade are: i. Pharmacology and Pharmacy; ii. Physical Chemistry; iii. Materials science - Multidisciplinary; iv. Environmental Sciences; v. Food Science and Technology; and vi. Economics.

4. An emerging potential, as measured by the growing number of publications, in the following areas: Respiratory System; Rheumatology; Energy and Fuels; Biomedical Engineering; Biology; Multi-disciplinary Geosciences; Multi-disciplinary Agriculture; and Forestry.

5. The areas of scientific specialisation in Portugal represent a compatible and complementary balance between basic research and applied research.

6. Scientific specialisation in the following areas: Fisheries; Marine and Freshwater Biology; Composite Materials Science; Ocean Engineering; and Agricultural Engineering.

7. The concentration of scientific specialisation in regions that have competitive advantages connected with natural resources, namely in the Algarve and the Azores.

8. A notable growth in trademark registrations.

Weaknesses

1. The productivity of the Portuguese research community is still below the productivity of the other countries in the benchmark group.

2. Computer Science, Computer Science – Theory and Method and Artificial Intelligence have a decreasing number of publications.

3. An absence of growth in the number of patent applications, which meant that the level of patents issued has not reached a level close to that of the countries used for comparison.

Opportunities

1. There is a potential to cooperate with a wide range of countries, as measured by the number of papers with international co-authorship.

2. Joining the open access movement has the potential to make Portuguese scientific production more visible to the outside world.

3. Scientific and technological areas that have reached a citation impact level above that of the world average: **i.** Space Science; **ii.** Physics; **iii.** Agricultural Sciences; **iv.** Neurosciences; **v.** Behavioural Sciences; **vi.** Plant and Animal Sciences; and **vii.** Clinical Medicine.

4. The impact of Decision Sciences and Mathematics can be seen in their h-index rankings when compared to the other benchmark countries.

5. The relative importance of the number of high-technology patents registered compared to the total.

6. The growth and consolidation of the country's research base is a positive factor that can eventually lead to an increased patenting level.

Threats

1. The number of publications with international co-authorship has dropped off, when compared with other benchmark countries.

2. A generalised trend for the relative weight of the High Quality Publications to decline for the Portuguese institutions that are part of the SIR.

3. The financial and economic crisis in the country may well affect at least a part of those entities that are able to make patent applications, namely within the business sector.

5.
Knowledge Circulation

Strengths

1. A high degree of knowledge circulation exists reflecting the growing geographical mobility of people trained to doctoral level and the number of co-authored academic publications.

2. A national system for research and innovation which comprises all the types of mediating actors necessary for knowledge to circulate.

3. A significant number of partnerships between companies, universities and R&D centres, with financial support from the SI I&DT of the NSRF analysed.

Weaknesses

1. Companies hire few doctorate holders; Portugal is the country where companies employ the lowest proportion of doctorate holders for the countries under comparison.

2. The interaction that occurs between the actors of the research and innovation system does not affect the mobility of qualified personnel (principally people with doctorates) for companies.

3. There is a lack of coordination between the funding programmes of the research and innovation system.

4. In international R&D projects (FP7), Portuguese companies collaborate preferentially with other companies and there exists only minimal collaboration between national companies and other actors that make up the national scientific system.

5. Relationships established at a national level through the national programmes funding R&D and innovation do not encourage collaboration at an international level.

Opportunities

1. Collaboration occurs in identical ways for international scientific publications and international projects (FP7) with companies (countries involved: Germany, Italy, Spain, United Kingdom and France). As such, there exists the possibility of increasing collaboration at a national level.

2. Those entities that make up the research system are well positioned to take part in international consortia for research projects or as providers of services or technological solutions to the European market.

3. Companies are more likely to apply for FCT R&D funds when the projects are part of the transnational area of collaboration (European programmes – JTI, JPI, ERA-NETs).

4. International collaborations can be fostered by the collaborative space covering all the actors of the System for Research and Innovation, created by the mechanisms of the SI I&DT programme of the NSRF.

Treats

1. It has not been possible to raise the technological profile of companies and industry. The lack of interconnection between the two sub-systems of research (science) and innovation (the economy) severely limits the circulation of knowledge.

6.
Knowledge Exploitation

Strengths

1. A significant proportion of enterprises are engaged in service and process innovation, developed either in-house or in collaboration with other enterprises or institutions.

2. Enterprises make a significant effort to train for innovation activities.

Weaknesses

1. Enterprises outsource little R&D to other actors within the system, outside of the collaboration mechanisms receiving funding.

2. There are few companies of significant size in Portugal. Only a part of those companies has in-house R&D activities.

3. A limited amount of effort is applied to introducing both radical and incremental innovation into the market.

4. The most common forms of innovation activities in Portugal still have low innovation--intensity.

Opportunities

1. Economic specialisation with a high degree of potential for benefitting from significant economies of both scale and scope as well as various types of synergies and positive externalities. This favours knowledge transfer and technological improvement in various regional clusters of manufacturing industry, namely those associated with less technological intensive industries, such as: **i.** Food products and Beverages; **ii.** Textiles,

Clothing and Footwear; **iii.** Mineral products; **iv.** Metal products; and **v.** Forestry based products; as well as with higher technological intensive industries, such as: **vi.** Chemical Products (except Pharmaceuticals); and **vii.** Electronic, Electrical and Transport Equipment, particularly that related to the Automotive Industry.

2. The capacity exists to increase specialisation in technology- and/or knowledge-intensive activities and develop sectors that show significant growth potential, such as: **i.** Production of electrical equipment (manufacture of electrical and electronic cables and wires; manufacture of motors, generators and electrical transformers); **ii.** Production of chemical products (industrial gases); **iii.** Telecommunications (wired and wireless telecommunications); **iv.** Research and security (activities related to security systems); and **v.** Pharmaceutical industry.

3. A significant level of scientific specialisation occurring in the following clusters which correspond to economic specialisation as well: **i.** Food products cluster / the fields of Food science and Technology and of Agronomic Engineering; **ii.** Textiles cluster / the field of Materials Science - Textiles; **iii.** Ceramics cluster / the field of Materials Science - Ceramics; **iv.** Paper, Furniture, Wood and Cork cluster (forestry based industries) / the fields of Materials Science – Paper and Wood and of Forestry and Logging.

Threats

1. An economy specialised in areas of low or medium-low technological intensity, in competition with high-growth emerging economies.

7.
Public Policies for Research and Innovation

Strengths

1. Improvements in the efficacy of the implementation structures, in the policy making functions and programme management in government and central administration.

2. Institutional flexibility facilitated by the existence of a layer of organisations, built up over time, that bridge the gaps between the traditional actors.

3. A long tradition of competitive allocation of resources, which for the last two decades uses international evaluation of projects and institutions.

4. Incentives and actors are present for the different levels of intervention.

Weaknesses

1. Little evaluation activity (ex-ante, interim, ex-post) of policies and national programmes.

2. The advisory system at different levels – political, programmes or agencies – have not worked properly over the last decade, due to long periods of inactivity.

3. Poor coordination of planning mechanisms at the various levels.

4. Limited use of organised forums for debate and insufficient involvement of stakeholders in supporting the design of policies and programmes.

Opportunities

1. Using a national strategy for research and innovation as an ex-ante condition for structural funds is an opportunity to re-launch the debate and develop national strategies for research and innovation.

2. The crisis has created a necessity to develop innovative solutions.

3. New channels for both system actors and policymakers to interact as a result of an increased coordination effort.

Threats

1. The sources of funding are concentrated among a small number of actors, which potentially could constrain the range of research supported and limit choices and options.

2. For the different levels, the ability to analyse and conceptualise the system as a whole is still emergent.

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Glossary of Terms and Abbreviations

A3ES – Agency for Assessment and Accreditation of Higher Education (Agência de Avaliação e Acreditação do Ensino Superior)

AdI – Innovation Agency (Agência de Inovação)

AESBUC – The Association of the Biotechnology School of Universidade Católica (Associação para a Escola Superior de Biotecnologia da Universidade Católica)

AIBILI – Association for Innovation and Biomedical Research on Light (Associação de Apoio ao Instituto Biomédico de Investigação da Luz e Imagem)

ALTIOR – Altior S.A.

AST – Active Space Technologies (Actividades Aeroespaciais, S.A.)

AT – Austria

BE – Belgium

BERD – Business Enterprise Expenditure on Research and Development

BIOTREND – Bioprocess Development in Industrial Biotechnology.

C3I – Interdisciplinary Coordination for Research and Innovation of the Portalegre Polytechnic Institute (Coordenação Interdisciplinar para a Investigação e a Inovação do Instituto Politécnico de Portalegre)

CAE – Portuguese Classification of Economic Activities (Classificação Portuguesa das Actividades Económicas)

CATAA – Centre for Agriculture and Food Product Technical Support (Centro de Apoio Tecnológico Agro-Alimentar)

CATIM – Centre for Technical Support to the Metalwork Industry (Centro de Apoio Tecnológico à Indústria Metalomecânica)

CBE – Centre for Biomass Energy (Centro da Biomassa para Energia)

CC JNICT – Advisory council of the National Directorate for Scientific and Technological Research

CCG – Centre for Graphics Computation (Centro de Computação Gráfica)

CCIs (JNICT) – Research coordination commissions (National Directorate for Scientific and Technological Research)

CEIIA – Centre for Excellence and Innovation in the Automotive Industry (Centro de Excelência e Inovação da Indústria Automóvel)

CENI – Centre for Integrating and Innovating Processes, R&D Association (Centro de Integração e Inovação de Processos, Associação de I&D)

CENTIMFE – Technology Centre for the Moulds, Special Tools and Plastics Industry (Centro Tecnológico da Indústria de Moldes, Ferramentas Especiais e Plásticos)

CENTITVC – Centre for Nanotechnology and Smart Materials (Centro de Nanotecnologia e Materias Técnicos, Funcionais e Inteligentes)

CERN – European Organization for Nuclear Research

CES – Economic and Social Council (Conselho Económico e Social)

CEVALOR – Technology Centre for Portuguese Natural Stone (Centro Tecnológico para Aproveitamento e Valorização das Rochas Ornamentais e Industriais)

CIES – Centre for Research and Studies in Sociology (Centro de Investigação e Estudos de Sociologia)

CIS – Community Innovation Survey

CITEVE – Technology Centre for the Textile and Clothing Industry of Portugal (Centro Tecnológico das Indústrias Têxtil e do Vestuário de Portugal)

CMF – Critical Manufacturing, S.A.

CMU – Carnegie Mellon University

COMPETE – Operational Competitiveness Programme (Programa Operacional Factores de Competitividade)

CNCT – National Council of Science and Technology (Conselho Nacional de Ciência e Tecnologia)

CNEI – National Council for Entrepreneurship and Innovation (Conselho Nacional para o Empreendedorismo e Inovação)

CPD – Design Centre of Portugal (Centro Português do Design)

CPU – Central Processing Unit (Unidade Central de Processamento)

CS – Critical Software, S.A.

CSCT – Higher Council for Science and Technology (Conselho Superior de Ciência e Tecnologia)

CSF – Community Support Framework

CTCOR – Cork Technology Centre (Centro Tecnológico da Cortiça)

CTCP – Portuguese Footwear Technology Centre (Centro Tecnológico do Calçado de Portugal)

CTCV – Ceramics and Glass Technology Centre (Centro Tecnológico da Cerâmica e do Vidro)

CTIC – Leather Technology Centre (Centro Tecnológico das Indústrias do Couro)

CWTS – Centre for Science and Technology Studies - Leiden

CZ – Czech Republic

DE – Germany

DG – the European Commission Directorates-General

DGEEC-MEC – Directorate-General for Education and Science Statistics – Ministry of Education and Science (Direcção Geral de Estatísticas para a Educação e Ciência - Ministério da Educação e Ciência)

DME – Deimos Engenharia S.A.

E&I – Entrepreneurship and Innovation

ECBIO – R&D in Biotechnology, S.A.

EDP – EDP Inovação, S.A.

EDP DISTR – EDP Distribuição de Energia, S.A.

EEC – Collective Efficiency Strategies

EEZ – Exclusive Economic Zone

EGI – European Grid Infrastructure

EIA – Ensino, Investigação e Administração, S.A.

EIP – Excessive Imbalances Procedure

ENDS – National Strategy for Sustainable Development (Estratégia Nacional de Desenvolvimento Sustentável)

ENGIZC – National Strategy for an Integrated Management of the Coastal Zone (Estratégia Nacional para a Gestão Integrada da Zona Costeira)

ENP – Estaleiros Navais de Peniche, S.A.

EPO – European Patent Office

ERA – European Research Area

ERA-NET – European Research Area Network

ERAC – European Research Area and Innovation Committee

ERAWATCH – Platform on Research and Innovation policies and systems

ES – Spain

ESF – European Science Foundation

ESFRI – European Strategy Forum on Research Infrastructures (Fórum Estratégico Europeu para as Infraestruturas de Investigação)

EU – European Union

FACC – Support Fund for the Scientific Community (Fundo de Apoio à Comunidade Científica)

FCG – Fundação Calouste Gulbenkian

FCT – Fundação para a Ciência e a Tecnologia

FDI – Foreign Direct Investment

FI – Finland

FoS – Fields of Science

FP6 – Sixth Framework Programme for Research and Technological Development

FP7 – Seventh Framework Programme for Research and Technological Development

FR – France

FTE – Full-Time Equivalent

GAAPI – Office Supporting the Research Projects of Universidade da Beira Interior (Gabinete de Apoio a Projetos de Investigação da Universidade da Beira Interior)

GBOARD – Government Budget Appropriations or Outlays for Research and Development

GAIN – Global Acceleration Innovation Network

GDP – Gross Domestic Product

GÉANT – Pan-European data network for the research and education community

GENIBET – GenIBET Biopharmaceuticals, S.A.

GERD – Gross domestic expenditure on research and development

GFCF – Gross Fixed Capital Formation

GMVIS SKYSOFT – GMVIS Skysoft, S.A.

GOP – Government Planning Options (Grandes Opções do Plano)

GPEARI – Office for Planning, Strategy, Assessment and International Relations (Gabinete de Planeamento, Estratégia, Avaliação e Relações Internacionais)

GPPQ – Office for the Promotion of the RTD Framework Programme (Gabinete de Promoção do Programa-Quadro de I&DT)

GVA – Gross Value Added

HU – Hungary

IAC – Higher Culture Institute (Instituto de Alta Cultura)

IADE – Instituto de Artes Visuais, Design e Marketing, S.A.

IAPMEI – Institute for Support to Small and Medium-Sized Enterprises and Innovation, currently Agency for Competitiveness and Innovation (Instituto de Apoio às Pequenas e Médias Empresas e à Inovação)

IBERGRID – Iberian Grid Infrastructure

IBET – Institute for Experimental Technology in Biology (Instituto de Biologia Experimental e Tecnológica)

IBILI – Institute for Biomedical Imaging and Life Sciences (Instituto Biomédico de Investigação de Luz e Imagem)

IC&DT – Scientific Research and Technological Development (Investigação Científica e Desenvolvimento Tecnológico)

ICAT – Institute of Applied Science and Technology of the Science Faculty of Universidade de Lisboa (Instituto de Ciência Aplicada e Tecnologia da Faculdade de Ciências da Universidade de Lisboa)

ICT – Information and Communication Technologies

ICTPOL – Polymer S&T Institute (Instituto de C&T de Polímeros)

IDIT – Institute for Technological Innovation and Development (Instituto de Desenvolvimento e Inovação Tecnológica)

IDITE-Minho – Minho Institute for Technological Innovation and Development (Instituto de Desenvolvimento e Inovação Tecnológica do Minho)

IE – Ireland

IEFP – Institute of Employment and Professional Training (Instituto de Emprego e Formação Profissional)

IGC – Instituto Gulbenkian de Ciência

IH – Hydrographic Institute (Instituto Hidrográfico)

IICT – Tropical Research Institute (Instituto de Investigação Científica Tropical)

IMF – International Monetary Fund

IMLCF – National Institute of Legal Medicine and Forensic Science (Instituto Nacional de Medicina Legal e Ciências Forenses)

INE – Statistics Portugal (Instituto Nacional de Estatística)

INEGI – The Mechanical Engineering and Industrial Management Institute (Instituto de Engenharia Mecânica e Gestão Industrial)

INESC – Institute for Systems Engineering and Computers (Instituto de Engenharia de Sistemas e Computadores)

INETI – National Institute of Engineering, Technology and Innovation (Instituto Nacional de Engenharia, Tecnologia e Inovação)

INGRID – National Grid Initiative (Iniciativa Nacional de GRID)

INIA – National Institute for Agricultural Research (Instituto Nacional de Investigação Agrária)

INIAV – National Institute for Agricultural and Veterinary Research (Instituto Nacional de Investigação Agrária e Veterinária)

INIC – National Institute for Scientific Research (Instituto Nacional de Investigação Científica)

INL – The International Iberian Nanotechnology Laboratory

INOVAMAIS – Inovamais - Serviços de Consultadoria em Inovação e Tecnologia, S.A.

INPI – Portuguese Institute of Industrial Property (Instituto Nacional da Propriedade Industrial)

INSA – National Health Institute Doctor Ricardo Jorge (Instituto Nacional de Saúde Doutor Ricardo Jorge)

IPC – International Patent Classification (Classificação Internacional de Patentes)

IPCTN – National Survey of the Scientific and Technological Potential (Inquérito ao Potencial Científico e Tecnológico Nacional)

IPL – Instituto Politécnico de Leiria

IPMA – Portuguese Institute for the Sea and Atmosphere (Instituto Português do Mar e da Atmosfera)

IPN – Instituto Pedro Nunes

IPP – Instituto Politécnico do Porto

IPQ – Portuguese Institute for Quality (Instituto Português de Qualidade)

ISA – ISA Intelligent Sensing Anywhere, S.A.

ISCED – International Standard Classification of Education

ISEP – Instituto Superior de Engenharia do Porto

IST – Instituto Superior Técnico

IT – Information Technology

IT – Italy

IT – Telecommunications Institute (Instituto de Telecomunicações)

ITN – Nuclear Technology Institute (Instituto Tecnológico Nuclear)

ITQB – Chemical and Biological Technology Institute (Instituto de Tecnologia Química e Biológica)

IUL – Instituto Universitário de Lisboa

JNICT – National Directorate for Scientific and Technological Research (Junta Nacional de Investigação Científica e Tecnológica)

JPI – Joint Programming Initiative

JTI – Joint Technology Initiative

LA – Associated Laboratory (Laboratório Associado)

LE – National Laboratory (Laboratório de Estado)

LINK – Link Consulting - Tecnologias de Informação, S.A.

LIP – Instrumentation and Experimental Particle Physics Laboratory (Laboratório de Instrumentação e Partículas)

LNEC – National Laboratory of Civil Engineering (Laboratório Nacional de Engenharia Civil)

LNEG – National Laboratory of Energy and Geology (Laboratório Nacional de Energia e Geologia)

LNETI – National Laboratory for Industrial Engineering and Technology (Laboratório Nacional de Engenharia e Tecnologia Industrial)

LW – Lifewizz, LDA

MA – Metropolitan Area

MCTES – Ministry of Science, Technology and Higher Education (Ministério da Ciência, Tecnologia e Ensino Superior)

MERIL– Mapping of the European Research Infrastructure Landscape

MIA – Ministry for Industry and Energy (Ministério da Indústria e Energia)

MIT – Massachusetts Institute of Technology

MPAT - Ministry of Planning and Territorial Management (Ministério do Plano e da Administração do Território)

MTCB – Meticube Sistema de Informação, Comunicação e Multimédia, LDA

MULTICERT – MULTICERT Serviços de Certificação Electrónica S.A.

NABS – Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets

NACE – Statistical Classification of Economic Activities in the European Community

NB – National Budget

NECTON – Necton Companhia Portuguesa de Culturas Marinhas, S.A.

NIS – National Innovation System

NL – Netherlands

NO – Norway

NRIS – National Reasearch and Innovation System

NPI – Private Non-Profit Institution

NREN – National Research and Education Network

NRP – National Reform Programme

NSRF – National Strategic Reference Framework

NUTS – Nomenclature of Territorial Units for Statistics

OC – Other Clusters

OECD – Organisation for Economic Cooperation and Development

OP – Operational Programme

OTIC.IPP – Technology Transfer Office of Instituto Politécnico do Porto (Oficina de Transferência de Tecnologia do Instituto Politécnico do Porto)

PCT – Patent Cooperation Treaty

PCT – Hubs for Competitiveness and Technology (Pólos de Competitividade e Tecnologia)

PDM&FC – Projecto Desenvolvimento Manutenção Formação e Consultadoria, LDA.

PEDIP – Specific Programme for the Development of Portuguese Industry (Programa Específico de Desenvolvimento da Indústria Portuguesa)

PIEP Associação – Innovation in Polymer Engineering (Pólo de Inovação em Engenharia de Polímeros)

PNACE – National Action Programme for Growth and Jobs (Plano Nacional de Crescimento e Emprego)

PNDES – National Plan for Economic and Social Development (Plano Nacional de Desenvolvimento Económico e Social)

PNRC – National Programme for Scientific Re-equipment (Programa Nacional de Re-equipamento Científico)

POCTI – Operational Programme: Science, Technology and Innovation (Programa Operacional Ciência, Tecnologia e Inovação)

POPH – Operational Programme for Human Potential (Programa Operacional Potencial Humano)

PRAXIS XXI – Science and Technology Operational Intervention (Intervenção Operacional Ciência e Tecnologia)

PREMAC – Plan to Reduce and Improve Central Administration (Plano de Redução e Melhoria da Administração Central)

PROINOV – Integrated Innovation Support Programme (Programa Integrado de Apoio à Inovação)

PT – Portugal

PT – Technology Plan

PTIN – Portugal Telecom Inovação, S.A.

QREN – National Strategic Reference Framework (Quadro de Referência Estratégica Nacional)

R&D – Research and Development

R&DE – Research and Development Expenditure

R&I – Research and Innovation

RAIZ – Forestry and Paper Research Institute (Instituto de Investigação da Floresta e do Papel)

RCTS – Science Technology and Society Network (Rede Ciência, Tecnologia e Sociedade)

RNA – Regional and National Accounts (Statitistics Portugal)

RTD – Research and Technological Development

RU – Research Unit

S&T – Science and Technology

SCTN – National Scientific and Technological System (Sistema Científico e Tecnológico Nacional)

SETSA – Sociedade de Engenharia e Transformação, S.A.

SGP – Stability Growth Pact

SI I&DT – System of Financial Incentives for Technological Research and Development in Companies (Sistema de Incentivo à Investigação e Desenvolvimento Tecnológico nas Empresas)

SIFIDE – System of Tax Incentives for R&D in Business (Sistema de Incentivos Fiscais em Investigação e Desenvolvimento Empresarial)

SIR – SCImago Institutions Rankings

SJR – Scientific Journal Rankings - Scimago Journal & Country Rank

SME – Small and Medium-Sized Enterprise

SPI – Sociedade Portuguesa de Inovação - Consultadoria Empresarial e Fomento da Inovação, S.A.

STEMMATTERS – Stemmatters, Biotecnologia e Medicina Regenerativa, S.A.

SWOT – Strengths, Weaknesses, Opportunities and Threats

TBP – Technological Balance of Payments

TEKEVER – TEKEVER Tecnologias de Informação, S.A.

TEKEVER ASDS – TEKEVER ASDS

TISPT – TIS.PT, Consultores em Transportes, Inovação e Sistemas, S.A.

TT-IST – Technology Transfer Office of Instituto Superior Técnico (Área de Transferência de Tecnologia do Instituto Superior Técnico)

UA – Universidade de Aveiro

UAç – Universidade dos Açores

UAII&DE – IPS – Research, Development, Innovation and Entrepreneurship Support Unit of Instituto Politécnico de Setúbal (Unidade de Apoio à Investigação, Desenvolvimento, Inovação e Empreendedorismo do Instituto Politécnico de Setúbal)

UAlg – Universidade do Algarve

UATEC – Technology Transfer Unit of Universidade de Aveiro (Unidade de Transferência de Tecnologia da Universidade de Aveiro)

UBI – Universidade da Beira Interior

UC – Universidade de Coimbra

UCP – Universidade Católica Portuguesa

UE – Universidade de Évora

UK – Reino Unido

UL – Universidade de Lisboa

UM – Universidade do Minho

UMIC – Knowledge Society Agency (Agência para a Sociedade do Conhecimento)

UNINOVA – Institute for the Development of New Technologies (Instituto de Desenvolvimento de Novas Tecnologias)

UNL – Universidade Nova de Lisboa

UP – Universidade do Porto

USA – United States of America

USPTO – United States Patent and Trademark Office

UT Austin – University of Texas at Austin

UTEN – University Technology Enterprise Network

UTL – Universidade Técnica de Lisboa

WIPO – World Intellectual Property Organization

YDR – YDREAMS Informática, S.A.

Other symbols and abbreviations

% – Percentage

‰ – Per thousand

Km2 – square kilometre

M – Million

M€ – Millions of Euros

p.p. – Percentage points

AAGR – Average Annual Growth Rate

pop. – Population

TB – Terabytes

EU27 – The EU comprises the following countries: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK

Introduction

The SWOT analysis of the National Research and Innovation System, presented in this report, is the first step in a process leading to the definition of a research and innovation strategy for smart specialisation, on a national basis in coordination with the regional strategies. The SWOT analysis and the specialisation profile is crucial for identifying the potential themes for strategic dialogue with the stakeholders - with research institutes and universities – as well as with companies and the national and regional organisations that are responsible for designing and implementing research and innovation policies.

The national and regional research and innovation strategies for smart specialisation are part of the structure of the first component of Smart Growth within the Europe 2020 Strategy. The goals of Europe 2020 entail an Innovation Union and fulfilling the 34 stated targets at a European and national level. The main objectives focus on strengthening Europe's position as a world producer of excellence in science, ensuring that the European area efficiently enables knowledge exploitation by reducing existing barriers, and in addition, the completion of the European Research Area for the free movement of people and knowledge, with solid research institutions and infrastructures, and open national funding programmes. The vision of an Innovation Union is a component of the process of constructing a 'European System for Research and Innovation', characterised by more homogeneity, less fragmentation, and increased concentrations of critical mass.

The national and regional strategies for research and innovation are fundamental for an effective national participation in the Common Strategic Reference Framework. This applies equally to competition and cooperation, as part of Horizon 2020, and to cohesion, as part of the Cohesion Policies. As such, for the period of the programme between 2014 and 2020, the national research and innovation strategy for smart specialisation, that opens the way to a structural transformation based on a competitive and specialised economy at multiple and interrelated levels – local, regional and national –, is an ex-ante condition for the Partnership Agreement between the European Commission and Portugal on Smart Growth.

To increase the systemic development of innovation, at a European level, the 'smart specialisation' concept was adopted, as proposed by Dominique Foray in the Knowledge for Growth group that advised the then European Commissioner for Research. This concept explores agglomeration in areas which are defined as priorities through consensus amongst the stakeholders involved, with a view to maximizing the production and exploitation of knowledge for economic development. Philip McCain, an advisor to the European Commission for Regional Policies, later added the space dimension to the concept of 'smart specialisation', underlying the importance of the idea of 'local-based research', as part of an approach covering regional systems of innovation.

As the main funding agency for R&D in the country, the FCT is uniquely positioned at a national level as 'translator' and intermediary. Firstly, it helps make clear the goals of national research and innovation policy for the scientific and business communities, and secondly, it helps ensure that the needs of these communities are understood by policy makers. As such, as part of the desire to transform the FCT into a driver catalysing collective strategic reflexion on research and innovation in Portugal, studies were carried out in mid–2012 to understand the state of play of the national system for R&I. The study helped feed an ongoing need for evidence-based policy and national programmes for formulating research and innovation.

Choosing the innovation system approach

Traditionally, the non-academic analyses of the system in Portugal tend to use the concept of the National Scientific and Technological System ('Sistema Científico e Tecnológico Nacional' – SCTN). The concept was developed in the first half of the last century, when the large majority of the systems were still emerging, having limited complexity and built primarily on the linear innovation model. However, in the 1980s an increasing body of literature showed that innovation mainly follows an iterative model (Kline and Rosenberg, 1986), of which the linear model is one component. The evidence produced by the studies in the area of Economics of Innovation showed that the success of innovations depends largely on networks of cooperation covering all the phases of the innovation process (Freeman, 1991). The conceptualization of the system changed to reflect this new understanding of the innovation process, evolving to the National Innovation System concept, as developed by Freeman (1987), Lundvall (1988) and Nelson (1993). This concept became widely used in the literature and it is this approach that has been adopted by the majority of OECD countries (OECD, 1997), by the European Commission and in the individual country public polices for research and innovation.

As such, this study applies the concept of a national innovation system as a framework – understood here to be a collection of components, relationships and attributes that contribute towards the production, diffusion and exploitation of knowledge for use in new products, industrial processes and services, to the benefit of society. We define the components as the actors that act within the system, either human or non-human, as organisations, or physical and technological objects, as well as institutions and the regulating legal and statutory system, or even traditions and culture. These components interconnect with one another via relationships whose characteristics and properties influence the direction and pace of the system's development (Carlsson et al., 2002). The concept of a national system of innovation underlines the importance of national borders for delimiting the space within which the components interact. These borders are defined by the culture, history, language and shared institutions inherent in the governance and the public policies in the system. There are other borders, apart from those of the nation-state, which were subsequently used as national delimiters. These include a sectoral delimitation (sectoral systems of innovation) (Breschi and Malerba, 1997) and a regional delimitation (Cooke et al., 1997), existing as organised subsystems that prevail in a national system.

The system functions: knowledge production-circulation-exploitation

As a starting point for the analysis, the national research and innovation system is considered to be integrated and reflect the structure of the economy, the culture and the institutional traditions of the country. It is also assumed that the way in which it works reflects the functioning of those institutions that formulate and implement policy, as well as the regulatory and legislative framework. If the analysis would be developed, as traditionally it has been, centred on the components of the research and innovation system, namely on the actors of the traditional performing institutional sectors (Business, Government, Higher Education and Private Non-Profit Institutions), it would neither add new knowledge, nor would it allow a SWOT analysis of the system. Nor would it serve as the basis for identifying the areas and the themes for specialisation or of strategic interest to the country, to be further discussed with stakeholders and eventually proposed as national and regional priorities in the future. The option was taken to apply the SWOT analysis technique to the innovation system functions (Bergek et al., 2008; Hekkert et al.,2007), defined as the contributions that each component or group of components makes to the research and innovation system working as a whole. As such, the following functions of the system were considered to be relevant to this analysis: i. knowledge production; ii. resource mobilisation; iii. knowledge circulation via networks; iv. the exploitation of knowledge.

It should be noted that the knowledge in this analysis is not just that resulting from research that defines hypotheses and constructs theories to help explain phenomena, but is also that which seeks out technological solutions (codified knowledge existing in publications and patents, or tacit, as held by people). This knowledge includes so-called social knowledge, defined by Mokyr (2005) as a collection of all the parts of individual knowledge that allow more specialisation, professionalization and experimentation that society has available for promoting economic growth.

The group of countries used for comparison (benchmarking)

A SWOT analysis has two main components, one internal to the system and the other external to the system, with the latter reflecting not only national factors but also European and international ones. With the construction of a European Research Area and the Innovation Union as part of the Europe 2020 Agenda, the national system will become more open. As such, its resources and effectiveness are highly dependent on the way in which it positions itself in these enlarged areas, leveraging off its competitive advantages and visibility.

On this basis, this study follows the recommendation of the European Commission Guide in defining a Research and Innovation Strategy for Smart Specialisation[1] by defining a group of countries against which the evolution of the system can be systematically compared. The choice of this group of countries took into consideration a combination of various criteria, namely the size of the country and its Innovation System as well as the system's financial dimension alongside other factors of an economic, demographic and geographic nature. The group of countries selected is composed of nine Member States of the European Union (EU) and one Associate-Member Country. The following countries were selected, based on their similar characteristics in several dimensions of particular interest to Portugal, in various key areas: Austria, Belgium, Spain, Finland, Netherlands, Hungary, Ireland, Italy, Norway and the Czech Republic.

The period of study

The analysis predominantly focuses on the first decade of this century, from 2000 to 2010, or wherever available data permit. An attempt was also made to contextualise changes over time of some variables or structures with long time series, extending the period under analysis to include previous decades.

The report structure

This report represents the results of applying both quantitative and qualitative methodologies, using information from primary and secondary sources, as well as from a workshop which took place between the 11 and 12 December 2012. The workshop brought together specialists and experts in the Portuguese innovation system and public policy and those responsible for the individual regions to help identify the factors, the areas of knowledge and the economic sectors in which each region held a competitive advantage, both in terms of competences and resources (see http://www.fct.pt/esp_inteligente/index.phtml.pt).

1. http://s3platform.jrc.ec.europa.eu/en/c/document_library/get_file?uuid=e50397e3-f2b1-4086-8608-b86e69e8553&groupId=10157

The report is divided into seven chapters, alongside the global SWOT analysis and the SWOT analysis on each function of the system that correspond to each chapter. Two types of SWOT analysis were carried out, both available at the start of the report; the first type is global in nature and combines and links up all the results and conclusions of the analysis carried out on the national system and its functions; the second type is thematic, per function of the system.

The first chapter contextualises the overall system of the country, covering general aspects such as geography, demography, and a macroeconomic analysis of the production structure, labour market, foreign direct investment and technological balance of payments.

The second chapter presents a brief characterisation of the research and innovation system, highlighting the main components of the system of the sectors performing R&D, both at a national and regional level.

The third chapter starts on an analysis of the selected functions, in this case, the mobilisation of financial, human and infrastructure resources. This allows the resources and their sources to be identified, with a view to a strategic definition.

The fourth chapter studies knowledge production by analysing scientific publications and patents and defines the scientific and technological specialisation profile, both at a national and regional level.

The fifth chapter studies how knowledge circulates, looking at whether it is codified or tacit. This chapter looks at the mediating structures and maps out the networks established through the NSRF for research and innovation, allowing the degree of systemness to be quantified, along with the density of the relationships.

The sixth chapter identifies the way in which knowledge is exploited by the economy. The economic specialisation profile of the country is outlined and the national clusters and the degree of variability related to the regions are identified via quantitative means. This chapter allows its results to be compared with those of the scientific specialisation analysis in chapter three. Both of the profiles took the developing areas into consideration, given that these, along with those areas with consolidated competitive advantages, will allow a structural change to take place in the Portuguese economy.

The seventh, and final, chapter starts by showing how the structure of the main components of the system, the implementation structures for policymaking in public policy for research and innovation and its functions have all evolved over time. As a conclusion, an analysis is presented following up on the objectives and the defined targets at a governmental level, analysing strategies, medium term plans and government planning options.

The last chapter of the report presents the general conclusions that link together the conclusions from all the individual chapters.

1.

The National Research and Innovation System in Context

An insight of the socioeconomic context of public policy is essential for understand the efficiency of the National Research and Innovation System (NRIS) that this chapter seeks to characterise. This chapter identifies some of those aspects which are crucial to developing a process for transforming the Portuguese economy as laid down in the objectives of the Europe 2020 Strategy for smart, sustainable and inclusive growth.

Territory and population size of the country

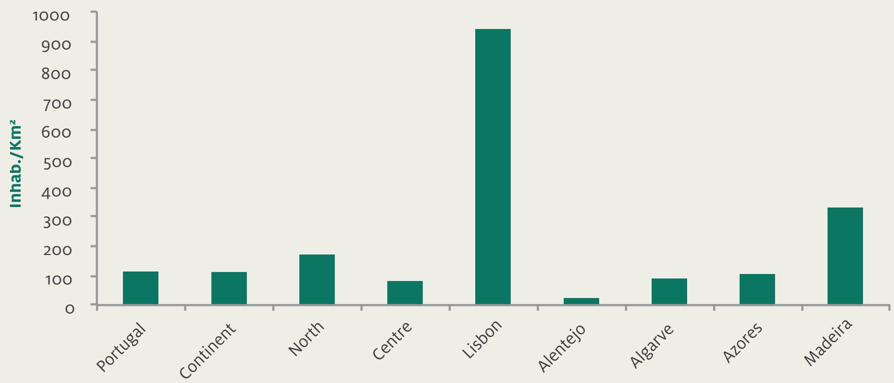
Portugal is a small country in terms of its territorial limits, with an area of 92.2 thousand km2 and one of the largest exclusive economic zones (EEZ) in Europe, at around 1.7 million km2 corresponding to around 18 times the land area. A proposal is currently under consideration by the United Nations for an enlargement of the continental shelf. The resident population reached 10.6 million people in 2011 (a growth of 2% since 2001), meaning a population density of 114.3 people per km2. This population density is close to the EU27 average, located in between densely populated countries such as Belgium and Netherlands, and sparsely populated countries, such as Norway, Finland, Ireland and Spain (Figure I.1).The country is characterised by significant asymmetries among the regions, with Lisbon having the highest population density (940.7 people/km2). The growing concentration of people in urban areas, to the detriment of intermediate and rural areas (Table I.1), is another tendency common to other European countries. This tendency is particularly notable in Netherlands and Belgium, and in the south, Italy. These imbalances in the population distribution have led to a emerging pattern with the population concentrating in the coastal area. This is reflected in the significant imbalance in the regional distribution of economic activity: 75% of total population and 85% of GDP is located in the coastal municipalities of continental Portugal and the islands (National Strategy for an Integrated Management of the Coastal Zone - ENGIZC). The spatial concentration of population helps enable wealth creation in those areas with net gains, in detriment to low density areas, associated with particular patterns of economic activity, a concentration of technological infrastructures and the emergence of knowledge- and information-intensive services (ISEG, 2005).

TABLE I.1.
Portuguese population by metropolitan area (2000–2011)

	2001	2011	2001	2011	Growth rate (AAGR)
	10^3 people		As a % of total population		
Total Population	10356.117	10562.178			2.0
Population in metropolitan areas	4309.319	4494.546	41.6	42.6	4.3
MA Porto	1647.469	1672.67	15.9	15.8	1.5
MA Lisbon	2661.85	2821.876	25.7	26.7	6.0

Source: INE/Statistics Portugal, (2001 and 2011 Census)

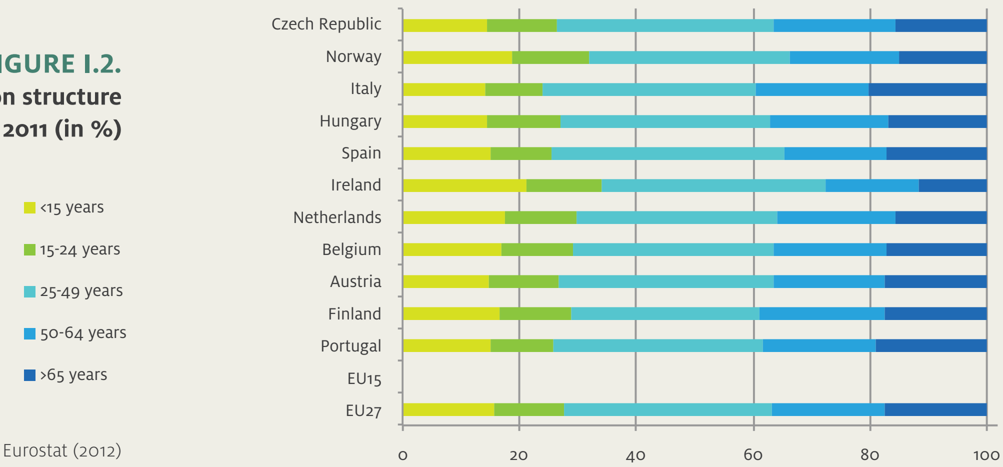
FIGURE I.1.
Population Density by region (in 2011)



Source: INE/Statistics Portugal (2013)

Portugal has a fast ageing population, following another structural tendency which is common to numerous countries around the world. With the exception of Ireland, almost all the countries selected in this report for benchmark[1] had 30-40% of their population over 50 years old in 2011, with Portugal at the upper end, after Italy and Finland (with 38.3%, 39.6% and 39.1% respectively) (Figure I.2).

FIGURE I.2.
Population structure by age group 2011 (in %)



Source: Eurostat (2012)

Portugal has an unfavourable ratio between the unemployed and the working age population[2] , which has worsened substantially between 2001 and 2011 (by 3.8 p.p.). This is consistent with the tendency seen in various countries, in particular Italy, Belgium, Finland and Norway where this ratio exceeds 50%. All regions, apart from the autonomous regions, saw a generalised deterioration in this indicator between 2001 and 2011, with the Alentejo, Centre and Algarve having the highest ratios (of 60.6%, 56.6% and 52.2% respectively) (Figure I.3).

1. As previously stated, these countries are Austria, Belgium, Spain, Finland, Netherlands, Hungary, Ireland, Italy, Norway and the Czech Republic.

2. As measured by the dependency ratio which calculates the ratio between the unemployed (those under 15 years old and those over 65 years old), and the population of working age (15-64 years old).

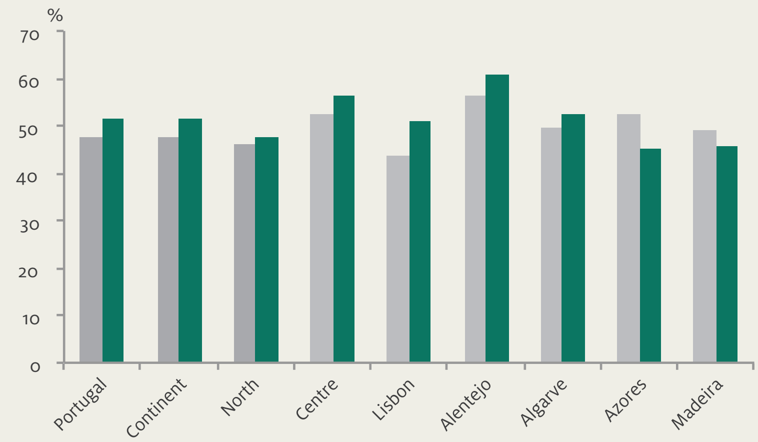


FIGURE I.3.
Dependency ratio by NUTS 2 region

2001
2011

Source: INE/Statistics Portugal (Census 2001 and 2011)

Brief macroeconomic overview

Portugal has been moving away from the economic convergence path with the European Union since the start of the first decade of this century (Figure I.4), with a GDP per capita, in terms of purchasing power parity, below the EU27 average and all of the benchmark countries except Hungary.

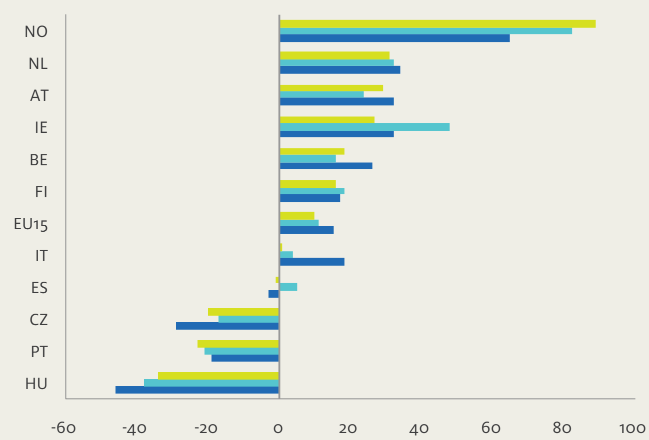


FIGURE I.4.
GDP per capita (in PPP)
Note:Relative to EU27 average

2011
2007
2000

Source: Eurostat (2013)

In keeping with the tendency observed in the post-crisis period in most European countries, GDP growth in Portugal also became negative (real average growth rate of 1.1% and -1.1% in the period before and after 2007 respectively). This was explained by the negative final consumption behaviour (-0.9% between 2008 and 2010) and, especially, investment[3] (-8.3% over the period 2008–2011), (Figure I.5). This decline worsened in 2011 for all agents (public, private, households and companies). This retraction in investment could well represent a severe limitation for developing innovation activity.

3. As measured by the Gross Fixed Capital Formation (GFCF)

According to the OECD (the Organization for Economic Cooperation and Development) the massive deleveraging of investment that occurred – associated with a still incipient growth of venture capital which does not compensate for the widespread destruction of the business fabric seen throughout the world – led to an immediate negative impact on innovation, with a worldwide decline in research and development expenditure (GERD) of 4.5% in 2009 (OECD, 2012).

FIGURE I.5.

GFCF AND EXPORTS (Chain-linked volume, reference year 2005) (average annual growth rate)

Source: Eurostat (2013)

It is worth noting the positive performance of Portuguese exports, having shown growth for both periods under analysis (4.5% and 1.4%, in average and volume terms). This development is, in spite of the slowdown in world trade seen in the post-crisis period, most conspicuously in the more advanced economies (Banco de Portugal, 2011).

The move towards the tertiary sector

The increasing weight of the services sector in the productive structure, to the detriment of manufacturing, is a significant trend seen in Portugal and in the majority of European countries (measured both in terms of Gross Value Added – GVA - and employment). This trend accelerated in the first decade of this century: the GVA created by services represented 74.5% [4] of the total GVA for Portugal in 2011 (above the EU27 average, at 72.6%, and all countries except Belgium), having risen 6.6 p.p. up since 2000 (Figure I.6). In the same vein, the sectoral distribution of employment in Portugal in 2010 was equally biased towards the tertiary sector (63.8% compared to 55.1% in 2000[5]). It should also be noted that manufacturing also saw a slight increase in total employment in 2011 (compared with the previous six years).

The need for policies focused on developing manufacturing is of a strategic importance for restarting growth in Europe, and a pre-requisite for escaping the crisis. Namely, for Portugal, the need for re-industrialization might be an important priority. According to the European Competitiveness Report 2012, "... in the long term sustainable growth will be generated through technical progress and productivity growth. It is in that sense that the modernization of the industrial base and the removal of institutional impediments to entrepreneurship can be seen as crucial for the European enterprises' competitive performance in and outside Europe".

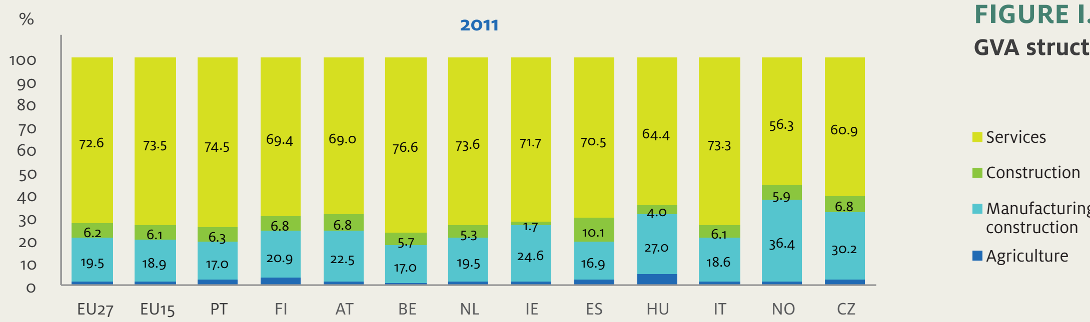


FIGURE I.6.
GVA structure by sector

Source: Eurostat

Analysing the GVA in Portugal across regions and sectors shows that this trend was observable, albeit unevenly, in all regions, with a generalised loss of activity in the primary and secondary sectors since the start of the first decade of this century, and a demarcation between the manufacturing and service regions. In 2010, the North, Centre and Alentejo[6] regions were of above average importance in terms of GVA generated by industry (including energy and construction), at around 30% in the first two cases and 27% for the Alentejo. Madeira, Algarve and Lisbon were the areas most focused on the tertiary sector (GVA from services above 80% of the total in each region). However, the Alentejo and Azores were the regions where the primary sector was of most importance (between 8 and 9%).

4. The values used for international comparison are sourced from Eurostat (GVA at base prices). The values used to study the country and the regions are sourced from the National and Regional Accounts of Statistics Portugal (GVA at current prices). A small discrepancy is notable in these values (Services GVA/Total GVA: 74.5% based on Eurostat and 73.93% based on RNA/Statistics Portugal).

5. Based on data from the National and Regional Accounts, Statistics Portugal (Employment in Services/Total Employment).

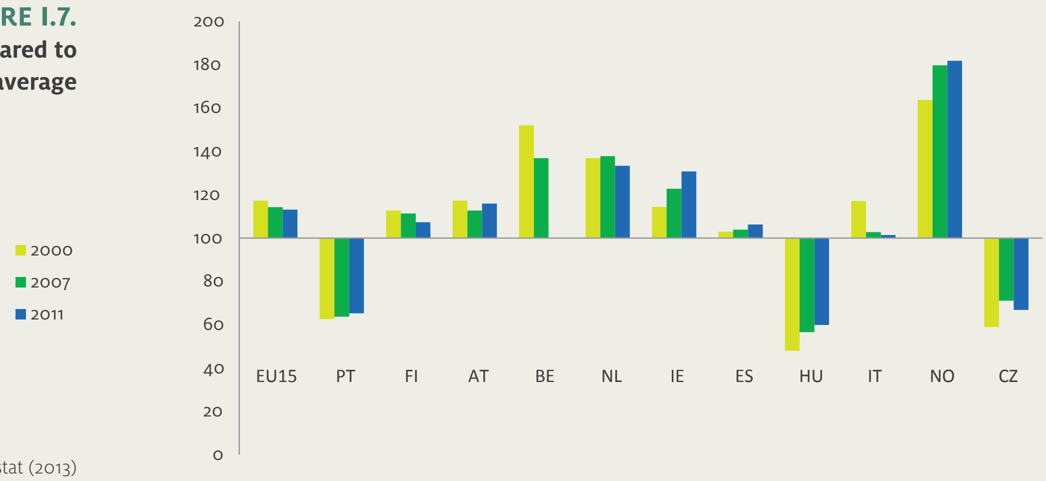
6. This is most notable in the activities occurring in the sub--region of Coastal Alentejo (DPP, 2008).

Productivity

Productivity is a determining factor for the competitiveness of the economy, and its performance is constrained by structural aspects such as the quantity and quality of the productive factors and the performance of the product and labour markets. Besides structural factors, productivity is also affected by the time lag that occurs when employment responds to changes in production, particularly when this occurs abruptly, displaying a tendency to destroy/create employment at a slower rate than the fall/recovery in economic activity. In Portugal, the quality of human capital and its adjustment to labour market is still major constraint on productivity growth.

In 2011, labour productivity, measured by the number of hours worked, was only 64.4% of the productivity level for the EU27. Portugal's productivity (between the levels of Hungary and the Czech Republic) was significantly below the levels recorded for the other countries under comparison, around one third the level recorded in Norway, and less than half that seen in Netherlands and Ireland (Figure I.7).

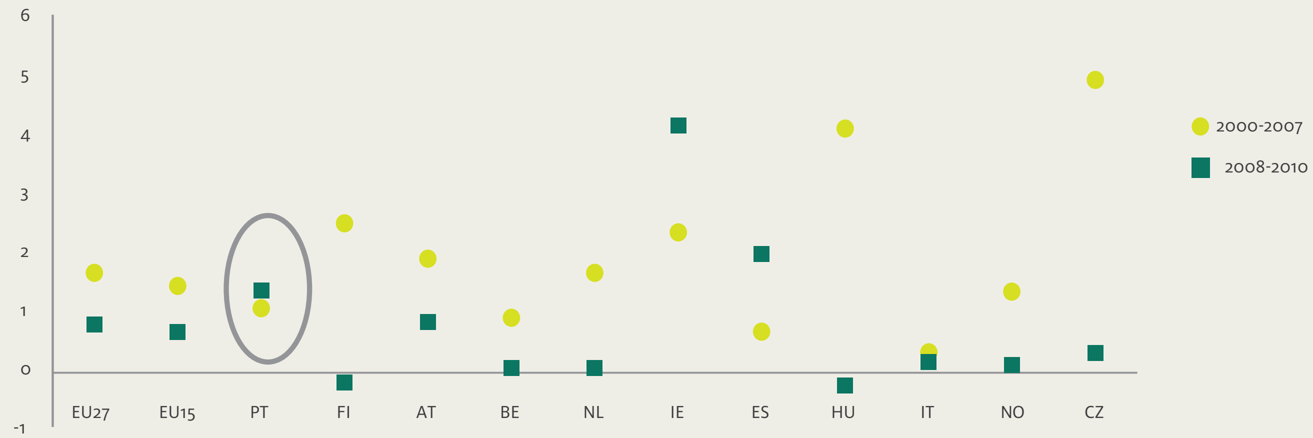
FIGURE I.7.
Labour productivity compared to the EU27 average



Source: Eurostat (2013)

Even though, the indicator showed some average growth (in volume), albeit tenuous, over the periods 2000–2007 and 2008–2011. The growth in productivity was however a long way from that achieved by benchmark countries, such as Ireland. The sustainability of this growth require a strong human capital base/endowment and a continual drive to increase the technological innovation capacity of the country, as referred to in "Avaliação do Impacto Macroeconómico do QREN 2007–2013, Relatório Final" (An Assessment of the Macroeconomic Impact of the NSRF 2007–2013, Final Report) (DPP, 2011).

FIGURE I.8.
Labour productivity (GVA/hours worked). Average annual growth rate (volume, prices for reference year 2005, 2005=100)



Source: Eurostat (2013)

The North and Centre regions, where 46.8% of the GVA and 56.2% of the employment are generated, recorded productivity values in 2010 below the national average (measured in nominal terms) (Figure I.9). The region of Lisbon managed to surpass the national average, as did Madeira. Moreover, it should be noted that the Alentejo had exceptionally high productivity, particularly the Coastal Alentejo which is linked to the port of Sines and its industrial and logistical zone, and the Lower Alentejo, with its mining activity in Neves de Corvo (DPP, 2008).

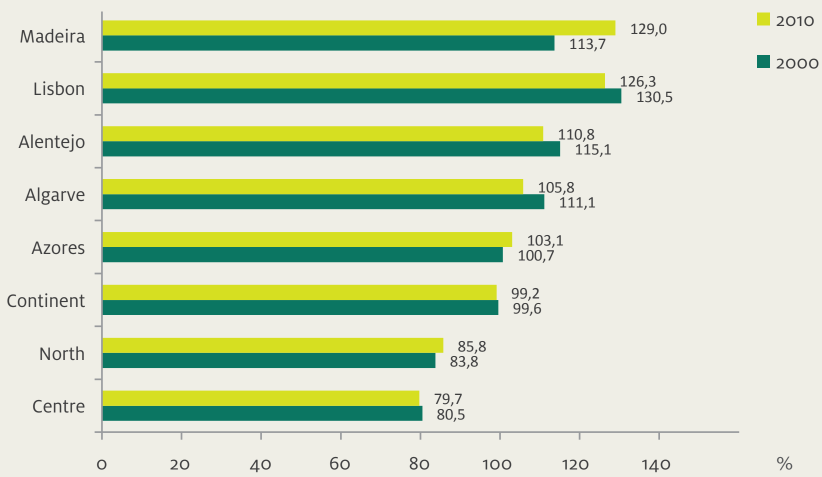


FIGURE I.9.
Labour productivity by region (in %, PT=100)

Note: The apparent labour productivity measured as the ratio of the GVA to underlying employment.

Source: INE/Statistics Portugal, National and Regional Accounts (2013)

Qualifications and skills creation

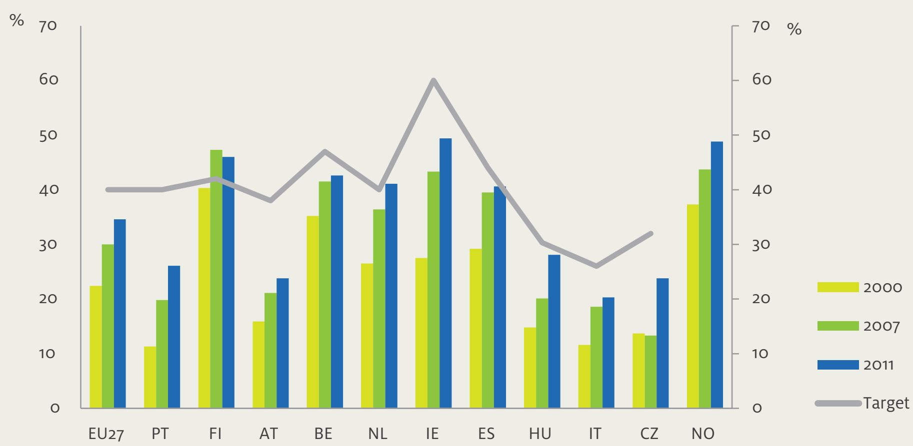
Formal education is the main vehicle for strengthening the supply of qualifications and capturing talent for innovation and, at the same time, for increasing the ability to use and absorb technology. It remains a priority for science, technology and innovation policies for the majority of countries, being centred on three main pillars: the stock of human capital, knowledge capital and creativity.

In 2011, only 17.8% of the population aged 25-64 years in Portugal had completed upper secondary education. This was the lowest percentage out of all the selected countries and flagrantly in contrast with Hungary and the Czech Republic whose populations are significantly more qualified than the EU27 average (60.6% and 74.1% respectively, against the EU27 average of 46.6%).

The national drive to increase the qualifications of the human resources is visible in the percentage of the population aged between 20 and 24 years that completed this level of education in 2011 (64.4%). This allowed the country to recoup the deficit visible at the start of the decade and move closer to achieving one of the goals defined in the scope of Objective 1 – Preparing Portugal for the Knowledge Society, of the National Strategy for Sustainable Development (ENDS 2015). However, Portugal remains in a quite disadvantaged position when compared to the European average (79.5%) and to the other countries. In addition, the percentage of the population in Portugal aged between 30 and 34 who have completed tertiary education[7] is also below the European average (26.1% compared to the average of 36.6% in 2011 – Figure I.10), as is also the case for the majority of the European countries selected. Notwithstanding the growth seen over the decade, the commitment and target which the country has signed up to in the National Reform Programme (NRP) will translate into a major effort to revitalise Portugal over a short period of time.

FIGURE I.10.
Tertiary Educational Attainment Level, age group 30-34 (share population aged between 30 and 34 who have completed tertiary education*) (%)

Note: * Bars- ISCED 5 or 6; line-target defined in the respective NRP



Source: Eurostat (2013)

7. International Standard Classification of Education (ISCED) 5 or 6

Concerning the tertiary graduates in science and technology fields (mathematics, science and technology), relative to the population (‰) aged 20-29, over the space of a decade the country was able to shore up one of its weaknesses in terms of technological competencies. By 2007 it had already reached the target for 2010 (12‰ of graduates), as defined in the National Strategy for Sustainable Development (ENDS 2015). By 2009, the rising trend seen over the whole period allowed the country to exceed, albeit only slightly, the average for the European Union. It should be noted that this trend also coincides with the Bologna process coming into effect. The number of graduates in these scientific areas (in 2010 14.6‰), found Portugal among countries such as Austria, the Czech Republic and Spain – indicative of a qualitative positive change in the formal supply of qualifications essential to the innovation system, and an asset with a multiplier effect equal or superior to other tangible and intangible assets (Figure I.11).

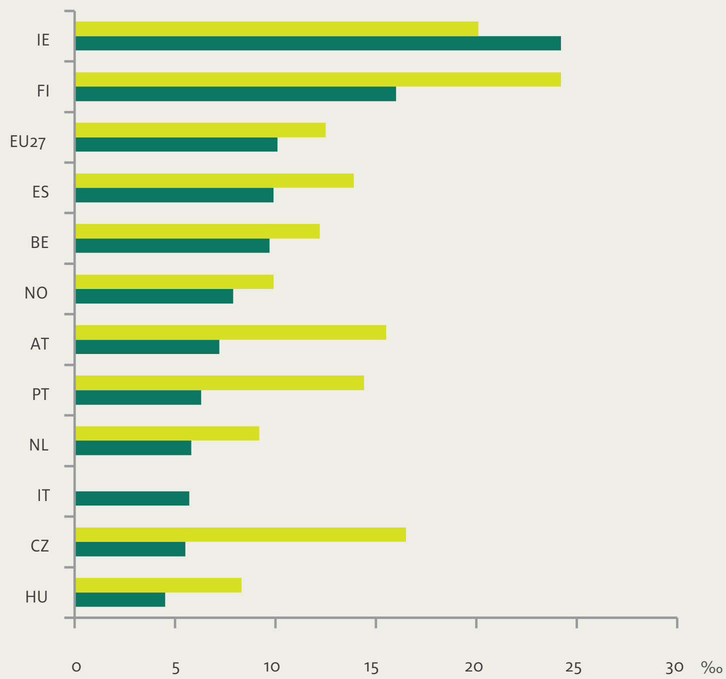


FIGURE I.11.

Tertiary graduates in science and technology (Mathematics, Science and Technology) per 1000 persons aged 20–29 years (‰)

Source: Eurostat (2013)

The labour market

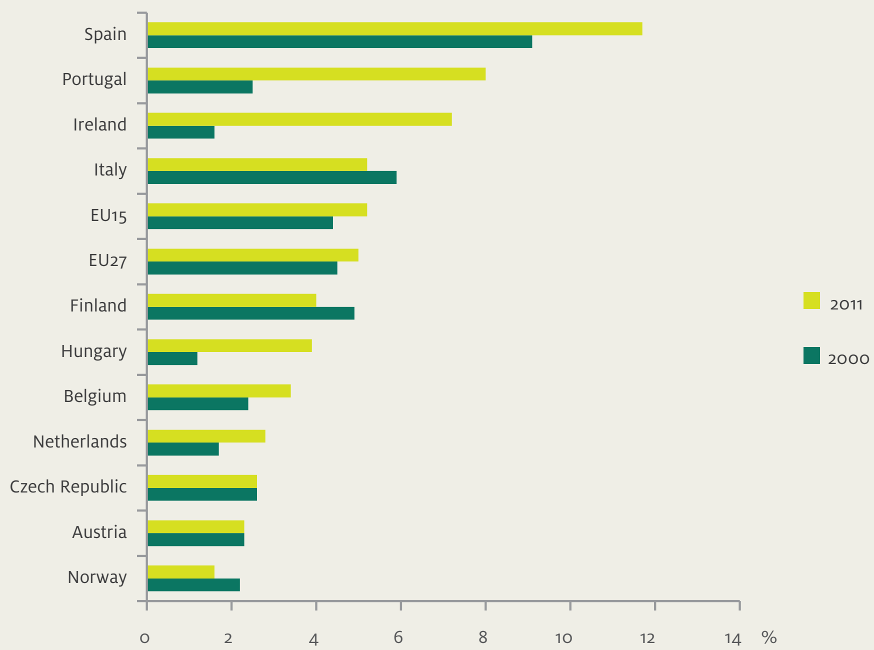
The last few years have seen a fall in the population of active age, in spite of the growth in the total population. This tendency will eventually have negative consequences for the future performance of the economy. This change was accompanied by a significant increase in youth unemployment (those under 25) (37.7% in 2012 compared with 10.5% in 2010).

The majority of the regions recorded a fall in the rate of employment[8] .

Out of the selected countries, only Spain has an unemployment rate higher than that of Portugal amongst the population with higher education (between 25 and 64 years old, 8% in 2011). This reflects the difficulties the labour market has in absorbing the more highly skilled workers, a tendency which became more prominent in the first decade of this century. Spain and Ireland also saw this indicator deteriorate over the same period (11.7% and 7.2% respectively) (Figure I.12).

However, those segments of the population with post-graduate qualifications are less susceptible to unemployment when compared with the rest of the segments. Over the period of economic restructuring this segment showed some relative advantages in terms of market absorption. The analysis by different type of degree, made possible by looking at the numbers of unemployed enrolled in the IEFP centres, showed that in 2011, 87% of those unemployed with higher education held a first or second stage university degree (ISCED level 5 or 6). Unemployd with a doctoral degree represented a residual number, as shown by the data available.

FIGURE I.12.
Unemployment rate of the population aged 25 to 64 years old with first or second stage tertiary education (ISCED 5 or 6)



Source: Eurostat (2013)

8. The rate of employment is defined as the ratio of the employed population to the population of working age (15-64 years old).

The low levels of enrolment of people with doctoral degrees in the employment centres reflects, on the one hand, that the advantages that accrue from this are not recognised, and, on the other hand, the impact of the benefits from active support given by the Fundação para a Ciência e a Tecnologia (FCT) to programmes encouraging professional placements, and essentially the high degree of mobility, both within Europe and internationally (Figure I.13).

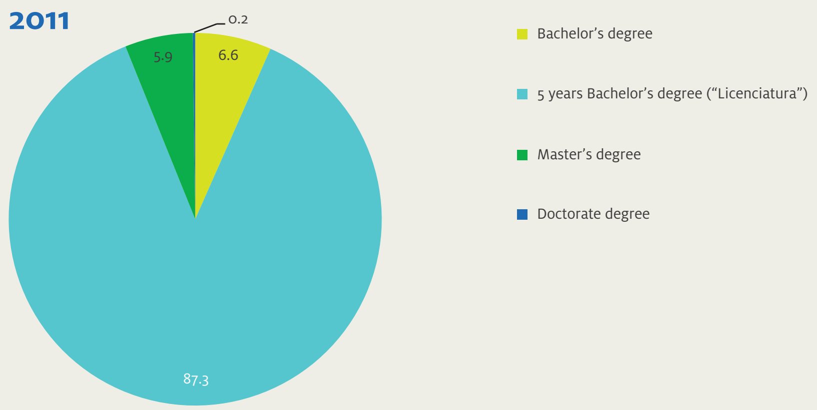


FIGURE I.13.
Portugal – Distribution of unemployed tertiary graduates, by academic degree, 2011 (%)

Source: IEFP

The productive structure

In 2010 the Portuguese productive structure was still based on low- and medium-low-technology sectors (77.6% of GVA in the manufacturing industry), notwithstanding the significance of medium-high-technology sectors (18.4% of GVA, in 2010, e 14.3% of employment in 2011) (Figure I.14). This production profile is in direct contrast with that of the countries under comparison, as is the case in Ireland, whose high-technology sector represents 53.3% of GVA for the manufacturing industry in the same year.

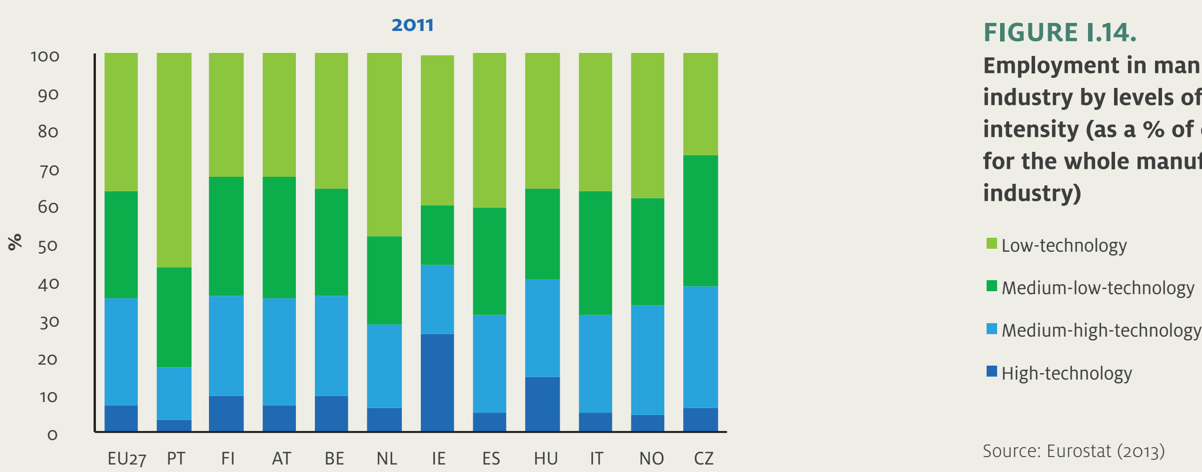
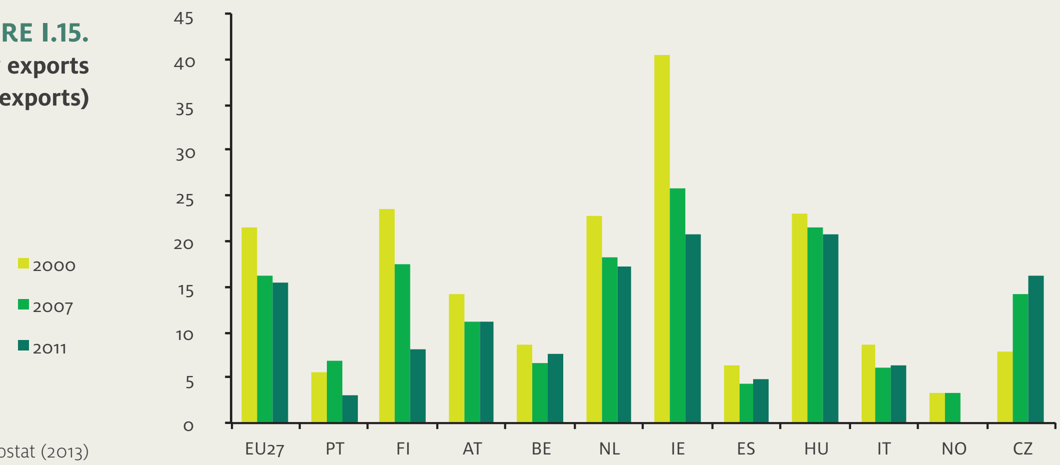


FIGURE I.14.
Employment in manufacturing industry by levels of technology intensity (as a % of employment for the whole manufacturing industry)

Source: Eurostat (2013)

In contrast, the share of high-technology exports as a percentage of total exports has fallen (3% in 2010, as compared to 5.6% in 2000), notwithstanding the peak of 2007. This reflects the fragility of Portugal´s export specialization pattern, when compared to other European countries that are also classified as moderate innovators, as are Hungary and the Czech Republic (with 20.8% and 16.2% respectively) (Figure I.15).

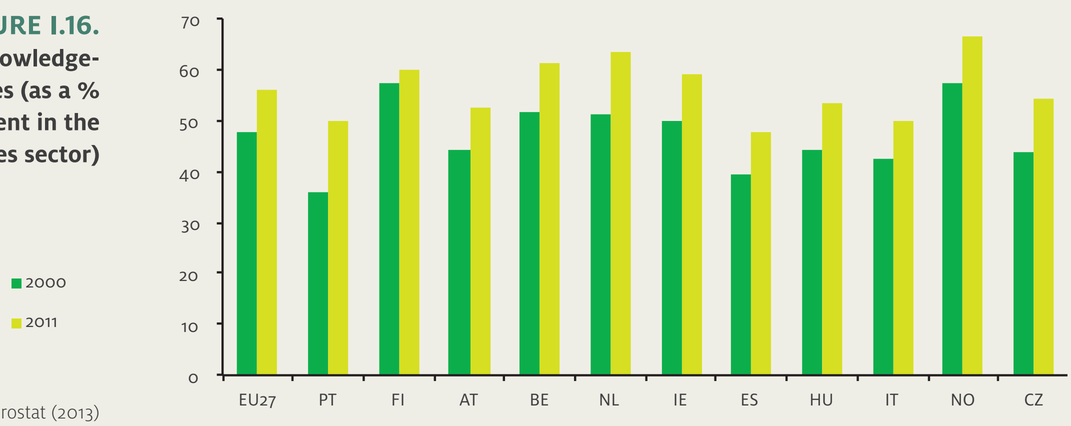
FIGURE I.15.
High technology exports (as a % of total exports)



Source: Eurostat (2013)

In 2011, employment in Portugal in knowledge-intensive services represented around 50% of total employment for the services sector, bringing the country closer to the EU27 average (6.2 p.p. below). However, this value is still some way from countries like Norway (66.4%) and Ireland (59.1%) (Figure I.16).

FIGURE I.16.
Employment in knowledge-intensive services (as a % of total employment in the services sector)



Source: Eurostat (2013)

An analysis of the Figure I.17, which relates the pattern of productive specialisation to the share of R&D expenditure by companies (BERD), leads to the conclusion that despite the significant increase in BERD over the decade (27.8% in 2000 compared with 46.1% in 2010), this did not feed through to an equal increase in the proportion of activities in high-technology areas (% GVA High Technology: 6.3% in 2000, compared with 3.9% in 2010). This is in contrast with the performance of countries such as Ireland.

Ireland's performance is largely explained by the flows of foreign direct investment (FDI) into the manufacturing sector, much of which relates to high-technology. This allowed the country to significantly alter its pattern of productive specialisation (Costa, 2004).

FIGURE I.17.
High technology value added and BERD

Notes: High Technology VA: High Technology Value Added refers to manufacturing industry

BERD: Business Enterprise Expenditure on Research and Development
GERD: Gross Expenditure on Research and Development

Source: Eurostat (2013)

International Investment

The capability to attract FDI[9] is an important factor for structural change and upgrading international specialization. Being frequently associated with those sectors of activity with some degree of sophistication and value added, it favours technology and knowledge transfer among countries. This draws the receiving country into exogenous technological innovation processes, via foreign companies that are based locally, or national companies with foreign bases. In a globalised world, the ability to attract FDI is not wholly dependent on the intrinsic characteristics of each country, but should be understood within a context of growing liberalisation of world trade and complexity in value chains.

Looking at the flows that have occurred, shows that over the whole period (2000–2011) Portugal has suffered from a negative trend in its international investment position[10], along with all its components, and in particular FDI (representing -103.7% and -18.5%, respectively, in 2011[11]).

An analysis by sectors for the period 2006–2010 shows that the flows of FDI entering the country primarily benefitted the areas of financial intermediation and real estate, renting and business in detriment to other sectors, namely manufacturing industry, whose strategic importance for sustained growth has already been noted (Figure I.18). However, the analysis developed as part of the Ex-Ante Evaluation for the National Strategic Reference Framework (NSRF) 2007–2013 shows that in previous periods "the foreign investment projects developed in Portugal were the major factor behind the changes in the specialisation pattern of the Portuguese economy, contributing to an increase in the technological content of the exported products and bringing about gains in productivity"[12] (DPP, 2007).

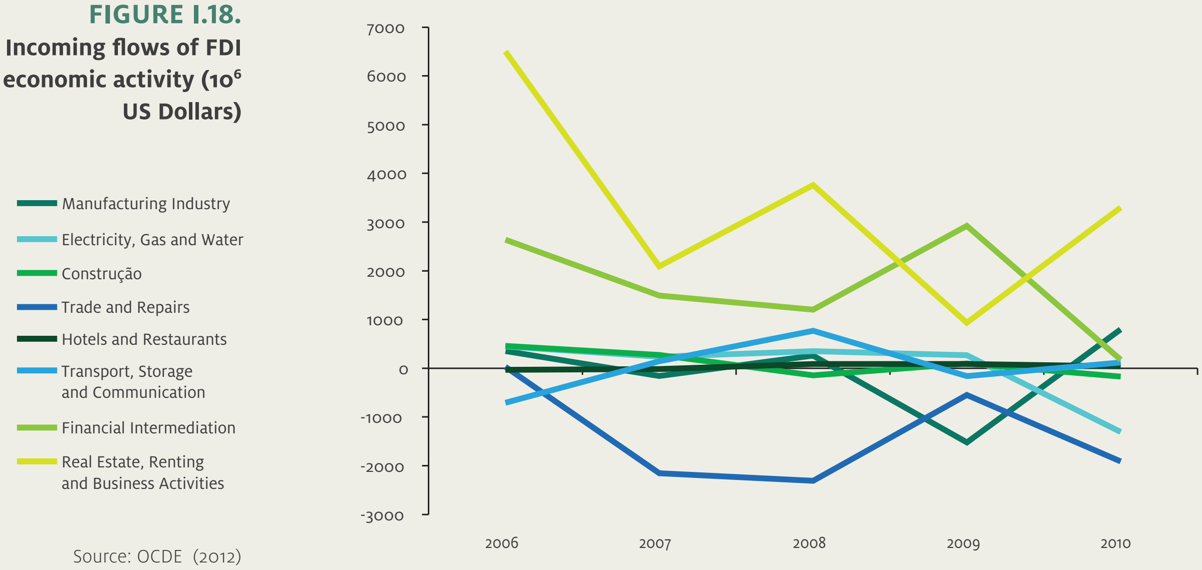
9. FDI – is defined by the OECD (OECD Factbook, 2011) as "investment by a resident entity in one economy that reflects the objective of obtaining a lasting interest in an enterprise resident in another economy. The lasting interest implies the existence of a long-term relationship between the direct investor and the enterprise and a significant degree of influence by the direct investor on the management of the enterprise. The ownership of at least 10% of the voting power, representing the influence by the investor, is the basic criterion used."

10. International investment position is defined by the IMF Balance of Payments Manual as end of period positions of external financial assets and liabilities, for a specific period of time.

11. A level of -35% signifies an alert from the Early Warning System Scoreboard as part of the Excessive Imbalances Procedure (EIP), a corrective measure contained in the Stability and Growth Pact (SGP). This EIP signals risks for macroeconomic imbalances and competitiveness.

12. This refers specifically to the period of analysis studied (1998-2002).

FIGURE I.18.
Portugal – Incoming flows of FDI by sector of economic activity (10^6 US Dollars)



Source: OCDE (2012)

However, according to this same NSRF report, there has been some difficulty in attracting new FDI. This could potentially hamper the much needed renovation of the exporting "business portfolio", which together with the upgrading of the innovation potential of the business community already underway, is a fundamental factor for boosting growth and leveraging productivity improvements (DPP, 2007).

Technological Balance of Payments

Technology needs drive economies to import sophisticated technology, not only via FDI, but also by acquiring 'disembodied technology'[13] from abroad. These flows can be seen in the Technological Balance of Payments (TBP).

Notwithstanding the traditionally negative performance of the technological balance, with a level of credits below that of debits over recent decades, a slowly ascending trend is visible, leading to a positive balance for the first time from 2007 onwards (Figure I.19).

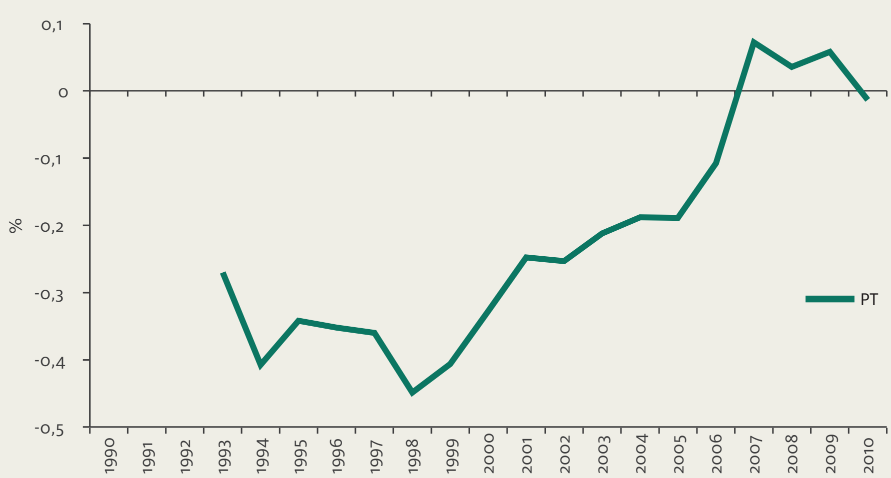


FIGURE I.19.
Portugal – Technology Balance of Payments (as a % of GDP)

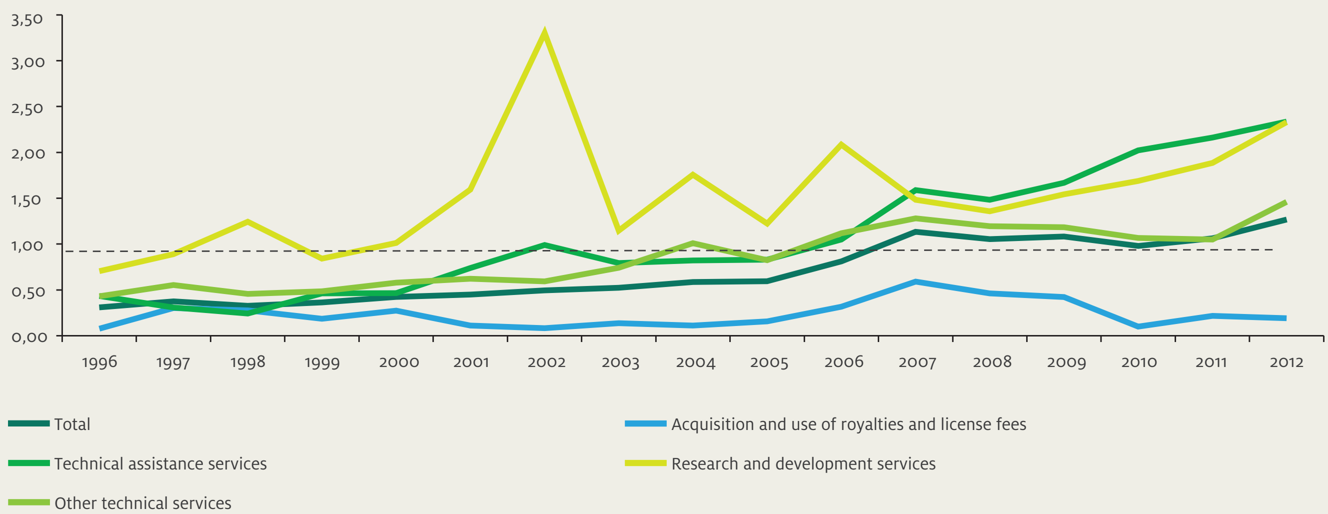
Source: OECD/Main Science and Technology Indicators (MSTI) (2012)

An analysis of the different components reveals that foreign sales of "research and development services" and "technical assistance services" primarily help support the TBP. In contrast, the "acquisition of and use of royalties and license fees" has a coverage rate of less than 1, reflecting the unfavourable performance of the country in terms of patent production (Figure I.20).

13. Patents, licences, knowledge and services with a technological content.

FIGURE I.20.

Portugal – Coverage rate of the Technology Balance of Payments, by component (1996–2012)



Note: 2012 values are up to and including November

Source: BP (2013)

Generically, economies which are highly R&D intensive tend to benefit from more endogenous technology and to be less dependent on imports, which take on a complementary character. Less R&D intensive economies tend to be more dependent on imports, which then develop a role as substitutes, as was the case in Spain and Portugal in the 1980s and 1990s (Figure I.21).

FIGURE I.21.
R&D intensity and imported technology (average values over the period)

Nota: TBP refers only to payments.

Source: OECD (1994) Science and Technology Policy: Review and Outlook 1994. OECD (2012a) Science, Technology and Industry Outlook 2012.

While the analysis developed above still stands, over the more recent period (2001–2011) it can be stated that Portugal has developed more endogenous technology, closing the gap on the countries where technological imports are complementary (a reduction in the ratio of TBP payments/BERD). The position of Ireland stands out here, whose company R&D intensity is seen to be associated with the acquisition of disembodied foreign technology (Figure I.21) (OECD, 1994, p.184).

Conclusions

The economic context within which the National Research and Innovation System operates is important for understanding its structure and evolution, as well as the results achieved. Portugal is a small country in terms of territorial dimension (92.2 thousand km2), located at the western edge of Europe and the Iberian Peninsula, with borders to the north and east with Spain. However, it also has one of the largest economic exclusion zones (EEZ) in Europe and a resident population of 10.6 million. The country displays strong regional asymmetries, with 75% of the population and 85% of GDP to be found in the coastal regions of continental Portugal and the islands. There is a rising tendency for population ageing.

The productive structure of the country is highly dependent on the services sector which represents 74.5% of the national Gross Value Added, and 63.8% of total employment. In terms of manufacturing, in 2010 the North, Centre, and Alentejo regions have shown themselves to be relatively more important, as measured by their share of national GVA. The primary sector is relatively more important in the Alentejo region and the Azores, at around 9% of total GVA. Labour productivity is below the EU average, although it has shown a tendency to improve over recent years.

The level of educational attainment in Portugal remains below the European average, namely for the elderly adults, with the youngest group attaining qualifications that are close to the European average. However, over the course of a decade, the tertiary graduates in scientific and technological areas (Mathematics, Science and Technology) aged 20–29 years old, paved the way for the country to address one of its weaknesses in terms of technological competencies.

The productive structure is based on low- and medium-low-technology sectors (77.6% of manufacturing GVA), notwithstanding some activity in medium-high-technology areas (18.4% of GVA, in 2010, and 14.3% of employment, in 2011). Employment in knowledge-intensive services is around 50% of total employment for the services sector, bringing the country close to the EU27 average. The foreign direct investment flows have shown an unfavourable development over the last decade, with inflows going primarily to financial intermediaries and real estate, renting and business activities.

The technological balance of payments turned positive for the first time in 2007, mainly as a result of foreign sales of “research and development services” and “technical assistance services”.

2.

Characterising the National Research and Innovation System

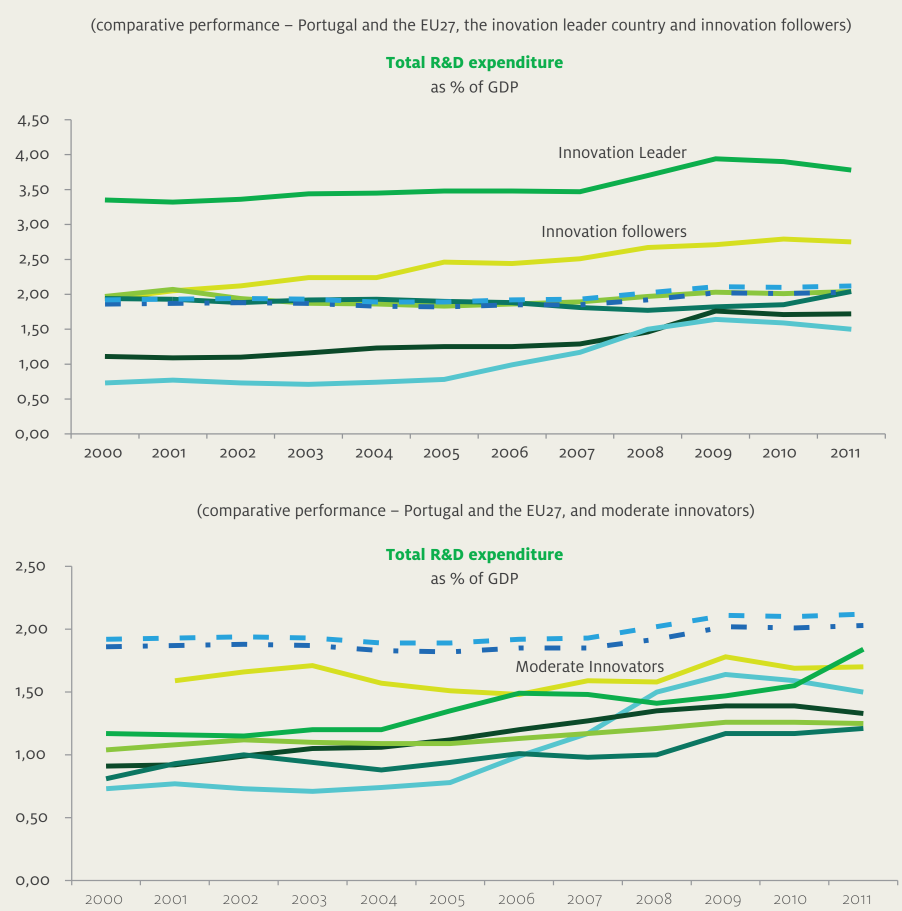
This chapter provides an overview of the national research and innovation system. The central theme of this characterisation is the institutional sectors performing R&D activities: Government, Higher Education, Business and Private Non-Profit Institutions. Besides the main institutional actors, the financing of the innovation system is also covered, and a brief analysis of venture capital is presented. This chapter closes with a sector by sector study of the regions, as well as the regional distribution of the R&D expenditure and human resources.

However, the characterisation of the system will only be completed when the resources are analysed in detail in Chapter 3 and their structural evolution is mapped out in Chapter 7, along with that of public policy.

Comparing the national research intensity and structure with Europe

The research intensity of an economy is measured by calculating R&D expenditure as a percentage of GDP. This indicator is used as a proxy for the contribution that R&D makes to a competitive, knowledge-based economy. As such, the data in Figure II.I shows that the average level of this indicator in Portugal is below the average for the EU countries, as well as for the majority of the benchmark countries. In 2011, R&D expenditure represented around 75% of the

FIGURE II.1.
Total R&D expenditure (as a % of GDP) (comparative performance – Portugal and the EU27, the innovation leader country, innovation follower and moderate innovators)



Source: Eurostat (2013)

TABLE II.1.

R&D expenditure by source of funds and sector of performance (%)

Sector for the source of funds						
Institutional Sector of Performance	**Total Expendi-ture**	**Business (self-financing + funds from other companies)**	**Government Funds**	**Higher Education Funds**	**Funds from Private Non-Profit Institu-tions**	**Funds from Abroad**
			2000			
UE27						
Total	100.00	56.41	34.14	0.57	1.58	7.29
Business	100.00	83.21	7.86	0.02	0.17	8.75
Government	100.00	6.32	87.36	0.17	1.53	4.61
Higher Education	100.00	6.51	82.18	2.53	4.47	4.32
PNPI*	100.00	13.47	29.68	2.07	43.83	10.96
			2001			
Portugal						
Total	100.00	27.05	64.79	1.05	1.92	5.19
Business	100.00	90.79	4.23			4.97
Government	100.00	3.63	92.34			3.61
Higher Education	100.00	0.99	89.46	2.80	2.20	4.55
PNPI*	100.00	5.32	73.96		9.26	11.47
			2009			
UE27						
Total	100.00	54.07	34.92	1.00	1.60	8.41
Business	100.00	83.05	6.95	0.03	0.11	9.85
Government	100.00	9.00	82.46	0.37	1.51	6.66
Higher Education	100.00	6.40	80.66	3.83	3.63	5.48
PNPI*	100.00	8.86	30.63	1.34	46.33	12.84
			2010 e)			
Portugal						
Total	100.00	44.10	44.90	3.20	4.60	3.20
Business	100.00	94.00	4.30	0.00	0.00	1.70
Government	100.00	3.60	83.00	0.00	0.20	13.10
Higher Education	100.00	0.60	88.00	8.60	0.40	2.40
PNPI*	100.00	2.80	47.00	0.30	43.90	6.00

*Private Non-Profit Institutions

Source: Eurostat e DGEEC/MEC

e) Provisional values

European Union average and 40% of the level in Finland. However, for the group of moderate--innovator countries selected, Portugal showed the highest annual average growth rate (6.8%), consolidating its path to convergence with the EU that started decades earlier (Figure II.1).

Tracking those trends, the part played by the Business and Higher Education sectors stands out. Their R&D efforts meant that the 2010 target set out in the National Strategy for Sustainable Development (ENDS 2015) had already been reached in 2009. Over the course of the last decade, these two sectors consolidated their leading roles performing R&D in the System, while the Government sector saw its role become almost completely limited to financing the System.

The analysis of the research and innovation system in this chapter is centred on a study of the main components of each institutional sector. This provides the necessary backdrop for an analysis of how the available resources have developed over time in Chapter 3. The Table II.1 shows the structure of the sources of funds for R&D Expenditure, by sector of performance, for the EU27 and Portugal, providing a starting point for the institutional analysis.

The institutional R&D performing sectors

As already mentioned, the Government sector is one of the main sources of funds for R&D activities (around 45%, in 2010) – with a percentage share slightly above that of the Business sector (44%) – with Higher Education the main recipient of its funding. The Government sector guarantees continuity in the funding of R&D activities and innovation, both directly, and by leveraging off of the expenditures of the Business sector (Table II.1).

Government

The Government sector, as a research performer, has come to progressively reduce its role over the last few decades (over the period between 2000 and 2010 its weight reduced from 23.9% to 7.5%). Currently, its relative importance in the System is at roughly the same level seen in countries such as Finland, Belgium, and the Netherlands.

Importantly, this sector includes the National Laboratories (LE), defined as public institutions benefitting from financial and administrative autonomy (Decree-Law No. 125/99). As Article 3 of the Decree-Law states, these laboratories are tasked with "(…) the explicit purpose of realising scientific and technological policy objectives, adopted by Government, by pursuing activities of research and technological development (…)".

This sector has been the subject of many reforms, most notably that pertaining to the Resolution of the Council of Ministers No. 124/2006, of 3 October, which introduced an alteration in the law changing the juridical status of the National Laboratories to one of corporate public entities or to autonomous funds and services of a business nature. More recently, as part of the Plan to Reduce and Improve Central Administration (PREMAC), the reform process culminated in a reorganisation of the network of National Laboratories, with new laboratories created and others merged in a bid to rationalise resources.

The laboratories in the fields of Exact Sciences and the Environment – the National Institute for Agricultural and Veterinary Research (IPIAV) and the Portuguese Institute for Sea and Atmosphere (IPMA) – Engineering Sciences – the National Laboratory of Civil Engineering (LNEC) – and Health Sciences – the National Health Institute (INSA) – together receive the majority share of the R&D budget. In total, they absorb 60.6% of all public funds and account for around 74.4%

TABLE II.2.

Share of the National Laboratories in the initial budgetary appropriations for R&D and human resources (2011)

	Abbrevia-tion	HR		2011 Budget (euros)			share in the Total Budget (%)	
				TOTAL S&T	TOTAL R&D	R&D/ S&T	TOTAL S&T	Total
National Institute for Agricultural and Veterinary Research I.P. (INIAV)	INIAV	906		49,986,505.00	49,986,505.00	100.0	24.72	1.95
National Laboratory of Civil Engineering I.P. (LNEC)	LNEC	556		36,794,794.00	36,794,794.00	100.0	18.19	1.44
National Health Institute Doutor Ricardo Jorge I.P. (INSA)	INSA	589	(1)	35,788,106.00	25,051,674.20	70.0	17.70	1.40
National Institute of Legal Medicine and Forensic Science I.P. (IMLCF)	INMLCF, I. P.	n.d.		27,785,826.00	4,167,873.90	15.0	13.74	1.09
National Laboratory of Energy and Geology I.P. (LNEG)	LNEG	386		24,185,112.00	24,185,112.00	100.0	11.96	0.95
Nuclear Technology Institute (ITN) part of Instituto Superior Técnico of UTL	ITN	78		10,732,245.00	10,732,245.00	100.0	5.31	0.42
Hydrographic Institute (IH)	IH	153	(2)	9,815,000.00	5,201,950.00	53.0	4.85	0.38
Tropical Research Institute I.P. (IICT)	IICT	n.d.		7,159,538.00	7,159,538.00	100.0	3.54	0.28
Portuguese Institute for the Sea and Atmosphere I.P.(IPMA)	IPMA	n.d.						
Portuguese Institute for Quality I.P. (IPQ)	IPQ	88						
Total S&T budget				**141,267,22**	**102,299,78**		**100.0**	**7.9**
Total				**2,556,942,20**				

Notes:
(1) Data for 2011
(2) Data for 2009
Source: DGEEC; FCT (2013)

of the human resources found in the National Laboratories. With the exception of the Hydrographic Institute (IH), the National Health Institute and the Institute of Legal Medicine and Forensic Science (IMLCF), all the other laboratories spend the totality of their resources on R&D activities.

Higher Education

In Portugal, research activities in Higher Education have shown a continual increase, outpacing the average for the EU27 countries. This increase is obvious when looking at the rise in expenditure relative to total R&D expenditures, which stood at 0.57% of GDP in 2011, against 0.27% at the start of the decade.

The importance of the Higher Education Sector can also be measured by the share of highly qualified human resources in the sector. In 2011, this sector absorbed 61% of all researchers in the system.

Particular measures were put in place or programmed by the "Acceleration of Scientific and Technological Development"[1] :

- Reinforcement of advanced training for human resources in S&T;
- Reinforcement and increased specialisation of the scientific base in higher education institutions;
- Internationalization of academic institutions, particularly driven by strategic alliances with institutions of international standing, such as Massachusetts Institute of Technology – MIT; Harvard University; Carnegie Mellon University – CMU; University of Texas at Austin – UT Austin; and Fraunhofer in Germany among others, with support from programmes for industrial affiliation[2] .

1. Strategic priorities as part of Objective 1 – "Preparing Portugal for the Knowledge Society", ENDS 2015.

2. Note: the information, as available from UTEN (University Technology Enterprise Network) relating to all the academic spin-offs and start-ups of a technological nature, created over the period of study between 2005 and 2010, shows the relevant role that the Portuguese universities have played in knowledge transfer.

TABLE II.3.

Portuguese Universities in the Academic Ranking of World Universities – 2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Portuguese Universities										
Universidade do Porto					403-510	402-503	402-501	401-500	301-400	301-400
Universidade Técnica de Lisboa										401-500
Universidade de Lisboa	301-400	404-502	401-500		403-510	402-503	402-501	401-500	401-500	401-500

Source: Academic Ranking of World Universities, 2012

A brief characterisation of Portuguese universities

Portuguese universities are classified mid-range in the tables of the world rankings, namely the Academic Ranking[3] of World Universities, also known as the Shanghai Ranking . According to this ranking, in 2012 only three universities made it into the top 500: Universidade de Lisboa (since 2003); Universidade do Porto (since 2007); and more recently Universidade Técnica de Lisboa (2012). In 2012, Universidade do Porto held a more competitive position in relation to the other two (300-400), although it continues to be some way from the top (Table II.3).

A brief summary of the characteristics of the Higher Education R&D units funded by the FCT

Portuguese universities' ability to train doctorates tends to be concentrated in the public sector. In particular, six universities represent more than 65% of all new doctorates awarded in Portugal over the decade 2000–2010. As such, Universidade do Porto contributed around 18% of all doctorates, followed by Universidade Técnica de Lisboa (14.1%), Universidade de Lisboa (12.5%), Universidade Nova de Lisboa (10.8%) and Universidade de Coimbra (9.8%). The Universidade Católica Portuguesa is the institution outside of the public sector which most added to the supply (1.6%)[4].

In higher education, R&D activities are mostly organised around centres or departments, which may be grouped in different ways with a view to being recognised by the FCT as R&D units with FCT approval. This approval shows that the unit was internationally peer reviewed and a strategic institutional financing package was awarded for the medium term. Besides the R&D units there are also "Associated Laboratories", which may comprise a thematic grouping of units, classified as excellent or very good. These laboratories, as well as some of the units, are to some degree responsible for organising the national research into topics.

In some cases it is not possible to uniquely associate the R&D units and associated laboratories with the originating institutions, given that they tend to be amalgams of various institutions, or parts of them. On the other hand, the R&D units tend to be project based institutions, or in other words, organisations with a non-permanent and flexible structure capable of changing over time. The National Survey of the Scientific and Technological Potential (IPCTN) from the DGEEC (Directorate General of Education and Science Statistics) was used

3.. The ranking of universities is based on six objective indicators: number of alumni and staff with Nobel prizes; number of highly cited researchers according to Thomson Reuters; number of articles published in respected academic journals, namely Nature and Science; number of papers indexed in the Science Citation Index; and the per capita academic performance of an institution. The results of this ranking are publicly available on the internet.

4. Source: MEC/DGEEC "Inquérito Estatístico ao Registo Nacional de Temas e Teses de Doutoramento concluídos no Ensino Superior" (Statistical Study of the National Registry of Themes and Theses of Completed Doctorates in Higher Education), 2013.

to identify whether an institution belongs to the institutional sector of Higher Education.

To characterise these R&D units we chose a sample containing those units classified as excellent and with a level of financing over of one million euros. The level of financing was determined as the total amount, coming either from the FCT or other European sources[5] , for the period 2007–2011. The final sample comprised 26 units.

In 2011, these R&D units accounted for 3% of all human resources (FTE researchers), but only 0.8% in terms of total funding for the period 2007–2011 (Table II.4). However, this value may be understated, given that the funding information available for the different R&D units and Associated Laboratories primarily reflects institutional funding. This may, as such, not reflect the total funding associated with projects and grants.

TABLE II.4.

Higher Education R&D units classified as excellent (2007) and with total funding over one million euros for the period 2007–2011

	Researchers (2011)		Total FCT and FP7 funding (2007–2011)		Total FCT Funding (2007–2011)	
Area and Research Unit (RU)	**Nº (FTE)**	**% of Total**	**Value (euros)**	**% of Total**	**Value (euros)**	**% of Total funding**
Exact and Engineering Sciences	790.7	1.7	63,784,779.5	0.5	14,698,759.4	0.1
Social Sciences and Humanities	464.3	1.0	22,803,806.3	0.2	6,337,276.2	0.1
Life and Health Sciences	63.4	0.14	5,533,240.2	0.04	1,882,897.3	0.01
Natural and Environmental Sciences	32.0	0.07	5,832,639.2	0.05	393,171.9	0.003
Total of RUs	**1,350.3**	**2.9**	**97,954,465.1**	**0.8**	**23,312,104.8**	**0.2**
Total	**45,915.0**		**12,627,523.800**			

Source: FCT, Multiannual Funding Programme for R&D units (2013).

With the same objective of characterising the system, a selection of Associated Laboratories was made using the same criteria as used for the R&D units.

Using data from 2011, a total of 11 Associated Laboratories were selected from the Higher Education sector, which were classified as excellent in the evaluation of 2007 and recorded total funding above one million euros over the period 2007–2011. These laboratories re-

5. Other sources of funding include international funding contracts awarded on a competitive basis (linked to projects or grants obtained by researchers in the respective institutions) and funding contracts with companies or other entities (national or international), as well as contracts for funding under the 7th Framework Programme for RTD of the European Commission. Values are cumulative for the period.

presented a total of 3.6% of the total human resources for the sector, and 1.8% of the total funding for the period 2007–2011. The funding value may be undervalued for the reasons outlined above.

The selected Associated Laboratories are in the scientific fields of Exact and Engineering Sciences and Life and Health Sciences. The laboratories in Engineering Sciences have the highest share of the total in terms of number of researchers and funding awarded.

TABLE II.5.
Associated Laboratories in the Higher Education Sector classified as excellent (2007) with total funding over one million euros for the period 2007–2011

	Researchers (2011)		Total FCT and FP7 funding (2007–2011)		Total FCT funding (2007–2011)	
Field	**Nº (FTE)**	**% of Total**	**Value (euros)**	**% of Total**	**Value (euros)**	**% of Total**
Exact and Engineering Sciences	768.7	1.7	102,245,099.5	0.8	43,556,529.4	0.3
Life and Health Sciences	399.6	0.9	81,018,111.8	0.6	16,536,735.3	0.1
Natural and Environmental Sciences	462.6	1.0	49,081,100.0	0.4	22,337,194.5	0.2
Associated Laboratories (Higher Education)	**1,630.8**	**3.6**	**232,344,311.3**	**1.8**	**82,430,459.3**	**0.7**
Total of all Associated Laboratories	**3,872.9**		**537,051,598.1**		**209,411,395.3**	
Total	**45,915.0**		**12,627,523.800**		**343,237,644.37**	

Source: FCT, Multiannual Funding Programme for R&D units (2013).

Business

Alongside the Government, the Business sector is the main source of R&D financing. However, business investment is mainly directed towards the activities of the companies themselves (95%). They transfer only a residual amount to other sectors through contracts for external R&D services. This behaviour is different from that observed in other countries of the comparison group, namely Finland, where the Business sector takes on a fundamental role in financing the system.

The Business sector is fundamental for the structural transformation of the economy. In 2010, R&D intensity in Portuguese companies, as measured by the ratio of R&D expenditure -BERD to GDP (%), represented around 60% of the average for the European counterparts.

At around 15%, this sector recorded the highest growth rate in researchers (AAGR) for the period of study. However, the number of permanent staff (FTE – Full Time Equivalent) repre-

TABLE II.6.

Top Portuguese R&D Companies by level of Investment (10^6 euros)

Name	Company Size	Industry – NACE	NUTS 2	Investment in R&D					
				2004	2005	2008	2009	2010	2011
PORTUGAL TELECOM		61 - Telecommunications		11	11		213	200	219
PT Comunicações, S.A.	Large	61 - Telecommunications	Lisbon						
Portugal Telecom Inovação, S.A.	Large	61 - Telecommunications	Centre						
SIBS	Medium	66 - Support services to the financial and insurance industry	Lisbon		4				
BIAL SGPS (**)	Large	21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations	North			60	60		58
CGD	Large	64 - Financial services, except insurance and pension funds	Lisbon			58	58	58	55
EDP	Large		Lisbon			24	31	37	66
EDP - Energias de Portugal, S.A.		35 - Electricity, gas, steam, hot and cold water and cold air	Lisbon						
EDP - Gestão da Produção de Energia, S.A.		35 - Electricity, gas, steam, hot and cold water and cold air	Lisbon						
EDP Distribuição - Energia, S.A.		35 - Electricity, gas, steam, hot and cold water and cold air	Lisbon						
EDP INOVAÇÃO, S.A.		71 - Architecture, engineering and other technical activities, tests and technical studies.	Lisbon						
EDP VALOR - Gestão Integrada de Serviços, S.A.		70 - Head office and management consultancy activities	Lisbon						
NOVABASE	Large	62 - IT programming and consultancy and related activities	Lisbon			11	9	11	8
CRÉDITO AGRÍCOLA FINANCIAL	Large	64 - Financial services, except insurance and pension funds					11	12	12
MARTIFER	Large		Centre				8		
Martifer II Inox, S.A.		25 - Manufacture of metal products, except machinery and equipment	Centre						
Martifer Solar, S.A.		28 - Manufacture of unspecified machinery and equipment	Centre						
BRISA	Large		Lisbon				6	5	
BRISA - Auto Estradas de Portugal, S.A.		52 - Warehousing and ancillary transport activities	Lisbon						
BRISA - Engenharia e Gestão, S.A.		71 - Architecture, engineering and other technical activities, tests and technical studies	Lisbon						

Notes: The companies in blue are included in the 1500 top world companies that carried out R&D in 2011.
(**) – Portuguese company with the highest number of patents filed with the European Patent Office (EPO) in 2008 and 2009.

Source: EU R&D Scoreboard; Science, Technology and Tertiary Education in Portugal, 2011.

sents less than one quarter of the total. **Portugal is the country with the lowest proportion of highly qualified human resources working in the productive base.**

However, Portugal does have a group of companies that are well positioned in terms of those companies that invest most in R&D at a European and world level (Table II.6).

For Portugal, the conclusions that are forthcoming from the information gathered by the EU R&D Investment Scoreboard (of the European Commission) are not totally comparable with the data collected at national level – in particular, the National Survey of the Scientific and Technological Potential (IPCTN). This is due to the fact that the Scoreboard does not cover all companies that invest in R&D, but only a sample of the top 1500 R&D investing companies at European and world level.

However, the data collected allows the following conclusions to be drawn: the prominent companies that operate worldwide are large, located in the Lisbon region, mostly within the services sector - knowledge-intensive services. In 2008 and 2009, the volume of R&D expenditure by these companies respectively represented 32% and 33.6% of the R&D expenditures of the top 100 R&D investing companies, according to the IPCTN[6] data for 2008 and 2009.

Another distinctive feature of Businesses Enterprises' increased involvement in the System is its financing share. This rose from 27.05% in 2000 to 44.10% in 2010, following the trend of the knowledge-based economies.

The share of Business Enterprises' direct financing absorbed by the Higher Education sector helps reveal the interaction that exists between the two (Dosi et al., 2006). The low values for Portugal indicate that this interaction still occurs on only a very small scale. This situation may be explained by the fact that cooperation is mainly financed by national programmes, as will be discussed later in the report.

Private non-profit institutions

Private non-profit institutions (Private NPIs) were always important in the national system, both in terms of performing R&D and its funding. The sector is characterised by a highly diverse set of R&D centres and institutes, associations and foundations with a particular vocation for R&D (Table II.1). Between 2000 and 2010, the importance of this sector rose from 1.9% to 4.6%.

The role of private foundations stands out, such as the Fundação Calouste Gulbenkian and, more recently (2010) the Fundação Champalimaud. Both these institutions have their own R&D institutes in the area of Life and Health Sciences, with sizeable self-financed budgets.

As Chapter 7 states, the evolution of the national research and innovation system has always been based on autonomous research units, which are dependent on the national Research Council, like the National Institute for Scientific Research (INIC). Similarly to what had happened in the United States, these organisations were the initiative of researchers, many of which perform R&D in partnership with business enterprises, in areas in which they collaborate.

6. O "Crédito Agrícola Financial" was not part of the IPCTN list in either year.

Latterly, other research units were created and fostered under the programmes of the First Community Support Framework, mainly with the legal standing of private non-profit institutions. Portugal is in line with many European countries in using these types of institutions for R&D activities (see, for example, the EUROLABS study)[7].

There also exist R&D units and Associated Laboratories funded by the FCT, with the legal status of Private NPIs, which were also classified by the IPCTN in this sector. Once again, the selection criteria were applied to the sample to provide an overview of the R&D units and the Associated Laboratories.

In 2011, this group of units represented 0.8% of the total human resources (FTE researchers) and 0.2% of the total financial resources (Table II.7). These units are mainly in the scientific areas of Social Sciences and Humanities, followed by Life and Health Sciences and Exact and Engineering Sciences.

TABLE II.7.

R&D units with PNPI status (Human Resources and Funding – Summary)

	Researchers (2011)		Total FCT and FP7 Financing (2007–2011)		Total FCT Financing (2007–2011)	
Field	**Nº (FTE)**	**% of Total**	**Value (euros)**	**% of Total**	**Value (euros)**	**% of Total Financing**
Social Sciences and Humanities	266.8	0.6	14,340,270.9	0.11	3,516,164.8	0.03
Life and Health Sciences	80.8	0.2	5,892,891.6	0.0	1,167,259.3	0.0
Exact and Engineering Sciences	35.0	0.1	2,656,831.6	0.02	660,319.6	0.01
Total RUs	**382.6**	**0.8**	**22,889,994.1**	**0.2**	**5,343,743.7**	**0.04**
Total PR&IS	**45,915.00**		**12,627,523.800**			

Source: FCT, Multiannual Funding Programme for R&D units (2013)

For the period under consideration (2007-2011), the funding of Associated Laboratories with Private NPI status represented 2.4% of the total expenditure on R&D and 4.9% of human resources. This was concentrated primarily in the areas of Exact and Engineering Sciences, Life and Health Sciences and Social Sciences and Humanities (Table II.8).

7. ftp://ftp.cordis.europa.eu/pub/indicators/docs/ind_report_prest4.pdf

ftp://ftp.cordis.europa.eu/pub/indicators/docs/ind_report_prest3.pdf

TABLE II.8.

Associated Laboratories with Private NPI status (Human Resources and Funding – Summary)

	Researchers (2011)		Total FCT and FP7 funding (2007–2011)		Total FCT funding (2007–2011)	
Field	**Nº (FTE)**	**% of Total**	**Value (euros)**	**% of Total**	**Value (euros)**	**% of Total**
Exact and Engineering Sciences	1,297.1	2.8	190,149,523.2	1.5	64,432,580.8	0.5
Life and Health Sciences	760.1	1.7	89,045,749.2	0.7	49,375,195.4	0.4
Social Sciences and Humanities	185.0	0.4	23,725,044.5	0.2	13,173,159.9	0.1
Associated Laboratories	**2,242.1**	**4.9**	**302,920,316.8**	**2.4**	**126,980,936.1**	**1.0**
Total Associated Laboratories	**3,872.9**		**537,051,598.1**		**209,411,395.3**	
Total	**45,915.0**		**12,627,523.800**		**343,237,644.4**	

Source: FCT, Multiannual Funding Programme for R&D units (2013)

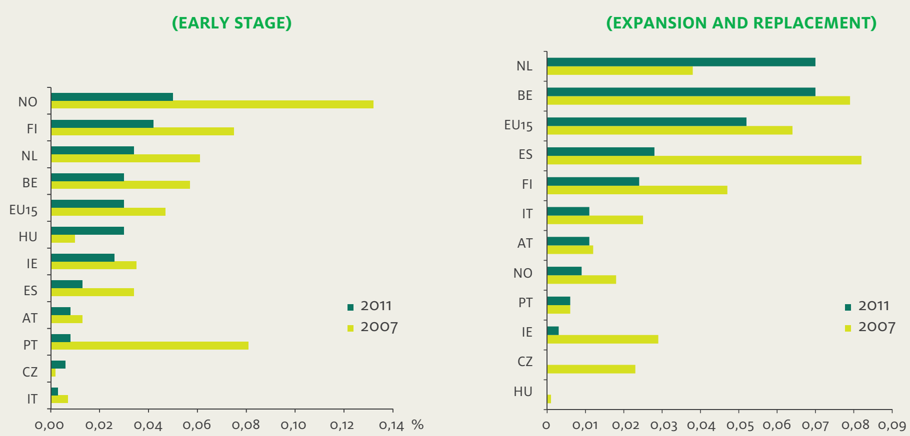
Relevant stakeholders financing innovation: Venture capital

As part of the innovation system, there exist both public and private funding agencies, leveraging off the financial system. Access to funds is of fundamental importance to the innovation process. Innovation and research activities have a significant element of risk that is often not compatible with the criteria applied by commercial banks for granting credit. This opens the way to a new set of potential actors and entities, both public and private, looking to promote entrepreneurship and technology based investment. With the existing restrictions on funding, venture capital has gained importance as a means of financing innovative SMEs. This source of funds is particularly important at an early stage of investment, allowing them to bring new products to market.

In Portugal, venture capital as a proportion of GDP (%) is still relatively insignificant, both during early and expansion stages. This pattern is reflected in almost all of the countries considered in the analysis (Figure II.2).

FIGURE II.2.

Venture Capital (as a % of GDP)



Source: Eurostat. (2013)

The recent merger of three public venture capital entities led to the creation of Portugal Ventures as a vehicle for achieving the government's objective of creating a support framework providing an alternative to traditional private sector financing[8]. In wider terms, this helps create the conditions for a continued expansion of a more innovative business sector.

Besides institutional investors, individual investors, known as business-angels, can also play an important role in financing new start-ups. In this respect, Portugal benefits from entities such as the Portuguese Association of Business Angels and the National Federation of Business Angel Associations.

The sectoral and intersectoral patterns among the regions (NUTS 2)

This section seeks to identify the regional dynamics and patterns of the system, looking at the performance, the resources allocated and the innovation profile of the companies in each region. Over the decade, one region – Lisbon – absorbed more than 50% of all available financial resources in the System. In addition, it absorbed the major share of R&D human resources and, in particular, researchers, reflecting the (socioeconomic) structural asymmetries that characterise the country (Figure II.3).

The North and Centre regions have shown an increasing rate of growth. The North, in particular, stands out due to its increased ability to absorb financial resources, which in 2010 represented more than one quarter of total R&D expenditure in the country (8.9% in 2000).

The intersectoral pattern of R&D expenditure at the beginning of the last decade was concentrated on the Higher Education and Government sectors. However, a significant share of Business R&D expenditure went to the North, Centre and Lisbon regions. The Government sector was predominant in Madeira and the Azores. It is worth mentioning that the Government sector still had a significant role in the region of Lisbon (32.5%), reflecting the local concentration of public services, laboratories and other such entities in this region. As previously stated, at the end of the decade the Government sector was responsible for performing less and less R&D, falling away to a residual value in all regions by 2010, with the exception of Madeira (48.4%) (Figure II.4).

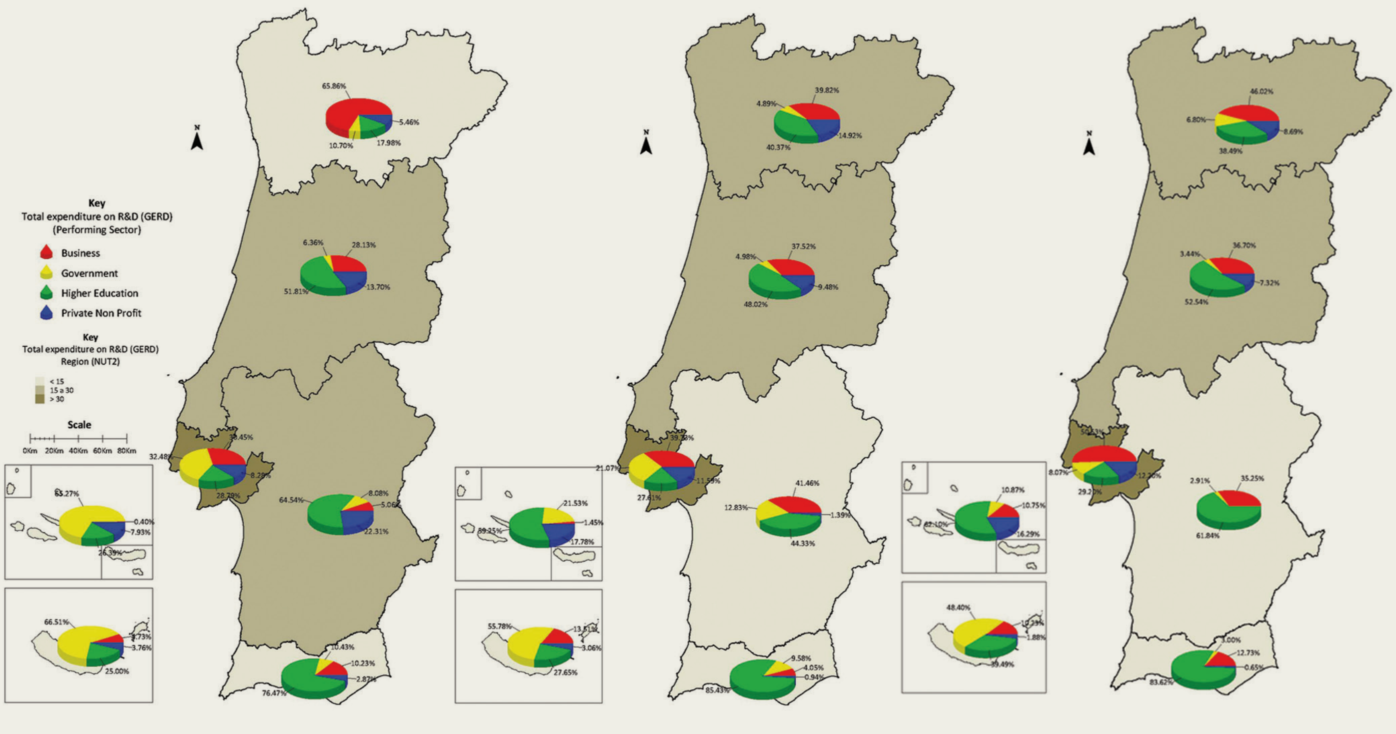
On the other hand, the Business sector recorded a significant rise in all regions, although in a somewhat uneven way: The Business sector in the regions of Lisbon and the North is more important than the Higher Education sector (50.5% and 46.0% of all expenditure carried out, respectively); while for the regions of the Centre and Alentejo the opposite is true, with the Business Sector only slightly less important than that of Higher Education (36.7% and 35.2%). The Private Non-Profit sector has shown itself to be relatively stable in terms of R&D performing sector, notwithstanding the relative increase in its activities recorded in the regions of the Azores and Lisbon at the end of the decade.

The regional analysis of R&D investment also reveals a divided country: the North, Centre and Lisbon regions have a higher record of R&D performance. In Lisbon R&D expenditure as a percentage of GDP was one and a half times the national average.

8.In the Community Innovation Survey, CIS 2010, the excessive costs associated with innovation and the lack of funds within the enterprise or group were identified as being the main obstacles to innovation.

FIGURE II.3.

Total R&D Expenditure (GERD), by sector of performance and NUT 2 regions (%)

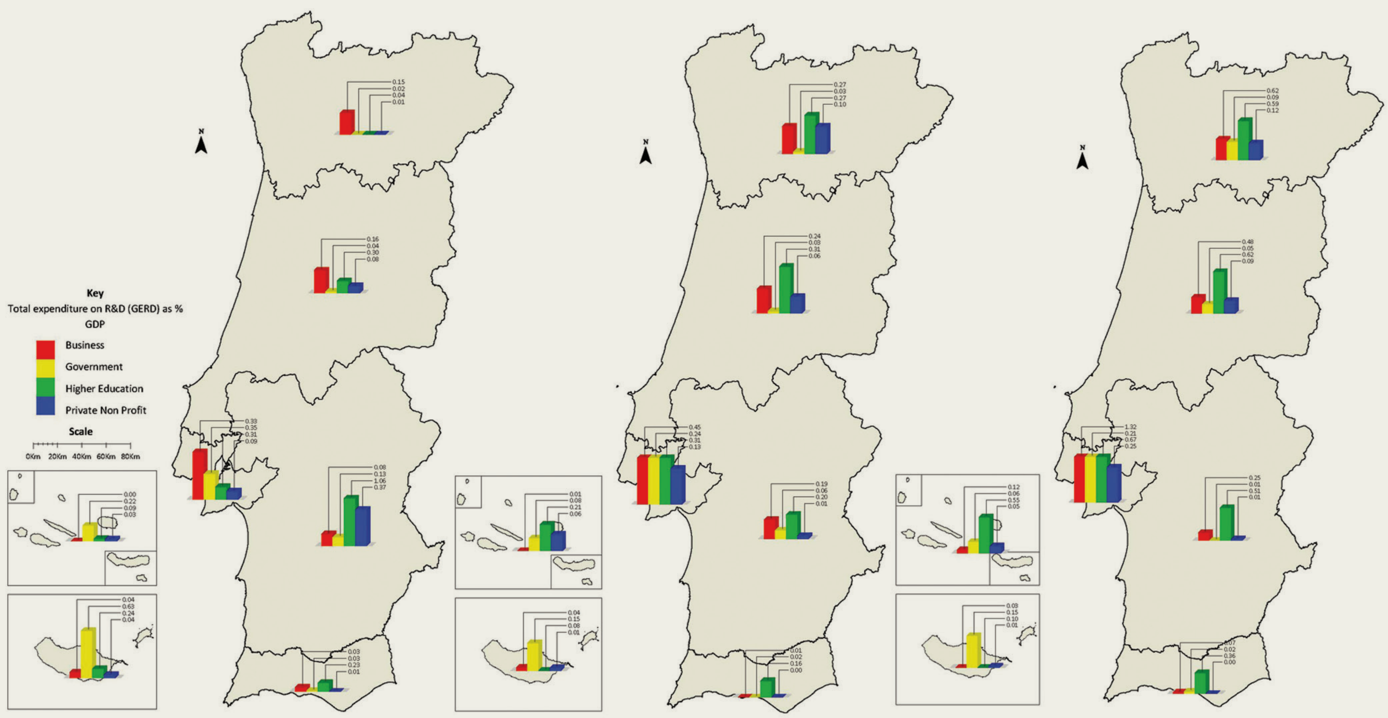


Source: Eurostat

2000 2005 2010

FIGURE II.4.

Total R&D Expenditure (GERD), by sector of performance and NUT 2 regions, as % GDP



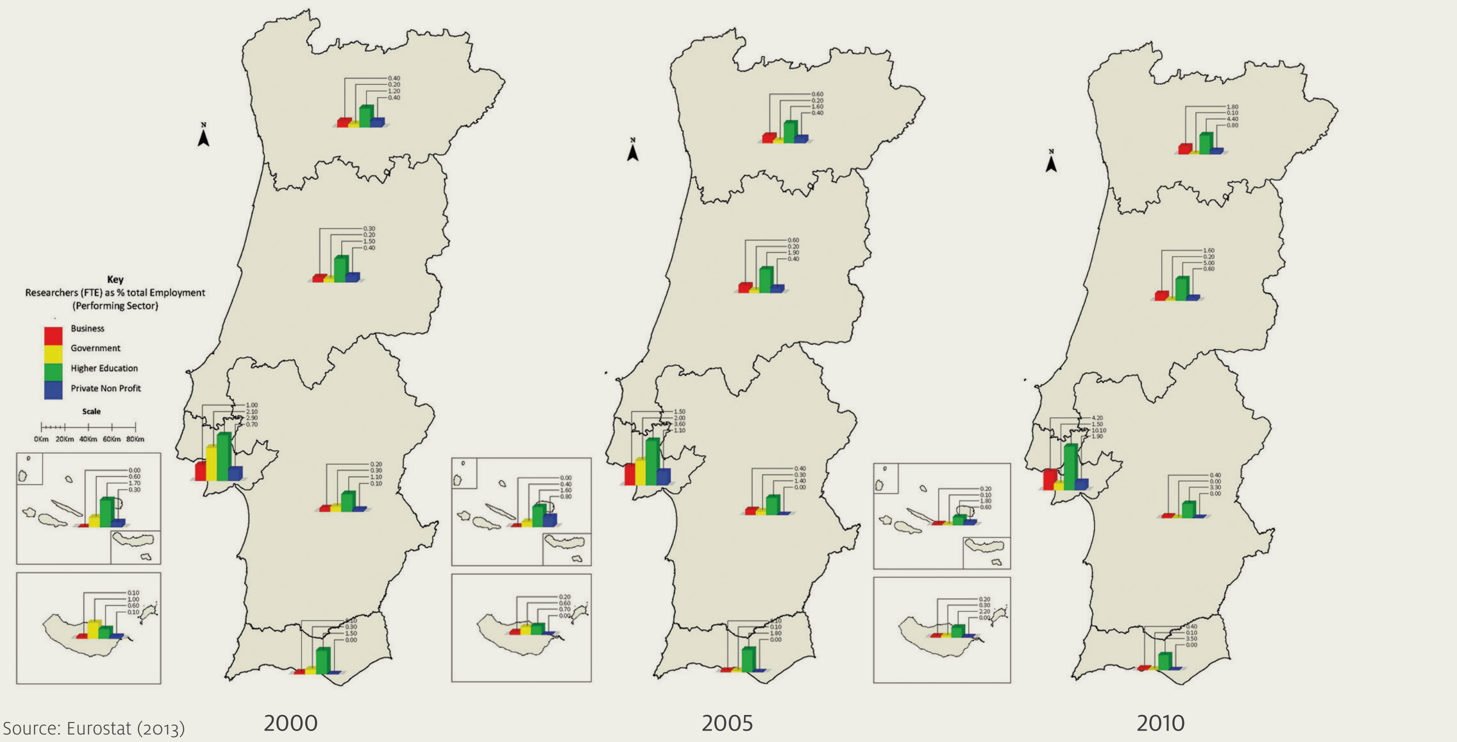
Source: Eurostat (2013)

2000 2005 2010

Looking at the distribution of human resources shows that in 2010 the regions of the North, Centre and Lisbon together absorbed 94.3% of the total. This reflects a high degree of concentration in the regional distribution of knowledge, a trend which has become more accentuated over time (94.3% in 2010 compared with 90.6% in 2000), even though the region of Lisbon has become relatively less important (Figure II.5).

FIGURE II.5.

Researchers (FTE) per thousand employment, by sector of performance and NUT 2 Regions



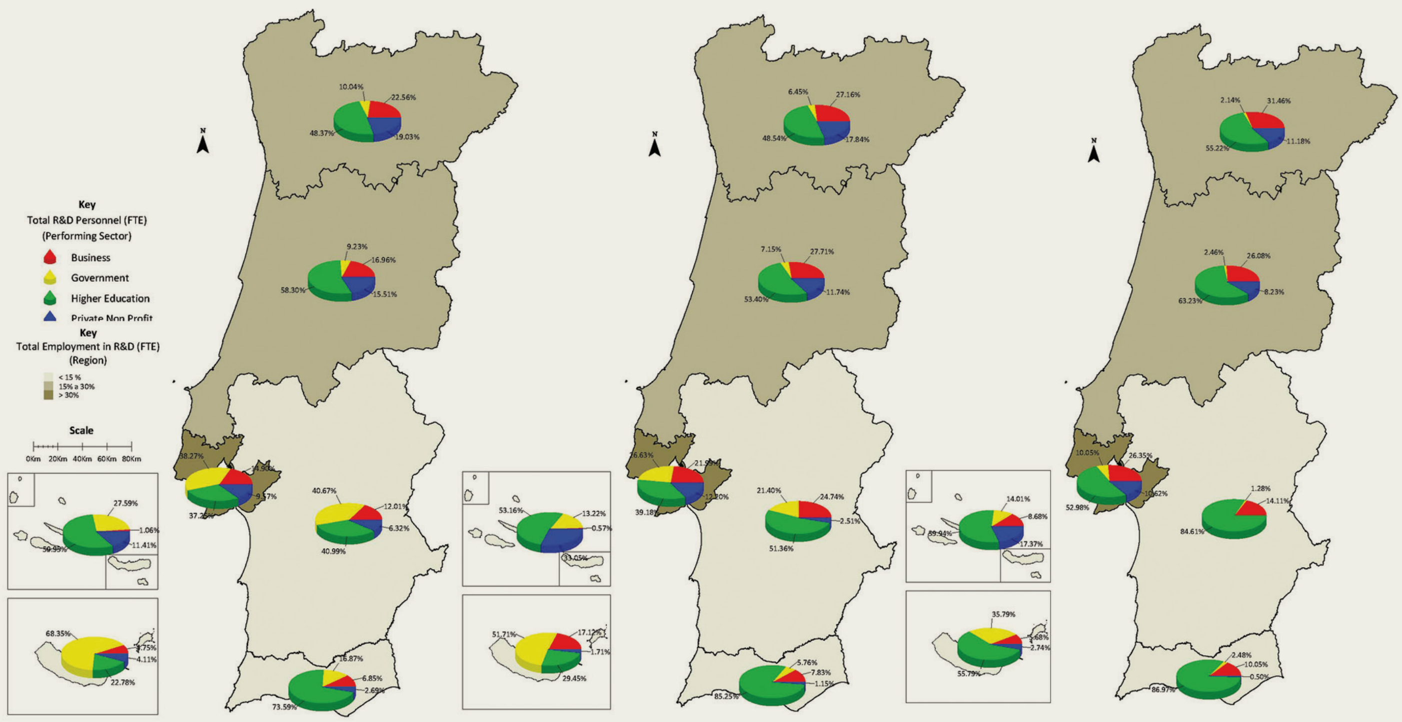
Source: Eurostat (2013)

However, analysing the regional and intersectoral distribution of researchers (FTEs) reveals a highly skewed pattern in favour of Higher Education. It should be noted, however, that there is a growing capacity for the Business sector to absorb researchers in the regions of the North, Centre and Lisbon, which accounted for 25.5%, 21.3% and 23.7% of all researchers, in each region respectively, in 2010. No such trend has been visible in the other regions (Figure II.6). The regional sectoral distribution of total R&D personnel reflects the same pattern observed for researchers, being concentrated in the two sectors with a leading role in fostering the development of the regions.

In 2010, the share of total R&D personnel in total employment was 10.5‰ for the country (compared with 4.4‰ in 2000), of which 6‰ was within the Higher Education sector and 2.8‰ was within the Business sector. In 2010, Lisbon was the only region of the country where employment in R&D was above the national average, with the Higher Education sector (10.6‰) and the Business sector (5.3‰) accounting for the largest share (Figure II.7).

FIGURE II.6.

Total R&D Personnel (FTE), by sector of performance and NUT 2 regions



Source: Eurostat 2000 2005 2010

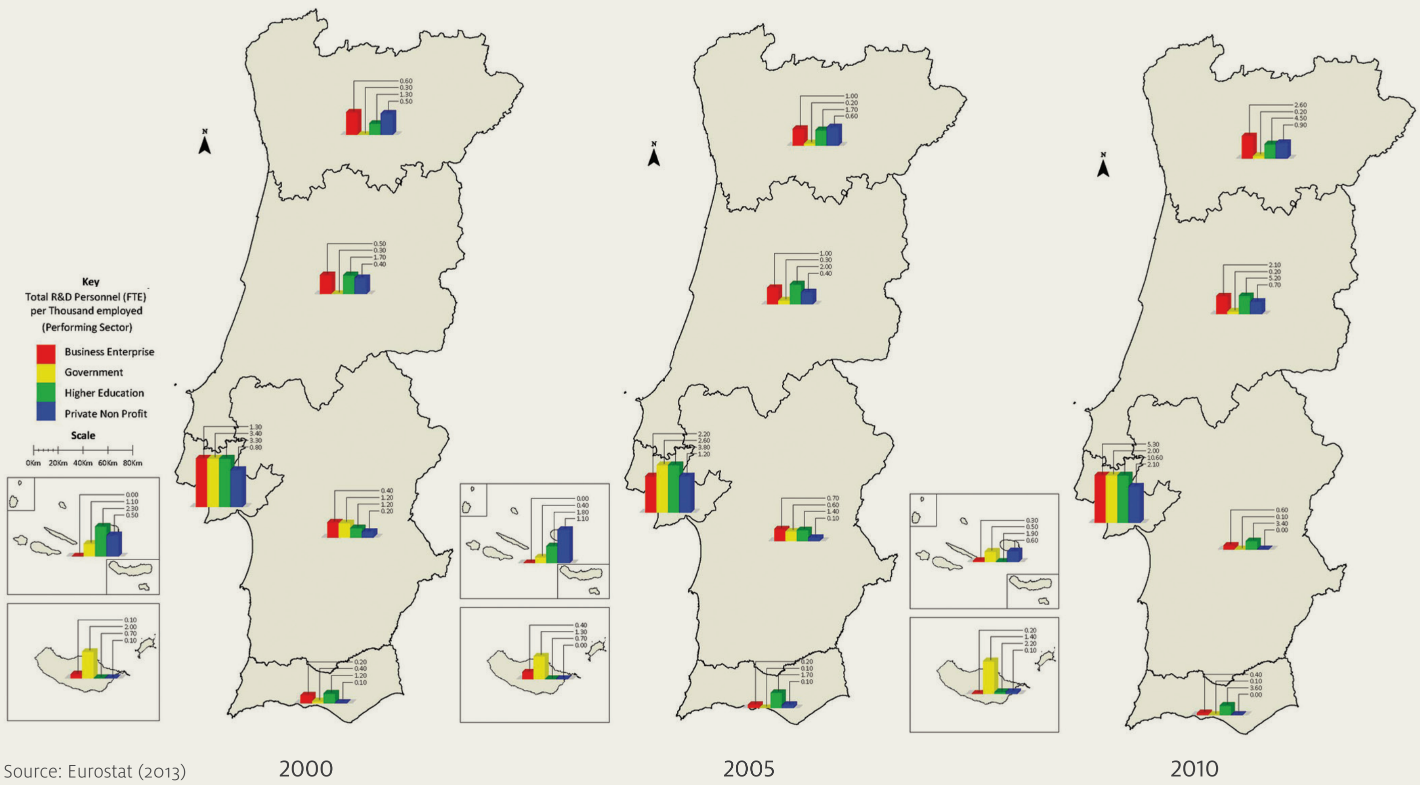
Business innovation activities in regional perspective

Due to sample stratification, the Community Innovation Survey (CIS) does not allow a representative regional approach prior to the survey of 2006–2008 (CIS 2008). Thus, an intertemporal analysis is only possible at a national level, and limited to a static interpretation of the regional data for 2008.

An analysis of the regional distribution of the total expenditure on innovation, based on the above mentioned survey with its stated limitations, shows that in 2008 the regions of Lisbon, North and Centre were those which invested most in innovation (respectively contributing to 45%, 28% and 22% of total innovation). This is a reflection of the significant business activity in those regions (88.6% of the SMEs and 94.9% of large companies) – which also helps explain Business R&D Expenditure (BERD) for these regions (Figure II.8).

FIGURE II.7.

Total R&D personnel (FTE), per thousand employment, by sectors of performance and NUT 2 regions



Source: Eurostat (2013)

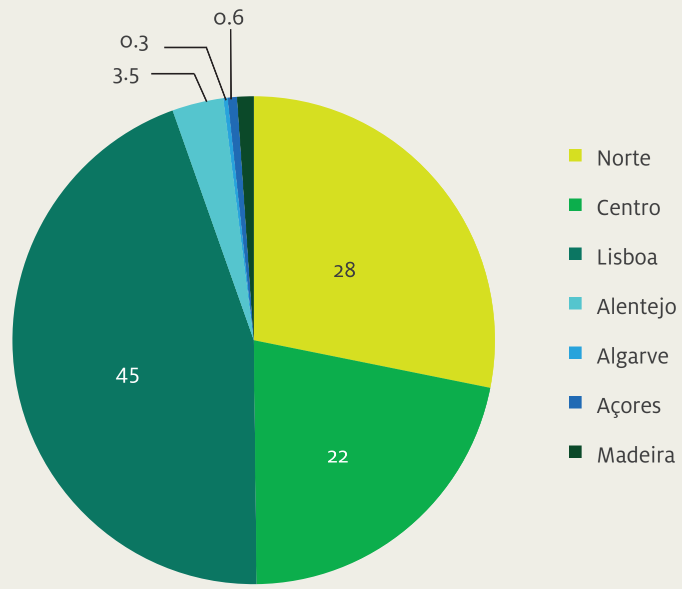
Comparing regions in the European context

In national terms, this pattern of expenditure shows an underlying positive change in the number of companies engaged in innovation activities, 60% in 2008 and 40% in 2004. In 2008, only the Alentejo and North (50%) were below the national level (Figure II.9).

The Regional Innovation Scoreboard helped fill a gap in the existing information, allowing innovation performance to be evaluated at a regional level and providing an understanding of the respective sources and patterns. The Scoreboard has provided evidence showing that, on the one hand, the best performing regions in innovation are located in the most innovative countries, and, on the other hand, that considerable diversity exists in the regions, in both socioeconomic and geographic terms, where it is possible to observe differing patterns of innovation.

Lisbon, as previously noted, stands out as being the most innovative region in the country, with the Centre occupying second place (follower). Still, the regions of the North, Algarve and Alentejo are classified as having a moderate level of innovation and the autonomous regions a modest level. It is worth highlighting the markedly positive trend observed for all the regions in a very short period of time (Table II.9).

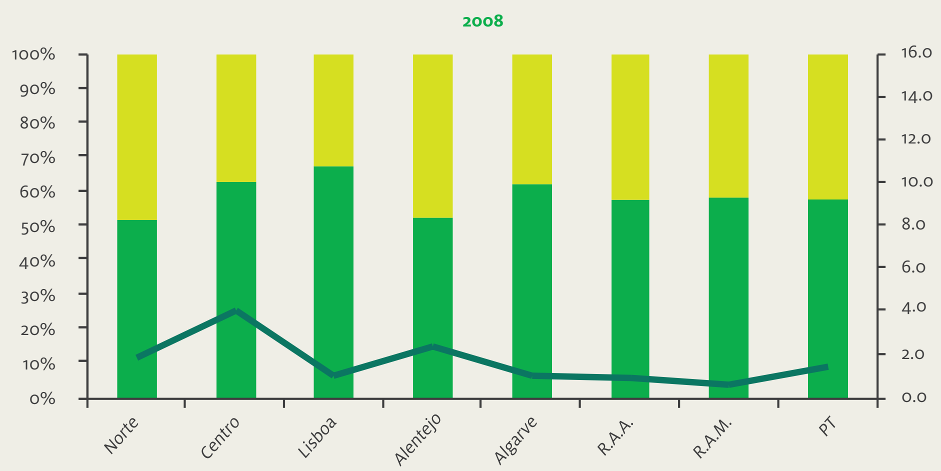
FIGURE II.8.
Enterprise Innovation expenditure - Regional breakdown, 2008 (%)



Source: Eurostat, CIS (2013)

FIGURE II.9.
Enterprises with and without innovation activity, by region, 2008 (%)

Sem Actividades de Inovação
Com actividades de Inovação
Intensidade de Inovação*



Source: Eurostat, CIS (2013)

Note: *Innovation intensity - Innovation expenditure as a percentage of total turnover of companies with innovation activities

TABLE II.9.
Regional innovation performance profile

	Classification group		
	2007	**2009**	**2011**
Innovative Country			
Portugal	MODERATE	MODERATE	MODERATE
Innovative Regions			
North	Modest-high	Moderate-low	Moderate-high
Centre	Moderate-low	Moderate-medium	Follower-low
Lisbon	Follower-medium	Follower-high	**Leader-low**
Alentejo	Moderate-low	Moderate-medium	Moderate-medium
Algarve	Modest-medium	Moderate-low	Moderate-high
Azores	Modest-medium	Modest-medium	Modest-high
Madeira	Modest-low	Modest-low	Modest-medium

Source: Regional Innovation Scoreboard, 2012.

Conclusions

The research and innovation system has been catching up reducing its gap to EU average. R&D expenditure (GERD) as a percentage of GDP (6.8%) has been growing quickly, consolidating the convergence trajectory that started decades earlier. This convergence process was largely driven by the Business Enterprise and Higher Education sectors. Over the first decade of this century these two sectors built on their dominant position in the System as R&D performers, while the Government sector concentrated on its funding role.

The Government has guaranteed the continued growth in R&D activities, funding around 45% of the system in 2010. Its importance as a R&D performer, on the other hand, has waned, with National Laboratories losing importance.

Higher Education plays a leading role as a R&D performer, whose increase in relative importance has been a constant factor, and having already overtaken the average for EU countries (GERD represented 0.57% of GDP in 2011). The relevance of the sector is reflected not only in the international recognition of its Education Institutions, but also by the Research Units classified as excellent. The research activities are largely carried out in the respective R&D Units and the Associated Laboratories, funded by the FCT after being internationally peer reviewed.

Companies have moved to the heart of the system in terms of R&D expenditure, although the Business sector is still relatively less important than in most of the systems in other European countries. The growth rate in the number of researchers in this sector has been considerable – around 15% (AAGR) – although the number of effective staff (FTE) still account for only one quarter of total R&D personnel (FTE). However, 16 national companies have reached a notable position in terms of their R&D investment in the context of the top R&D investing companies at European and world level (EU Industrial R&D Investment Scoreboard, 2011).

PNPIs have for a long time been an important sector in Portugal, both in terms of financing and performing R&D. Their relative importance in financing has grown over the period between 2000 and 2010, rising from 1.9% to 4.6% of the total.

Looking at the sectoral and intersectoral patterns at a regional level shows how human resources are concentrated in the North, Centre and Lisbon regions, which, in 2010 accounted for 94.3% of both researchers and total R&D personnel for the country. These regions equally dominated the financial resources, with the region of Lisbon receiving more than 50% of the total. The intersectoral pattern of expenditure at the start of the last decade was characterised by a focus on the Government and Higher Education sectors, notwithstanding the significant weight of the Business sector in the North, Centre and Lisbon regions. By the end of the decade, the Business sector had grown in importance and the Government sector had ceased to have a significant role for the majority of the regions, except Madeira.

Lisbon, as a region, stands out as being the most innovative in the country, with the Centre in second-place (follower). The regions of the North, Algarve, and Alentejo still find themselves at a moderate level of innovation, and the autonomous regions at a modest level.

3.

Mobilising Financial and Human Resources and Infrastructures

Introduction

Mobilising resources is a fundamental and structural function in an Innovation System. Together with its other functions, it contributes decisively to its dynamism and development.

Drawing on the available literature regarding the structure and functions of innovation systems (in particular Hekkert and Negro, 2008; Hekkert et al., 2007 and Bergek et al., 2008), resource mobilisation can be defined as that process/function which helps provide the innovation system with the financial resources, the skills and the infrastructures necessary for constituting and sustaining the other system functions, namely knowledge production and distribution. This chapter seeks to identify and discuss resource mobilisation (financial, human and infrastructure) for scientific and technological activities in the Portuguese system, using officially available statistical data and other secondary sources of information.

The chapter starts by analysing the way resources have been used by scientific area. The resources used by the different types of R&D are also analysed. In what follows, we will provide an analysis of "Total R&D personnel", considering their functions, scientific area and gender. In the last part of the chapter, an analysis is given of the little information that is available on R&D infrastructures.

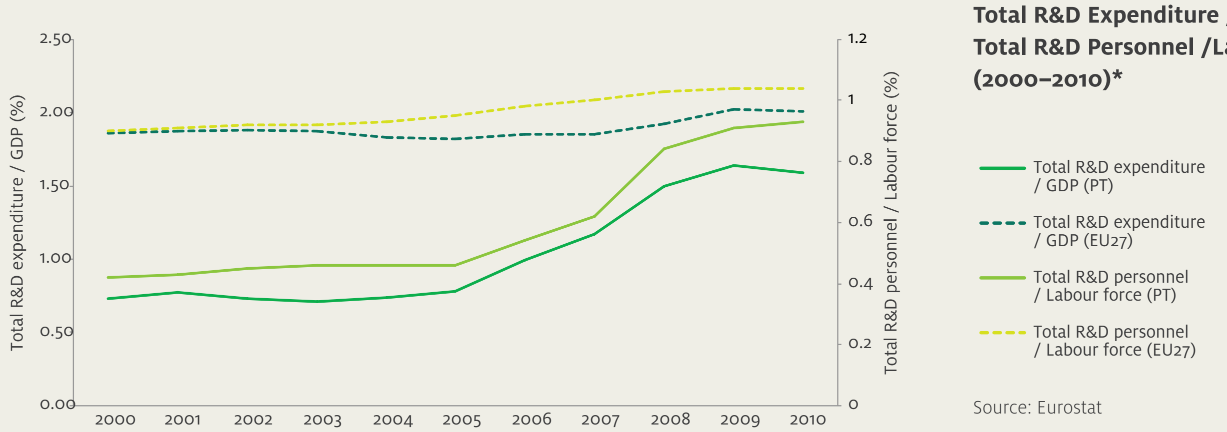
Expansion and transformation of the scientific and technological base of the Portuguese R&I system

R&D expenditure and human resources are converging with the European average

Over the last decade, resource mobilisation of the Portuguese system capacity can be characterised by a sustained growth in R&D human resources expenditure. This process was crucial for helping the country catch-up with the rest of the EU27.

Total R&D expenditure grew at a considerable pace from 2000 to 2010 (AAGR of 8.1%), reaching 1.59% of GDP in 2010, when in 2000 it was 0.73% (Figure III.1). The same growth was observed in Total R&D Personnel (FTE) as part of the labour force (AAGR: 8.3%), rising from 0.42% in 2000 to 0.93% in 2010. As such, the gap between Portuguese R&D expenditure and the EU27 average was reduced from -1.13% p.p. to -0.41 p.p. and the gap relating to total R&D Personnel was reduced from -0.48 p.p. to -0.11 p.p.

FIGURE III.1.
Total R&D Expenditure /GDP and Total R&D Personnel /Labour force (2000–2010)*



Source: Eurostat

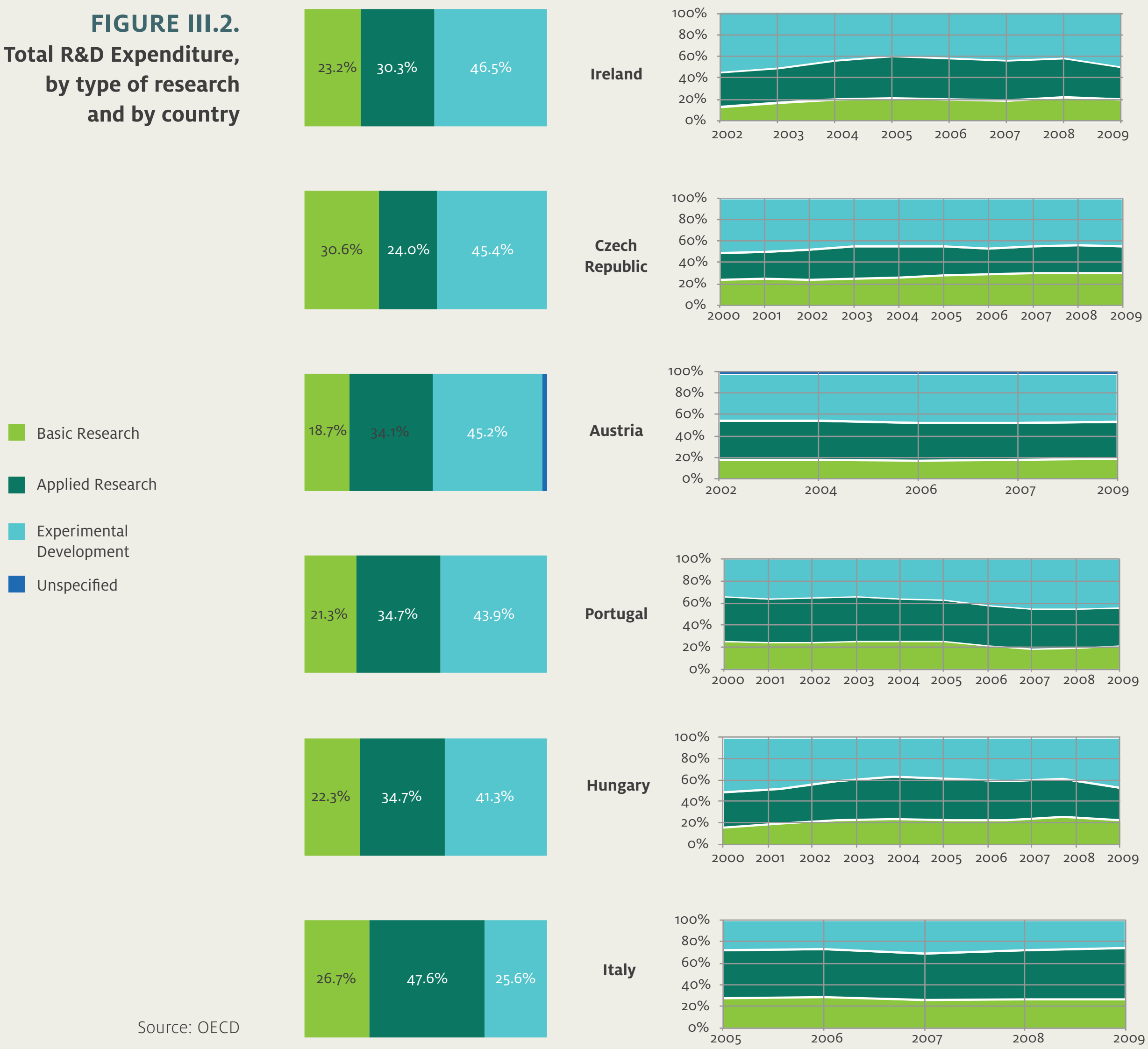
Note: * In 2007 there was a break in the statistical series due to the enlargement and improvement in the use of the administrative sources for updating the national directory of enterprises surveyed in Portugal (in IPCTN – the National Survey for Scientific and Technological Potential), resulting in an increase in the number of companies answering the national survey as R&D performers. In 2008, another break in the statistical series occurred as a result of exchanging information between the IPCTN and the national system for monitoring Higher Education lecturers (REBIDES). From this point on, the survey results include R&D activity in the Higher Education sector, carried out by lectures and students writing master's and doctoral theses, which was not reported by the R&D centres in the survey response.

However, as stated in the previous chapter, the capacity of the scientific and technological base continues to suffer from a number of failings, despite efforts to expand the system.

Type of research

Systematic work, based on existing scientific knowledge and/or practical experience and focusing on experimental development (to produce new knowledge materialized in new or significantly improved materials, products / devices , new processes, systems and services) accounts for the largest slice of R&D expenditure in Portugal (43.9%).

FIGURE III.2.
Total R&D Expenditure, by type of research and by country



Source: OECD

Experimental Development activities together with Applied Research (original research work undertaken in order to produce new knowledge, oriented towards previously defined practical objectives) help maintain the pace of expansion, together representing three quarters of Portuguese R&D expenditure.

The distribution of R&D expenditure by type of research in Portugal is in-line with other countries (where data exists for international comparison). The exceptions here are the Czech Republic (where Basic Research accounts for 30% of expenditure) and Italy (with almost half – 47.6% – dedicated to Applied Research alone) (Figure III.2).

Business sector

Historically, R&D expenditure by the Business sector in Portugal is largely directed towards Experimental Development (70.5% in 2009) and Applied Research (27.8% in 2009). Basic Research, or that research which has no particular application in view, represents a residual proportion (1.6% in 2009).

A comparison with benchmark countries, where data is available[1], shows that Portuguese enterprises have some notable differences in their pattern of R&D expenditure: Basic Research by Portuguese enterprises represents a much smaller proportion of expenditure than in any other country; it is relatively far away from Hungary, which dedicates the second smallest proportion of expenditure to this category (4.8%, 3.2 p.p. more than Portugal). In contrast, only enterprises in the Czech Republic (73.9%) devote a higher proportion of R&D resources into Experimental Development than Portuguese enterprises.

Government sector

Government R&D expenditure in Portugal is mainly associated with Applied Research activities (64.7% in 2009), having maintained this dominant position over time (55.3% in 2000). This is despite the growth in the proportion of expenditure being absorbed by Basic Research (16.8% in 2009). The weight of Experimental Development in the Government sector has narrowed over the last ten years (dropping from 36.4% in 2000 to 21.9% in 2009).

Higher Education sector

Higher Education R&D expenditure is fairly equally divided between Basic Research (41.7% in 2009) and Applied Research (39.7% in 2009). However, the last decade has seen a decline in the proportion of expenditure devoted to Basic Research (dropping from 48.8% in 2000 to 41.7% in 2009).

Compared to the benchmark countries (where data is available), the Higher Education sector in Portugal dedicates the smallest proportion of R&D expenditure to Basic Research and the largest proportion to Experimental Development (rising from 11.4% in 2000 to 18.9% in 2009).

1. Published data does not exist for all benchmark countries providing a breakdown of R&D expenditure by research type.

Private non-profit sector

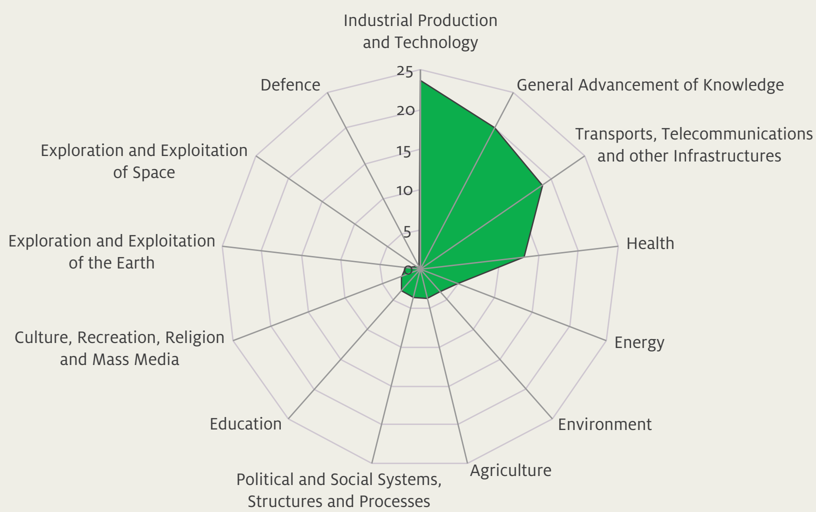
Basic Research dominates R&D expenditure of private NPIs in Portugal (49.9% in 2009), a result of a continual growth over the last decade (35.8% in 2000). This situation is specific to Portugal (compared with the group of benchmark countries), where the tendency is for private NPIs to concentrate on Applied Research.

Resources by socioeconomic objectives

A significant part of the financial resources spent on R&D in 2009 (76%) under the National System for R&I were assigned to four main socioeconomic objectives: “Industrial Production and Technology”, “General Advancement of Knowledge”, “Transports, Telecommunications and other Infrastructures” and “Health” (respectively, 24%, 20%, 19% and 13%) (Figure III.3).

R&D expenditure for “Industrial Production and Technology” traditionally has held a dominant position, although this has shown a marked reduction in its weight since 2007 (when it was 38%).

FIGURE III.3.
Total R&D Expenditure by Socioeconomic Objectives (NABS) (2009)



Source: GPEARI/MCTES

In contrast, socioeconomic objectives linked to “Health” and “Transports, Telecommunications and other Infrastructures” have rapidly increased their share of R&D expenditure (with average annual growth rates of 45.3% and 33.5%, respectively).

Traditionally, “Defence” and “Exploration and Exploitation of Space” (respectively 0.3% and 1.8% in 2009) are socioeconomic objectives which receive the smallest share of R&D financing. However, while R&D expenditure on “Defence” has trended down towards zero (AAGR 2003–2009: -0.9%), expenditure on “Exploration and Exploitation of Space” has moved in the opposite direction (with an AAGR of 30.3% between 2003 and 2009).

Agriculture is unique among the “civil objectives” (as opposed to “Defence” objectives) with a negative annual average growth rate between 2003 and 2009 (-1.2%), despite a slight increase in the level in 2009.

Socioeconomic objectives of Business R&D expenditure

The Business sector focuses its R&D expenditure primarily on those socioeconomic objectives that are most likely to directly impact their activities as economic agents. The objectives linked to "Industrial Production and Technology" and to "Transport, Telecommunications and other Infrastructures" represent around two thirds of the R&D expenditure by Enterprises (73.1% overall in 2009, and respectively 41.9% and 31.2%).

The other sectors have a more disperse pattern of R&D expenditure, particularly because of the proportion of R&D expenditure relating to research activities connected with "General Advancement of Knowledge " socioeconomic objectives (42% in Higher Education, 33.1% in the private NPIs and 12.2% in the Government sector) (Figure III.4).

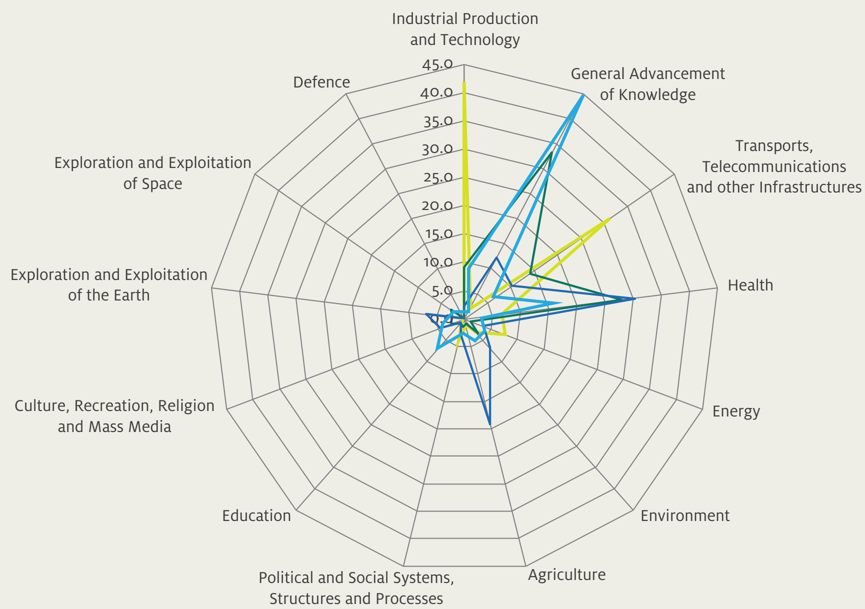


FIGURE III.4.
Total R&D Expenditure by socioeconomic objectives (NABS) and by sector of activity (2009)

Source: GPEARI / MCTES

Expenditure by scientific fields

"Engineering and Technology" is the main scientific field mobilising R&D resources in Portugal (absorbing 43.5% of R&D expenditure in Portugal in 2009). "Electrical Engineering, Electronic Engineering and Information Engineering" is the most prominent area within this scientific field, absorbing the largest share of the system's financial resources (more than one fifth of Total R&D Expenditure in 2009 – 21.8%) and representing half of all expenditure in the field of "Engineering and Technology" (50.2% in 2009) (Figure III.5).

An analysis of the R&D expenditure pattern reveals that there is a tendency to allocate more financial resources to scientific areas that are, or can be, directly related with Information and Communication Technologies: together, one third of R&D expenditure (32.1% in 2009) is concentrated on "Electrical Engineering, Electronic Engineering and Information Engineering" and "Computer and Information Sciences" (two out of the 40 areas in the Fields of Science – FoS classification).

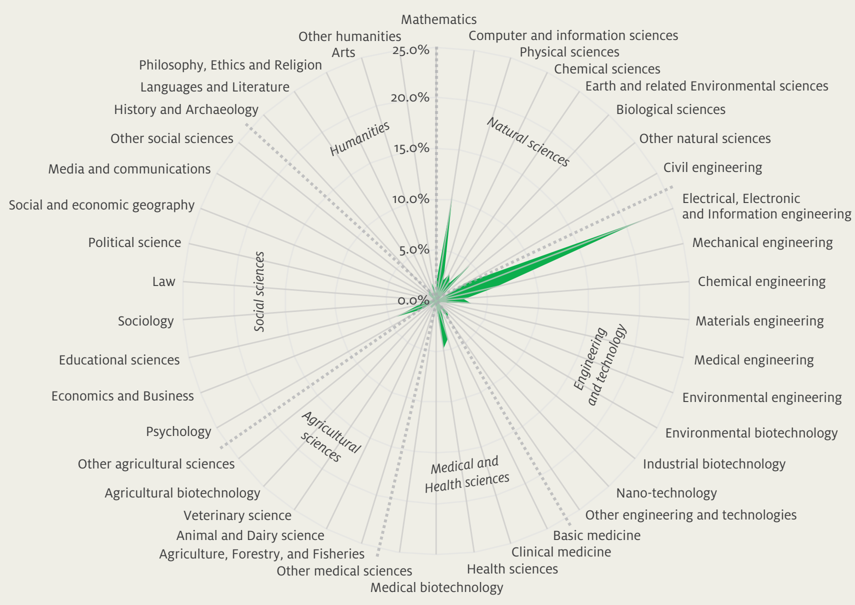
The largest proportion of R&D expenditure in the "Exact Sciences" is absorbed by "Computer and Information Sciences" (60.2%); "Exact Sciences" are the second most important field in terms of R&D expenditure, representing 10.3 % of the Total R&D expenditure (2009).

"Economics and Business" accounted for more than one third (34.5%) of "Social Sciences" expenditure, which itself is the sixth biggest scientific field in terms of R&D expenditure in the system, representing 4.3% of the Total R&D expenditure (2009).

R&D expenditure in "Medical and Health Sciences" is concentrated on two areas that together represent almost 84% of the total ("Health Sciences", 45.7%, and "Clinical Medicine", 38%, in 2009) R&D Expenditure in the field.

The field of "Agricultural Sciences" benefits from the smallest share of R&D expenditure (3.9% in 2009).

FIGURE III.5.
Total R&D Expenditure by Field of Science – FoS (2009)



Source: Eurostat

Business sector

The Business sector has a decisive influence on the way investment is distributed over the different scientific fields and technological areas. This reflects the weight this sector has in the system and the fact that it concentrates resources on a limited number of scientific fields.

Business R&D expenditure on "Engineering and Technology" and "Exact Sciences" together represents 40.7% of all system expenditure on R&D (Total R&D Expenditure).

Data from 2009 reveals that Portuguese enterprises concentrate 85.1% of all expenditure on

R&D on these two fields (with "Engineering and Technology" taking 62.1% and "Exact Sciences" taking the remaining 23%). These fields include the areas "Electrical Engineering, Electronic Engineering and Information Engineering" and "Computer and Information Sciences", that together represent more than half of the expenditures on R&D in the Business sector (55.1% in 2009), with a significant impact on the overall pattern of resource mobilisation by scientific area in the national system.

Higher Education sector

The horizontal nature of Higher Education in knowledge production means it has a diversified R&D expenditure profile across scientific domains. Among the scientific areas, only the relative weight of "Electrical Engineering, Electronic Engineering and Information Engineering" and "Economics and Business" stands out (respectively representing 6.2% and 6.1% of Higher Education R&D Expenditure in 2009).

Government sector

More than half of Government R&D Expenditure (54.9% in 2009) is concentrated on two major fields ("Engineering and Technology", 33.1% and "Medical and Health Sciences", 21.5%). On the other hand, this sector is also responsible for the most significant contribution to "Agricultural Sciences" (14.8%).

Private non-profit sector

The proportion of expenditure directed towards "Natural Sciences" (30.3%, excluding "Exact Sciences") is the distinguishing feature of the private non-profit sector, although the largest slice of expenditures goes to "Engineering and Technology" (38.3%).

Sources of funds

Data from 2010 show Government and Business jointly supporting 89.0% of the financing requirements for R&D in the country, with Government contributing 44.9% and Business 44.1% (Figure III.6). The discussion below shows the differences in the way these two sectors attribute funds.

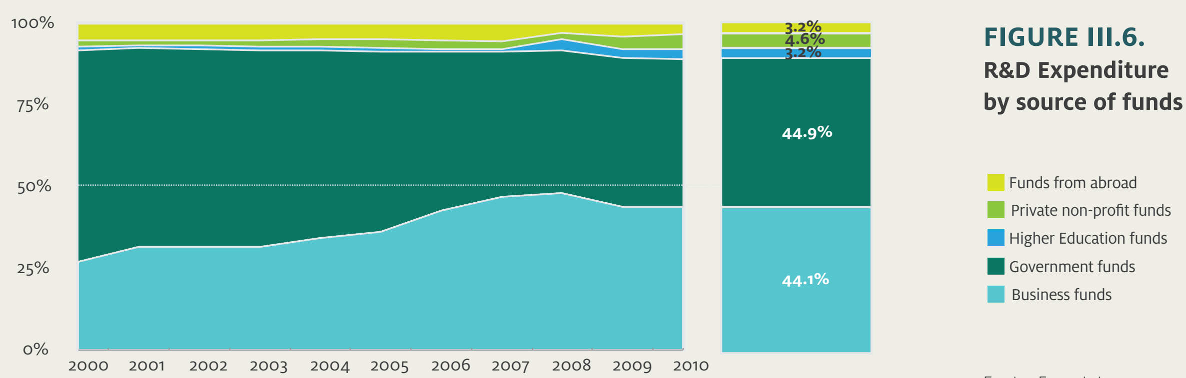


FIGURE III.6.
R&D Expenditure by source of funds

Fonte: Eurostat

Government funds

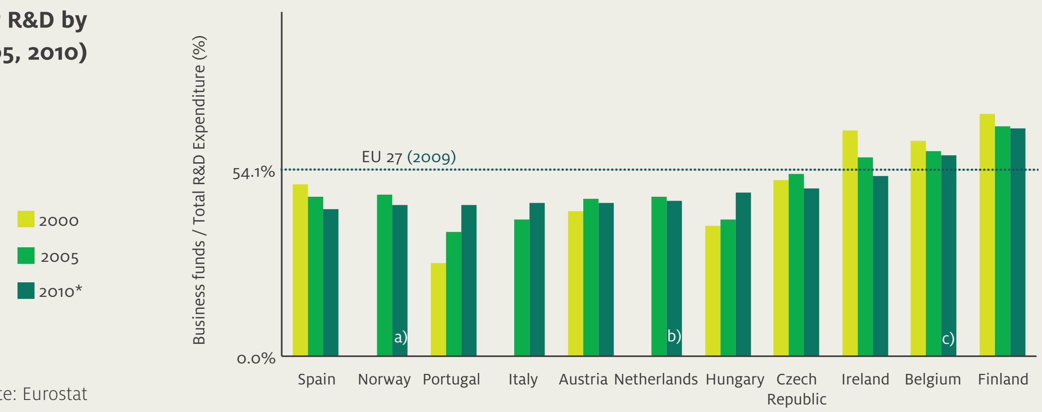
"Government funds", including Structural Funds from the EU, have begun to lose relative importance over the last decade (dropping by an average 3.6% per year, between 2000 and 2010, sliding from 64.8% to 44.9% overall), although they continue to secure the biggest share of R&D expenditure financing, with a proportion above that of the average for the EU27.

Business funds

"Business funds" have grown significantly in importance (at a rate of 5.0% per year between 2000 and 2010, rising from 27.0% to 44.1%), bringing it close to the level of financing provided by "Government funds".

While the growth of "Business funds" over the last few years has been the fastest among the benchmark countries, and meant that Portugal is closing the gap with the majority of other systems used for comparison in this report, it continues to be insufficient. The contribution that the business sector makes to the system financing is still below the average for the EU27 (10.1 p.p. below in 2009) and a long way from systems considered as a reference (for example, Finland has the largest proportion of funding coming from the Business sector, standing at 66.1% in 2010) (Figure III.7).

FIGURE III.7.
Business funds for R&D by country (2000, 2005, 2010)



Fonte: Eurostat

Note: * a); b) ; c) = data for 2009

Higher Education and Private non-profit funds

The importance of "Higher Education funds" in financing R&D expenditure rose from 2007 (increasing fivefold from 2007 to 2008, from 0.7% to 3.6%). The fact that this level continued through to 2010 (3.2%), marks out the national system among the benchmark countries. The proportion of funding coming from Higher Education is almost three times the average for the EU27 (1% in 2009) and only surpassed by Spain (3.9%).

"Private non-profit funds" also showed an increase in their relative importance in financing R&D over the period 2000–2010, reinforcing their particular profile within the Portuguese system. "Private non-profit funds" grew at an annual rate of 9.1%, rising from 1.9% in 2000 to 4.6% in 2010. In Portugal, these funds represented more than the double of the EU27 average in 2009 (1.6%), with only Italy (3.0%) and Netherlands (2.8%) close by.

Funds from abroad

"Funds from abroad" financing R&D Expenditure in Portugal is not only the lowest out of all the countries used for benchmark but has actually been falling (at an average annual rate of 4.7% between 2000 and 2010). As a matter of fact, out of all the benchmark countries (with the exception of Austria and Netherlands, which both had levels above the EU27 average in 2009), the Portuguese system is the only one where the importance of "Funds from abroad" has declined over the last decade.

In 2010, "Funds from Abroad" financed only 3.2% of the R&D expenditure in Portugal. At the time, this was 13.3 p.p. below the country with the highest level for this indicator (Ireland, with 16.5%) (Figure III.8).

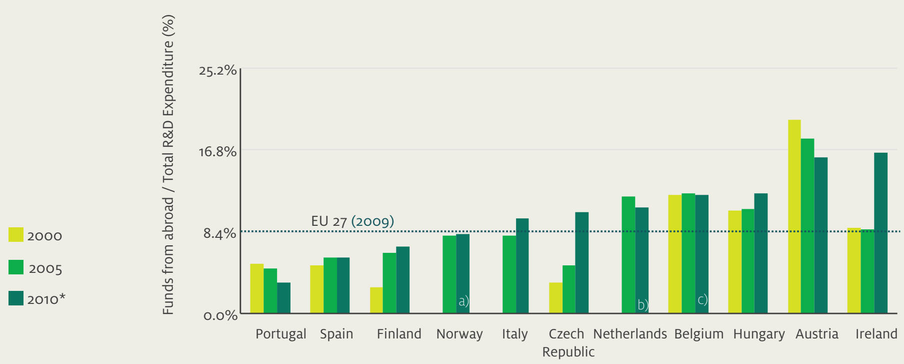


FIGURE III.8.
Funds from abroad for R&D, by country (2000, 2005, 2010)

Note:* a); b); c);= data from 2009

Source: Eurostat

The largest part of the "Funds from Abroad" comes from the "European Commission" although this has shown a tendency to decrease (AAGR 2000–2010: -4.3%)[2].

European funds: Participation in the 7th Framework Programme (2007-2013)

Portuguese teams have been improving their participation in the European Framework Programmes over the last two cycles. The rate of return, as measured by the contribution that Portugal makes to the budget of the Framework Programme and the return on the level of funding obtained by the Portuguese teams in that programme, rose from 79% in the 6th Framework Programme (Rietschel et al., 2009) to 88.45% in the 7th Framework Programme, which in other words corresponds to 1.2% of the total funding attributed. Proposals presented to the current programme by consortia including a Portuguese element have a success rate of 19.2%, close to the average success rate for the EU27 of 19.3%[3]. For the countries under comparison, Portugal has the fourth best success rate, after Netherlands (21.6%), Belgium (20.3%) and Norway (20.3%).

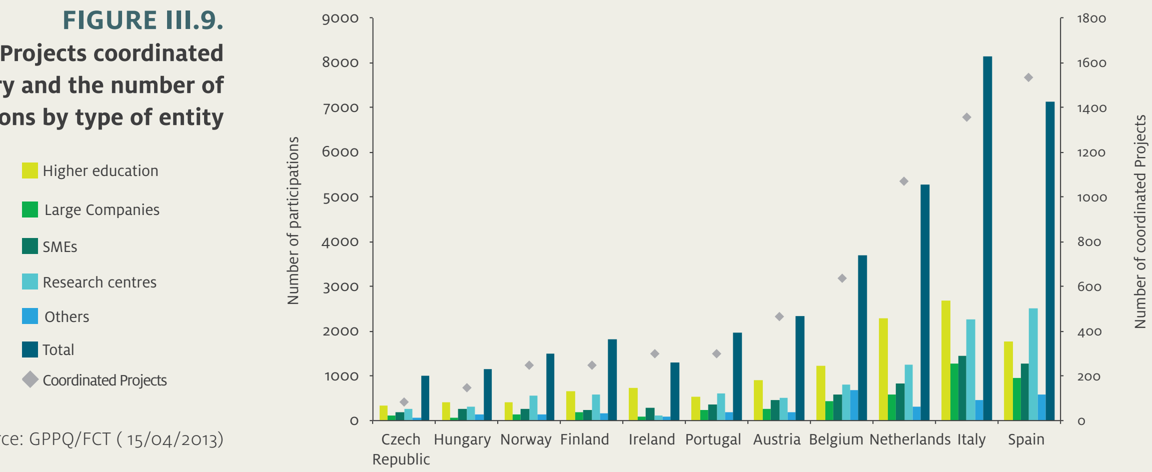
2. Data up to 15/04/2013.

3. The success rate for FP6 was 18%.

Portugal coordinates only 20.4% of the projects in which it participates, which signifies one of the lowest rates of leadership among the countries under comparison, ahead of only Hungary (16.4%) and the Czech Republic (9.8%).

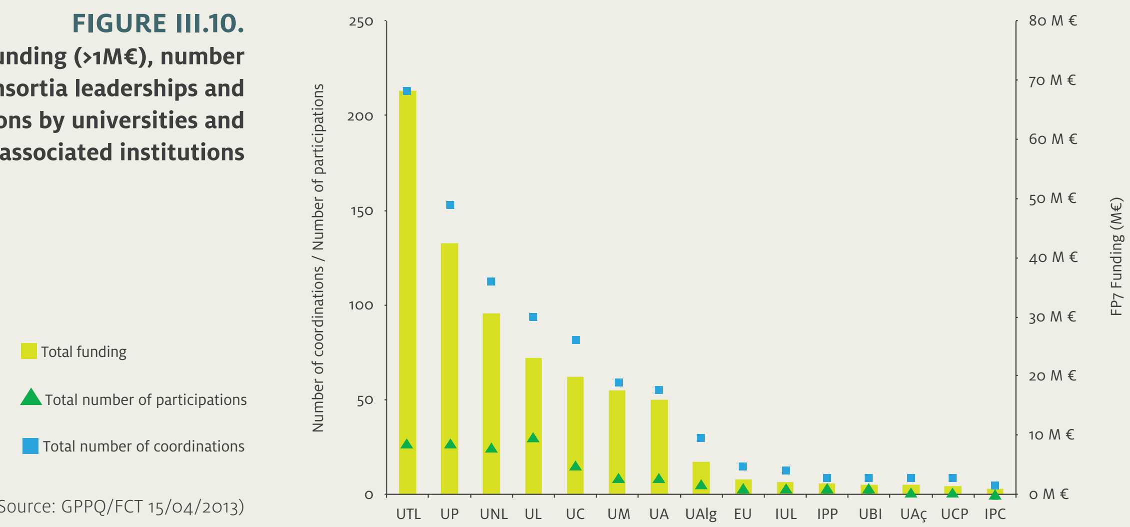
The institutional distribution of the Portuguese participation is similar to the other countries in the analysis (Figure III.9). Higher education and R&D centres make up around 60% of all participation in consortia where a Portuguese element is present, while companies account for around 30%. The division between large Portuguese companies (11.9%) and SMEs (19%) is roughly in-line with European counterparts.

FIGURE III.9.
Number of Projects coordinated by country and the number of participations by type of entity



Source: GPPQ/FCT (15/04/2013)

FIGURE III.10.
FP7 funding (>1M€), number of consortia leaderships and participations by universities and associated institutions

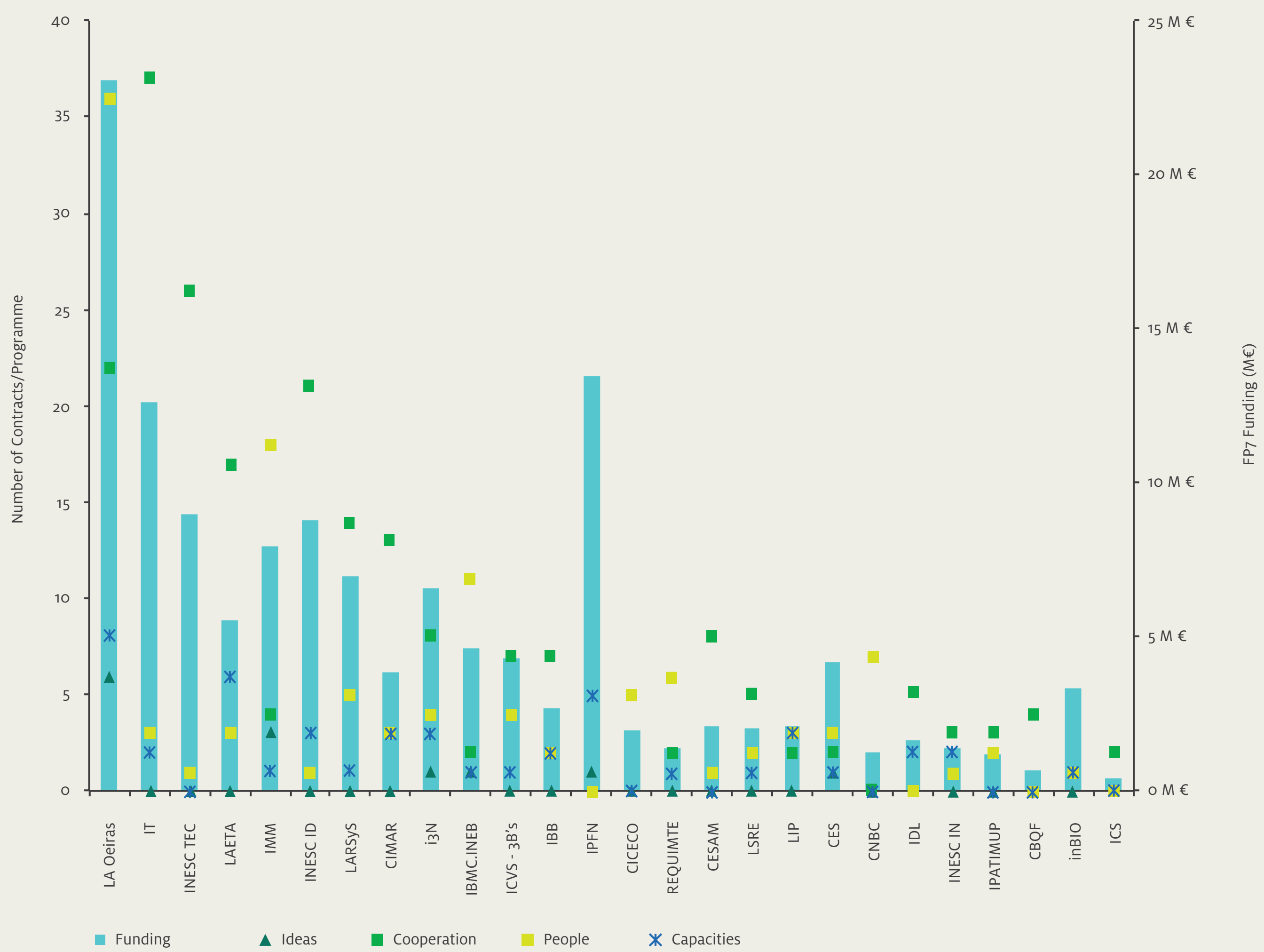


Source: GPPQ/FCT 15/04/2013)

Three universities stand out as being the biggest recipients of FP7 funding: Universidade Técnica de Lisboa (where IST is considered to be a 'hub' since the first Framework Programme – see Heller-Schuh et al., 2011) followed by Universidade do Porto and Universidade Nova de Lisboa (Figure III.10).

The Associated Laboratories have also had a significant role in Portugal's participation in the European Framework Programme, with a level of funding of 133,048,815.4€. The Associated

FIGURE III.11.
FP7 Funding and the number of Associated Laboratory contracts



Source: GPPQ/FCT (15/04/2013)

Laboratory ITQB, including the IGC and IBET (Oeiras Associated Laboratory), is particularly worthy of mention, representing 17.3% of the total value (Figure III.11).

Looking at participation by the Business sector, there were 28 companies that stood out as having managed to attract funding over 1M€. As can be seen in Figure III.12, there is a wide variety of different companies, ranging from PT Inovação (large company) to small companies, many of which are spin-offs of Portuguese universities, such as YDreams and Bioalvo.

FIGURE III.12.

FP7 funding (>1M€) and the number of participations by companies

Source: GPPQ/FCT (15/04/2013)

Business Funds

Analysing the sectoral financing profiles for R&D activities demands an understanding of the sources of funds being mobilised by each sector, allowing the most relevant financing flows among the different NSR&I actors to be identified.

Business as a sector is financially self-sufficient in terms of its R&D activities, employing minimal levels of financial resources coming from other sectors. In 2010, 94.0% of the R&D expenditure by the Business sector was financed with funds supplied by the enterprises themselves (Table II.2). The influence of Business sector on R&D financing strongly depends on the weight of this "self-financing", which represents 98.2% of all the financing that the Business sector pumps into the system as a whole (43.3% of all financing available in the system). Consequently, "Business funds" is found to be of minimal importance for R&D Expenditure in other sectors.

Government funds

"Government funds" are the main source of financing for the so-called institutional sectors (the Government itself, 83.0%, Higher Education, 88.0%, and Private Non-Profit, 47.0%). However, more than two thirds (68.9%, in 2010) of "Government funds" is allocated to the financing of Higher Education R&D Expenditure.

The Private Non-Profit sector comes in second place after the Business sector in the list of those sectors which benefit least from "Government funds". A substantial amount of the funding for R&D activities in the Private Non-Profit sector comes from within (43.9%) while "Government funds" accounted for less than half.

The Government sector proportionally receives the most R&D funds from "abroad". However, the levels are still not very sizeable, with only 13.1% of Government R&D Expenditure being financed in this way. The Private Non-Profit sector comes in second place, after the Government, in the relative importance of "Funds from abroad" (6%).

Public funding for companies

It should be recognised that public support for Business R&D in Portugal occurs mainly via indirect funding, or in other words, through measures such as tax incentives (OECD, 2011c) which are part of the "System of Tax Incentives for R&D in Business" (SIFIDE) (Figure III.13).

Portugal belongs to a small group of countries that use tax incentives in a major way for stimulating Business R&D. Among the countries in the benchmark list, Portugal is comparable

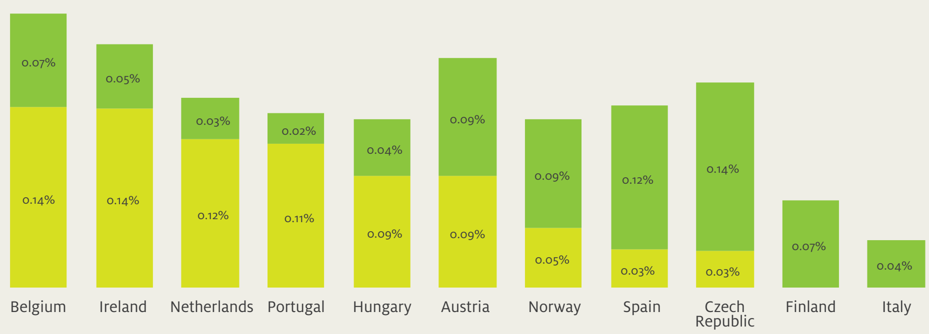


FIGURE III.13.
Direct competitive funding by Government and tax incentives for R&D in Business (2009*)

Note: *Portugal, Italy, Hungary and Ireland: 2008; Belgium, Austria and Spain: 2007

Tax incentives for R&D/GDP

Direct funding by Government of R&D in Business/GDP

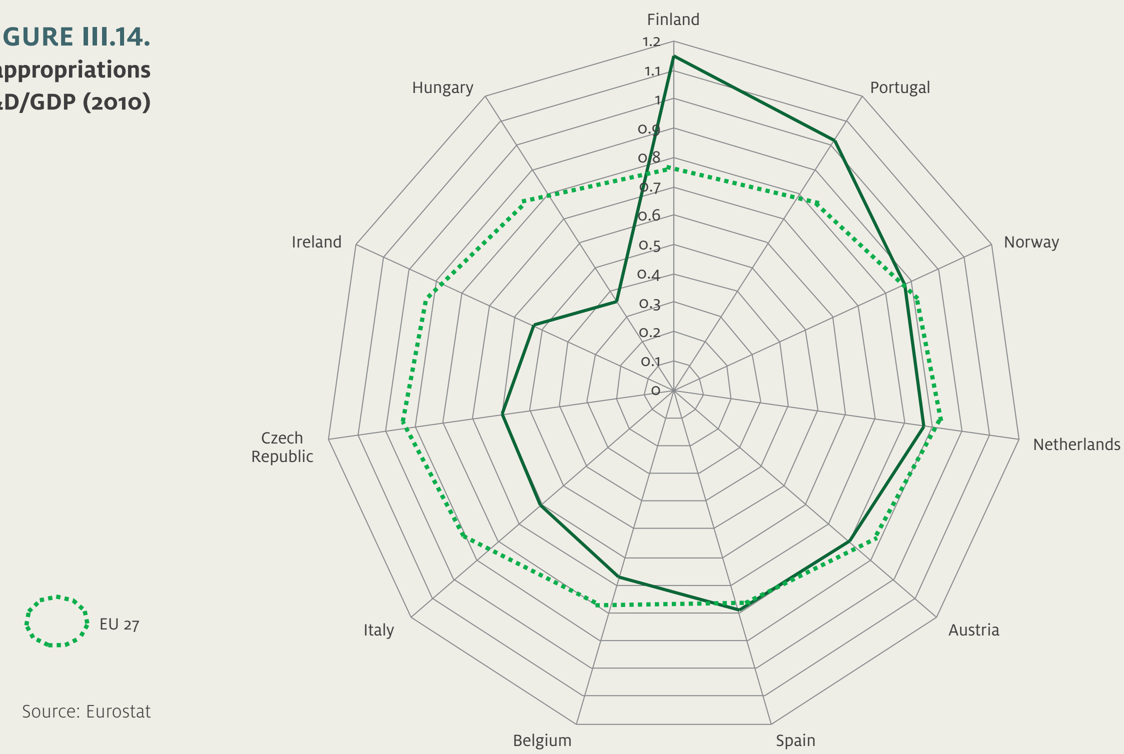
Source: OECD

with the Netherlands, and very close to Belgium and Ireland, which are leading examples of the use of tax incentives as a policy instrument (0.14% of GDP).

Government budget appropriation for R&D

Initial budget appropriations[4] for R&D in 2010 represented 1.02% of GDP in Portugal, placing Government direct R&D financing on an equal footing with the systems of more advanced countries in the benchmarking group, and well ahead of the average for the EU27 (+0.26 p.p. in 2010). Only Finland made a larger initial budget appropriation for R&D as a percentage of GDP (+0.13 p.p. in 2010) (Figure III.14).

FIGURE III.14.
Initial budget appropriations for R&D/GDP (2010)



Source: Eurostat

The budget forecast by the Government for R&D expenditure in 2010 represented around 64% of the overall R&D expenditure across the whole system (Total R&D Expenditure in 2010 represented 1.59% of GDP).

Between 2007 and 2010, Portugal led the countries in the benchmarking group, with the highest level of growth relative to the initial budget appropriations for R&D as a percentage of GDP (AAGR of 8.0%).

4. While the budgetary appropriations for R&D are in respect of the forecast funds allocated to R&D within the context of the National Budget (NB – provisions made when drawing up the budget that do not reflect actual expenses), they do allow the direction of S&T public policy to be ascertained along with the way that the government directly intervenes in the funding of the scientific system.

In 2010, the expenditure anticipated in the initial budget appropriations for R&D in Portugal fell predominantly within the objective of "General Advancement of Knowledge" (58.9%) which covers all knowledge which does not have an application for immediate economic benefit. The initial budget appropriations also assigned special importance to the socioeconomic objectives connected to "Health" (13.3%), clearly shown by the difference compared to the average for the EU27 (+4.8 p.p.), as well as "Industrial Production and Technology" and "Transports, Telecommunications and other Infrastructures", together representing 10.8% of the total anticipated public financing. Less significance was placed on the objectives of "Agriculture", "Education" and the "Environment" (Figure III.15).

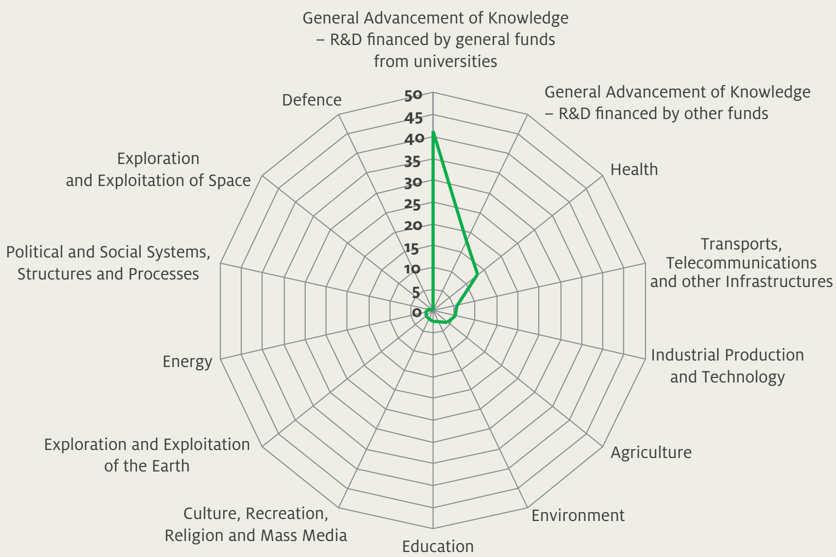


FIGURE III.15.
Initial budget appropriations for R&D by socioeconomic objectives (NABS) (2010)

Source: OECD

Indirect and competitive funding by Government – the central role of the FCT

Based on its legally endorsed mandate as the funding agency for the national system of R&I, the FCT funds research activity at different levels, ranging from individual researchers, at different stages of their careers, to groups of researchers and institutions. With priority given to competitive funding instruments, the FCT organises a large number of public competitive calls for scientific and technological activities (for funding grants and other types of advanced training, as well as for projects and institutions). The range of instruments used includes selective support for initiatives of general benefit to the Portuguese research community. Covering any scientific area, these include the advancement of R&D activities or knowledge transmission which would not gain funding through any other specific FCT programme, as well as support for various prizes in the area of S&T.

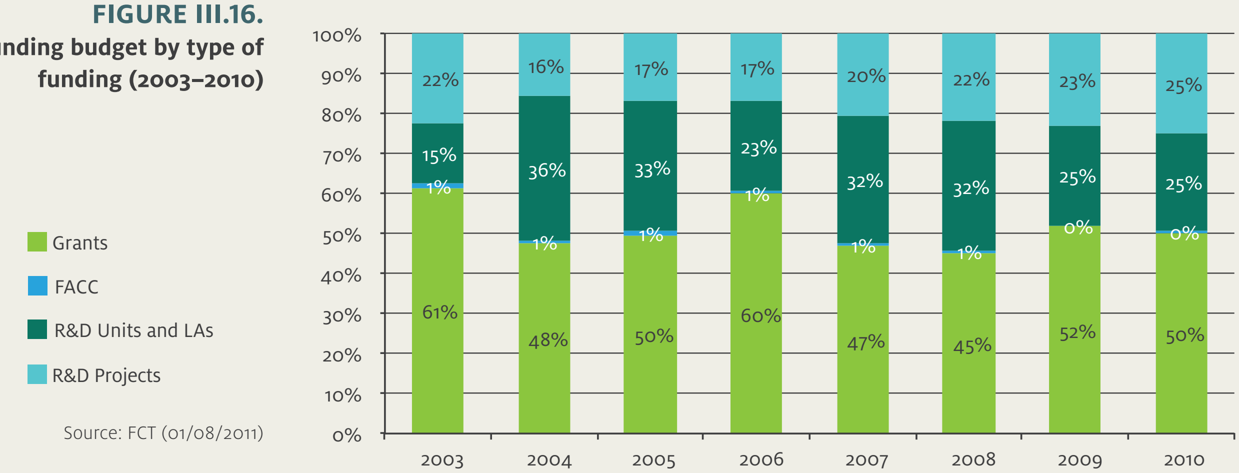
The FCT's contribution is fundamental for mobilising the system's financial resources. Even accounting for the fact that FCT funding includes support for activities based abroad, the importance it plays for total R&D expenditure (referring only to that carried out within the country) allows an idea of its influence on the mobilisation of financial resources within the national system.

In 2010, the FCT's funding activities across the different areas in which it is active, supporting people, ideas and institutions, represented 11.6% of the recorded R&D expenditure for the whole of the national system. Since 2003 this level has held steady at around 10%. The level of FCT funding has thus accompanied the expansion of the system, almost tripling between 2003 and 2010 (rising from 114,228,823 euros to 319,351,549 euros).

While there has been some variability over time, support for advanced training of human resources has absorbed the largest share of total funding disbursed by the FCT – 61% in 2003, 45% in 2008 and 50% in 2010 – illustrating the role the FCT plays in creating the high-level competencies that are essential to the development of the national system (Figure III.16).

The way that FCT funding is distributed by scientific area has not changed over recent years. Engineering and Technology has been the main scientific field supported by the FCT, absorbing on average more than one quarter of the annual funding allocation. Agricultural Sciences and Humanities are the fields which receive least.

FIGURE III.16.
FCT funding budget by type of funding (2003–2010)



Source: FCT (01/08/2011)

Natural Sciences (excluding Exact Sciences) and Social Sciences were the fields where the advanced training of human resources was most evident (Figure III.17). Engineering and Technology has been the field which has received the most support from the FCT, both in terms of institutional funding of the public sector (namely by way of R&D units and Associated Laboratories, together 36%), and in terms of support for ideas via R&D projects (30%).

Support for the promotion of R&D activities, namely knowledge dissemination, has traditionally been the responsibility of the FACC – Support Fund for the Scientific Community, which tends to be mainly allocated to the fields of the Social Sciences (27% in 2010) and Humanities (26% in 2010).

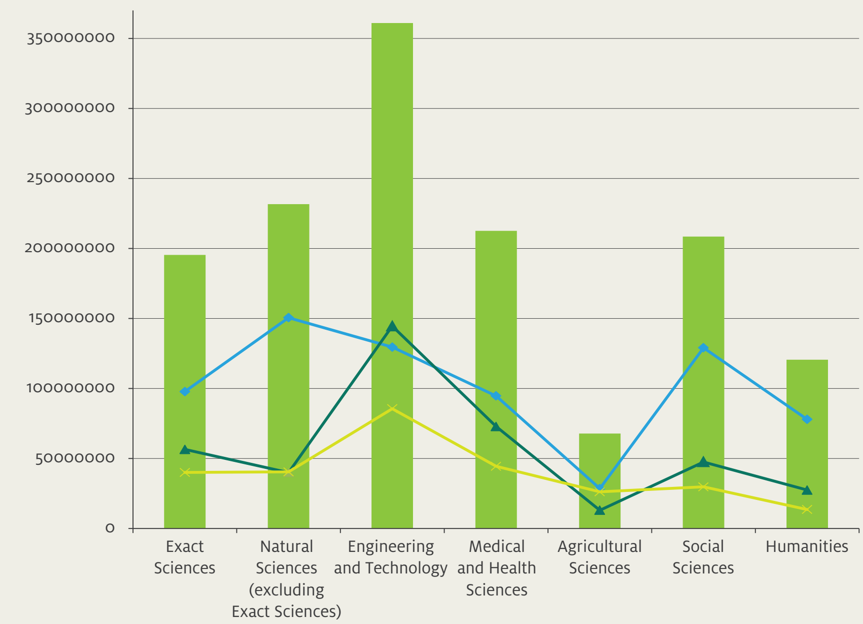


FIGURE III.17.
FCT – funding by scientific/technological field and by type of funding (2003–2009)

Source: FCT

A brief analysis of the investment made in human resources

National programmes designed to endow research and innovation institutions with scientific potential by contracting people with doctorates and supporting researchers returning to Portugal have recently been a focal point in the FCT's work.

Over the period between 2007 and 2012, 1225 people with doctorates (41.8% of which were foreigners) were contracted as part of the programme to hire people trained to doctoral level for the Research and Innovation System. These people were spread across 264 scientific bodies (of which, 43% were in Exact Sciences and 24% in Engineering and Technology). This programme was open to residents and non-residents, having recruited people from 61 nationalities, with 10 nationalities supplying more than 26 people with doctorates (Table III.1).

Nationality	Nº of people hired
Portugal	713
Spain	50
Italy	49
Brazil	44
France	34
Germany	33
India	29
Russia	28
China	27
United Kingdom	26

TABLE III.1.
Researchers contracted as part of the Programme for hiring doctorates for the R&I system, by nationality

Note: Only nationalities with 26 or more people are shown

Source: FCT (data as of 08/11/2012).

The countries of the EU accounted for 23% of the places, while 19% went to countries outside of the European area.

Launched in 2012, the FCT Investigator Programme, designed to create a stable base of high calibre researchers in Portugal, received applications from people with 45 different nationalities. Researchers from 18 different countries were hired to be part of 71 national institutions. The 119 hired from Portugal represented 76.8%, six came from Italy (3.9%), five from Spain (3.2%) and four from the UK (2.6%).

The advanced training programme for doctoral studies in industry is still not significant. There are only 108 business enterprises that participated in the advanced training of 153 new doctorates (Table III.2).

TABLE III.2.
The 10 largest Business enterprises which host the most grants for doctoral studies in industry (2007-2012)

Host Business Institution	Nº of Doctoral Students
Petróleos de Portugal - Petrogal, S.A.	7
Nokia Siemens Networks Portugal, S.A.	6
CUF - Químicos Industriais, S.A	5
Critical Software S.A	4
E.N.E.I.D.A. - Energia Natural, Electricidade e Instrumentação do Alentejo, Lda.	4
CIN – Corporação Industrial do Norte, S.A.	3
Euroresinas Industrias Quimicas S.A.	3
Laboratórios ATRAL S.A	3
Paradigmaxis - Arquitectura e Engenharia de Software S.A	3
Portugal Telecom Inovação, S.A.	3

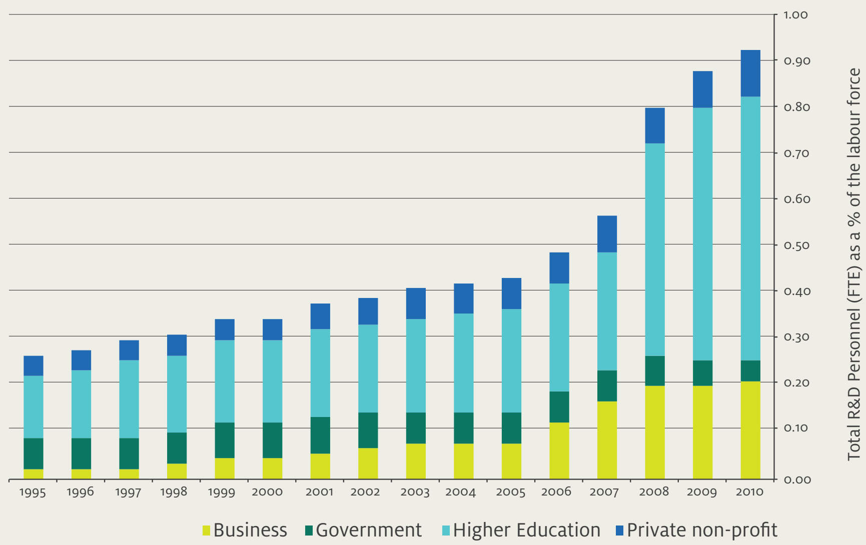
Source: FCT (data up to 22/02/2013).

In comparison with the 10 companies which receive the most funding from the FCT (Chapter 5), it can be seen that only one company hosts doctoral students as part of the Programme, placed in fourth position. Notwithstanding the small scale, this advanced training programme has attracted a few business enterprises, some of which are spin-offs from higher education institutions.

Human resources in R&D

Human resources in R&D by sector of activity

While the first part of this chapter looked at the growth of human resources in Portugal, this study now continues by focusing the analysis on its composition and sectoral distribution. Thus, looking at the sector of activity, it can be seen that over the period between 2000 and 2010 human resources grew primarily in Higher Education (reaching 51% of all researchers in 2010). Business ranks as the second sector, both in terms of Total R&D Personnel and in terms of Researchers relative to the labour force, although the levels are clearly insufficient when compared to the benchmark countries. The Government is the only sector that saw its share decline and the total number of personnel fall (Figure III.18).



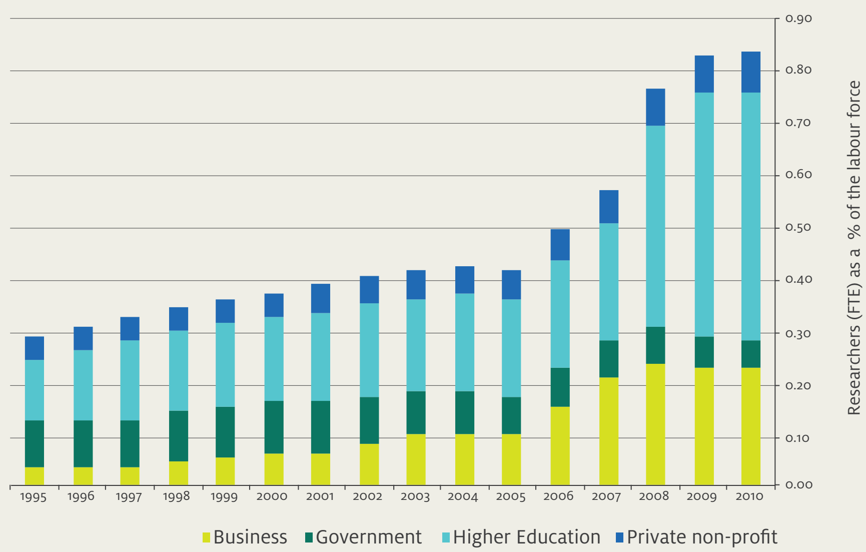


FIGURE III.18.
Growth in R&D human resources/ labour force (%), by sector of activity (1995-2010)*

Note: * In 2007 there was a break in the statistical series due to the enlargement and improvement of the administrative sources used for updating the national directory of companies (the IPCTN - National Survey of the Scientific and Technological Potential), resulting in an increase in the number of companies with R&D. In 2008, another break in the series occurred as a result of exchanging information between the IPCTN and the national system for monitoring Higher Education lecturers (REBIDES). From this point on, the survey included R&D activity in the Higher Education sector, carried out by lecturers and students writing master's and doctoral theses, which was not reported by the R&D centres.

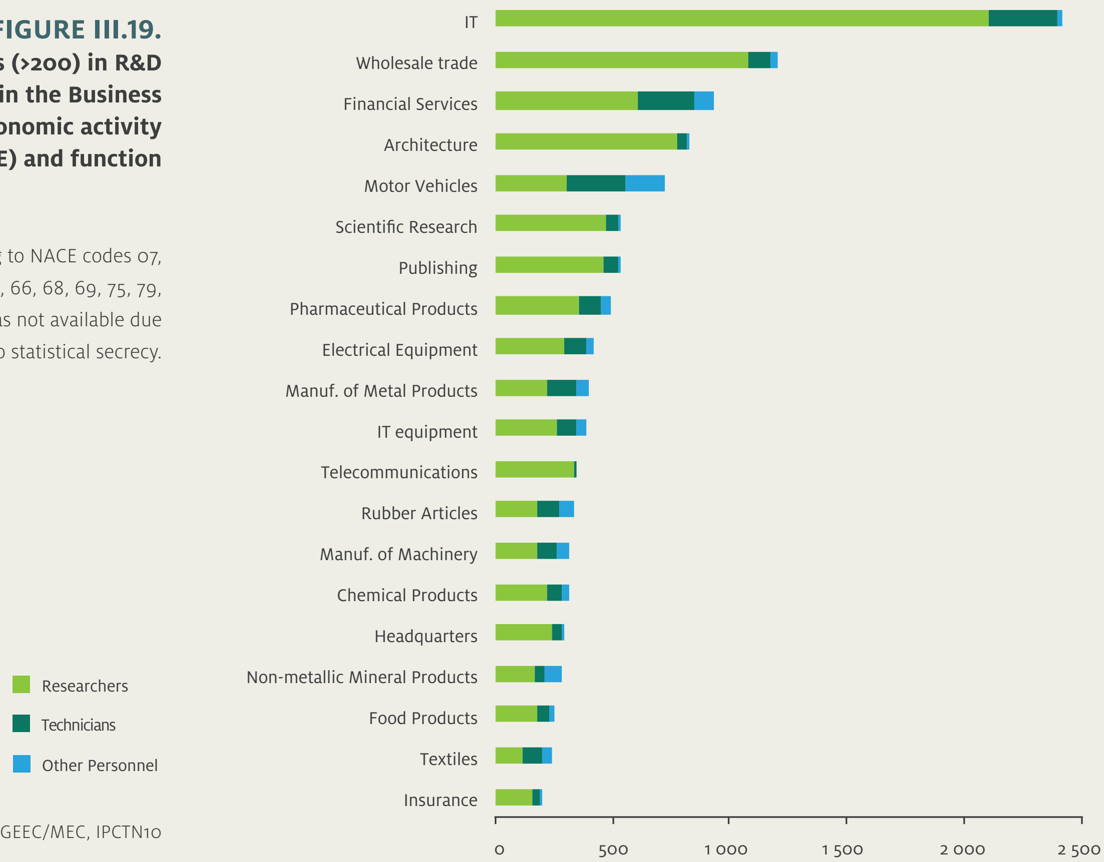
Source: Eurostat

Total R&D personnel in the Business sector

An analysis by sector of economic activity shows that the majority of the total R&D personnel in the Business sector are found linked to ten economic activities: Consulting and IT Programming; Wholesale Trade; Financial Services; Architecture and Engineering activities; Motor Vehicles; R&D; Publishing; Manufacture of Pharmaceutical Products; Electrical Equipment and manufacture of Metal Products (Figure III.19). The fact that there are quite a few areas of economic activity with no significant number of research personnel is a reflection of the way the national product is structured; at the same time this does limit growth into areas of increased value added, even in the more traditional sectors of activity.

FIGURE III.19.
Human resources (>200) in R&D activities (FTE) in the Business sector, by main economic activity (NACE) and function

Note: The data referring to NACE codes 07, 09, 19, 39, 50, 51, 53, 55, 66, 68, 69, 75, 79, 80, 84, 90, 91 and 95 was not available due to statistical secrecy.



Source: DGEEC/MEC, IPCTN10

R&D personnel by function and gender

Portugal is the country where researchers have the largest share of all R&D personnel. Researchers represent 96% of all personnel in the Higher Education sector, reaching the highest level out of all sectors; at 73%, the Government sector has the lowest percentage (Figure III.20). In overall terms, the largest number of researchers is to be found in the Higher Education sector (62%), while most of the technicians and other personnel can be found among companies (53% and 49% respectively).

The distribution by gender in Portugal of research personnel in the labour force shows a female participation (0.88%), above the average for the EU (0.76%).

Making a comparison with the benchmark countries shows that Portugal is the country where the largest majority of people working in R&D are researchers. In 2009, researchers accounted for 85.9% of all R&D people (Figure III.21), while Finland came in second with 13 p.p. less; Netherlands and Italy, at the bottom of the list, had a little over 40%.

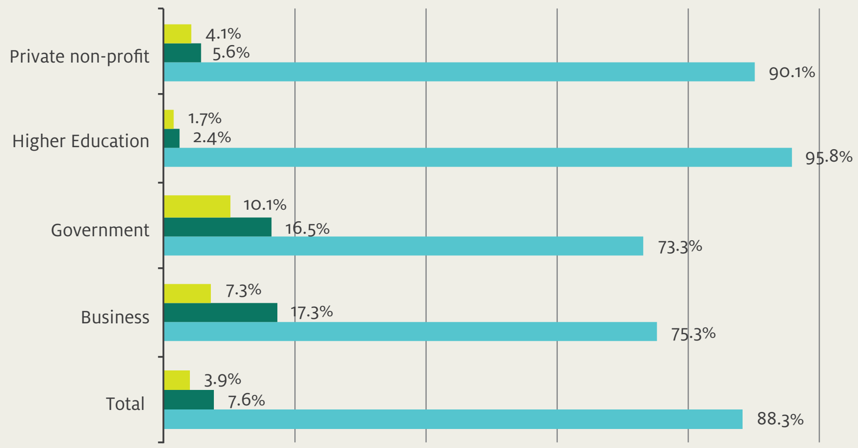


FIGURE III.20.
Human Resources associated with R&D activities (FTE) by function and sector of activity (2010)

Source: DGEEC/MEC, IPCTN10

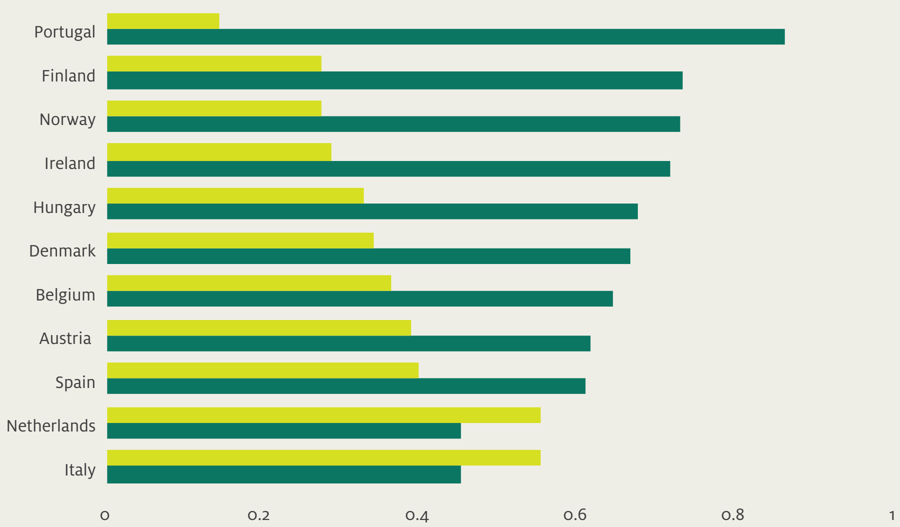


FIGURE III.21.
Comparative analysis of the functions of all R&D personnel (FTE) – 2009

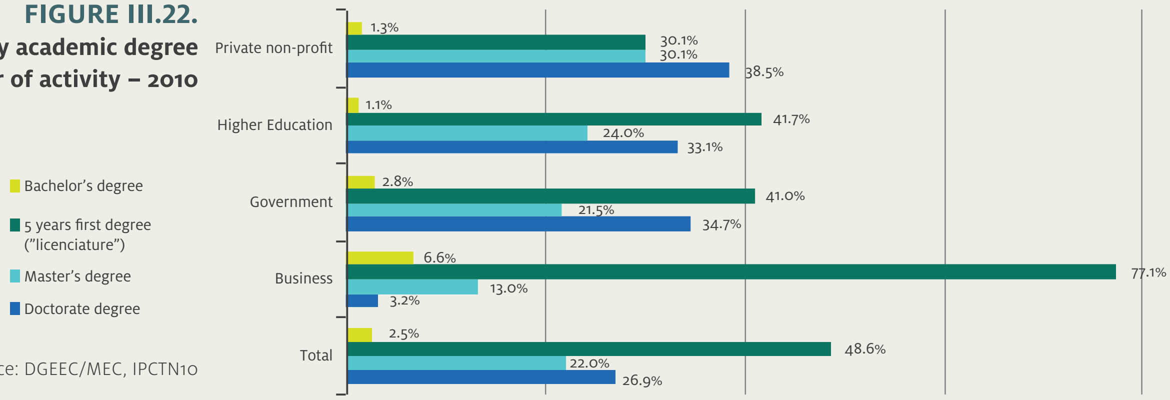
Source: Eurostat

Researchers by academic degree

Researchers with doctorates represented around 27% of the total, while the majority of researchers are graduates with a licenciatura (48.6%) and the remainder are either holders of a master's or bachelor degree (24.5%). Those researchers who have attained the highest level of qualification are fairly evenly spread over the different sectors, with the marked exception of Business which still has a very small number of research personnel trained to doctoral level (3.2%) (Figure III.22).

The Private Non-Profit sector has the highest percentage of researchers with doctoral degrees (38.5%).

FIGURE III.22.
Researchers by academic degree and by sector of activity – 2010

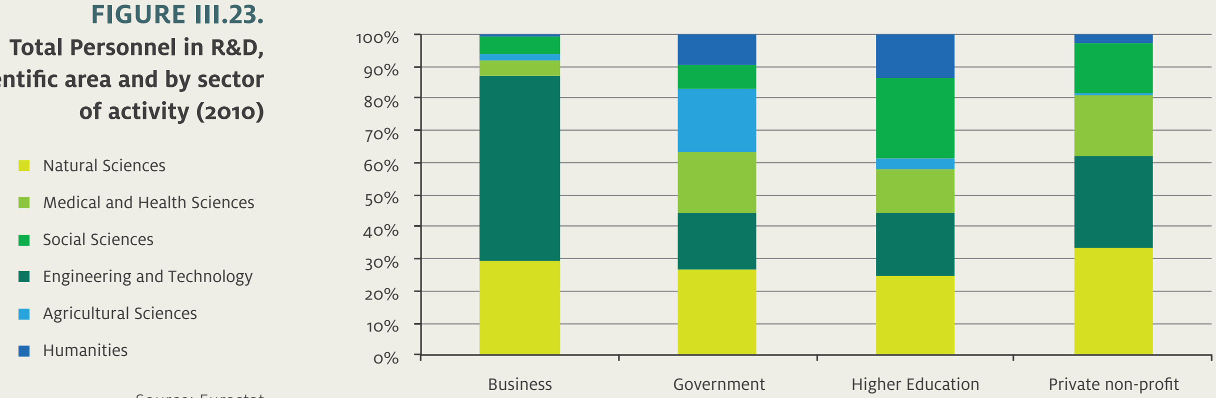


Source: DGEEC/MEC, IPCTN10

Total R&D personnel by field of science

The distribution by scientific area of all personnel at a national level shows the relative importance of Engineering and Technology (31%) and Natural Sciences (27%). The distribution by scientific area moreover shows that there exists a natural tendency for the Government and Higher Education sectors to exhibit a more equal distribution among the areas. This is a natural result of their functions, reproducing and transmitting knowledge, and their activities, focusing on public goods and missions. In contrast, Businesses and NPIs are more highly concentrated on particular fields of science due to their choices in terms of specialisation (Figure III.23). For example, Engineering and Technology (58%) and Natural Sciences (29%) are predominant in Business. The Private Non-Profit sector is more specialised in Natural Sciences, Engineering and Technology and Medical and Health Sciences.

FIGURE III.23.
Total Personnel in R&D, by scientific area and by sector of activity (2010)



Source: Eurostat

R&D Infrastructures

The conceptual basis of the project for the Mapping of the European Research Infrastructure Landscape (MERIL) was established by the European Science Foundation (ESF). The following definition was based on the formulations presented by the European Commission and the European Strategy Forum on Research Infrastructures (ESFRI), which we have adapted to reflect the needs of this report:

"A European Research Infrastructure is a facility or (virtual) platform that provides the scientific community with resources and services to conduct top-level research in their respective fields." [5]

R&D infrastructures in this sense can be isolated resources, networks of distributed resources, or they can be virtual services, supplied electronically. They can, as such, be integrated into networks or national/international facilities and/or be part of interconnected networks of scientific instruments.

The European Union has invested in promoting R&D infrastructures by making use of their ability to make high quality scientific and technological results available with recognised relevance for Europe. At the same time, transparent access based on excellence is guaranteed to European scientific users along with a stable and effective management.

No exhaustive and up-to-date study exists detailing the R&D infrastructures available in Portugal. It has only been possible to find information in two online databases with little detail regarding the coverage and depth of the information available:

- 'The European Portal on Research Infrastructures' Services – An online database', managed by the European Commission http://www.riportal.eu/public/index.cfm?fuseaction=ri.search). This is assumed not to be exhaustive, with only nine Portuguese infrastructures registered and the information last updated in 2007 (four in Environmental, Marine and Earth Sciences and the remaining five spread over the areas of Energy, Engineering, Life Sciences, Humanities and Behavioural Sciences, Information and Communication Technologies and Mathematics).

- The MERIL portal. This project is led by the ESF with the objective of mapping European R&D research infrastructures. At the time of writing it is still in a data collection phase, meaning that the information is as such incomplete and subject to concerns regarding its validity and final quality. There are 25 R&D infrastructures registered for Portugal (out of 894 European R&D infrastructures registered).

However, the quality of large national infrastructures and scientific and technological platforms led Godinho and Simões (2011: p34) to classify Portuguese R&D infrastructures overall as good. This is a result primarily of the effort exerted since the end of the 1990s drawing on Structural Funds and the National Programme for Scientific Re-equipment (PNRC).

Managed by the FCT, the PNRC contemplated funding for the acquisition, upgrading and expansion of scientific equipment to a total of 91.8 million euros. This resulted from a funding process where "412 applications were received, covering 5343 pieces of equipment at a total cost of 308.3 M€" (FCT, 2012).

5. According to the perspective of the European Commission, R&D infrastructure includes facilities, resources and associated services used by the scientific community for carrying out top-level R&D activities in their respective fields, as for example: singular large-scale research installations, collections, special habitats, libraries, databases, biological archives, clean rooms, integrated arrays of small research installations, high-capacity/high speed communication networks, highly distributed capacity and capability computing facilities, data infrastructure, research vessels, satellite and aircraft observation facilities, coastal observatories, telescopes, synchrotrons and accelerators, networks of computing facilities, as well as infrastructural centres of competence.

Over the last few years, a number of infrastructures of note have been set up (including electronic infrastructures) that contribute significantly to the expansion of the scientific and technological possibilities and capabilities of the Portuguese R&I system (RCTS, B-on and INGRID – National GRID Initiative) (Godinho and Simões, 2011).

Electronic infrastructure for S&T

R&D activities are increasingly dependent on the ability of so-called electronic infrastructure (e-infrastructure) for science and technology to integrate and interact. Electronic infrastructure for S&T (e-infrastructure) can be defined as that set of technologies and institutions that support S&T activities as carried out by distributed collaborative networks (at a regional, national and international level) established by electronically connecting the different parties. In this context, the Internet looms large as the most important infrastructure. These collaborative networks supply researchers with access to, for example, large repositories and collections of data, advanced information processing tools, large scale computing resources and high performance visualization.

The concept of an e-infrastructure covers a multitude of possibilities, including networks and GRIDs, but also Data Centres and the so-called collaborative environments, as well as operational support centres, record centres, certification authorities, and training and help-desk services.

ICT have made a place for themselves as a transformational factor and resource in science, making it possible for scientists around the world to enjoy close and almost instantaneous collaboration and supplying access to unprecedented quantities of scientific information which, in turn, can be processed and treated by high performance computing platforms.

The last decade has seen a significant enlargement in the coverage of the National Research and Education Network (NERN) (the Portuguese NREN is called Rede Ciência Tecnologia e Sociedade – RCTS") which in 2009 linked-up practically all public higher education institutions (99.5%). However, in the private higher education sector only 43.0% of institutions were connected, although in 2009 there were 86% of all higher education institutions linked into the network (in 2000 only 75.5% were connected).

RCTS is a high performance network for scientific and educational institutions with large communication demands (namely, universities, National Laboratories and polytechnic institutes). It also works as an experimental platform for advanced communications applications and services. This network allows access to a wide range of Connectivity and Infrastructure services, drawing on different applications and services in the areas of Collaboration, Knowledge and Security.

The Portuguese National Research and Education Network (RCTS) is built on a dark fibre cable backbone with 48 fibres operating at 10 Gb/s, which has been progressively upgraded to a current 1100km, starting from an initial stretch of 400km between Lisbon and Braga. This increase significantly expanded the coverage of public higher education institutions by dark fibre cable, which meant that in 2009 some 54.8% of students enrolled in public higher education institutions benefitted from coverage by RCTS dark fibre cable (by comparison, 5 years earlier, in 2004, the proportion of students who potentially benefitted from this service was only 6.9%).

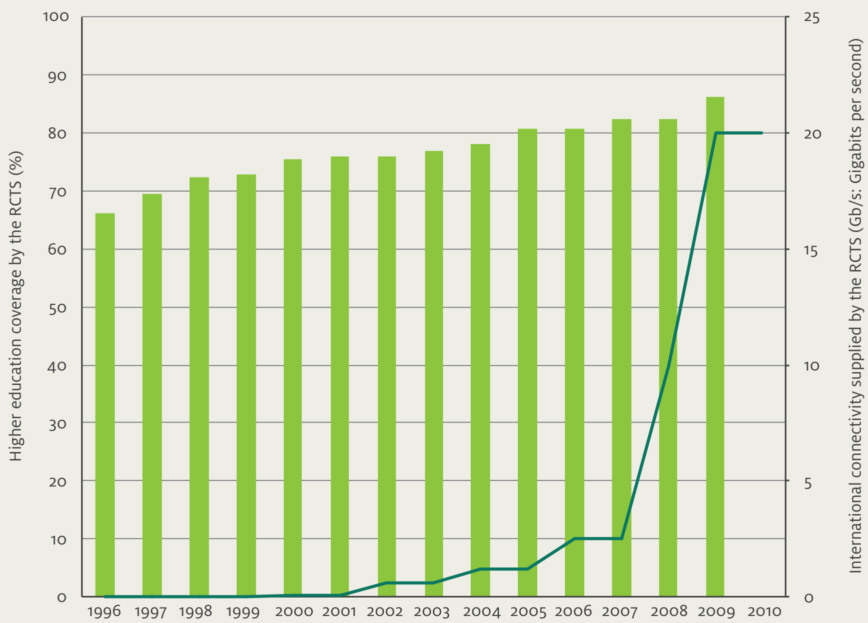


FIGURE III.24.
Coverage and international connectivity of the Portuguese National Research and Education Network (RCTS) (1996-2010)

Source: UMIC – Knowledge Society Agency, IP and FCCN – Foundation for National Scientific Computing

Between 2000 and 2010 the international connectivity provided by RCTS was strengthened with an exponential increase in the available bandwidth, rising from 0.034 Gb/s to 20 Gb/s (including the connectivity that was acquired in joining the pan-European data network for the research and education community, GÉANT).

GÉANT is a high speed European network dedicated to R&D and education. Together with the managers of the national research networks, GÉANT represents a high speed, secure R&D infrastructure which serves more than 40 million researchers in more than 8000 institutions, spread over 40 countries in Europe. Supported by FP7 funds, the GÉANT infrastructure is central to the European Research Area.

In recent years wireless access has become a universal trait across the Portuguese higher education system in the form of the “e-U Virtual Campus” system (the Portuguese system for wireless access via Eduroam authentication). Between 2005 and late 2010, the number of users rose from around 3,000 to more than 81,000 and the number of sessions jumped from around 200,000 to around 11 million. Since 2007, almost all of the enrolled students (99.5%) in public higher education can connect to the Internet using “e-U Virtual Campus”.

In 2006 INGRID – the national GRID initiative – was launched, coordinating and maintaining a distributed computer infrastructure for scientific applications. This is based on a network of computational resources – a “grid” – belonging to different academic and scientific organisations and allowing tasks and resources to be divided and managed more efficiently. This infrastructure responds to the growing needs of researchers the world over involved in scientific activity for increased computational capacity and storage for large quantities of data.

Between 2006 and 2010, INGRID went from having 70 to 2,092 Central Processing Units (CPUs) and from 22 to 743 terabytes (TB) of disk space.

The capabilities of this infrastructure were, however, reinforced when it was integrated with its Spanish counterpart as part of the IBERGRID initiative, allowing Portugal to become an active part of the European GRID Initiative (EGI). In 2010, Portugal was responsible for 6.5% of the "jobs" executed and 6.8% of the EGI CPU time (in 2006, both the percentage of "jobs" and CPU time stood at 0.03%).

With the implementation of "b-on – Online Knowledge Library" and the institutional repositories of open access scientific information, access and free usage of online scientific content has come to represent a resource of growing importance for the R&I system.

Between 2004 and 2010, the availability and the usage of scientific publications via "b-on" grew considerably. In terms of availability, in 2010 all public scientific and higher education institutions along with subscribing private institutions had access to 49,978 scientific publications through the central service of "b-on" (in 2004 only 7,007 publications were available). Concurrently, the total number of downloads of full text articles in international scientific publications rose from 1.7 million in 2004 to 5.6 million in 2010.

The period between 2004 and 2010 also saw an expansion in the number, the coverage and the range of institutional repositories of open access scientific information in Portugal. The number of institutional repositories of open access scientific information grew from just 1 to 31, and the coverage of higher education (measured as the ratio between students enrolled and the number of repositories) rose from 6% to 70.2%. The number of documents available in these repositories rose from 626 to more than 50 thousand in 2010 (50,251), representing an increase in the ratio of documents per higher education researcher (FTE) from 0.04 in 2004 to 1.06 in 2010.

Conclusions

Over the last decade the Portuguese system of R&I benefitted from relevant developments in the resource mobilisation structure helping widen its scientific and technological base. A significant growth in research intensity as a percentage of GDP has been visible. For the first time R&D Expenditure reached levels above 1% of GDP, and a high of 1.59% in 2010 having stood at only 0.73% in 2000. This intensification resulted from an exceptional rate of growth in expenditure (AAGR: 8.1%).

The level of financial and human resources mobilised (and in particular research personnel) reduced the gap between Portugal and the European average. The Business sector overcame its secondary role in the system, almost taking central stage as the dominant actor.

R&D investment has been concentrated on activities related to Applied Research and Experimental Development, accounting for three quarters of the total R&D expenditure in the country, and continuing to grow.

"Industrial Production and Technology" is traditionally the dominant socioeconomic objective in R&D expenditure, although it has recorded a steep fall relative to the total from 2007 onwards.

The Government sector has contributed 44.9% of the total investment funds in the system, largely for onward redistribution to other sectors, while Business finances 44.1% of total R&D Expenditure, mainly directed towards self-financing. The Business sector receives most public funding indirectly, by way of tax incentives. In this way, Portugal is part of a small group of countries that rely primarily on indirect tax incentives for stimulating R&D in Business enterprises.

“Funds from Abroad” are less important in Portugal for financing R&D expenditure than any of the other countries compared; they have also been falling over time, reflecting an inability to attract external financing. However, in recent years, Portugal has been improving its ability to capture European funds with national teams participating in European consortia, as such improving the “rate of return” in relation to the national contribution made to the budget for the European Framework Programme.

The human resources, for the period studied between 2000 and 2010, show significant growth, mainly in Higher Education (representing 51% of researchers in 2010). Business also increased its capabilities even though it continues to be markedly under resourced when compared with the benchmark countries. Government is the only sector that lost share over the period and saw the number of people fall in absolute terms. By function, researchers represent the majority in the system, although only a relatively small share of them are trained to doctoral level (26%).

Analysing the resource mobilisation in the system reveals the particular significance of Engineering and Technology, namely Enabling Technologies such as ICT. The national ability to develop financing instruments within the “Innovation Union” framework has allowed developments in areas that help confront challenges faced by society.

4.

Knowledge Production

Introduction

This chapter seeks to identify the capacity of the Portuguese scientific community to produce scientific and technological knowledge. To this end, the analysis here focuses on quantifying the results of scientific and technological activity. Scientific knowledge production is measured by looking at publications in scientific journals, using relevant bibliometric indicators, while technical knowledge production is measured by looking at patents, and related intellectual property indicators. This distinction helps orientate the analysis and will also determine the structure of this chapter.

It is of primary interest to identify the different specialisation profiles for both the scientific knowledge and technical knowledge produced in Portugal, contextualised using international comparison. In a first phase, comparisons are carried out using the 27 countries of the European Union; a second phase then uses the group of countries selected for benchmarking. This process helps identify the strengths, weaknesses, opportunities and threats that confront the Portuguese research and innovation system surrounding the production of these types of knowledge.

Generally speaking, the indicators used here are well accepted as appropriate instruments for analysing scientific and technological production. However, they are not without their limitations resulting from factors that condition the available information sources. For both scientific and technological output, one particularly important source of limitations linked to indicators stems from the different propensity to publish or/to patent in the different fields of knowledge. In fact, publications in journals are less common in some fields of science than in others, with preference being given to other ways of disseminating knowledge. Equally, in some technological fields, patents are not the preferred way for the valorization or protection of results, alongside the fact that a significant number of inventions are not patentable.

As this may be, bibliometric and intellectual property indicators are fundamental for understanding the innovation process as they allow the strengths and weaknesses of knowledge production to be identified, both in terms of scale and in terms of impact (Pavitt, 1988).

Scientific knowledge produced in Portugal

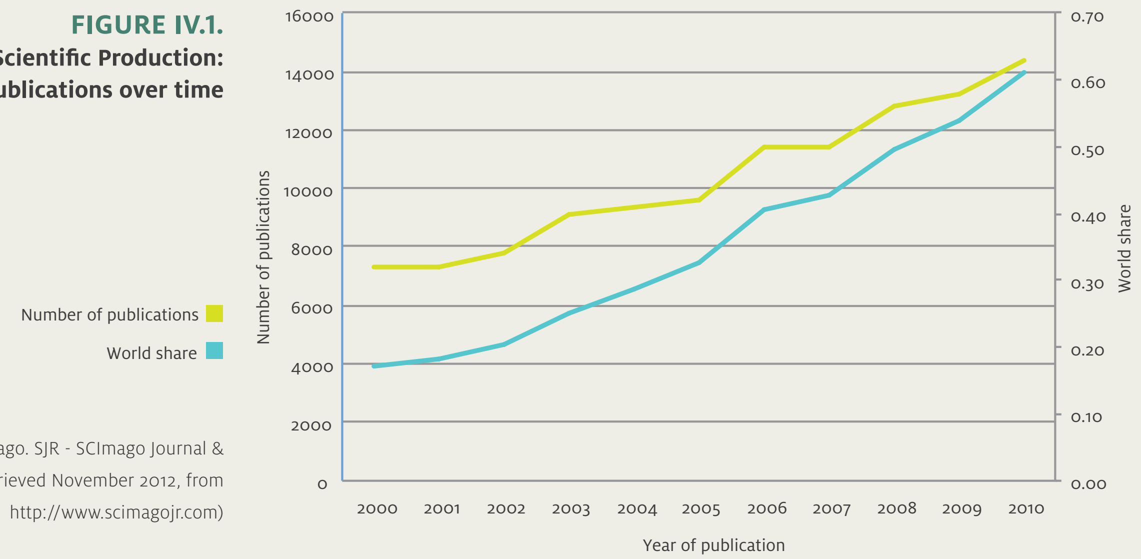
Production over the period 2000-2010

Portuguese scientific production[1] has witnessed considerable growth rates as a result of its convergence path with the European average. Between 1996 and 2010, the Portuguese contribution to the global[2] production and publication of knowledge almost tripled (2.7 times). Over the last decade it recorded an average annual growth rate of 14% (however, over the period 2005–2010 this slowed slightly to an AAGR of 13%) (Figure IV.1). This increase in production is a result of the research and innovation system reaching maturity, namely reflecting an increased number of researchers, better institutions and conditions (see Chapters 1 and 2) and the fulfilment of the political goal of increasing the internationally referenced Portuguese scientific production. However, in relation to the European Union and in terms of world share, Portugal was ranked 15th in 2010, having climbed only one place over the 10 year period.

1. Portuguese scientific production, as regards publically available scientific knowledge, which is validated and published, is national inasmuch as at least one of the authors comes from a research institution based in Portugal: this is the objective criterion that commonly delineates the boundaries of national scientific production (Glanzel and Schubert, 2004).

2. The sources of information used in this study to identify and characterise the Portuguese scientific production come from the Web of Science – Thomson Reuters (via authored publications and information supplied by the DGEEC/MEC, as well as through information supplied by CWTS – Centre for Science and Technology Studies , University of Leiden) and Scopus (via the Scimago site). The fact that a scientific work is accepted for publication in a journal is probably the best indicator that a significant contribution to knowledge has been made (Braun, 2004). However, in the Social Sciences and Humanities there are other types of scientific literature that are not published in journal form, namely books, and these do not appear in databases (Hicks, 2004). The respective sites on the Internet list the criteria used for selecting the journals.

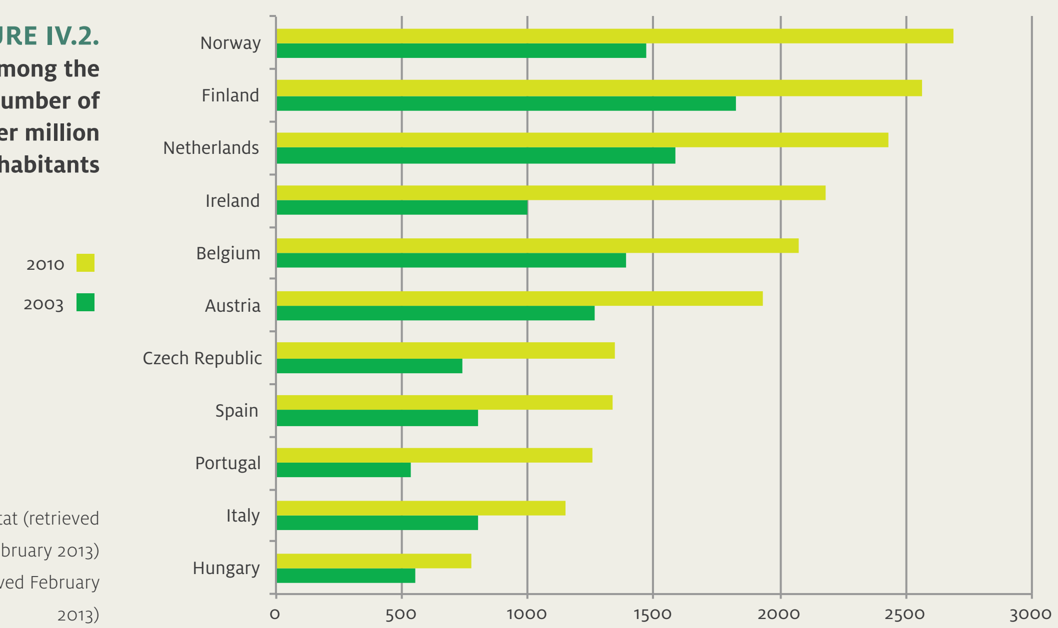
FIGURE IV.1.
Portuguese Scientific Production: Number of publications over time



Source: Scimago. SJR - SCImago Journal & Country Rank (retrieved November 2012, from http://www.scimagojr.com)

Compared against the benchmark countries, Portugal was placed in 9th position in terms of world share in 2010, having risen just one place since 2000. This position remains unaltered when taking into account the production relative to the size of the population (Figure IV.2).

FIGURE IV.2.
Scientific production among the benchmark countries: Number of citable publications per million inhabitants



Source: Population: Eurostat (retrieved February 2013)
Publications: Scimago (retrieved February 2013)

Portuguese productivity measured using the "ratio of citable publications[3] to total FTE researchers" is the third lowest when compared against the benchmark countries (Figure IV.3).

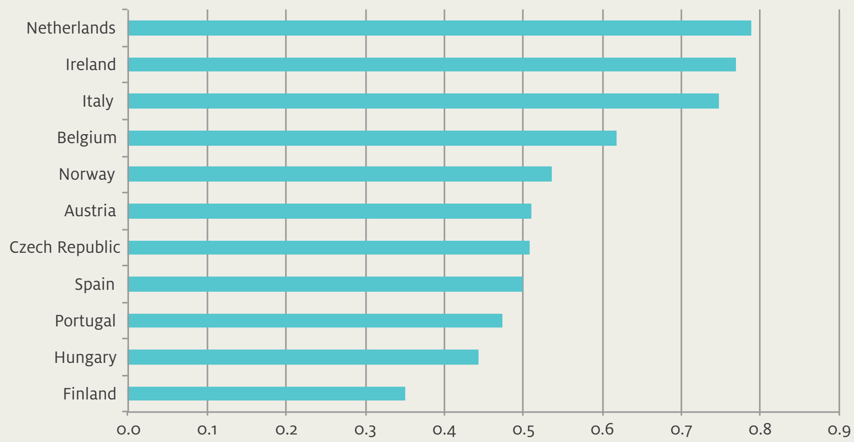


FIGURE IV.3.
Scientific production of the benchmark countries: A comparison using the ratio of the number of citable publications per FTE researcher

Citable publications 2010 / FTE researchers 2007

Source:
Researcher data – Eurostat (retrieved February 2013)
Publication data – Scimago (retrieved February 2013)

This positioning of Portugal in the last places leads to the conclusion that the growth that occurred over the course of the decade was not enough to leverage the country to a higher level of productivity. This is the case even considering that Portugal had the highest rate of growth in scientific publications for the period out of all of the countries mentioned (Figure IV.4). There are certainly efficiency gains to be achieved in the near future given the recent increase in the system's human resources (see Chapter 3).

3. Articles, reviews and conference papers.

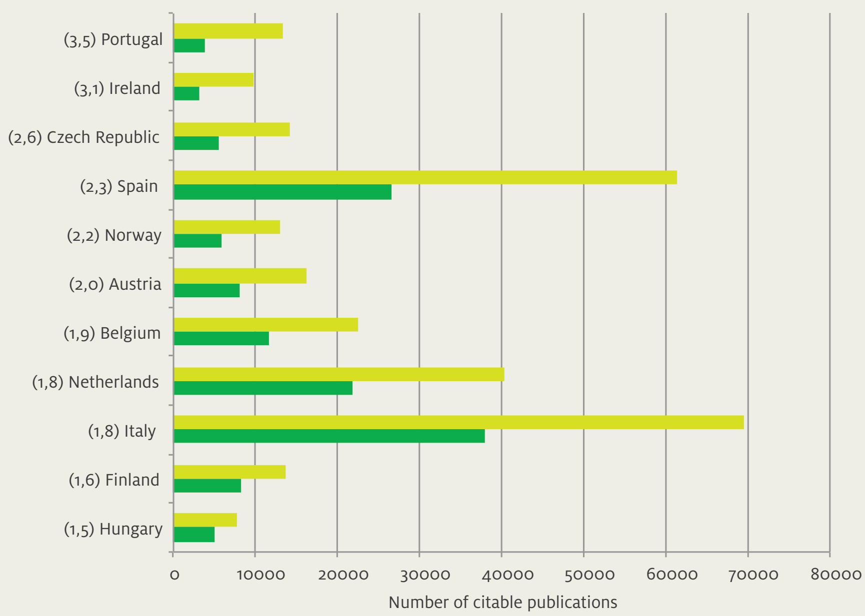


FIGURE IV.4.
Scientific production of the benchmark countries (growth in the number of publications)

2010
2000

Note: The name of the country is preceded by the growth rate in the number of publications over the period studied.

Source: Scimago. SJR – SCImago Journal & Country Rank

Scientific activity of Portuguese institutions in a world context

4. Those universities that most contributed to an increase in Portuguese scientific production are identified using the two international rankings of scientific production: the Scimago Institutions Rankings – SIR World Report 2012, and the 2011/2012 Leiden Ranking. The SIR ranking is the most used in this study as it covers more Portuguese institutions (29) than the Leiden ranking (6 universities). The SIR (available from www.scimagoir.com) studies the scientific production of institutions belonging to a variety of sectors, calculating 14 volume and impact indicators for each institution. Among these is an indicator for specialisation, which indicates the thematic concentration or dispersion of the institution, providing a means of gauging to what extent they may be comparable. The 2012 edition includes indicators relating to 3290 scientific and/or academic institutions from 106 countries around the world. The selection criterion required that the institution had to have at least 100 publications indexed in Scopus in 2010.

The seven Portuguese universities that stand out in terms of the number of publications over the period 2006-2010, are, in decreasing order: Universidade do Porto, Universidade Técnica de Lisboa, Universidade de Lisboa, Universidade de Coimbra, Universidade de Aveiro, Universidade Nova de Lisboa and Universidade do Minho[4]. According to the SIR World Report 2012, each one of these universities was responsible for (co-)authoring upwards of 5,000 publications over the stated period. The first placed institution was responsible for 11,159 publications; that placed last, 4,824 publications (the institution that was ranked eighth nationally was the Telecommunications Institute - Instituto de Telecommunicações - with 2,105 publications).

In world context, according to the SIR and the Leiden rankings, the seven institutions previously mentioned are still a long way from the top, as can be seen in the comparison of the number of publications in Table IV.1. By comparison, it can be seen that the Leiden ranking exchanges the places of U. Coimbra and U. Lisboa, while the U. Minho disappears – this ranking orders the institutions using the production of each university normalised by the size of the institution. The best positioned Portuguese university is the U. Porto, which finds itself among the top places of the second half of the Leiden University ranking and just over the 300 mark in the Scimago ranking of scientific institutions. It can be concluded that those institutions which are better placed in terms of scientific production are located in the North (Minho and Porto), Centre (Coimbra and Aveiro) and Lisbon.

TABLE IV.1.
Position of the seven top Portuguese institutions in a world context (by decreasing order of the number of internationally referenced publications)

Position in the Scimago Institutions Ranking 2012 (3290 institutions in total)	Portuguese institutions ordered by production volume	Position in the 2011/2012 Leiden Ranking (500 universities in total)
270	Universidade do Porto	259
294	Universidade Técnica de Lisboa	318
511	Universidade de Lisboa	413
531	Universidade de Coimbra	412
550	Universidade de Aveiro	425
663	Universidade Nova de Lisboa	489
684	Universidade do Minho	

(continuation)

Publications for the whole of the 2006-2010 period were analysed over all areas (29 Portuguese universities were selected on this basis, visible in Figure IV.30). The 2011/2012 Leiden Ranking (available at www.leidenranking.com) brings together information concerning the 500 top universities world-wide by number of Web of Science registered publications over the 2005-2009 period, considering only articles, conference papers and reviews, and excluding Arts and Humanities publications. Various indicators are also provided regarding the production volume and scientific impact, enabling multiple ways to order the universities.

Open Access is a central theme for the production and diffusion of scientific knowledge, enabling widespread dissemination and cost-free access, reinforcing the nature of knowledge as a public good. Figure IV.5 shows the number of documents that are included in institutional repositories with free access that belong to Portuguese institutions, including those seven that produced the most publications over the period under consideration.

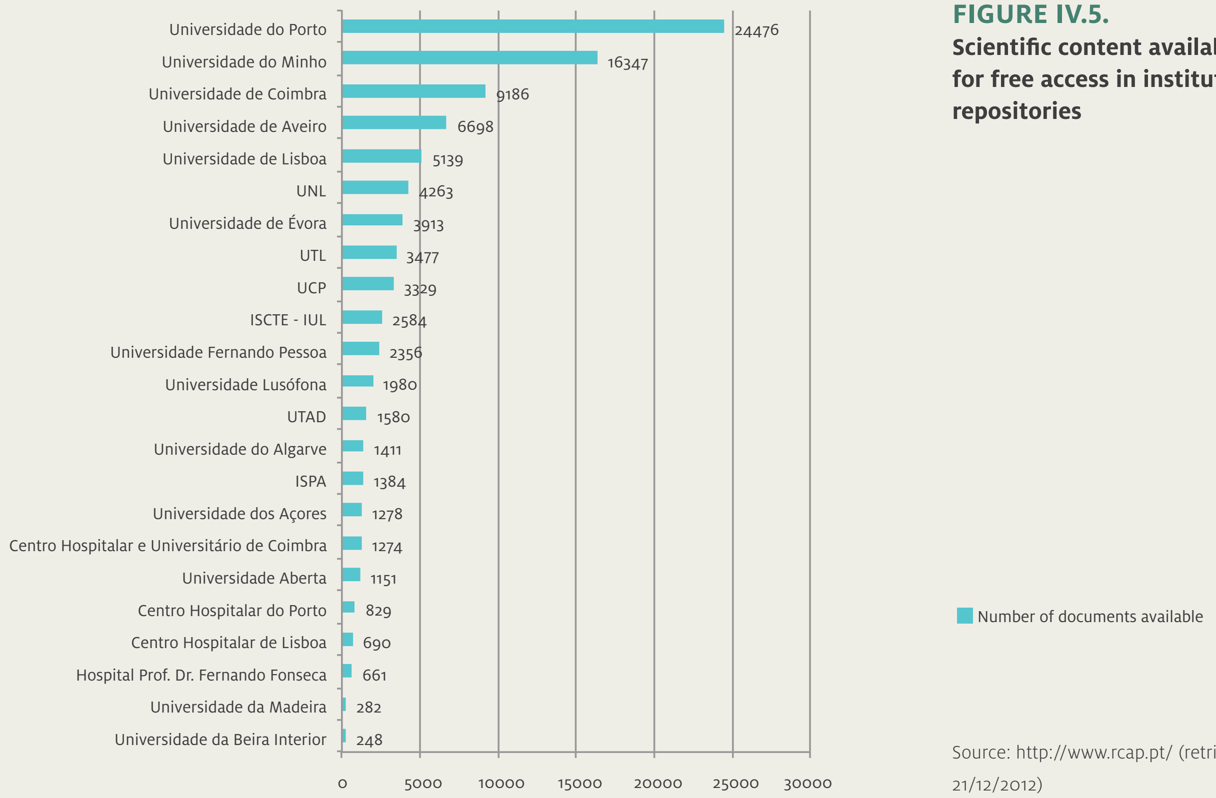


FIGURE IV.5.
Scientific content available for free access in institutional repositories

Source: http://www.rcap.pt/ (retrieved 21/12/2012)

The volume of internationally referenced scientific production analysed in this section is an indicator of international visibility. The approach of international visibility will be complemented in the next section with an analysis of international collaboration underlying the scientific production itself (co-authorship).

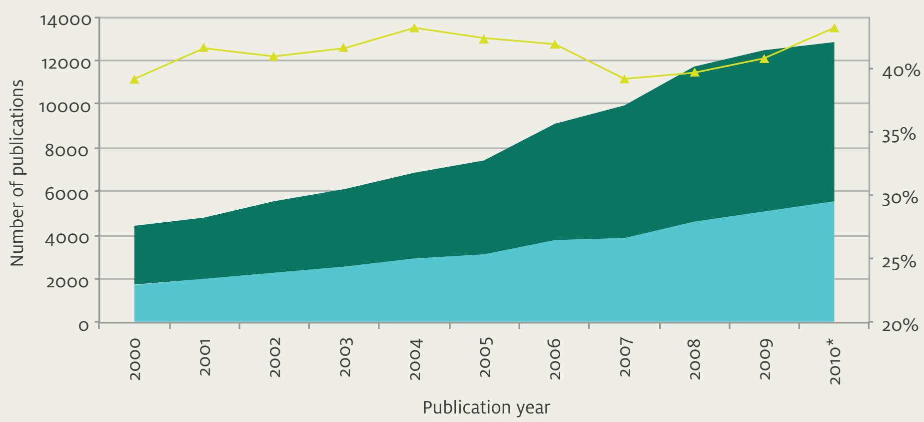
International collaboration in the process of creating scientific knowledge

The number of Portuguese publications involving international collaboration tripled between 2000 and 2010 (Figure IV.6)[5]. In relative terms, there was a tendency for the number of these publications to grow: in 2000 they represented 39% of national production, which subsequently rose to 43% by 2010.

The Portuguese scientific community collaborated with researchers from 166 countries between 2000 and 2010, although a significant majority (83%) was focused on just 20 countries. Figure IV.7 shows the top ten most preferred countries for Portuguese researchers to collaborate with. We may consider the data series for the period up to 2010 to represent a well-developed trend. In this case, the data for 2010 represent a new direction being taken, and a change has recently undergone concerning the choice of countries which the Portuguese scientific community most collaborates with.

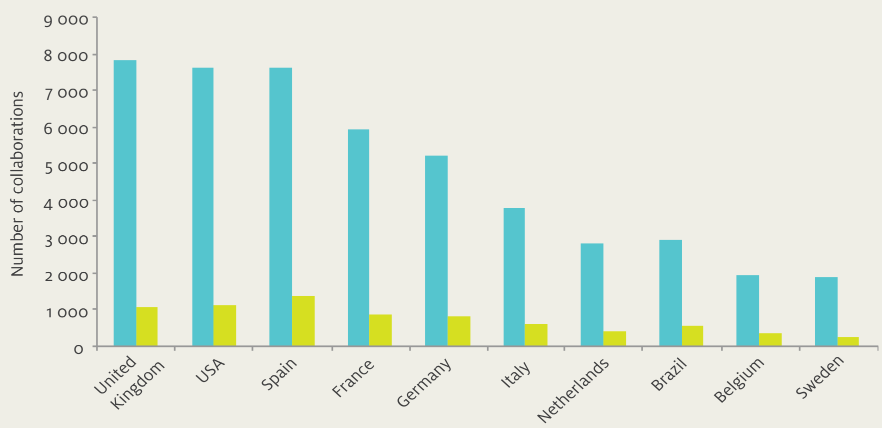
5. International collaboration is considered to be part of the globalization process of scientific research, and can be measured by looking at co-authored publications (Glanzel and Schubert, 2004). The motives for international scientific collaboration can vary, one of which being to increase scientific impact (Glanzel, 2001). The measurement of co-authorship is an important factor when undertaking a SWOT analysis.

FIGURE IV.6.
Portuguese scientific production: International collaboration over time



Source: GPEARI / Thomson Reuters (2010)
Note: * Provisional values

FIGURE IV.7.
Portuguese scientific production: Countries that most collaborate with Portugal



Source: GPEARI / Thomson Reuters (2010)
Note: * Provisional values

Spain stands out as being the country which Portugal has collaborated with most since 2007, with a high annual average rate of growth between 2000 and 2010. Closely following the growth rate of Spain are Canada, Brazil and Poland. However, in absolute terms the differences are considerable: there were 1,390 registered collaborations with Spain in 2010, while Brazil recorded 544, Poland, 222, and lastly, Canada, 207 collaborations (Figure IV.8)[6].

The distribution of the publications that result from international collaborations by field of study is shown in Figure IV.9. From 2000 to 2010, international collaboration grew mainly in the areas of Medical and Health Sciences, closing the gap on the levels of Exact Sciences and Natural Sciences. Engineering and Technology, as with Social Sciences and Humanities, did not change the level of international collaboration over the decade studied[7] In 2010, Spain topped the list of collaborating countries for all fields, with the exception of Social Sciences and Humanities. It is also noticeable that Brazil is still an emerging leader, only managing to reach the top seven in the area of Medical and Health Sciences.

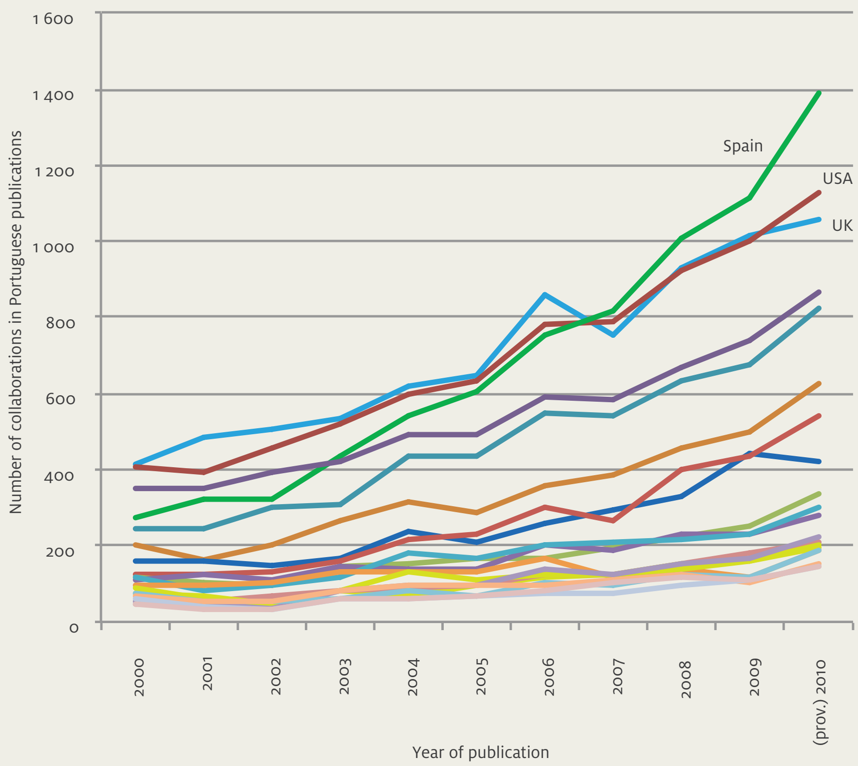


FIGURE IV.8.

The evolution of international collaboration between Portugal and the 20 countries which have established most co-authorship links

- United Kingdom (9,9%)
- USA (10,8%)
- Spain (17,6%)
- France (9,4%)
- Germany (12,9%)
- Italy (11,9%)
- Netherlands (10,3%)
- Brazil (15,7%)
- Belgium (11,3%)
- Sweden (9,4%)
- Switzerland (9,8%)
- Russia (7,3%)
- Denmark (7,8%)
- Canada (16,5%)
- Austria (10,4%)
- Poland (15,4%)
- Greece (9,8%)
- Finland (8,5%)
- Norway (8,9%)
- Czech Rep. (11,5%)

Source: GPEARI/ Thomson Reuters (2010)

Note: The average annual growth rates over the period studied, appear in brackets in the captions, following the name of the country

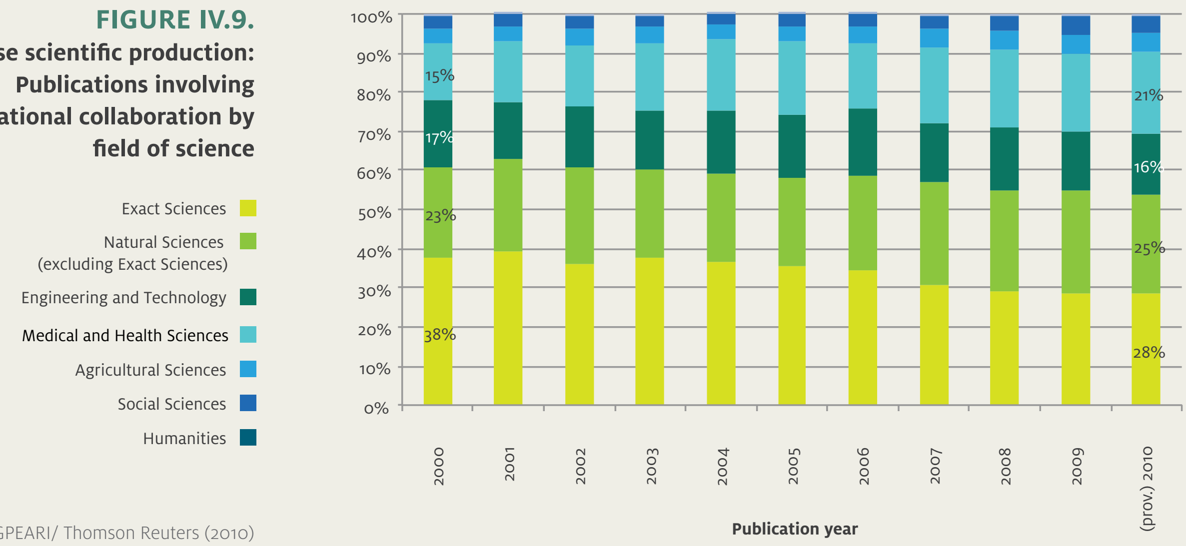
A similar pattern is visible for all benchmark countries in the way that international collaboration has developed over time, with an upward trend in the relative weight of publications involving international collaboration, albeit with some variability over the 2000-2010 period. The larger countries, such as Spain and Italy, have a lower percentage of publications with international collaboration, which reflects the fact that smaller countries are more inclined to collaborate internationally. The Czech Republic is the exception here, being a small country and at the same time registering the lowest level of collaboration in 2010.

Looking at the 29 institutions listed in the SIR World Report 2012 reveals significant differences in terms of international collaboration. The institution with the highest rate is the Instituto Gulbenkian de Ciência (69.5%), and the lowest rate, the Instituto Politécnico do Porto (20.7%). Focusing on the universities shows the Universidade dos Açores as the most collaborative (58%) and the Universidade da Beira Interior as the least collaborative (27%).

6. In an ibero-american context, various initiatives exist to strengthen the bonds between the different national scientific communities, namely to increase the visibility of their respective scientific production which is not adequately covered by the Web of Science (WoS). Examples here include that of Scielo (available at www.scielo.org), which provides open access to full text versions of scientific journals while also making the respective bibliometric indicators available, and Latindex (available at www.latindex.unam.mx) that, having the same objective of increasing visibility but with different action principles, makes it possible to access a wider range of journals. Some of the journals available on these platforms went on to be included in the WoS.

7. It should be recognised that the areas which apparently maintained the same level of collaboration are those whose researchers habitually find the information sources that are used for quantifying scientific production to be inadequate (namely the Web of Science).

FIGURE IV.9.
Portuguese scientific production: Publications involving international collaboration by field of science



Source: GPEARI/ Thomson Reuters (2010)

Overall, the volume of Portuguese scientific production has been seen to show consistently positive growth over the last decade, with a significant part of that production occurring in collaboration with other countries.

Visibility of Portuguese scientific production

This section covers the profile of Portuguese scientific production by field and by region (NUTS 2), and seeks to identify specific themes for comparison with the European Union (27) and the benchmark countries. In so doing, it should be realised that publication and citation practices vary significantly between the fields of science and that the information sources used cannot be considered equally valid in all cases.

The changing profile of Portuguese scientific production by field of science

The changing structure of scientific production by field of science, that can be seen grouped into seven scientific areas in the Figure IV.10, is most emphatically visible in the growth of the number of publications in Medical and Health Sciences, moving to become the area with most publications in 2010. It should be noted that the share of publications of Social Sciences and Humanities (8% in 2010) is proportionally less than their share of doctorates completed in Portugal (38% in 2010 – source: DGEEC/MEC). This can be a result of the recognised fact that the outputs of these sciences may not be covered to the same level by sources such as the Web of Science and Scopus.

Each one of the areas covered in Figure IV.10 can be broken down into component scientific fields[8] which together account for 80% of the publications over the 2005-2010 period (Figure IV.11 to Figure IV.17 – fields organised by decreasing order in the number of publications). This characterisation defines the profile of each area in the national context.

8. Three levels of classification are used (for example, 'Medical and Health Sciences – Clinical Medicine – Oncology'): the first two belong to the Fields of Science classification (FoS) from the OECD; the more specific level belongs to the classification provided by the Web of Science (WoS) for the scientific journals included in the constituent databases. The correspondence between the two was provided by DGEEEC/MEC.

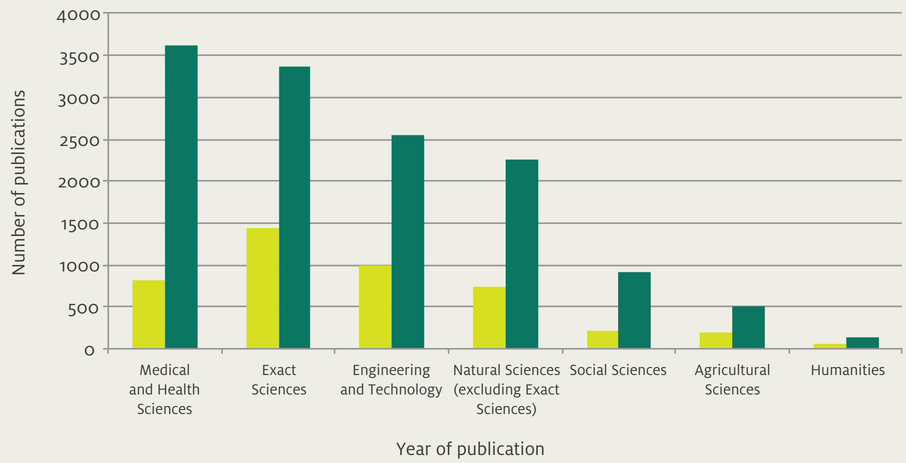


FIGURE IV.10.
Changes to Portuguese scientific production by scientific area

Source: GPEARI/ Thomson Reuters (2010)

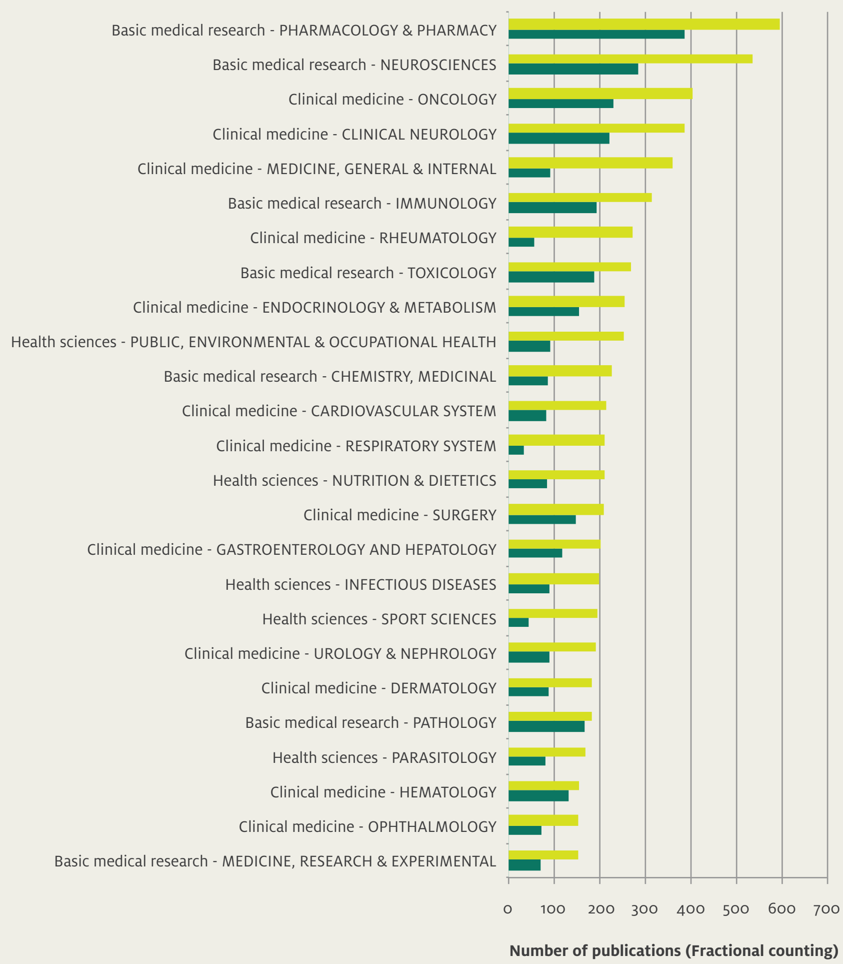


FIGURE IV.11.
Medical and Health Sciences – fields covering 80% of the Portuguese publications for the period 2005-2010

Source: Web of Science (data supplied by CWTS, January 2013)

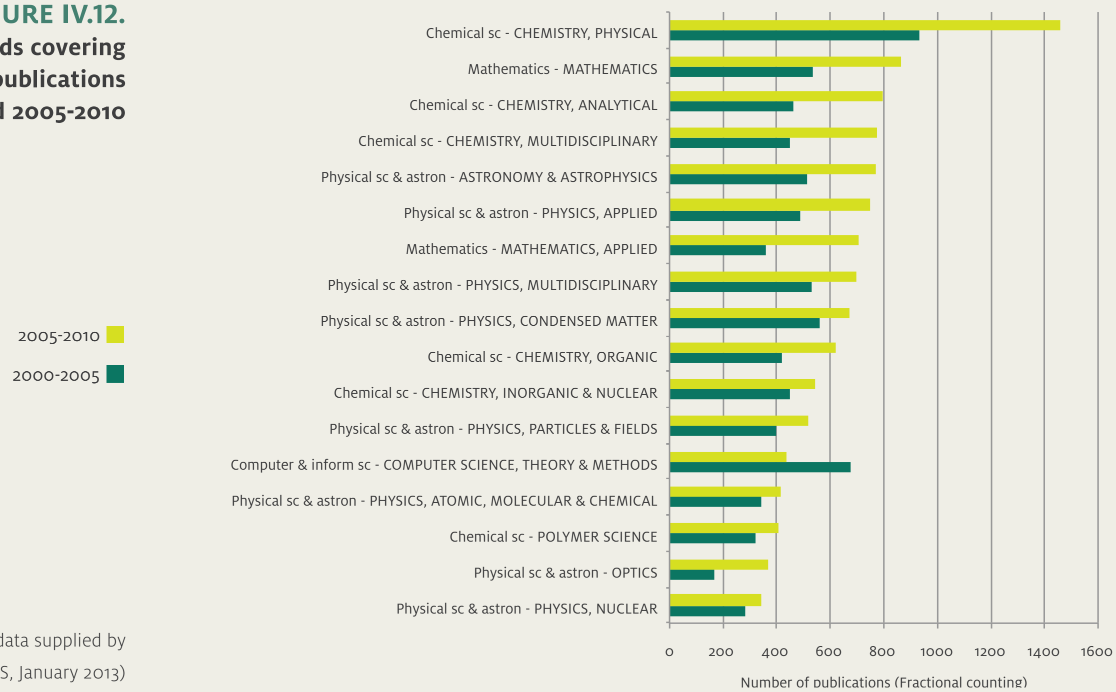
Looking at the number of publications over the 2005-2010 period, the following fields can be highlighted for the area of Medical and Health Sciences (Figure IV.11): Pharmacology and Pharmacy, Neurosciences, Oncology, Neurology, General and Internal Medicine and Immunology.

A number of the fields within Medical and Health Sciences can be found within the top 100 by number of Portuguese publications between 2000 and 2010[9]. Of these, those that had the highest AAGR between 2005 and 2010 are: i. Respiratory Systems (78%); ii. Psychology - Multidisciplinary (46%) (not included in Figure IV.11); iii. Medicine - General and Internal (41%); iv. Rheumatology (40%); v. Sport Sciences (38%).

Those areas that exhibited a negative AAGR between 2005 and 2010 were Pathology and Radiology, Nuclear Medicine and Medical Imaging (not visible in the Figure IV.11), both at a rate of -1%.

Looking at the number of publications over the 2005-2010 period, the following fields can be highlighted for the area of Exact Sciences (Figure IV.12): Physical Chemistry, Mathematics, Analytical Chemistry, Chemistry - Multidisciplinary and Astronomy & Astrophysics.

FIGURE IV.12.
Exact Sciences – fields covering 81% of Portuguese publications for the period 2005-2010



Source: Web of Science (data supplied by CWTS, January 2013)

9. As a complementary effort, and considering all areas together, the 100 top fields by number of publications were identified for the period 2000-2010. The AAGR was calculated for each one of these scientific areas for the second half of the period (2005-2010), allowing the respective growth trends to be identified.

A number of the fields within Exact Sciences can be found within the top 100 by number of Portuguese publications between 2000 and 2010. Of these, those that had the highest AAGR between 2005 and 2010 are: i. Mathematics (12%); ii. Applied Mathematics (12%); iii.

Chemistry – Multidisciplinary (12%); iv. Astronomy & Astrophysics (11%). The fields which had a negative AAGR for the period 2005-2010 were Nuclear Physics, Computer Science – Artificial Intelligence (not visible in Figure IV.12) and Computer Science – Theory and Methods, respectively with -2%, -4% and -34%. It is worth noting that the AAGRs for this area are considerably below those recorded for Medical and Health Sciences.

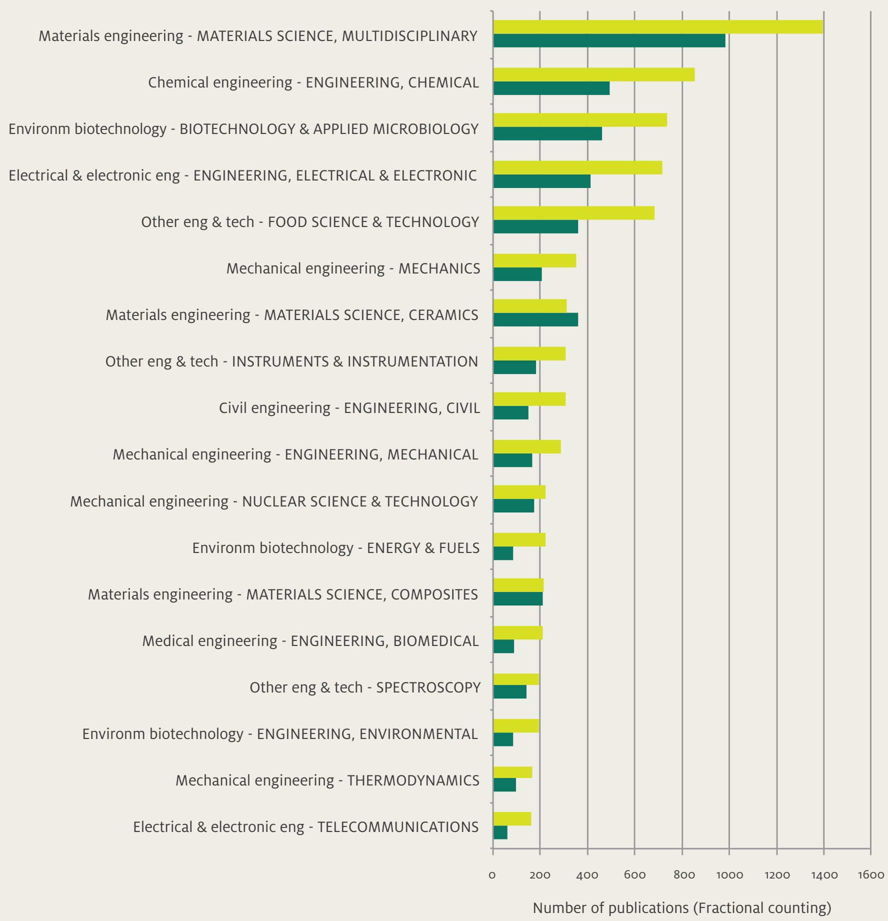


FIGURE IV.13.
Engineering and Technology - fields covering 81% of Portuguese publications for the period 2005-2010

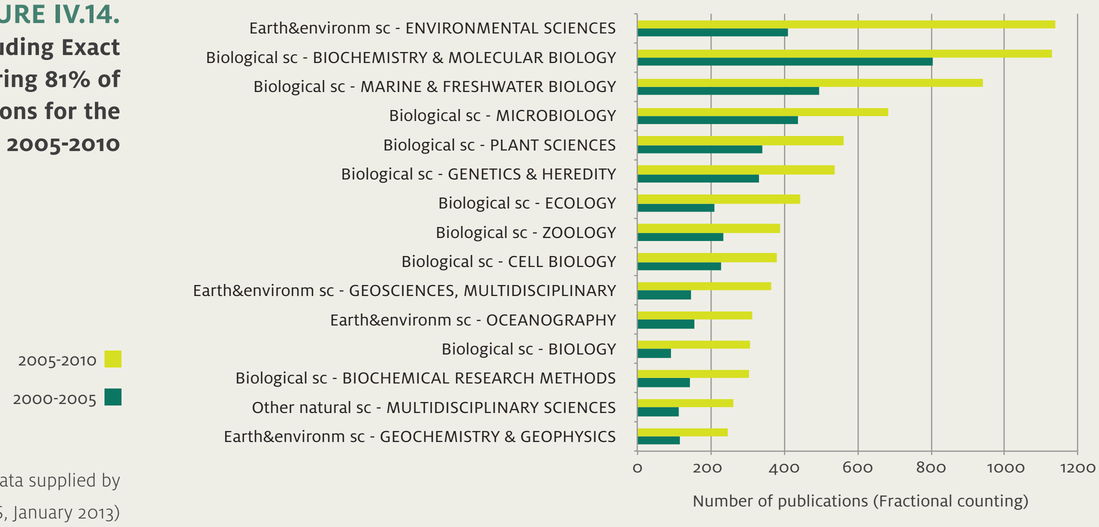
Source: Web of Science (data supplied by CWTS, January 2013)

Looking at the number of publications over the 2005-2010 period, the following fields can be highlighted for the area of Engineering and Technology (Figure IV.13): Materials Science - Multidisciplinary, Chemical Engineering, Biotechnology & Applied Microbiology, Engineering - Electrical & Electronic, and Food Science & Technology. This last field is also considered to be part of Agricultural Sciences (Figure IV.15).

A number of the fields within Engineering and Technology can be found within the top 100 by number of Portuguese publications between 2000 and 2010. Of these, those that had the highest AAGR between 2005 and 2010 are: i. Civil Engineering (24%); ii. Energy &

Fuels (24%); iii. Biomedical Engineering (23%); iv. Instruments & Instrumentation (22%); v. Telecommunications (21%); and vi. Food Science & Technology (20%). Those fields with a negative AAGR for the period 2005-2010 were Materials Science – Coatings and Films (not visible in Figure IV.13) and Materials Science – Ceramics, respectively with -3% and -10%.

FIGURE IV.14.
Natural Sciences (excluding Exact Sciences) - fields covering 81% of Portuguese publications for the period 2005-2010



Source: Web of Science (data supplied by CWTS, January 2013)

Looking at the number of publications over the 2005-2010 period, the following fields can be highlighted for the area of Natural Sciences (excluding Exact Sciences) (Figure IV.14): Environmental Sciences, Biochemistry & Molecular Biology, Marine & Freshwater Biology, Microbiology, Plant Sciences, and Genetics & Heredity.

A number of the fields within Natural Sciences (excluding Exact Sciences) can be found within the top 100 by number of Portuguese publications between 2000 and 2010. Of these, those that had the highest AAGR between 2005 and 2010 are: i. Biology (40%); ii. Geosciences – Multidisciplinary (25%); iii. Ecology (19%); iv. Meteorology and Atmospheric Sciences (19%) (not visible in Figure IV.14); and v. Biochemical Research Methods (18%). In this area there were no fields with a negative AAGR for the 2005-2010 period; those that grew least were Biochemistry & Molecular Biology and Marine & Freshwater Biology, both with an AAGR of 6%.

Looking at the number of publications over the 2005-2010 period, the following fields can be highlighted for the area of Agricultural Sciences (Figure IV.15): Food Science & Technology, Fisheries and Veterinary Sciences.

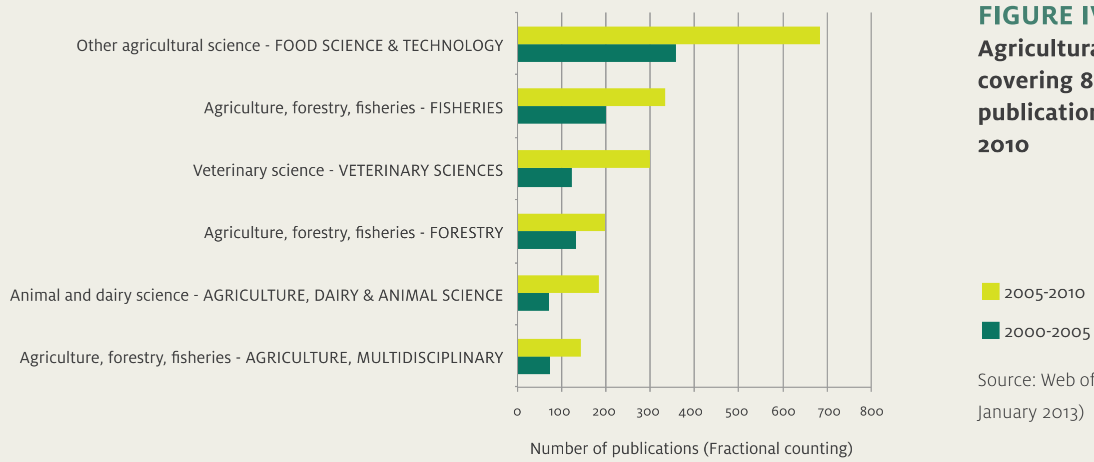


FIGURE IV.15.
Agricultural Sciences - fields covering 83% of Portuguese publications for the period 2005-2010

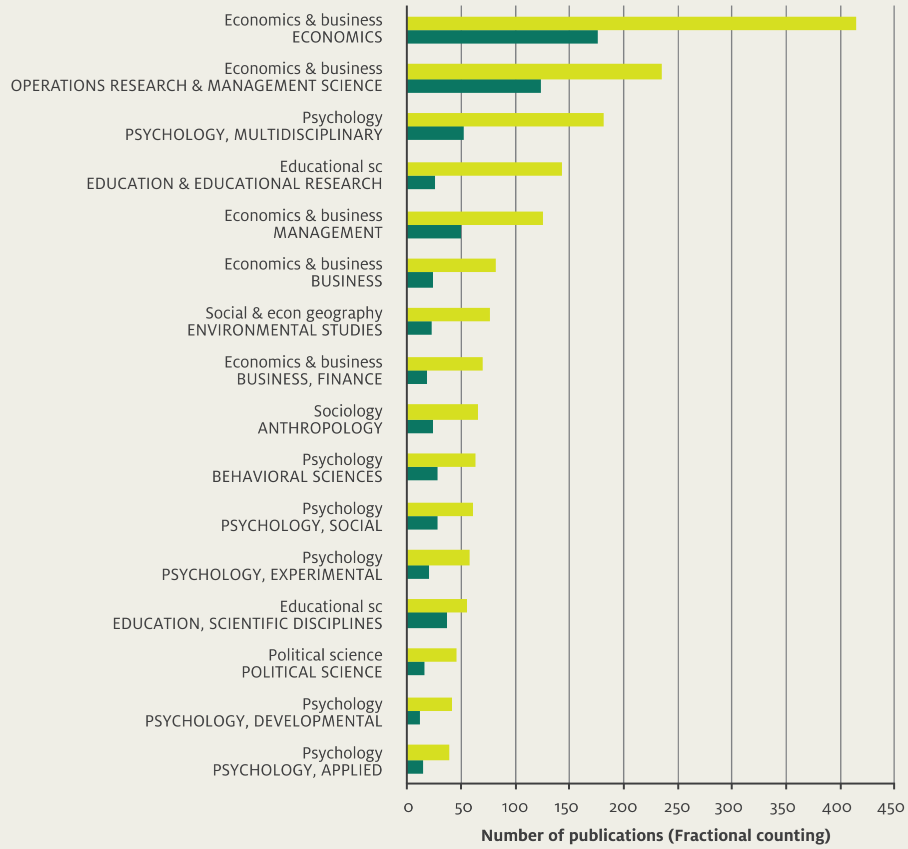
Source: Web of Science (data supplied by CWTS, January 2013)

There are six fields within the area of Agricultural Sciences that reach the top 100 fields by number of Portuguese publications over the period 2000-2010: i. Multidisciplinary Agriculture, with an AAGR between 2005 and 2010 of 26%; ii. Food Science & Technology (20%) (also included in Engineering and Technology); iii. Forestry (18%); iv. Veterinary Sciences (18%); v. Agriculture – Dairy & Animal Science (17%); and, with less growth, vi. Fisheries (7%).

Looking at the number of publications over the 2005-2010 period, the following fields can be highlighted for the area of Social Sciences (Figure IV.16): Economics, Operations Research & Management Science and Psychology - Multidisciplinary.

There are two Social Science fields that reach the top 100 by number of Portuguese publications for the period 2000-2010: i. Operations Research & Management Science; and ii. Economics, with respective AAGRs between 2005 and 2010 of 19% and 18%.

FIGURE IV.16.
Social Sciences - fields covering 80% of Portuguese publications for the period 2005-2010



Source: Web of Science (data supplied by CWTS, January 2013)

Looking at the number of publications over the 2005-2010 period, the field of Humanities – Multidisciplinary can be highlighted for the area of Humanities (Figure IV.17), but this has a comparatively small number of publications in relation to the other areas (see the above figures). As noted above, it is generally accepted that the Web of Science does not effectively represent the production of either the Humanities or the Social Sciences.

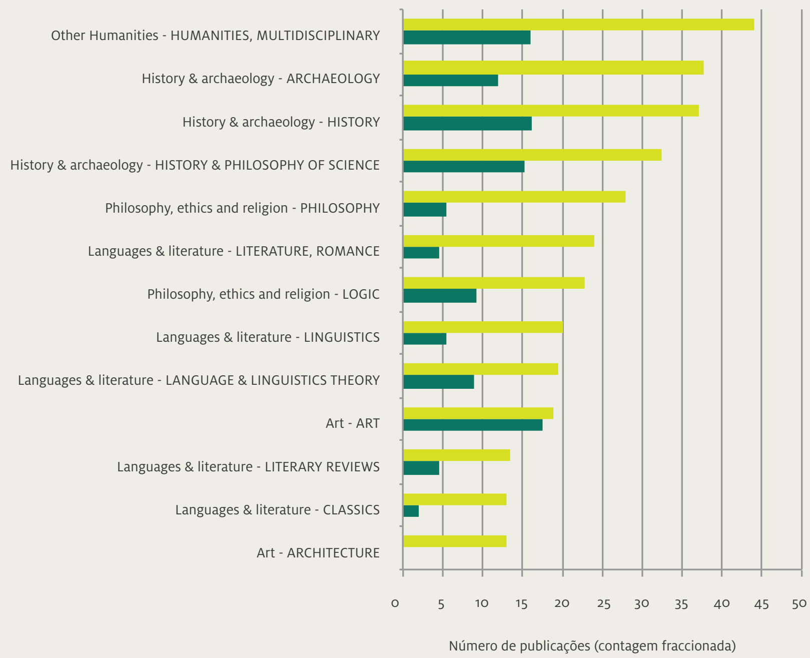


FIGURE IV.17.
Humanities - fields covering 81% of portuguese publications for the period 2005-2010

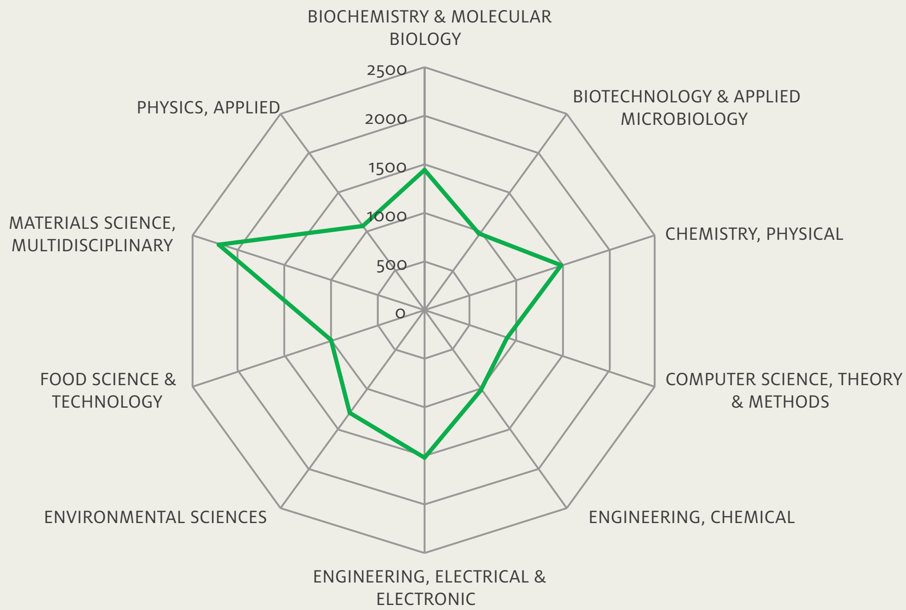
Source: Web of Science (data supplied by DGEEC/MEC, April 2013)

The regional distribution of portuguese scientific production (NUTS 2)

The profile of Portuguese scientific production for each of the regions of the country (NUTS 2) can in essence be related to the respective industrial structure and the competitive advantages of each region in terms of resources. For example, the scientific profiles of the Azores and Algarve are notably influenced by the proximity to the sea; in regions such as the Alentejo, Algarve, and Azores, the increased importance of fields connected with the Environment and Agriculture is noticeable; while the other regions are more likely to predominantly associate themselves with more technologically applied scientific areas.

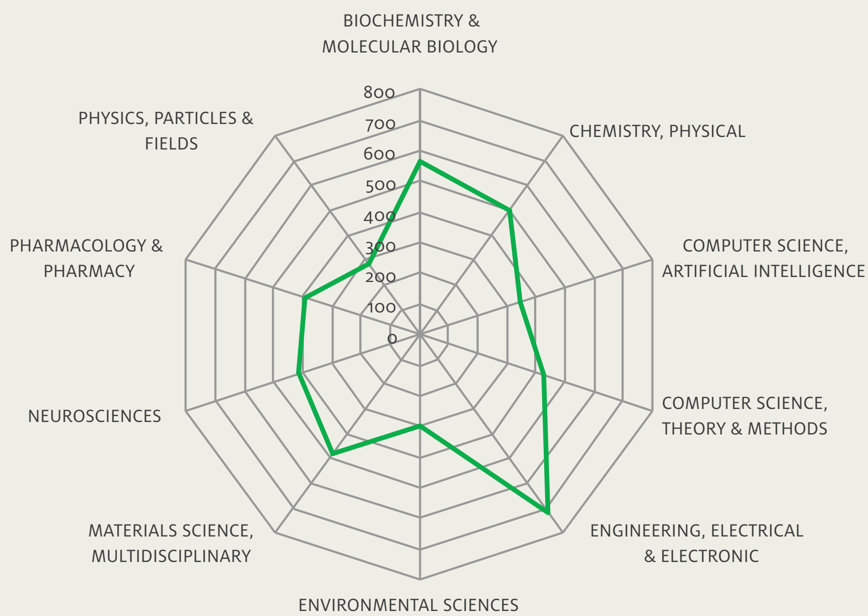
Focusing the analysis on the ten areas with the highest number of publications per region (Figure IV.18 to Figure IV.24), it can be seen that preference is given to Engineering fields in the North and in Lisbon; Exact Sciences in the Centre and Madeira; and Natural Sciences (excluding Exact Sciences) in the Alentejo, Algarve and Azores. Biochemistry & Molecular Biology as well as Environmental Sciences are the two fields which recur in every region, with the exception of Madeira. It should be noted that all of the ten fields in the Azores are within the Natural Sciences (excluding Exact Sciences).

FIGURE IV.18.
Distribution of scientific production by region (NUTS 2): North. Number of publications in each of the top ten fields for the 2005-2010 period



Source: Web of Science (data supplied by DGEEC/MEC, April 2013)

FIGURE IV.19.
Distribution of scientific production by region (NUTS 2): Centre. Number of publications in each of the top ten fields for the 2005-2010 period



Source: Web of Science (data supplied by DGEEC/MEC, April 2013)

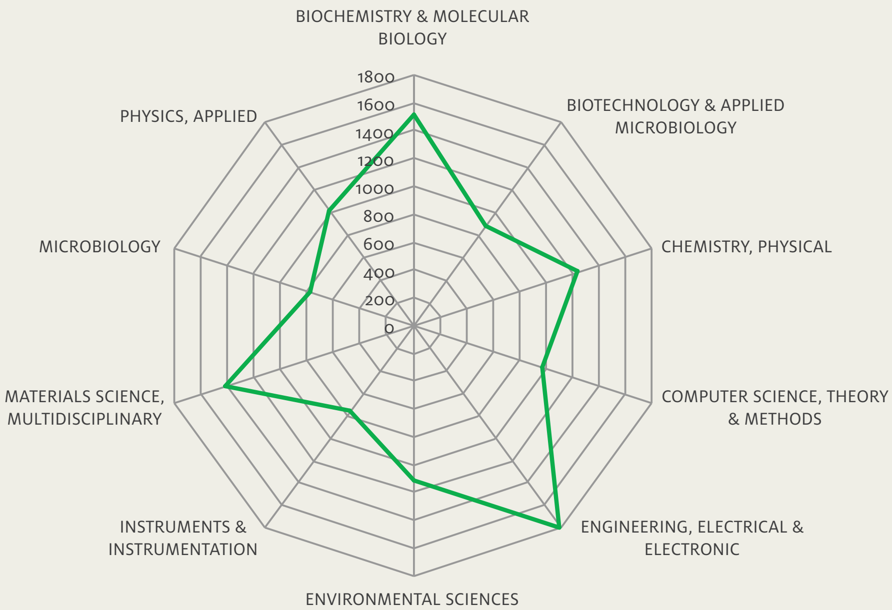


FIGURE IV.20.
Distribution of scientific production by region (NUTS 2): Lisbon. Number of publications in each of the top ten fields for the 2005-2010 period

Source: Web of Science (data supplied by DGEEC/MEC, April 2013)

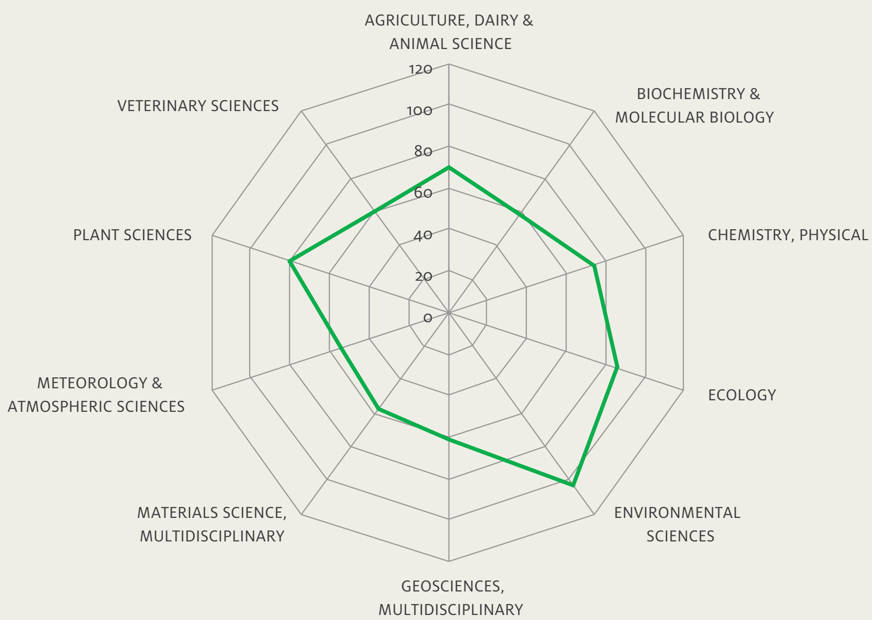
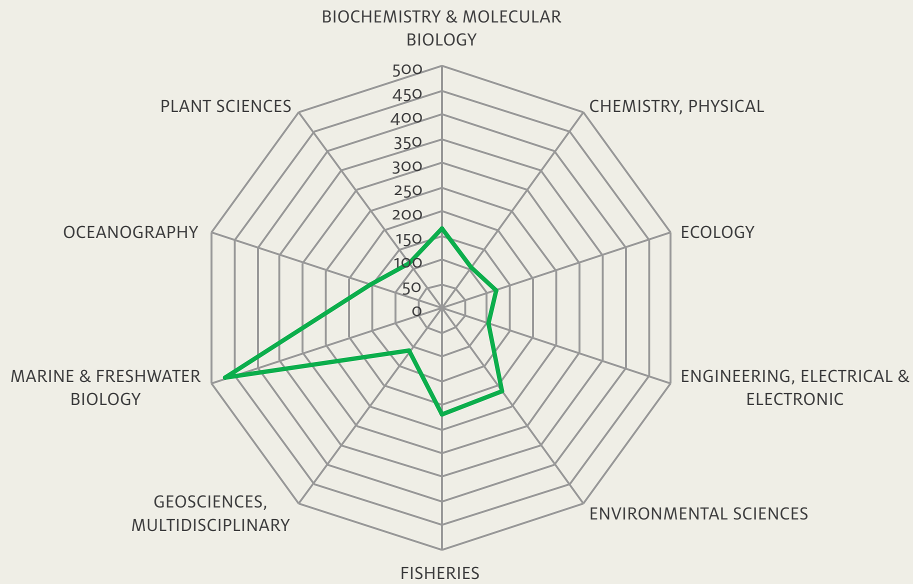


FIGURE IV.21.
Distribution of scientific production by region (NUTS 2): Alentejo. Number of publications in each of the top ten fields for the 2005-2010 period

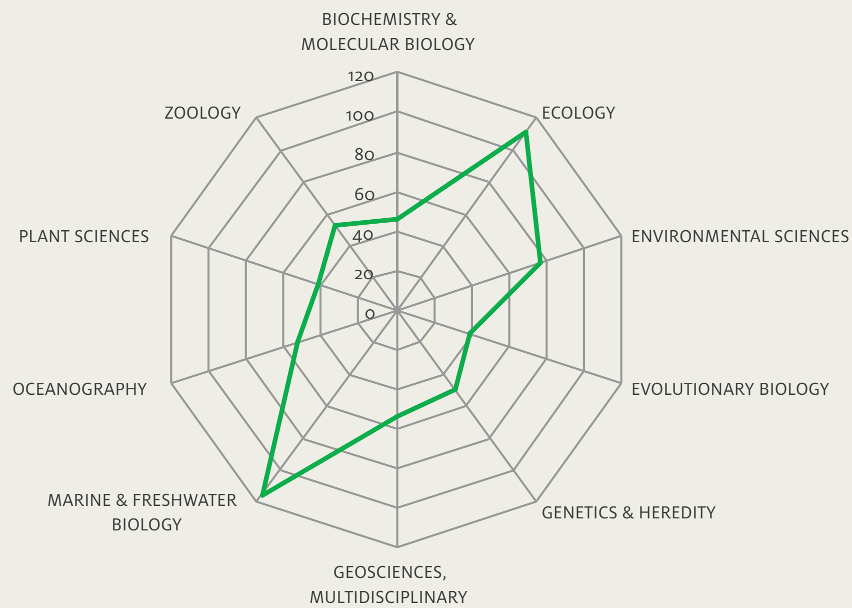
Source: Web of Science (data supplied by DGEEC/MEC, April 2013)

FIGURE IV.22.
Distribution of scientific production by region (NUTS 2): Algarve. Number of publications in each of the top ten fields for the 2005-2010 period



Source: Web of Science (data supplied by DGEEC/MEC, April 2013)

FIGURE IV.23.
Distribution of scientific production by region (NUTS 2): Azores. Number of publications in each of the top ten fields for the 2005-2010 period



Source: Web of Science (data supplied by DGEEC/MEC, April 2013)

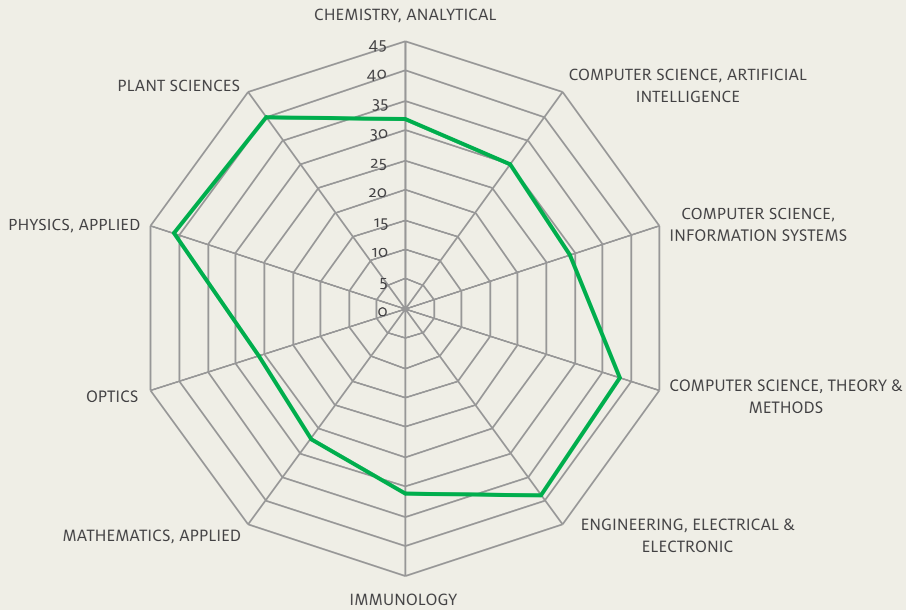


FIGURE IV.24.
Distribution of scientific production by region (NUTS 2): Madeira. Number of publications in each of the top ten fields for the 2005-2010 period

Source: Web of Science (data supplied by DGEEC/MEC, April 2013)

Comparing the scientific production profiles for Portugal and the European Union 27

This section sets out to explore the differences between Portuguese scientific production and that of the European Union (27) as regards the distribution of publications over the different scientific fields. To this end, two specialised indices were constructed for the scientific production in Portugal, one for the period 2000-2005 and the other for the period 2005-2010[10]. The objective here is to identify the fields and topics where Portugal excels in the European context, and, as such, assess the areas of competitive scientific advantage. To aid the analysis and interpretation, only those fields are shown where Portugal has a specialisation index greater than or equal to 1.5 when compared to the EU27 over the more recent period (2005-2010). Figure IV.25 shows the 47 categories that conform to the stated criterion, by decreasing order of the respective indices.

For the second half of the period 2000-2010, the specialisation of scientific production is characterised by a fall in those values of the specialisation index which registered the highest values in the first half of the period (Figure IV.25). Some fields, however, increased their specialisation advantage in the second period, namely those that contributed to the cluster associated with the Sea, such as Fisheries, Marine & Freshwater Biology and Oceanography.

Agricultural Engineering and Food Science & Technology are also important specialisation fields for national clusters. A number of fields associated with the environment are also worthy of mention, for example, Environmental Sciences and Environmental Engineering. While not trying to be exhaustive, it is also worth drawing attention to various fields in the areas of Engineering and Technology: Manufacturing Engineering, Industrial Engineering and Biotechnology & Applied Microbiology.

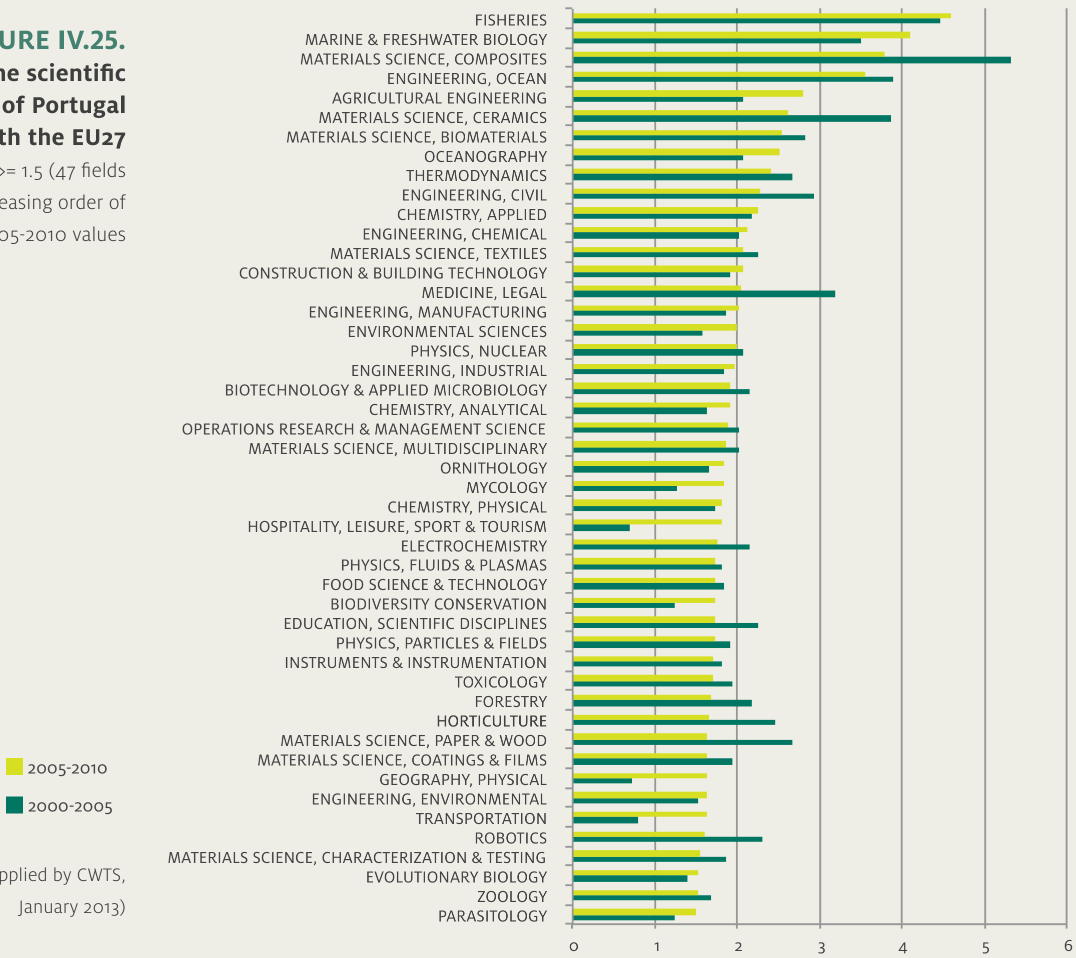
Figure IV.26 provides a different perspective to that in the previous figure, showing the same fields but ordered according to the FoS classification from the OECD. Notably, some areas are well populated with their constituent fields, as is the case with the Natural Sciences (with topics

10. These indices were created by first calculating the ratio between the 'number of Portuguese publications in field x' and the 'total number of Portuguese publications', which was then divided by the ratio between the 'number of EU27 publications for field x' and the 'total number of EU27 publications' (Archibugi and Pianta, 1992; Horta and Veloso, 2007). In this way, a value is assigned, in each of the periods, to each of the 250 scientific fields studied (the same level of detail used in the previous section): the larger the value, the bigger the Portuguese advantage for a certain field, and vice-versa (European Union, 2011).

FIGURE IV.25.

Comparing the scientific specialisation index of Portugal with the EU27

Scientific fields with a value >= 1.5 (47 fields out of a total of 250), in decreasing order of 2005-2010 values



Fonte: Web of Science (data supplied by CWTS, January 2013)

related to Biology and Earth and Environmental Sciences), Agricultural Sciences and Engineering and Technology. In this last category, Materials Science stands out as all the fields related to this area are present. This area has shown a high degree of specialisation over the last decade and a high degree of international visibility, with Portugal ranking 25th in the world and 9th within the European Union (27) in a recent Thomson Reuters report (2011).

A set of fields of basic research exist (areas of Chemistry, Physics and Biology), classified as specialised, which constitute the basis of the system capacity and which underpin the development of the previously mentioned categories, thus providing cohesion to the group as a whole, while expressing the interaction between basic and applied research.

Chapter 6 will develop the relationship between scientific specialisation and economic specialisation.

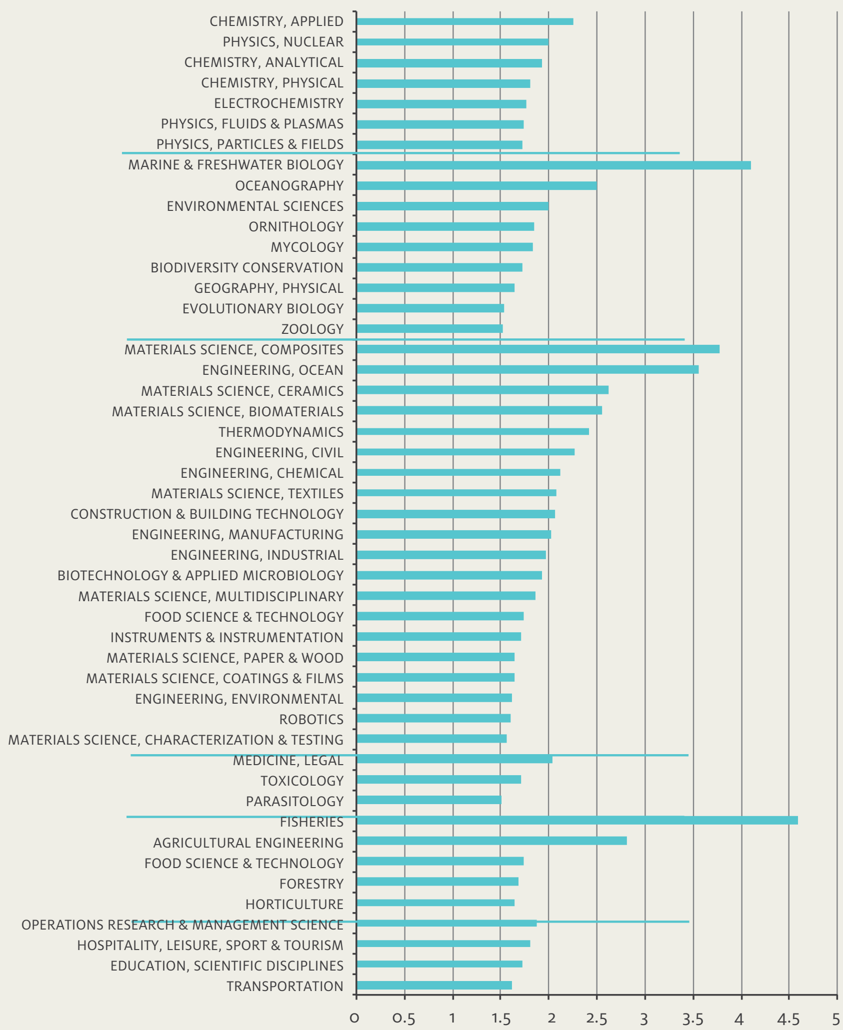


FIGURE IV.26.

Comparing the scientific specialisation index of Portugal with the EU27

Scientific fields with a value >= 1.5 (47 fields out of a total of 250), organised using the FoS classification from the OECD

Source: Web of Science (data supplied by CWTS, January 2013)

Comparing the scientific production profile in Portugal with the benchmark countries

To complement the analysis, a further indicator was calculated focusing only on those countries in the benchmark group. For each country, the ratio was calculated between 'the number of publications in each scientific field[11] and 'the number of researchers (FTE)[12]', allowing the eleven benchmark countries to be ranked in decreasing order of productivity. Table IV.2 summarises these rankings, showing the position of Portugal (among the eleven) for each of the 27 rankings performed.

11. In this table, the publications are aggregated into 27 scientific fields (representing all scientific production), in accordance with the classification used by Scimago (the source of the information).

12 Covering researchers from all scientific areas.

TABLE IV.2.
Ratio between the number of publications in the different scientific fields and the number of FTE researchers: A comparison among benchmark countries

Position of Portugal in the rankings for each scientific field	1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH	11TH
Chemical Engineering	■										
Materials Science	■										
Decision Sciences			■								
Environmental Science			■								
Chemistry				■							
Engineering				■							
Energy					■						
Business, Management and Accounting						■					
Economics, Econometrics and Finance						■					
Mathematics						■					
Pharmacology, Toxicology and Pharmaceutics						■					
Computer Science							■				
Psychology							■				
Nursing								■			
Agricultural and Biological Sciences								■			
Physics and Astronomy								■			
Immunology and Microbiology									■		
Dentistry										■	
Health Professions										■	
Social Sciences										■	
Veterinary										■	
Biochemistry, Genetics and Molecular Biology										■	
Earth and Planetary Sciences										■	
Medicine										■	
Neuroscience										■	
Arts and Humanities											■
Multidisciplinary											■
Number in each placing (total 27)	**2**		**2**	**2**	**1**	**4**	**2**	**3**	**1**	**8**	**2**

Sources: Number of publications 2010 – Scimago
FTE 2007 – Eurostat

In terms of productivity, the information in Table IV.2 complements the more generic findings in Figure IV.3 (where Portugal was placed 9th), pinpointing those areas where the Portuguese scientific community is more productive in comparison with the scientific communities of the benchmark countries. In point of fact, Portugal attained first place in the areas of Chemical Engineering and Materials Science.

13. According to the classification used in this case by Thomson Reuters, covering all areas.

14. The group of benchmark countries has a notable advantage when making comparisons using bibliometric indicators, given that only Ireland uses English as an official language, leaving the other ten countries on an equal footing. The effects of the publication language are well known, with the journals in languages other than English, while still part of the Web of Science, having considerably less impact than those in English (Van Raan, 2004).

The impact of Portuguese scientific activity

This section analyses the impact and visibility that science in Portugal has worldwide, as measured by the number of citations globally and in comparison with the benchmark countries. In closure, the quality indicators available as part of the Scimago ranking are used to position Portuguese institutions.

The citation impact of Portuguese scientific production

The fields with the highest relative citation impact are Space Science, Physics, Agricultural Sciences, Neurosciences & Behaviour, Plant & Animal Sciences and Clinical Medicine. All these fields have a relative citation impact index above the world average (Figure IV.27)[13]. This indicator puts into perspective the Portuguese citation impact for each field (the ratio of the number of citations to the number of publications) by comparing it against the world citation impact for the same field.

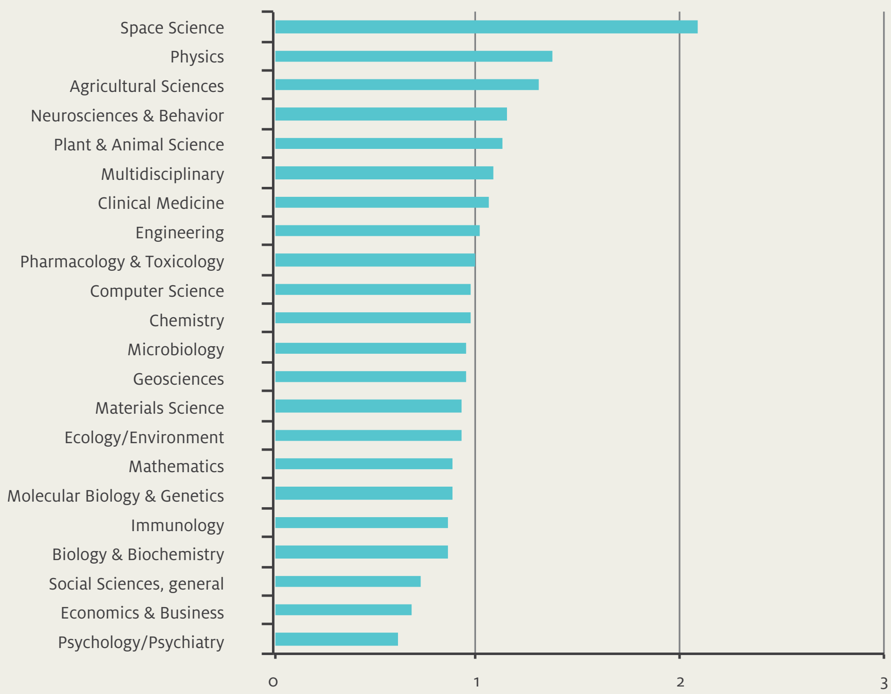


FIGURE IV.27.
Relative citation impact by area, calculated using publications for the period 2006-2010 (all areas)

Source: GPEARI/Thomson Reuters (2010)

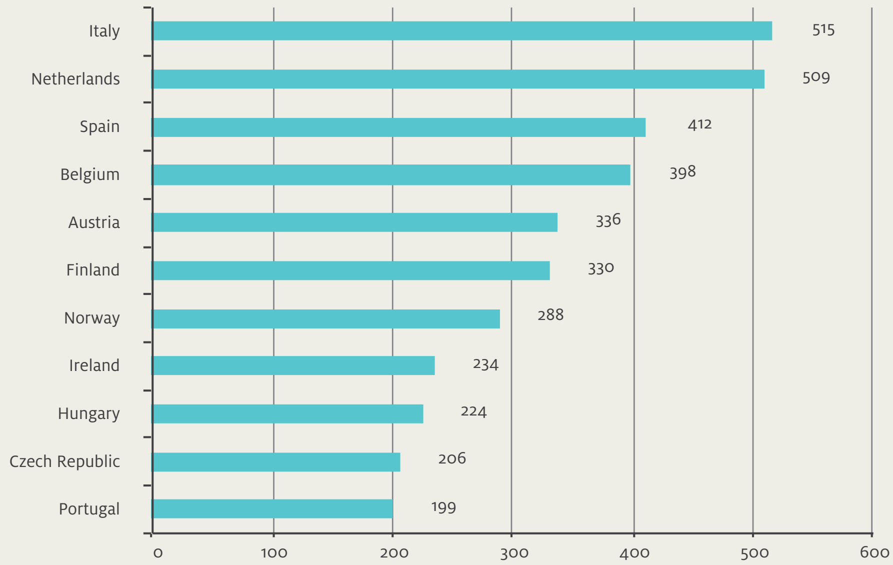
Portugal occupies the last place compared with the benchmark countries[14], with the lowest h-index[15] of the group (Figure IV.28). As may be expected, the top three positions are occupied by the three countries with the largest scientific communities (as measured by FTE researchers).

15. This indicator corresponds to the number of articles (h) which, for a given scenario (country, institution, researcher,...), received at least h citations (according to the definition used by Scimago, available at www.scimagojr.com). This indicator attempts to measure the robustness of the volume and impact of scientific production. For this indicator to be accurately representative, the volume of production has to be statistically significant in each case, as well as having common conditions in place for the entities under comparison. The h-index shown here is calculated in relation to countries, covering publications over the period 1996-2011. While this period gives a significant length of time (16 years), it does not, however, show the evolution of impact over the period. This indicator has the disadvantage that it does not take into account the size of the scientific community; for this reason it is to be expected that the larger countries would be found at the top of the rankings constructed using the respective h-indices.

FIGURE IV.28.
The 2010 h-index for the benchmark countries

H Index 2010

Source: Scimago, data retrieved October 2012



The Portuguese position improves slightly when considering those articles that are most cited worldwide (9th position). It is worth noting that this improvement is in relation to articles published more recently, showing an improvement in qualitative performance and the ability to produce quality output at a world level (Figure IV.29).

For the group of benchmark countries, calculating h-indices using a breakdown by scientific area leaves Portugal always in the bottom half of the ranking (Table IV.3[16]). The best placed position is 7th, achieving some measure of success in areas such as Decision Sciences and Mathematics.

16. This table was drawn up in a similar way to Table IV.2: 27 rankings were performed covering the different scientific fields, where the eleven countries were ordered by decreasing value of the h-index attributed to each field. Table IV.3 summarises these rankings, showing the position given to Portugal (1st- 11th) for each of the 27 rankings performed.

FIGURE IV.29.
Highly cited papers (2002-2012): International comparison

Highly cited papers

Source: Essential Science Indicators, retrieved 16/10/ 2012

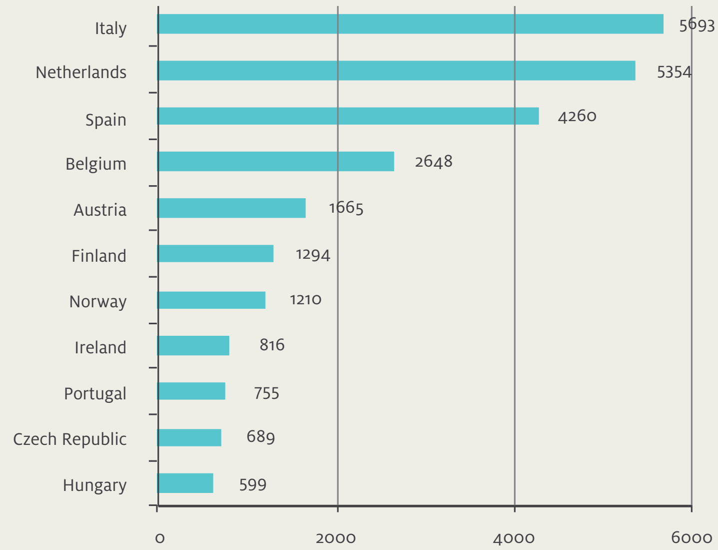


TABLE IV.3.
Portugal's position among the benchmark countries using h-index rankings for the different scientific fields

Ranking among the group of 11 countries compared by h-index											
Portugal's position by scientific fields	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
Decision Sciences							■				
Mathematics							■				
Materials Science								■			
Engineering								■			
Environmental Science								■			
Economics, Econometrics and Finance								■			
Energy								■			
Chemical Engineering									■		
Chemistry									■		
Business, Management and Accounting									■		
Computer Science									■		
Health Professions									■		
Physics and Astronomy									■		
Earth and Planetary Sciences									■		
Agricultural and Biological Sciences										■	
Dentistry										■	
Pharmacology, Toxicology and Pharmaceutics										■	
Psychology										■	
Social Sciences										■	
Arts and Humanities										■	
Immunology and Microbiology										■	
Nursing											■
Veterinary											■
Biochemistry, Genetics and Molecular Biology											■
Medicine											■
Multidisciplinary											■
Neuroscience											■
Number in each placing (Total 27)							**2**	**5**	**7**	**7**	**6**

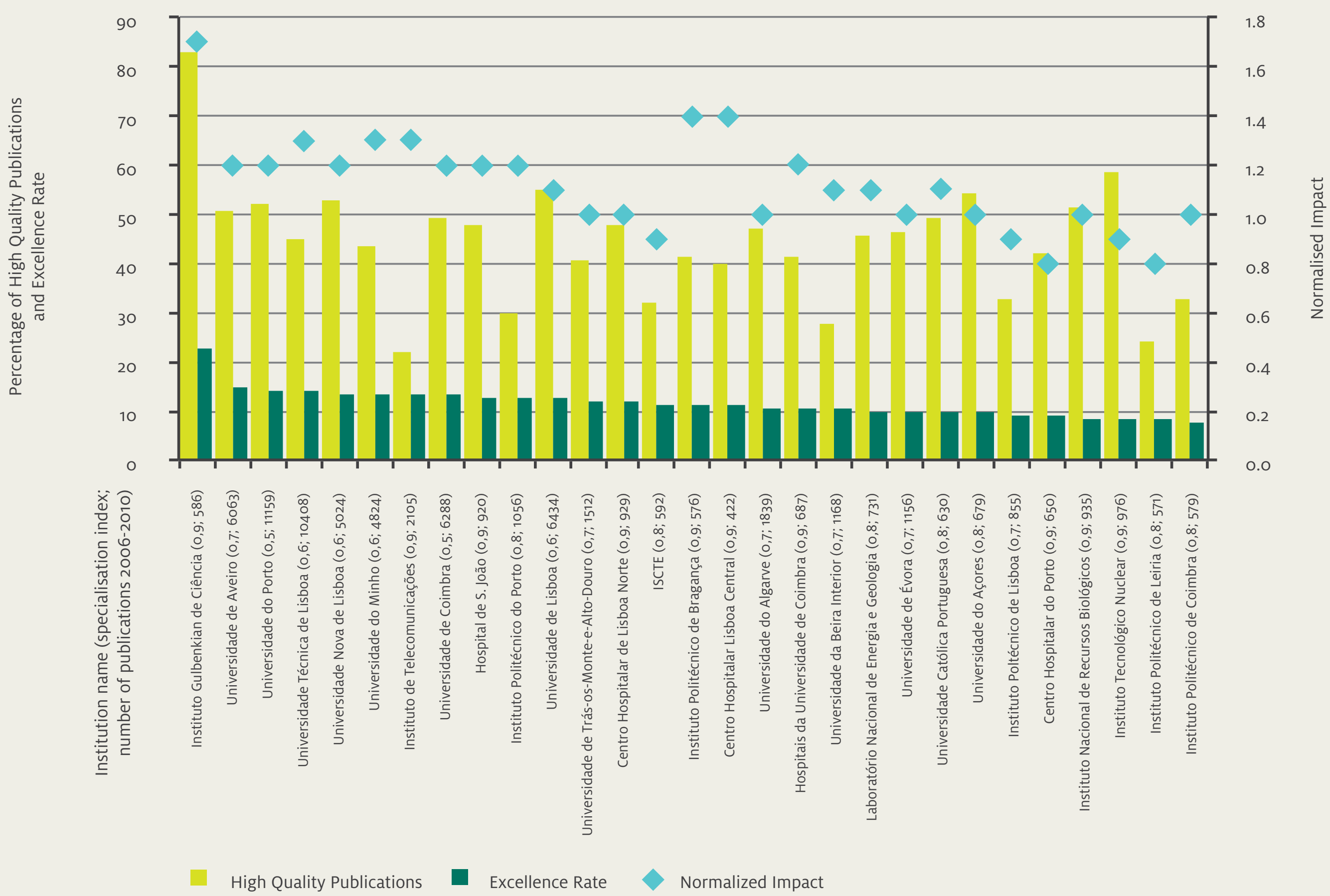
Source: Scimago SJR – SCImago Journal & Country Rank, retrieved October 2012, http://www.scimagojr.com

Impact indicators for the institutions

Using the SIR Report[17] 2012 rankings as a basis, Figure IV.30 was constructed using quantitative and qualitative indicators for the 29 Portuguese institutions included in the ranking. Institutions are present from various sectors, including National Laboratories, hospitals and scientific institutions, besides higher education. The (institutional) specialisation index[18] characterises each institution according to its thematic range. The figure shows the differences that exist in production between the institutions and also that 25 of them have the "corresponding author" in at least 50% of the publications (the SJR considers that the corresponding author indicates the institution that provides the main contribution to the publication, or in other words, indicates leadership).

FIGURE IV.30.

Portuguese institutions included in the SIR, selected by Scimago group (criterion: institutions with at least 100 publications in 2010 indexed in Scopus)



Source: 2014 SIR World Report

The institutions are organised according to the Excellence Rate (Exc)[19] indicator, and complemented by the High Quality Publications[20] (Q1) and the Normalised Impact indicator[21]. The Portuguese institutions have an Excellence Rate value which varies between around 20% (for the IGC) and around 10% (for the Instituto Politécnico de Coimbra). Only five institutions are situated below the world average for impact, as given by the Normalised Impact. There were only six institutions which had managed to improve the quality indicator, suggesting that there has been a tendency for these values to slip compared to the previous edition of the SIR. The Instituto Gulbenkian de Ciência is the institution with the highest values in all indicators analysed (for excellence, quality, normalised impact and also international collaboration).

To put the previous figure into context, another similar graph was prepared for those institutions that appeared in first position (using the criterion "most publications") for each of the countries selected for benchmarking (Figure IV.31).

17. Specialisation index – This indicator is bounded between 0 and 1, respectively indicating institutions that teach or research many scientific areas or and institutions that teach or research a specific set of scientific areas or fields.

18. As previously mentioned, the SIR (available at www.scimagoir.com) analyses the scientific production of institutions that belong to various sectors. Among other indicators of volume or impact, each institution has a specialisation indicator which expresses its degree of thematic concentration or dispersion, as such showing to what extent institutions may be easily comparable. The 2012 edition includes indicators for 3290 scientific and/or academic institutions from 106 countries the world over. The selection criterion was for the institution to have at least 100 publications in 2010 indexed in Scopus, with the analysis covering all academic areas over the years 2006-2010 (29 Portuguese institutions were selected on this basis).

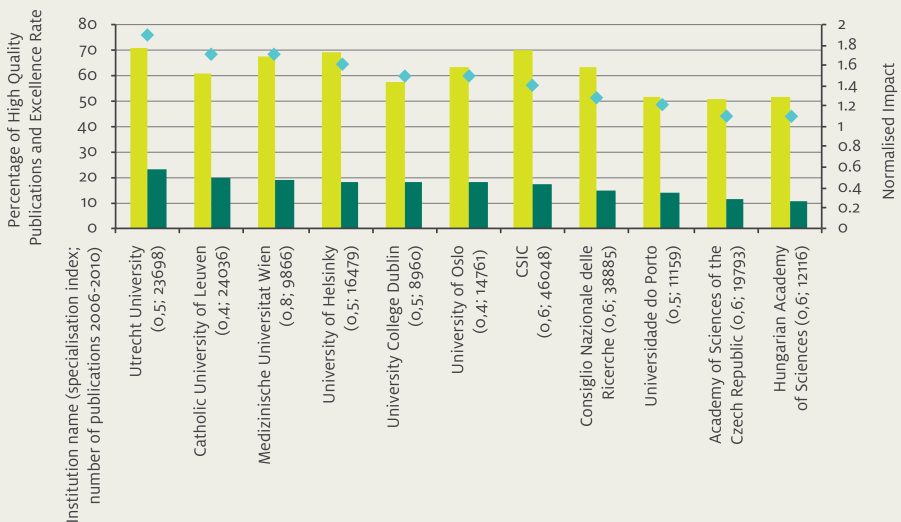


FIGURE IV.31.
Top institutions out of the benchmark countries

Source: 2012 SIR World Report

Comparing the Figure IV.30 with the Figure IV.31, it is evident that the last figure shows a correlation between the excellence indicator and the normalised impact (R-squared = 0.9505), which is not perceptible in the first Figure. The Portuguese institutions have, in the majority of cases, a level of production which is substantially below that of the foreign institutions under comparison. Here it is worth noting that some authors point to the fact that medium or large sized institutions have increased research capabilities compared to small institutions due to the effects of concentration and proximity (Sarrico et al., 2009).

19. The proportion of publications for each institution found in the set formed by the top 10% of papers by citation in the given field.

20. The proportion of publications of each institution published in the journals positioned in the top quartile of each scientific field of the SCImago Journal Rank.

21. Indicates the relation between the average scientific impact of an institution and the average scientific impact for the world (a value of 0.8 indicates that an institution is cited 20% less than would be expected).

Producing technological knowledge

Patents as indicators of technology-based knowledge production

Technological production in this section is analysed in terms of patent and trademark applications, with most emphasis on the former. Particular emphasis is placed on Europe-wide patent requests lodged with the European Patent Office (EPO), because of its high degree of selectivity. However, where possible, the indicators associated with the actual number of patents granted are also used.

Measuring knowledge production which is then protected so that its value can be subsequently exploited puts emphasis on indicators based on patents granted in the areas of interest. On the other hand, patents can be highly correlated with the output from research and innovation activity. This relevant fact is one of the central elements in understanding the role patents have in innovation systems and their capacity to produce applicable knowledge with economic value. As this may be, some limitations to do with indicators based on patents have to be taken into consideration. In particular, this is due to two main reasons: (i) the diverse propensity different sectors show for generating patents; (ii) patent requests are sometimes largely driven by strategies to increase competitive advantage and reserve the market for the patent holder. These limitations, however, should not unduly influence the use of indicators based on patents[22].

BOX 1 – The patenting process

This box takes a quick look at the different critical phases of the patenting process, starting with the filing of a patent application and finishing with its acceptance (or rejection).

As such, an author that wishes to protect an invention should submit a patent application for registration at a national or international level. This process creates a reference which is known as the priority date or priority right.

After submitting an application, a long period of time may elapse before the patent is granted or rejected, lasting up to several years in more complex cases. Because of this, analysis of recent trends commonly places more emphasis on data relating to patent applications than patents granted.

The possibility exists for any inventor to submit a patent application centrally with the EPO – through the designated European channels – which will protect rights in a significant number of countries by obtaining a European patent with a wide ranging territorial coverage.

An International Patent application, as envisaged by the Patent Cooperation Treaty (PCT), is another powerful means of registering patents. In this context, the important role played by WIPO (the World Intellectual Property Organization) should be recognised.

22. It should be noted that patents can be obtained for any sort of invention in all areas of products or processes, as well as new processes for making products, substances or composites already known. It is important to state that one of the criteria for evaluating patents is crucially linked to the economic value that the product or process under consideration can create by being introduced into a certain value chain. On the other hand, the fact that long time series exist for indicators associated with patents decisively contributes to the significant demand that is shown for these types of indicators in analysing innovation systems.

On a different note, the fact that the patenting process is complex and involves a number of phases implies that the statistical data available will be determined by those process phases as well as by the numerous sources of information with their differing levels of reliability and impact. In particular, the collection of results used to feed into indicators based on patents can be quite slow, namely in the case of granted patents.

The decision was taken not to utilise indicators based on patent citations, given that: (1) some methodological uncertainty exists regarding the value of using patent citations as a proxy for their visibility and, more importantly, (2) only a small number of patents have been published – using the EPO – for Portuguese residents[23].

The growth in Portuguese patenting activity compared with the benchmark countries

A sizable growth, albeit somewhat uneven, has been visible in the number of patent applications made by Portugal through European channels over the period 2000-2009. This number then fell back over the course of 2010 and 2011, as can be seen in Figure IV.32. The number of patent applications made under the PCT followed a similar trend to that shown by European applications and since 2007 has consistently exceeded the latter. Both means of registering patents showed a peak of activity in 2009.

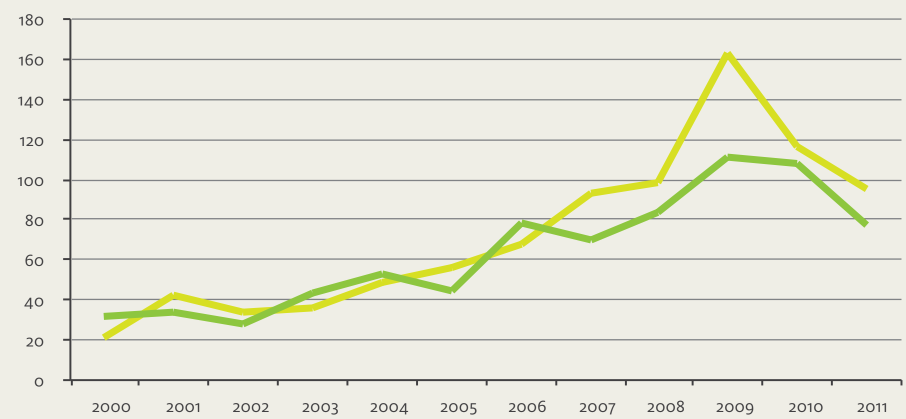


FIGURE IV.32.
Number of patent applications in Portugal filed using the EPO and filed by Portuguese residents using the PCT

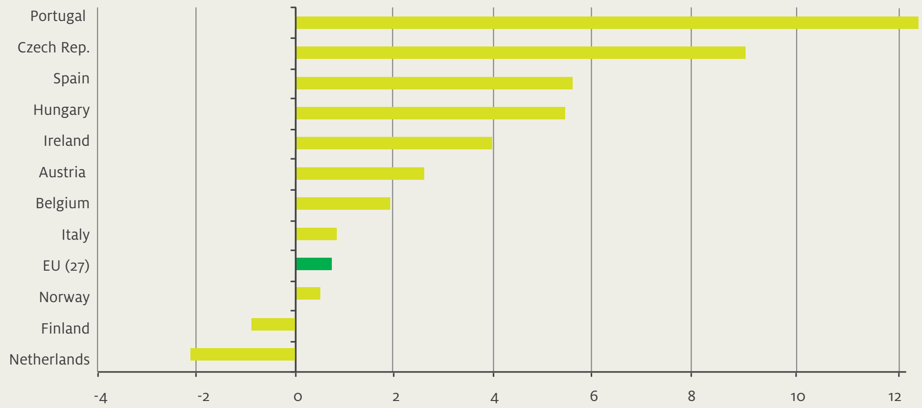
Source: EPO

Looking at the ranking of patent applications for all the countries that use the PCT, Portugal rose from 46th place in 2000 to 40th in 2011 (having peaked at 34th in 2009). Some patent applications may co-exist in the two systems (European and PCT) in which case it does not make sense to sum the two series.

Figure IV.33 shows the growth observed in the number of patent applications in the EUROSTAT database for the 2000-2010 period for the group of countries under comparison. The high average annual growth rate of Portugal stands out, accompanying the Czech Republic; these are countries with R&I systems which have not traditionally been patent-intensive and are in a catch-up process with European average.

23. This fact is particularly noteworthy given that the citations will be boosted following the publication of the patents. It should be noted that the citations included in the documents filing a patent application request naturally tend to include a significant number of self-citations. In any case, the very low number of European patents published over the period in question (as previously mentioned) for residents in Portugal was decisive in the option not to analyse patent citations due to their being statistically of very little relevance. In contrast, priority was given to patent filing requests at a European level (European Patent Office), with national data being (secondarily) employed (National Industrial Property Institute) allowing analysis of variables not available from European or international sources.

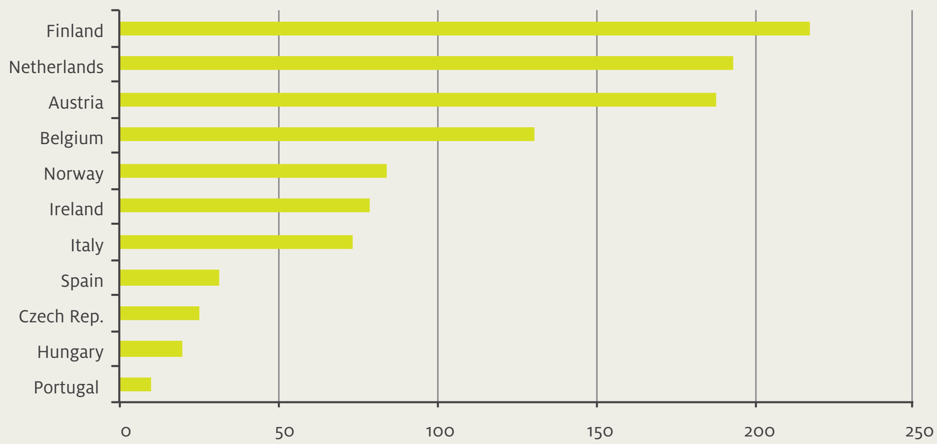
FIGURE IV.33.
Growth (AAGR) in the number of patents applications per million inhabitants for the bemchmark countries over the 2000-2010 period



Source: EUROSTAT (2014)

Figure IV.34 shows the situation in 2010 with respect to the number of patents applications per million inhabitants for the countries under comparison. The particularly low figure achieved by Portugal in 2010 stands out despite the sizable growth seen for the decade in question. As such, Portugal is characterised as a country where the number of patent applications grew most, but where the level of patenting continues to be a long way behind comparable countries.

FIGURE IV.34.
Number of patent applications lodged with the EPO per million of inhabitants in 2010 for the benchmark countries



Source: EUROSTAT (2013)

Figure IV.35 shows the growth in the number of high-technology patent applications for the countries under comparison between 2004 and 2010[24]. Once again, Portugal and the Czech Republic stand out as the countries with the highest average annual growth rates for the period of study. It should be emphasised that, in the case of Portugal, growth in this area was faster than that seen for the total number of patents over the period.

24. High technology areas are as defined by Eurostat, being chosen from within the subdivisions of the International Patent Classification (IPC). The areas considered are the following: Computers and Automated Office Equipment; Genetically Engineered Micro-organisms; Aviation; Communications Technology; Semiconductors; Lasers.

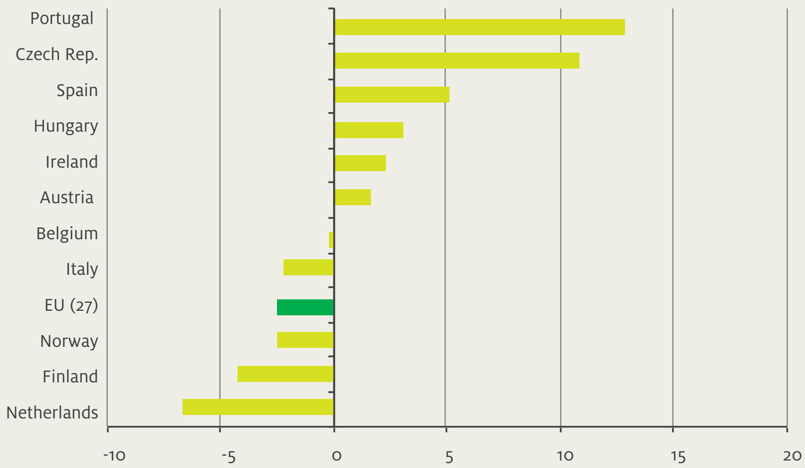


FIGURE IV.35.
Growth (AAGR) in the number of high-technology patent applications per million inhabitants for the benchmark countries over the 2004-2008 period

Source: Eurostat (2014)

Patent applications may be filed by entities in the Business, Higher Education, Government and Private Non-Profit sectors as well as individuals. Companies submit the majority of the patent applications to the EPO, although a closer look at the way the series has grown over time shows that there were several periods of stagnation over the course of the decade. In addition, it is worth remembering that the order of magnitude is very low. Higher Education saw a significant rise over the period 2002-2004, followed by a period of anaemic growth. The Government sector entities showed little effort in this area, and a reduction in their importance in relation to Higher Education. The private NPIs held steady over the period under study, registering a continually low level of patent applications, notwithstanding the growth over the period 2003-2006 which subsequently relapsed.

Patent applications made by individuals represent a specific case for the sectoral analysis here. Obviously, many of the individuals that submitted patent applications are included in the sectors mentioned above and it would be of interest to know how they were distributed among those sectors. In this context, it can be seen that individuals (as a “sector”) were responsible for the second largest number of patents as submitted to the EPO over the period of study. Universities occupy a central role in patent applications made at a national level (INPI) over the decade in question. It is interesting to note that a significant number of Portuguese companies prefer to file patent applications internationally (namely at a European level).

Table IV.4 shows the Portuguese entities that made the most patent applications using the PCT in 2011; the top four positions are occupied by universities, with the Universidade de Aveiro leading the group.

TABLE IV.4.
Portuguese entities by number of patent applications made using the PCT in 2011

Entities	Number
Universidade de Aveiro	18
Universidade do Minho	6
Universidade de Coimbra	4
Universidade de Trás-os-Montes e Alto Douro	4
YDREAMS – Informática, S.A.	4
Instituto Politécnico de Leiria	3
Universidade Nova de Lisboa	3
BIOSURFIT, S.A.	2
BODYFEEL – Produtos de Saúde, Lda.	2
CTR, Lda.	2

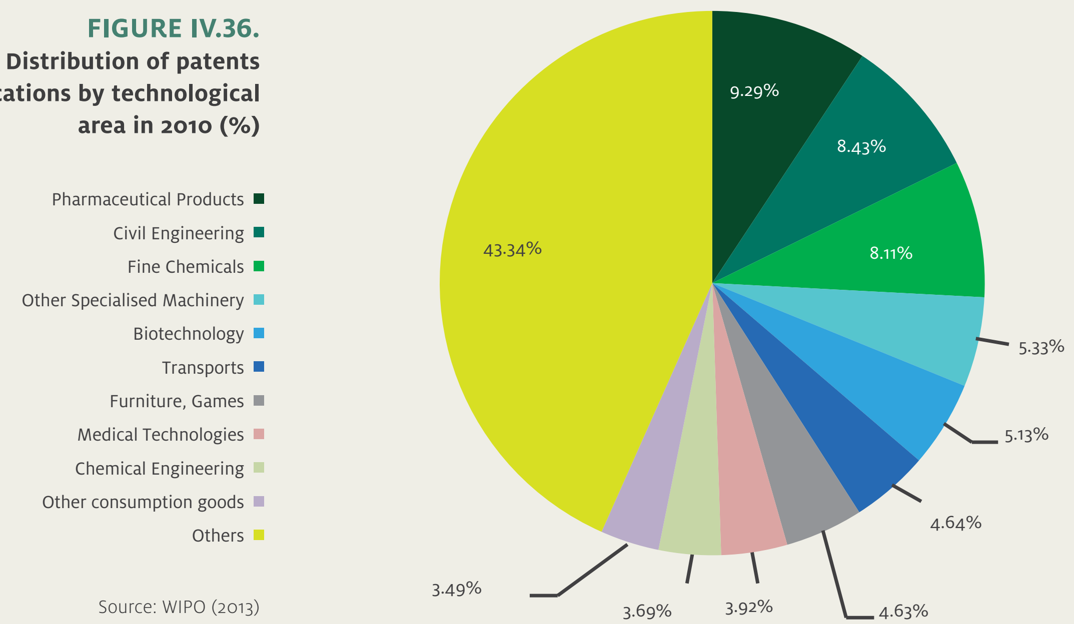
Regional distribution of patent applications

As noted by Godinho (2009), "over the period of 1980 to 2008, the Lisbon and Tagus Valley region held pride of place in patenting. In more recent years, however, a group of adjoining regions along the Northern Coast have increased their relative weight."This statement as relative to applications at national level. This author also highlights the fact that "this change is occurring within a period where demand for patents has been picking up since 2000, following a prolonged stagnation over the previous two decades".

The profile of the regional distribution of patents at the NUTS 2 level (through the EPO) shows some differences between the two halves of the decade. However, Lisbon maintained its dominance over the whole period, with faster growth than the other regions (at least over the period 2002-2007 where data from EUROSTAT[26] is available).

26. Regionalisation of European patents is still an area which is undergoing technical refinement and has been the subject of pilot studies.

FIGURE IV.36.
Distribution of patents applications by technological area in 2010 (%)



Source: WIPO (2013)

The profile of national patenting activity

Distribution among the classes of the International Patent Classification

Figure IV.36 shows the distribution of patent applications made using the PCT in 2010, originating in Portugal. The distribution uses the technological areas defined in the IPC (International Patent Classification) and adopted by WIPO.

While the sector "Others" occupies the largest share of Figure IV.36, a significant proportion of patents is taken up by the sectors Pharmaceutical Products, Civil Engineering and Fine Chemicals.

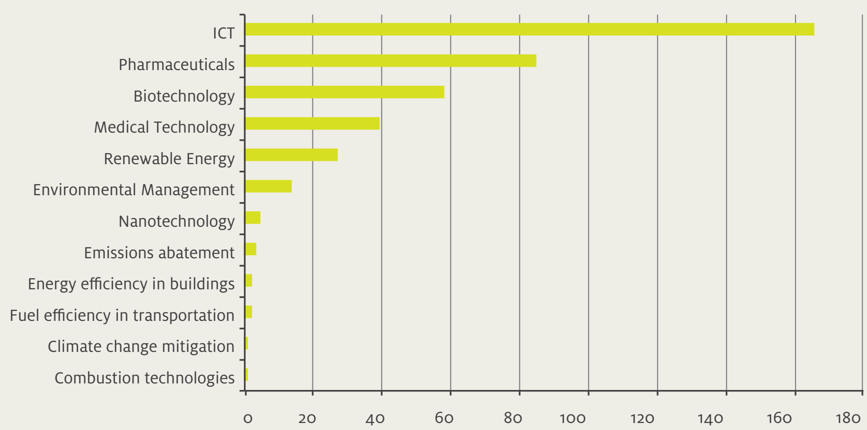


FIGURE IV.37.
Number of patent applications (lodged with the EPO) by technological area over the period 2000-2008

Number of patent aplications lodged with the EPO, 200-2008

Source: OCDE (2013)

The distribution of patent applications made using the technological areas defined by the OECD (based on data from the EPO) is shown in Figure IV.37. The values are shown relative to the total number of applications over the 2000-2008 period. The fact that data is presented for the whole period helps improve the consistency of the information.

Technological area	Number of patents granted
Handling	3
Other Consumption Goods	3
Pharmaceutical Products	3
(Organic) Fine Chemicals	3
Measurement Instruments	2
Furniture, Games	2
Heat-based Processes and Equipment	2
Audio-visual Technologies	2
Transports	2

TABLE IV.5.
European patents granted to residents in 2010 by technological area (for areas with a number of patents > 1)

Source: EPO

On this basis there is a particular focus on ICT, Pharmaceuticals, Biotechnology, Medical Technology, Renewable Energy and Environmental Management.

On the other hand, the total number of patents granted by the EPO in 2010 was 29. Table IV.5 shows the distribution of patents across the technological areas defined in the EPO classification.

All the other technological areas either have only one[27] or no patents granted in 2010 – although it is always possible that at the time the data was collected (2012) there could still have been some patents pending[28].

The specialisation profile of the country in the European context

While it would be interesting to see which technological areas are responsible for the most patenting activity, it is necessary to treat such data with caution. This is because, to some extent, different areas have different tendencies to produce patents, a factor which is universally shared across countries. As such, to complete the information given above, the technological specialisation[29] indices were calculated, for each technological area in Portugal for the two periods, 2000-2004 and 2004-2008, revealing some interesting results regarding the specialisation found.

These results suggest that the specialisation profile, based on the number of patent applications for the different technological areas, could have changed from the first half to the second half of the decade. However, the very low number of patents under consideration, especially in some of the technological areas, greatly limits the validity of such analysis, which it will require a more in depth analysis at a later stage .

International cooperation in the benchmark countries

The level of collaboration with innovators from other countries on the number of patents filed varies for the countries studied. Here, it can be seen in Figure IV.38 that Portugal is among those countries that have the highest level of involvement by foreign entities in patent filings.

To some degree, it can reflect a certain tendency for larger countries to be less collaborative in the preparation of patents. On the other hand, it is a fact that some sectors are less inclined to cooperate internationally in the patent preparation process. Thus, the sectoral specialisation profile may also influence the corresponding level of cooperation. In any case, the level of international cooperation remained fairly stable for all the countries over the decade long period (particularly so in the case of Portugal).

27. The following areas had one patent granted: Chemical Engineering; Coatings and Films Technology; Biological Material Analysis; Medical Technologies; Motors, Pumps, Turbines; Tooling Machines; Civil Engineering.

28. No patents were granted in the following areas: Basic Materials Chemistry; Biotechnology; Environmental Technology; Food Chemistry; Macromolecular Chemistry and Polymers; Materials and Metallurgy; Micro-structures and Nanotechnology; Basic Communication Processes; Computer Technology; Digital Communication; Electrical and Energy Equipment and Machines; Management Information Technologies; Semiconductors; Telecommunications; Control Instruments; Optics; Mechanical Elements; Other Specialized Machinery; Textile and Paper Machinery.

29. The technological specialisation indices were calculated as the ratio of the European patent application requests made by Portuguese residents, in each technological area, to the total number of patent application requests for the country relative to the share that the same technological area has in the EU27.

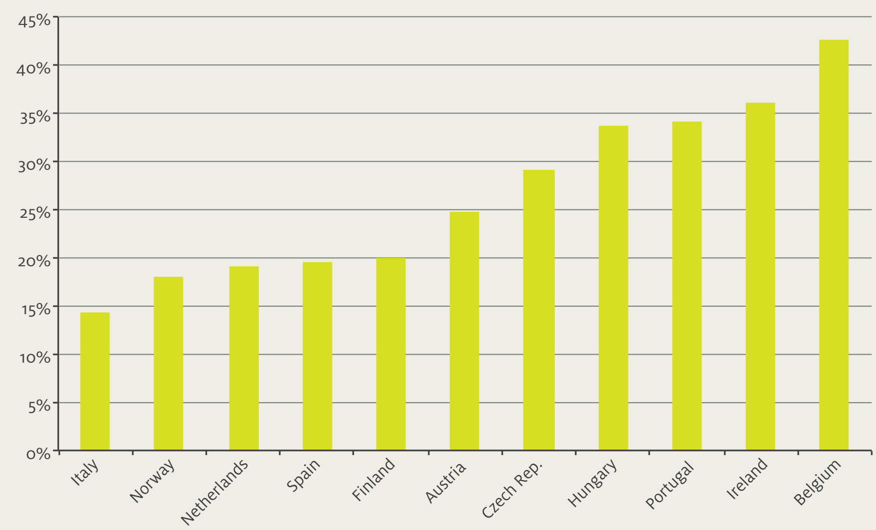


FIGURE IV.38.
Share of patents submitted (under the PCT) with international involvement for the countries under comparison in 2010 (%)

Share of patent submitted (under the PCT) with international involvement, 2010.

Source: EPO (2013)

Trademarks as an indicator of technological production in Portugal

Although less emphasis is placed on trademarks, various authors consider them to be worthwhile indicators for analysing the performance of companies, reflecting the level of innovation activity they exert (Greenhald and Rogers, 2007). Mendonça, Pereira and Godinho (2004) highlight the value of trademarks as pertinent indicators, not only for the service sector, but also for manufacturing industry. Focusing on Portugal, it can be seen that significant growth occurred over the decade in question, as can be seen in Figure IV.39.

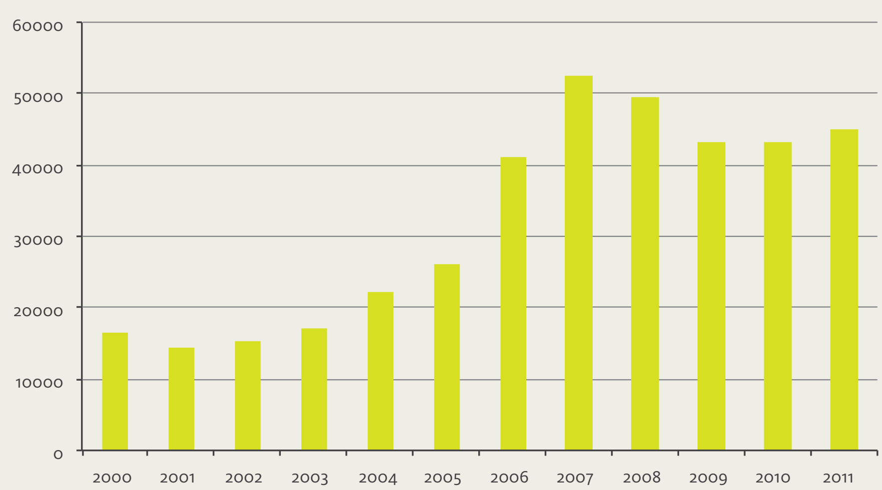


FIGURE IV.39.
Yearly number of trademark registrations for the period 2000-2011

Source: WIPO (2013)

The data reveal a significant growth in the number of trademark registrations, namely between 2002 and the peak in 2007.

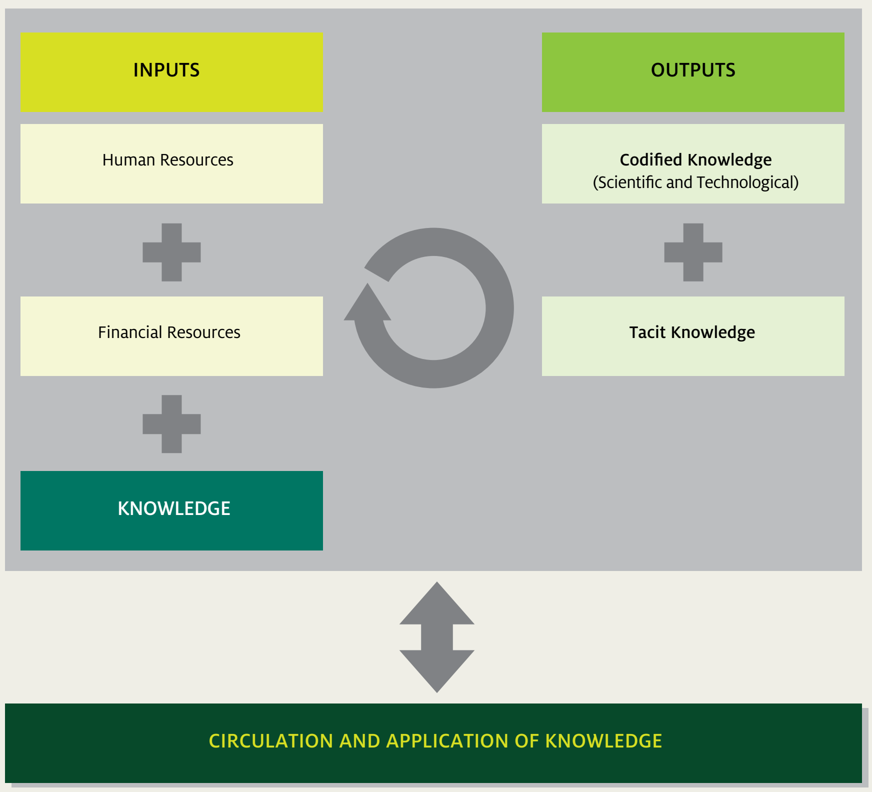
Codified knowledge as part of the circulation and exploitation of knowledge

This chapter separated the analysis of scientific production from that relating to technological production as they each correspond to different types of production and require distinct methodologies. Whilst this is the case, the interdependence between scientific and technological knowledge should not be forgotten: the results from basic research flow into technology, while technological needs of industry act as strong stimuli for the corresponding scientific fields (Pavit, 1998). The flows of knowledge generated, be they technological or scientific in nature, simultaneously represent inputs and outputs of the research and innovation system: they exhibit links and synergies of varying levels depending on the "density" of codified and tacit knowledge in the respective system.

At a more general level, the accumulated knowledge (codified or tacit) plays a key role in the R&I system by way of the flows which catalyse the application and circulation of knowledge as well as the corresponding interfaces and reciprocal actions among agents, institutions and sectors.

Apart from this, accumulated knowledge represents a determining factor in the research and innovation potential of a country, in particular with respect to its application and circulation (Figure IV.40). This will be the subject of study for the following chapters, where the case of Portugal will be contextualised with the set of countries used for comparison.

FIGURE IV.40.
Knowledge accumulation dynamics for innovation



Conclusions

Out of the group of countries being studied, Portugal registered the highest rate of growth in scientific production over the period 2000-2010. In terms of world share, and relative to the EU 27, Portugal was placed 15th in 2010, having risen one position over a period of 10 years. For the group of countries studied, Portugal was placed 9th both in terms of world share and in terms of production volume adjusted for population size; Portugal was also placed 9th in terms of productivity. As such, it can be seen that despite the significant growth observed, Portugal continues to be placed at a level below its potential (namely if we consider the favourable position of Portugal in terms of FTE researchers). The level of patents continues to be particularly low compared with the European average; this is in spite of the recent growth seen which has had to contend with the low initial level at the start of the century.

The number of publications involving international collaboration tripled between 2000 and 2010, while collaboration was mainly concentrated among a small group of countries, namely the United Kingdom, the USA, Spain, France, Germany, Italy, the Netherlands, Brazil, Belgium and Sweden. With the exception of the Czech Republic, the comparison group as a whole, and the small countries in particular, increased their level of publications involving international cooperation.

Between 2000 and 2010 the most significant change in the structure of Portuguese scientific production by area saw Medical and Health Sciences rising to first place when ranked by the number of publications. Within this area, Pharmacology and Pharmacy was the field with most publications and the Respiratory System was the field with the highest AAGR between 2005 and 2010. Exact Sciences occupy second place, where Physical Chemistry is the field with the highest number of publications and Mathematics delivered the fastest growth (AAGR) between 2005 and 2010. In third place comes Engineering and Technology with most publications in the field of Materials Science – Multidisciplinary and the highest level of growth (AAGR) between 2005 and 2010 in Civil Engineering. Fourth place is occupied by Natural Sciences (excluding Exact Sciences), where most publications are to be found in Environmental Sciences and the fastest growth (AAGR) was observed in Biology for the period 2005-2010. Agricultural Sciences follow, with most publications in the area of Food Science and Technology and the highest AAGR over 2005-2010 in Agriculture -Multidisciplinary. In penultimate position are the Social Sciences, with most publications in the area of Economics and the fastest growth (AAGR) for the 2005-2010 period in Operations Research & Management Science. In last place are the Humanities, which have a comparatively small number of publications, as is to be expected due to the nature of the information sources.

The profile of the structure of Portuguese scientific production by NUTS 2 is diversified, with each region contributing in a specific way to the national production. This as it may be, if we look at the field with the most publications in each region we can see some revealing facts: in the North, the main field is Materials Science - Multidisciplinary; in the Centre and in Lisbon, it is Electrical and Electronic Engineering; in the Alentejo, it is Environmental Sciences; in the Algarve and Azores, it is Marine and Freshwater Biology; and lastly in Madeira it is Applied Physics. Looking only at the top ten fields by number of publications for each region shows that the North and Lisbon are stronger in Engineering fields; the Centre and Madeira excel in Exact Sciences; and the Alentejo, Algarve and Azores are focused on Natural Sciences (excluding Exact Sciences).

An analysis of the number of publications by researcher (measured using FTE over all fields of science), for the set of countries used for comparison, shows that Portugal stands out in Chemical Engineering, Materials Science, Operations Research & Management Science, Environmental Sciences, Chemistry, Energy and Engineering.

Using the scientific specialisation index to uncover competitive advantage over the period 2000-2010, Portugal showed a high degree of specialisation in those fields of science linked to the Sea. While the degree of specialisation of scientific production dropped in the second half of the decade, areas such as Fisheries, Marine & Freshwater Biology, Oceanography and Ocean Engineering increased their importance over the same period. It is also important to note that Food Science, Agricultural Sciences, and Biotechnology, as well as Environmental Sciences and Biology are important areas (namely for national clusters). Bringing together the most specialised areas by theme points to groupings that correspond to clusters of a technological or economic nature related to the Sea, Biotechnology, Manufacturing, Civil Engineering, Transports and Materials.

Those areas which stand out for the impact produced by Portuguese scientific production include Space Science, Physics, Agricultural Sciences, Plant and Animal Sciences, Neurosciences and Clinical Medicine, which all have an impact above the world average. However, when looking at the h-index, Portugal does not reach the top position for any of the 27 scientific fields covered.

A significant rise in the number of patent applications made by Portuguese residents to the EPO has been observed for the period 2000-2009, which subsequently decreased in 2010 and 2011. At the same time, the number of patent applications made under the PCT mirrored the pattern shown by requests filed with the EPO, with the latter showing increased activity after 2007. Ranking countries by the number of applications under the PCT shows that Portugal rose from 46th position in 2000 to 40th in 2011. For the set of countries under comparison, Portugal was in second place when ranked on the growth of number of EPO patent requests. However, such growth was not enough to significantly raise the level of patenting activity from its very low base.

By 2010 Portugal still displayed a low level of patent filing activity in high-technology areas, even though it was the country where this indicator grew most for the countries studied. The very low level of patenting with international collaboration that existed at the start of the decade also meant that the significant growth over the period in such applications was not able to raise the level meaningfully. In addition, the natural dominance of companies in submitting patents was a constant theme visible over the decade, while a significant rise in applications coming from the Higher Education sector should not be overlooked.

Using the International Patent Classification to analyse the division of patent applications by technological areas highlighted Pharmaceutical Products, Civil Engineering and Fine Chemicals in 2010. Looking at the distribution of all patent applications (made to the EPO) over the different technological areas for the period 2000-2008 showed high levels of activity in the areas of ICT, Pharmaceutical Products, Biotechnology, Medical Technologies, Renewable Energies and Environmental Management.

The total number of patents granted by the EPO has been very low, where, for example, only four technological areas were granted more than two patents in 2010: Fine Chemicals, Pharmaceutical Products, Handling and Other Consumption Goods. For the group of countries under analysis, Portugal stands out as having the largest share of patents made with international collaboration and submitted under the PCT. However this fact refers to a very low number of patents overall, which somewhat detracts from its relevance.

5. Knowledge Circulation

Introduction

This chapter will analyse the way that knowledge circulates through the system actors, identifying patterns of cooperation and intermediation functions. To this end, a mapping was made showing the main entities with specific roles in the intermediation process between the production and economic exploitation of knowledge. This mapping describes the role played by knowledge brokers by looking at their functions in the system and analysing their collaborative patterns using data from participation in national[1,2] and international[3] cooperative R&D projects.

It is possible to find a number of different actors operating in the national research and innovation system, including, but not limited to, those that fall in between knowledge production and companies (Figure V.1). As we shall see, this action takes on diverse forms depending on the type of institution, its mission, its technological capability and the sector or region where it is located. In addition, it is influenced by the incentives included in public policy instruments, as is the case with co-promoted projects and mobilisation projects under the NSRF, the FCT's programmes supporting research, or the 7th Framework Programme for Research, Development and Innovation (FP7).

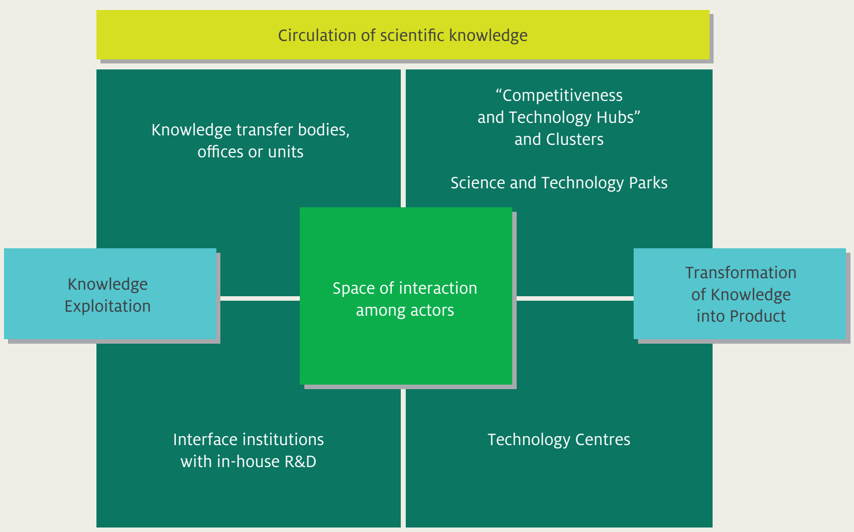


FIGURE V.1.
The circulation of scientific-based knowledge

We underline the three components that seem to us to be the most important in the knowledge circulation process, while also outlining the limits of the analysis developed in this chapter:

1. The nature of the knowledge transferred – not all knowledge can be codified in the form of patents or academic articles. Much of that knowledge circulates with the people in whom it resides. As such, the economic exploitation and utilization of knowledge depends on the "technological base" of a particular region or company, or in other words, its capacity to absorb, develop and apply that knowledge (Nelson & Winter, 1982; Adler, 1989; Cohen & Levinthal, 1990; Godinho, 2003; Laranja, 2007). This chap-

1. Projects financed by the NSRF between 2007 and 2012, including Mobilising Projects as part of the Strategies for Collective Efficiency.

2. Projects funded by the FCT between 2004 and 2011. Data from the Scientific Research and Technological Development ("IC&DT") Projects Database.

3. Projects funded as part of the 7th Framework Programme for RTD from the European Commission, Cooperation Programme 2007-2012.

ter focuses on the functions of those actors which specialise in the intermediation or transfer of knowledge. We also present data showing the mobility of doctorate holders providing an important proxy for gauging the ability of national companies to absorb technology; as well as looking at collaboration in codified knowledge production using data on the number of co-authored scientific articles related to specific indicators of knowledge circulation;

2. The placement of actors in the intermediation process – the activities of the institutions that take part in the intermediation process are focused on knowledge that can be exploited by companies. As such, their place in the market for technological knowledge is based on two defining elements: the level of the technological requirements in the target sectors (companies) and the ability to develop, absorb and transmit the knowledge from the technology producing sectors (Egreja, 2003: p.250). Analysing both the functions of the different types of institutions and data from participation in the types of projects referred to above, allows us to form a picture of these entities within the knowledge circulation arena and gain an overview of the relationship between the scientific and innovation system. The analysis in this chapter does not seek to evaluate the efficiency or efficacy of the actions of the different actors in their specific roles; the objective here is merely to confirm the existence or potential for knowledge circulation and specialists whose job it is to encourage it;

3. The territorial element of the innovation and scientific production process – the importance of the territorial element is widely recognised in the academic literature, which identifies distinct models of spatial organization[4]. This study cannot afford to ignore the existing national examples of attempts to maximise systemic interaction, at differing local levels, as for example with science and technology hubs or clusters, or technology parks. However, here they are treated as merely functional elements, with the focus on the activities which are identified and developed internally, designed to encourage collaboration among members.

Identification and characterisation of the actors within the knowledge circulation space

The different types of intermediation in the innovation and knowledge production process

An intermediary can be defined as an organisation that takes part in the intermediation of science and technology and innovation, providing information regarding potential partners, mediating knowledge transactions between two or more parties, mediating relationships between organisations that already collaborate, and helping with advisory services, financing and support for the output of these collaborations.

However, intermediary entities establish relationships that go beyond resolving individual problems, creating long-term associations based on a trust established with the customer (those applying the knowledge), by gaining an understanding of their key competencies so as to be able to respond to their current and future technical needs. Intermediaries also provide services on a one-to-one basis, or in other words, services where they do not act as brokers but rather as providers, namely in activities such as technical training, pre-market technology tests, contract research, among others.

According to Howels (2006: p. 716-17), this activity can be categorised within the following classes of activity and analysis:

i. Technology transfer and diffusion: this was allegedly the area that started to shape

4. Among others: innovative milieu (Aydalot, 1998; Maillat, 1995), the industrial district (Becattini, 1990), the technological district (Pecquer, 1989; Storper, 1992), learning regions (Florida, 1995) or the Regional Systems of Innovation (Iammarino, 2005; Asheim and Gertler, 2005).

the work regarding the role of the so-called change agents in increasing the speed of knowledge diffusion and the assimilation of new products and services by the market. Technology diffusion also includes support for the decision process for adopting a technology, the definition of parameters and the development of specifications and the evaluation of technology after having been commercialised. Technology transfer includes identifying partners, support in adapting technology to be transferred, as well as selecting the suppliers for technological development and contract negotiation;

ii. Innovation management: focuses on intermediary organisations and their role in transferring knowledge between people, organisations and industries. It is a process that goes beyond the linking together of entities. It can work as a knowledge repository: a work in progress and under development helping provide solutions that are, in reality, new combinations of existing ideas;

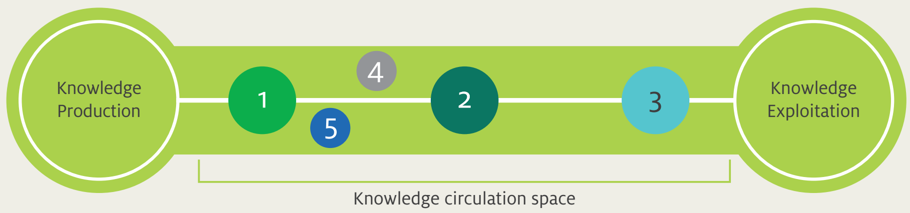
iii. Innovation systems and networks: the specialised literature in this area recognises various types of intermediaries:- "intermediary companies" help develop specialised solutions that exist in the market, adapting them to the needs of each individual client (Stankiewicz, 1995); "bridging institutions" help connect different actors within a technology system (Stankiewicz, 1995); "innovation communities" identify a group of organizations that help to connect and transform relations in a network or innovation system. These entities can be public or private and are frequently known as "superstructure organisations", acting to provide public goods to their members and helping to coordinate the flow of information to the substructure (the companies that actually produce the innovation). These organisations can be public or private (Lynn et al., 1996); brokers operating as organisations that supply services to ease the process of innovation, such as technical training, support for innovation management, patent management, etc.

It is within this context (while at the same time considering the composition of the research and innovation system) that we map out and organise the organisations that exist within the knowledge intermediation space and support the circulation of knowledge in Portugal into five major groups:

1. Knowledge transfer entities, offices or units;
2. Interface institutions with in-house R&D;
3. Technology centres;
4. Clusters and "Competitiveness and Technology Hubs";
5. Technology parks.

Figure V.2 does not intend to illustrate the functioning of the national innovation system, but it does show the relative position of each of these groups of actors with respect to the production and exploitation of scientific and technological knowledge, based on an analysis of the functions of the entities specified, in the previously identified knowledge circulation space.

FIGURE V.2.
The knowledge circulation space



1- Knowledge transfer bodies, offices or units
2- Interface Institutions with in-house R&D in specific areas
3- Technology centres
4- Clusters and "Competitiveness and Technology Hubs"
5- Technology parks

The different brokerage roles carried out by the key actors in the knowledge circulation space also correspond to different objectives and target groups in the realm of private companies. In what follows we take a careful look at the characteristics of each type of intermediation that occurs in each of the five groups of entities identified.

Knowledge transfer entities, offices or units

Knowledge transfer entities, offices or units are characterised by their direct relationship with the knowledge producers, being for the most part integrated into higher education institutions. They focus their activity on the process of searching out and identifying ways to apply knowledge by support for the creation of technology based spin-offs and exploitation of intellectual property.

In being part of university structures and by working to find market solutions for the knowledge produced there, knowledge transfer entities, offices or units work as generic intermediaries between the research developed and the small and medium sized companies. These companies are more likely to be based on technology and include start-ups which are better prepared to receive research directly from universities (Figure V.3). These organizations are close to the discovery or invention process of higher education institutions and, because of this, are well positioned to mediate and encourage the relationship between university R&D structures and the business world. There were 17 units identified, hosted in 5 higher education institutions in the North, 3 in the region of Lisbon, 4 in the Centre, 3 in the Alentejo, 1 in the Algarve and 1 in Madeira. It is noteworthy that the Fundação Gaspar Frutuoso was recently launched in the Azores, whose statutes indicate that its objective is to support scientific research and technological development activities in close contact with the Universidade dos Açores. However, no reference is made to other functions more in-line with technology transfer, help with launching start-ups or innovation in general, and for this reason it is not included in Table V.1. In any case, this was the only reference found to an entity in some way connected to the support of knowledge circulation activities in the region.

The Polytechnic Institutes ("Institutos Politécnicos") also promote entrepreneurship and technology transfer through their R&D centres (as for example in the case of Castelo Branco), research support offices, projects, communication and entrepreneurship, directly through their Technology Schools (Bragança, Cávado e Ave, Guarda, Lisbon, Santarém, Viseu) or specifically through partnerships with technology parks and local business incubators (for example, in Coimbra). They have a strong regional and local presence and a particular focus on activities in support of entrepreneurship and the creation of new companies. Detailed studies and data collection are necessary regarding the activities and impact of the Polytechnic Institutes and universities in the knowledge circulation process.

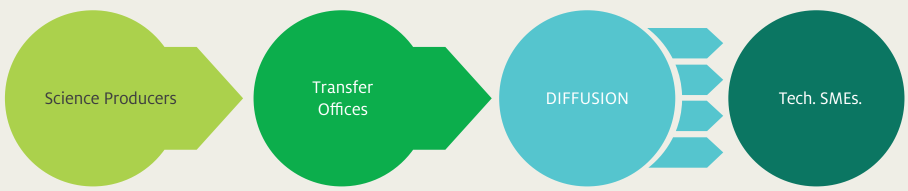


FIGURE V.3.
Intermediation process of the Knowledge Transfer Entities, Offices or Units (Type 1)

TABLE V.1.
Identified Knowledge Transfer Entities, Offices or Units

NUT 2	Name
North	TECMinho – Universidade do Minho
	UPIN – Universidade do Porto Innovation
	GAPI-OTIC of Universidade de Trás-os-Montes e Alto Douro
	Technology Transfer Office of Instituto Politécnico do Porto
	Technology, Innovation and Knowledge Transfer Office of Instituto Politécnico de Viana do Castelo
Lisbon	TT-IST – Technology Transfer Office of Instituto Superior Técnico Unit
	OTIC.IPP – Entrepreneurship and Technology Transfer Unit – Sciences and Technology Faculty of Universidade Nova de Lisboa
	UAII&DE – IPS – Research, Development, Innovation and Entrepreneurship Support Unit of Instituto Politécnico de Setúbal
Centre	UATEC – Technology Transfer Unit of Universidade de Aveiro
	GAAPI – Research Projects Support Office of Universidade da Beira Interior
	Centre for Transfer and Valorization of Knowledge – Instituto Politécnico de Leiria
	Technology and Knowledge Transfer Office of Instituto Politécnico de Tomar
Alentejo	Luís de Molina Foundation of Universidade de Évora
	Knowledge Transfer Centre of Instituto Politécnico de Beja
	C_3I – Interdisciplinary Coordination for Research and Innovation of Instituto Politécnico de Portalegre
Algarve	CRIA – Division for Entrepreneurship and Technology Transfer of Universidade do Algarve
Madeira	Technology and Knowledge Transfer Office of Universidade da Madeira

Interface institutions with in-house R&D

The interface institutions, producers of R&D, are entities which work to accelerate the process of introducing new technologies into industrial processes, being notable for carrying out in-house research and development. Their role starts with knowledge production and can extend to its exploitation, or in other words, they can adopt a position as knowledge intermediaries or simultaneously act as both producers and users of knowledge. These entities are frequently supported by industry, maintaining a close relationship. In some cases they promote the creation of new technology based companies (start-ups).

The partners of interface institutions with in-house R&D units tend to be private companies (mainly medium and large sized companies) and public organizations (including universities). They are primarily focused on bringing together the necessary skills for the development of high-technology products and processes and knowledge production. As actors in the knowledge circulation space they find themselves in an intermediary role, placed between the producers and users of knowledge, taking on the organization and direction of the knowledge produced in a close-knit symbiosis with those actors that are more directly involved in a particular value-chain (Figure V.4).

As Table V.2 shows, these institutions are mainly found in the Lisbon (5), North(6) and Centre (5) regions, with one more in the Azores and two which are present in more than one region, with sites located in the three regions where the interface institutions are most commonly located. While a significant number of the institutions are, by nature, multidisciplinary, analysing the scientific area of activity shows the prominence of Engineering and Technology (8), followed by Natural Sciences (5) and Medical and Health Sciences (2), and another 4 institutions where it was not possible to identify a main scientific area.

FIGURE V.4.
Intermediation process for the Interface Institutions with in-house R&D (Type 2)

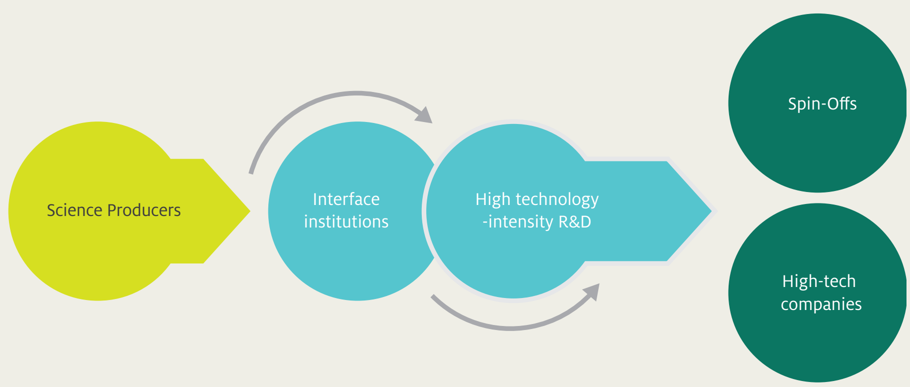


TABLE V.2.
Interface Institutions with in-house R&D

NUT 2	Name
Multi-region	INESC Holding & Subsidiaries - Institute for Systems and Computer Engineering
	IT – Telecommunications Institute
North	INEGI – The Mechanical Engineering and Industrial Management Institute
	CCG/ZGDV – Centre for Graphics Computation
	Fraunhofer Research Centre for Assistive Information and Communication Solutions
	AESBUC – The Association of the Biotechnology School of Universidade Católica
	ICTPOL – Polymer S&T Institute
	IDITE Minho – Minho Institute for Technological Innovation and Development
Lisbon	LNEG - National Laboratory for Energy and Geology
	CENI – Centre for Integrating and Innovating Processes, R&D Association
	IBET – Institute for Experimental Technology in Biology
	UNINOVA – Institute for the Development of New Technologies
	ICAT – Institute for Applied Science and Technology of the Science Faculty at Universidade de Lisboa
Centre	IPN – Pedro Nunes Institute
	IDIT – Technological Innovation and Development Institute
	CBE – Centre for Biomass Energy
	AIBILI – Association for Innovation and Biomedical Research on Light
	RAIZ – Forestry and Paper Research Institute
Azores	INOVA – Azores Institute for Technological Innovation

Technology centres

Technology centres are entities "focused on specific industrial sectors, with the primary objective of supplying technological and technical support to the companies in the sector, by way of activities such as the introduction of new technologies, quality certification and control, training and information regarding those technologies which are applicable to the respective sector"[5]. Their approach is directly linked to specific industrial sectors, with a strong focus on technological and technical support, applied research and experimental development.

Technology centres are a heterogeneous group, with services, in-house institutional capacity and their size all very much dependent on the sector and on the ability to adapt and modernize over the last few years, namely with respect to its relationship with R&D. For the most part they are entities with a direct interaction to the national business sector, and in particular small and medium-sized low-technology companies. Because of this, they have mainly collaborated on incremental research/experimental development (process improvements), being very different in their ability to foster in-house R&D as well as providing support for organisational change.

5. First National Meeting on Technological Infrastructures – Ministry for Education – INETI (1996).

Out of the 11 technology centres identified, 5 are located in the North and 4 in the Centre, with the others in the Alentejo and Lisbon.

FIGURE V.5.
Intermediation process for the Technology Centres (Type 3)

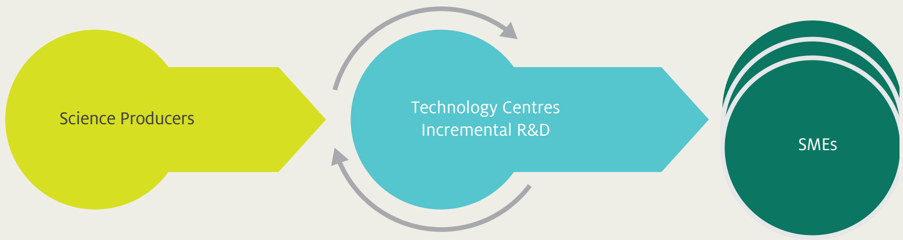


TABLE V.3.
Identified Technology Centres

NUT 2	Name
North	CATIM – Centre for Technical Support to the Metalwork Industry
	CITEVE – Technology Centre for the Textile and Clothing Industry of Portugal
	CTCOR – Cork Technology Centre
	CTCP – Portuguese Footwear Technology Centre
	CEIIA – Centre for Excellence and Innovation in the Automotive Industry
Lisbon	CPD – Design Centre of Portugal
Centre	CENTIMFE – Technology Centre for the Moulds, Special Tools and Plastics Industry
	CTCV – Ceramics and Glass Technology Centre
	CTIC – Leather Technology Centre
	CATAA – Centre for Agriculture and Food Product Technical Support
Alentejo	CEVALOR – Technology Centre for Portuguese Natural Stone

"Competitiveness and Technology Hubs" and Clusters

Within the context of the NSRF driven Collective Efficiency Strategies[6], this type of organisation is divided amongst "Other Clusters" (thematic and regionalised) and "Competitiveness and Technology Hubs" (thematic and with national coverage), both of which are classed as clusters. The members of the cluster include entities with competences in all phases of the knowledge circulation process (direct circulation), from production to exploitation, from a collective efficiency perspective.

On the other hand, both their role in creating geographical clusters and their role in providing support activities and networking makes them important actors in the circulation of tacit knowledge and influencing behavioural cultures towards technology. However, the cluster's activities are not completely insular and it is often the case that its members will be cooperative with institutions outside of the cluster.

6. The Collective Efficiency Strategies are public policy measures for promoting clusters within business sectors and within research and innovation. They are based on an open innovation platform designed to promote collaboration within the ecosystem of the target cluster. These strategies are being implemented and financed under the 2007-2013 NSRF.

As can be seen in Table V.4, the Natural Stone cluster aside, the "Competitiveness and Technology Hubs" and clusters are located in the North (9) and the Centre (10).

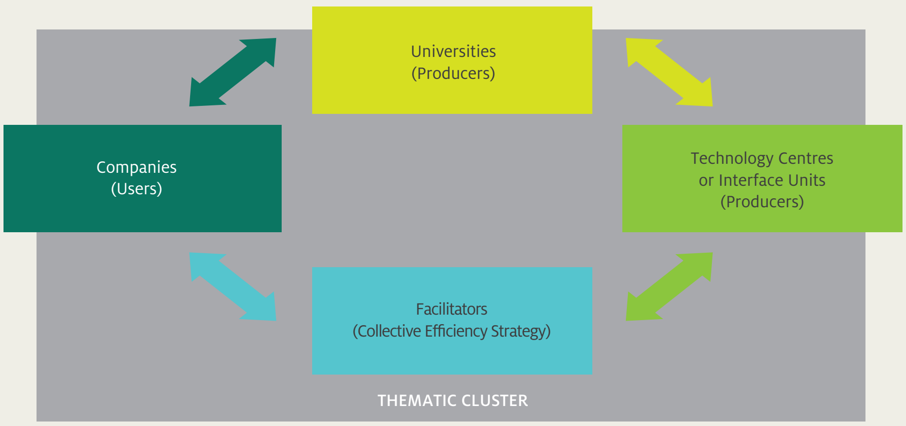


FIGURE V.6.
"Competitiveness and Technology Hubs" and clusters (Type 4)

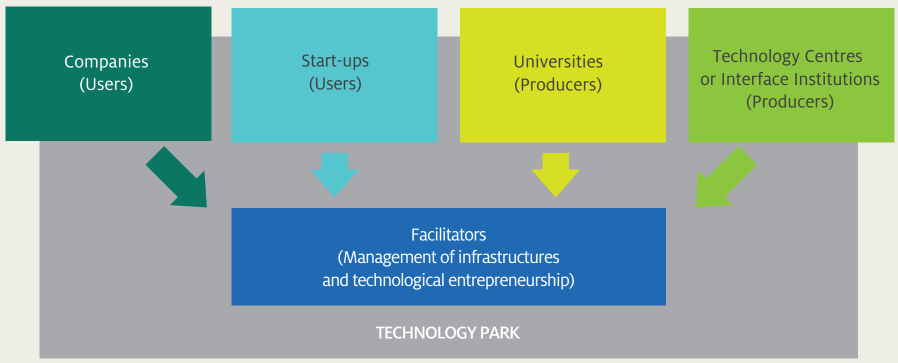
TABLE V.4.
Identified "Competitiveness and Technology Hubs" and Clusters

NUT 2	Name
North	PIEP Association – Innovation in Polymer Engineering Hub
	Health Competitiveness Hub
	Fashion Competitiveness Hub
	Agro-industrial Technology and Competitiveness Hub: food products, health and sustainability – Portugal Foods
	Technology and Competitiveness Hub for the Mobility Industry
	Production Technology Hub – PRODUTECH
	Portuguese Furniture Business Cluster
	ADDICT - Cluster of Creative Industries in the North
	OCEANO XXI – Knowledge and Economy of the Sea Cluster
Centre	EnergyIN – Energy Competitiveness and Technology Hub
	Forestry based Industries Competitiveness and Technology Hub
	Engineering and Tooling Competitiveness and Technology Hub
	Refining, Petrochemical and Industrial Chemistry Industries Competitiveness and Technology Hub
	Information, Communication and Electronic Technologies Hub – TICE.PT
	Tourism 2015 – Tourism Competitiveness and Technology Hub
	Sustainable Habitat Cluster
	InovCluster – Agro-industrialCluster for the Centre
	Agro-industrial Cluster of Ribatejo
	ADVID – Wine Cluster of the Demarcated Douro Region
Alentejo	ValorPedra – Natural Stone Cluster

Technology parks

Technology parks are based on the concept of geographical clustering and can include entities which cover all aspects of the innovation process, from production to exploitation, and normally do not focus on a specific theme. They facilitate the access to infrastructure and associated services, with the objective of creating economic externalities based on physical proximity. Their work helps support the incubation of new technology based companies (Figure V.7).

FIGURE V.7.
Technology Parks (Type 5)



Technology parks distinguish themselves from clusters by the fact that they do not have a thematic strategy that guides and orientates their work. Knowledge circulation in technology parks is driven by the existence of a select set of services within a tight physical proximity which are overseen by an infrastructure manager.

The 14 Technology Parks are split over the regions of the country as follows: Lisbon (4), North (3), Centre (4), Alentejo (1), Algarve (1), Madeira (1) (Table V.5).

TABLE V.5.
Identified Technology Parks

NUT 2	Nome
North	TecMaia
	Avepark
	UPTEC – S&T Park of Universidade do Porto
Centre	ParkUrbis
	Tecnopolo Coimbra
	Tagus Valley
	BIOCANT - Biotechnology Technology Transfer Association
Lisbon	Madan Park
	Lispólis
	Taguspark
	PTM/A - Mutela
Alentejo	Sines Tecnopolo – Vasco de Gama Business Incubator for Technology Based Firms
Algarve	Algarve STP – The Algarve S&T Park
Madeira	Madeira Tecnopolo

The National Research and Innovation System is made up of all types of intermediation actors that are potentially needed to circulate knowledge; some are closer to universities and R&D centres (knowledge producers), others to companies (knowledge users), and some types cover both, such as clusters or technology parks.

Collaboration among the Research and Innovation System actors: Indicators

Mobility of doctorate holders

Not all knowledge can be recorded in the form of patents or academic articles because it is based on the intellectual capital of each individual and/or organization, circulating with the people in whom it resides, within and between organizations (Amin & Cohendet, 2004). In this respect indicators are necessary to measure the existence of the correct conditions for knowledge to circulate, even when it is not codified. The Doctoral Mobility Indicator seeks to measure this tacit circulation of knowledge, whilst also allowing us to gauge the inherent ability of companies to absorb knowledge and create innovation.

The most recent data (2009) show Portugal's doctorate holders to be well internationalised in Europe (Figure V.9), slightly ahead of the countries used for comparison (benchmark countries) and with a rate of international mobility in-line with the others (Figure V.8).

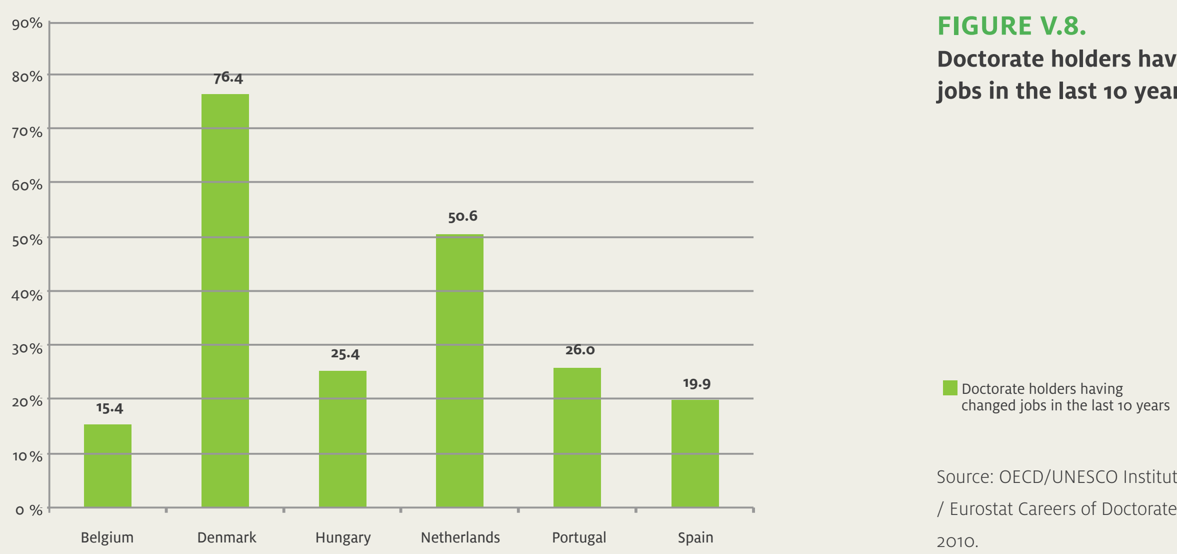
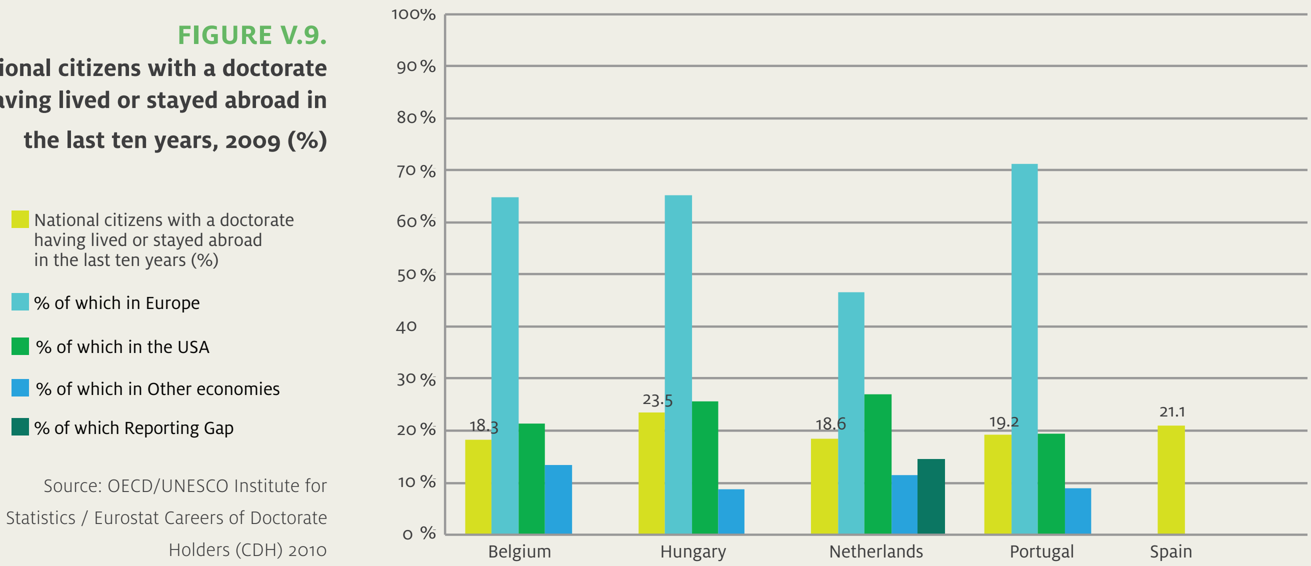


FIGURE V.8.
Doctorate holders having changed jobs in the last 10 years, 2009 (%)

Source: OECD/UNESCO Institute for Statistics / Eurostat Careers of Doctorate Holders (CDH) 2010.

FIGURE V.9.

National citizens with a doctorate having lived or stayed abroad in the last ten years, 2009 (%)

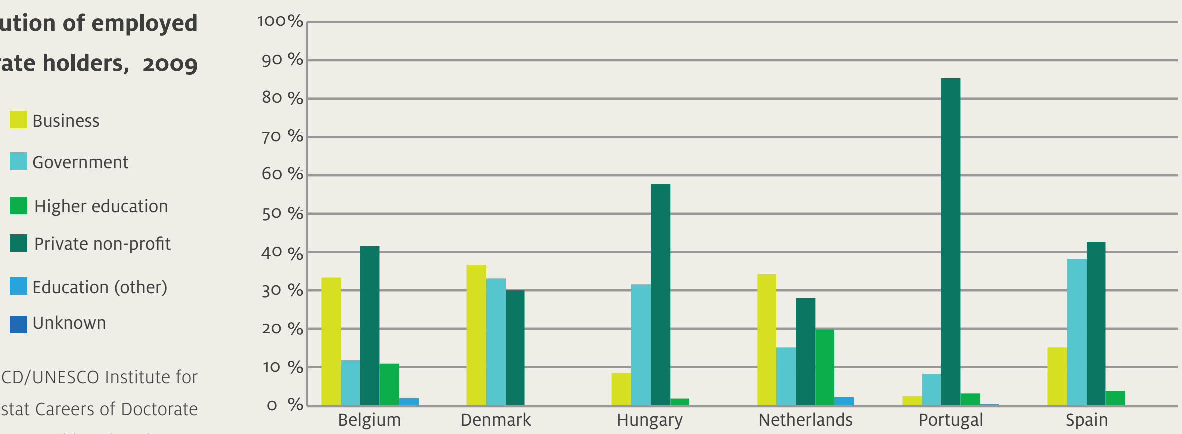


Source: OECD/UNESCO Institute for Statistics / Eurostat Careers of Doctorate Holders (CDH) 2010

The discrepancies with other countries become more obvious in the professional occupation sector (employment). Portugal has more than 80% of its doctorate holders employed within the Higher Education sector. At the same time, it is the country with the lowest percentage of PhD holders employed in the Business sector (Figure V.10), which results in poor direct circulation of knowledge between the doctorate holder/researcher and companies.

FIGURE V.10.

Sectoral distribution of employed doctorate holders, 2009

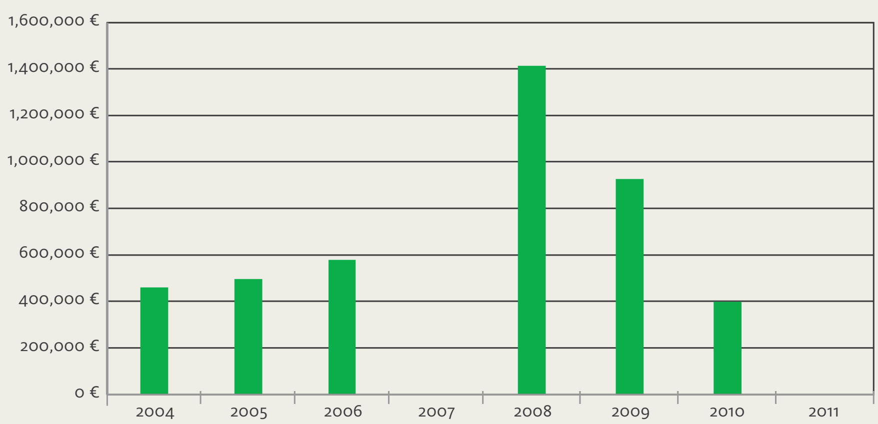


Source: OECD/UNESCO Institute for Statistics / Eurostat Careers of Doctorate Holders (CDH) 2010

Companies collaborating nationally in the FCT programmes/competitions

The Funding Programme for R&D Projects run by the Fundação para a Ciência e a Tecnologia (FCT) of the Ministry for Education and Science is the main national mechanism driving scientific production, or in other words, the first phase in the linear innovation model. It is as such important to understand how companies are involved in the production process along with the type of actors and the areas of activity.

The most recent data covering FCT funded projects (2004-2010) shows only minimal collaboration between companies and the other actors in the national research and innovation system. In point of fact companies receive on average less than 1% of the total competition funding (Figure V.11) in each year. Only 2005 stands out, where this percentage reached 5%, and even then this does not reflect an increase in the total amount received by companies but rather a cyclical reduction in the amount of funding, causing the percentage attributed to companies to rise. Within this universe, those companies receiving most funding are to be found in IT and computing related areas: Computer Engineering, Electrical Engineering and GRID computing (Figure V.12).



	2004	2005	2006	2007	2008	2009	2010	2011
%	0.52%	5.14%	0.32%	0.00%	0.68%	0.79%	0.52%	0.00%
FCT funding for companies	460,525.62€	497,828.05€	579,461.93€	0.00€	1,413,834.00€	927,525.75€	398,792.80€	0.00€
Number of companies funded	14	6	26		30	31	15	

FIGURE V.11.

Company funding as a percentage of total RTD FCT funding, per Call year (2004-2011)

Source: OFCT_SIG (IC&DT projects database 27/11/2012)

Table V.6 shows the list of the top 10 companies by FCT funding which together represent 62% of the total amount of funding from this agency for the business sector (over the period 2004-2011). Only one company received more than 267 thousand euros over the eight year period, showing the low level of interest that companies have for participating in the funding mechanisms of the main funding body of the scientific system. Two of the companies on the list are also founding bodies of two higher education institutions: IADE and Universidade Atlântica (EIA).

TABLE V.6.

Top 10 companies by amount of FCT funding (2004-2011) (euros)

Top 10 companies by FCT funding (62%)	
Critical Software, SA (CS)	914,840.52
MULTICERT - Serviços de Certificação Electrónica S.A. (MULTICERT)	266,700.00
ISA - Intelligent Sensing Anywhere, SA (ISA)	265,276.80
Meticube - Sistema de Informação, Comunicação e Multimedia Lda. (MTCB)	211,560.00
Quinta do Lorde - Promoção e Exploração de Empreendimentos Desportivos e Turísticos, S.A. (Quinta do Lorde S.A.)	199,261.05
Instituto de Artes Visuais, Design e Marketing, SA (IADE)	185,491.00
EIA - Ensino, Investigação e Administração, SA (EIA)	176,496.73
Critical Manufacturing, SA (CMF)	141,533.48
Lifewizz Lda (LW)	141,000.00
ECBIO, Investigação e Desenvolvimento em Biotecnologia, S.A. (ECBIO)	135,150.00

Source: FCT-SIG (RTD Projects database 27/ 11/2012).

Notwithstanding the limited level of participation (both in terms of the number and money disbursed) by companies in all the FCT funding mechanisms, it can be seen that significantly more companies participate in the transnational mechanisms, where the FCT acts alongside its European counterparts. Projects which are funded by actions such as the Joint Technology Initiatives (ENIAC – nano-electronics; ARTEMIS – embedded systems), the Joint Programming Initiatives (Ambient Assisted Living) or ERA-NETs (HY--CO, Pathegenomics, IWR) register higher participation rates than the regular national FCT calls (Figure V.12).

The transnational space enhances the participation of companies in FCT funded R&D projects.

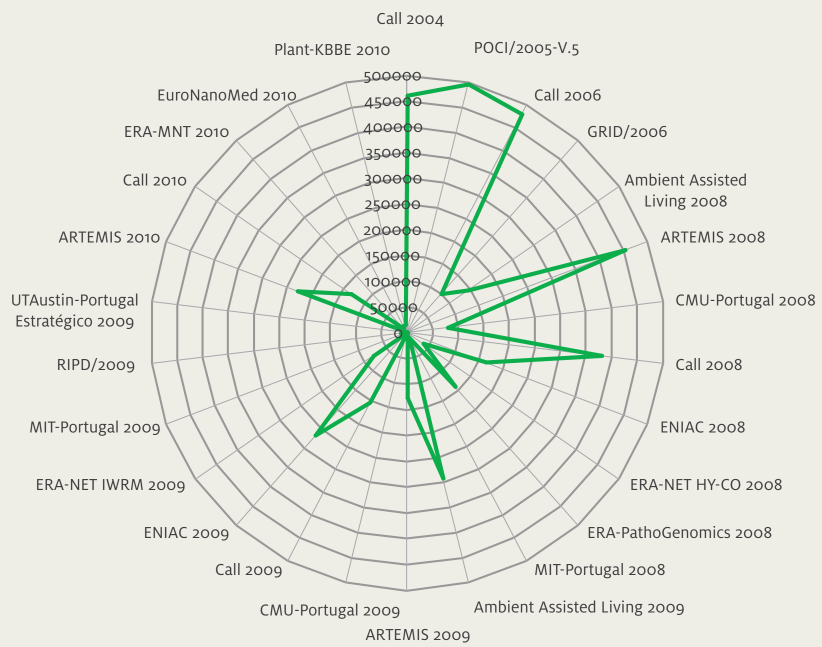


FIGURE V.12.
RTD FCT funding of companies by Call (2004-2011)

Source: FCT-SIG (RTD Projects database), 27/11/2012

National collaboration and the NSRF financial incentives system

The System of Financial Incentives for Research and Technological Development for companies (SI I&DT), part of the NSRF, encourages individual and networked RTD. Two types of incentives exist for promoting networked RTD that envisage collaboration between entities of the Public Research System and companies as being a central factor: co-promoted projects and mobilisation projects. In both cases the objective is to foster economic development strategies by employing ideas of systemic innovation, relying on collaboration between producers, intermediaries and users of knowledge.

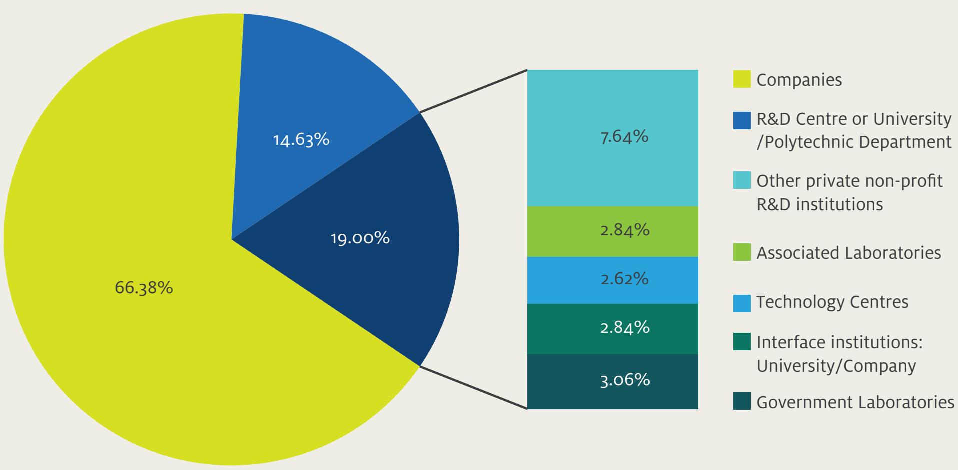


FIGURE V.13.
Participation in co-promoted projects - % of all participations, by type of co-promoting entity, in the RTD funding mechanisms of the NSRF

Source: COMPETE, RTD Funding Mechanism – Co-promoted Projects, Mobilisation Projects and Simplified Projects 2012

Looking at the breakdown of the participations in the SI I&DT by different types of entity shows that companies represent the majority (66%) – this is because the programme is designed to engage and develop companies. However, other entities are also present, either as knowledge producers or brokers, representing around 34% (Figure V.13), a level which is significantly higher than that visible in the FCT managed RTD funding mechanism.

Analysis of the relationship between the research and innovation system actors

In analysing the circulation of knowledge we are presupposing that its production and use occurs in a network. A knowledge network is: "a set of nodes – which can represent knowledge elements, repositories and/or agents that search for, transmit and create knowledge – that are interconnected by relationships that enable and constrain the acquisition, transfer and creation of knowledge" (Phelps et al., 2012).

In this section we map out the positioning, centrality and strength of the relationships between the participating entities in the co-promoted and mobilising projects of the NSRF SI I&DT Programme between 2007 and 2012, using network analysis based on software designed for this purpose.

There are three characteristics of network analysis that stand out as being of central importance and which benefit from being defined so as to help the reader in the text that follows.

1. Degree/Centrality: An actor with a high degree of centrality is an active element in the network and/or is frequently a conduit or central point in the network. This characteristic is measured by the number of ties the actor has, representing more or less intensity of the activity in the relationship. In the analysis that follows, we consider that a tie is "strong" when it reoccurs, or in other words when a relationship is repeated between two actors on the network;

1. Intermediation: An actor with a high level of intermediation generally holds a position of power or prevalence in the network; it represents a single point of failure, or in other words, if we were to remove it from the network we would cut the ties between various components; it is highly influential of what happens in the network; it is an indicator of the gatekeeping potential for a network actor;

2. Proximity: an actor with a high degree of proximity is able to quickly gain access to other network actors; they are close to other actors; they have good visibility of the network activity.

Co-promoted projects

Co-promoted projects "are RTD projects carried out in partnership between different companies or between companies and SCTN (National Scientific and Technological System) entities. Led by companies, they cover activities relating to intellectual or industrial research and/or experimental development leading to the creation of new products, processes or systems or to the introduction of significant improvements in existing products, processes or systems"[7].

7. As appears in the Call for Applications on the COMPETE site –http://www.pofc.qren.pt/concursos/concursos-abertos/entity/aviso-para-apresentacao-de-candidaturas-no-08si2012--iedt-projecto-em-co-promocao--fase-ii??fromlist=1 (1 February 2013).

Looking at the universe analysed shows us that between 2007 and 2012 there were 522 entities part of the NSRF SI I&DT, which established 852 collaborative relationships between each other, 95 (11.15%) of which are considered to be "strong", or in other words reflect repeated collaboration between the same two actors (Table V.7).

Number of entities in the network	**522**
Number of network ties	**852**
Number of strong ties (> 1 relationship/project between the same two entities)	**95**
% strong ties (> 1 relationship/project between the same two entities)	**11.15%**

TABLE V.7
General descriptive statistics for the network of co-promoted projects (NSRF SI I&DT) 2007-2012

Two types of intermediary entities were particularly evident for the co-promoted projects: Technology Centres (8) and Interface Institutions with in-house R&D (24), corresponding to the types previously described (Table V.8). It should be noted that these types of entities are on average more likely to create relationships (12.38 and 12.17 ties respectively), closely followed by the group of knowledge producers (10.59 ties created on average per entity). Companies, however, only managed 1.76 ties on average per entity; this is a good indicator that companies use this instrument to search out research and innovation solutions in a collaborative effort with non-business entities.

	Producers	Users	Technology Centres	Interface Institutions
Number of entities	51	439	8	24
% of entities in the network	9.77%	84.10%	1.53%	4.60%
Number of ties established by the entities with entities of another type	540	773	99	292
% of ties established by the entities	31.69%	45.36%	5.81%	17.14%
Average number of ties per entity	10.59	1.76	12.38	12.17

TABLE V.8
Descriptive statistics, by type of entity, for the network of co-promoted projects (NSRF SI I&DT) 2007-2012

Given the scale of the system, the fact that close to 20% of all entities are knowledge producers or intermediary entities (83 in total) (over all co-promoted projects) is important for a programme which is centred on companies. It is, as such, a good indicator that the innovation system has a good coverage of the different types of actors.

TABLE V.9.
Number and weight of the relationships for all the ties established between entities of different types – co-promoted projects (NSRF SI I&DT), 2007-2012

Relationships between entities of different types	Weight	Number of ties
Producers – Users	54.0%	461
Producers – Intermediaries (Technology Centres)	2.1%	18
Producers – Intermediaries (Interface Institutions)	7.2%	61
Users – Intermediaries (Technology Centres)	9.5%	81
Users – Intermediaries (Interface Institutions)	27.2%	231
Total	**100%**	**852**

Table V.9 shows that out of all the different types of relationships between different entities, the majority of relationships are between producers and users (54%). This indicator accounts for the fact that the process of knowledge circulation for the universe of entities which participate in the Co-promoted Projects of the NSRF SI I&DT mainly reflects a direct relationship between knowledge producers and users. More specifically, most collaboration occurs between companies and universities (their departments), or between companies and research centres or laboratories (461 ties), followed by relationships between users and interface institutions with 231 ties, and between users and technology centres (81 ties created).

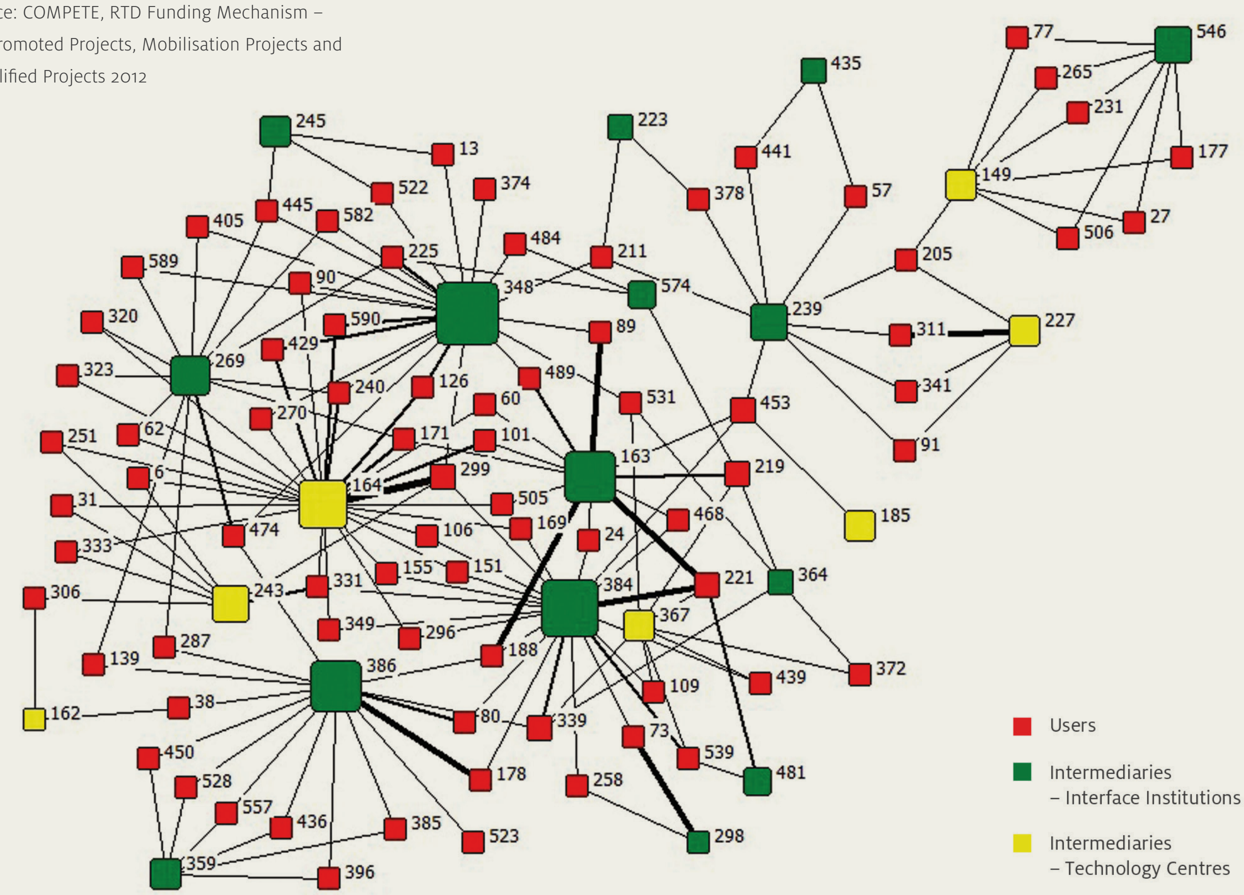
For the Co-promoted projects of the NSRF SI I&DT, knowledge circulation mostly occurs directly between producers (universities, or their departments and institutes) and users (companies).

Figure V.14 isolates the relationships between companies (users) and the technology centres and interface institutions (intermediaries). The picture we get is that in these types of projects interface institutions assume a stronger position over technology centres, given that the companies establish more numerous and stronger relationships with the former. Strong ties are indicators of lasting collaborations which are central to company's activities; examples of which include collaborations with INEGI – The Mechanical Engineering and Industrial Management Institute (163), ADIRA S.A. (89), SETSA – The Engineering and Manufacturing Society S.A. (188) or with Amorim Cork Composites S.A. (221) which also collaborates strongly with PIEP – Innovation in Polymer Engineering (384). Besides those mentioned above, there is another interface institution with a high degree of centrality in the system: INESC Porto (348). The Footwear Technology Centre of Portugal (164) is the entity which collaborates most out of all the technology centres included.

FIGURE V.14.

Network of relationships between Users and Intermediaries – Interface Institutions and Technology Centres

Source: COMPETE, RTD Funding Mechanism – Co-promoted Projects, Mobilisation Projects and Simplified Projects 2012



Collaborations of a sectoral nature are also in evidence, revealing the complementarity of the services offered by the technology centres and the interface institutions. This is the case for PIEP (384) and a number of companies that are concurrently looking for a partner, with CEIIA – The Centre for Excellence and Innovation in the Automotive Industry (367), or the case of a group of companies that collaborate with the National Laboratory for Energy and Geology (546) and the Ceramics and Glass Technology Centre (149).

Ranking the companies by the strength of their relationship to Technology Centres shows that the majority (6) of the top 10 are from low- and medium-low-technology manufacturing industries (Table V.10). In contrast, Table V.11 allows us to see that the companies that collaborate most with interface institutions are SMEs and large service sector companies which are highly knowledge-intensive or large, low-technology companies from the manufacturing sector.

In the case of co-promoted projects, the technology centres mainly forge collaborations with the manufacturing industry in sectors of low- or medium-low--technology. The companies that are most likely to collaborate with the interface institutions are either SMEs or large, highly knowledge-intensive service sector companies, or large, low-technology manufacturing industry companies, suggesting different relationship and capability strategies.

TABLE V.10.
Knowledge Users with more links to Technology Centres

Code	Company	NUT 2	CAE (Classification of Economic Activities)[8]	Technological Intensity	Company Type	Number of Links
6	ANTÓNIO NUNES DE CARVALHO, SA	ALCANENA / CENTRE	15111 - Tanning and dressing of leather	Low-tech manufacturing industry	SME	2
299	CEI - COMPANHIA DE EQUIPAMENTOS INDUSTRIAIS, LDA	SINTRA / LISBON	28992 - Manufacture of other assorted machinery for a determined use (unspecified)	Medium-high-tech manufacturing industry	SME	2
31	CONFORSYST, SA	S. JOÃO DA MADEIRA / NORTH	15201 - Footwear manufacture	Low-tech manufacturing industry	SME	2
331	CURTUMES AVENEDA, LDA	AVEIRO / CENTRE	15111 - Tanning and dressing of leather	Low-tech manufacturing industry	SME	2
251	INDUTAN - COMÉRCIO E INDÚSTRIA DE PELES, SA	SANTAREM / CENTRE	15111 - Tanning and dressing of leather	Low-tech manufacturing industry	SME	2
306	J.TEX - INDÚSTRIAS METALOMECÂNICAS, SA	PAREDES / NORTH	28293 - Manufacture of other assorted machinery of general use (unspecified)	Medium-high-tech manufacturing industry	SME	2
205	MOLDIT INDÚSTRIA MOLDES, SA	AVEIRO / CENTRE	25734 - Manufacture of metallic moulds	Medium-high-tech manufacturing industry	SME	2
333	VEGA INDUSTRIES - COMPONENTES P/CALÇADO, SA	TROFA / NORTH	15202 - Manufacture of footwear components	Low-tech manufacturing industry	SME	2

8. The Portuguese classification structure (CAE) is identical to the NACE Rev.2 up to the 4-digit level (class) and has a national level (subclass).

TABLE V.11.
Knowledge users with more links to Interface Institutions

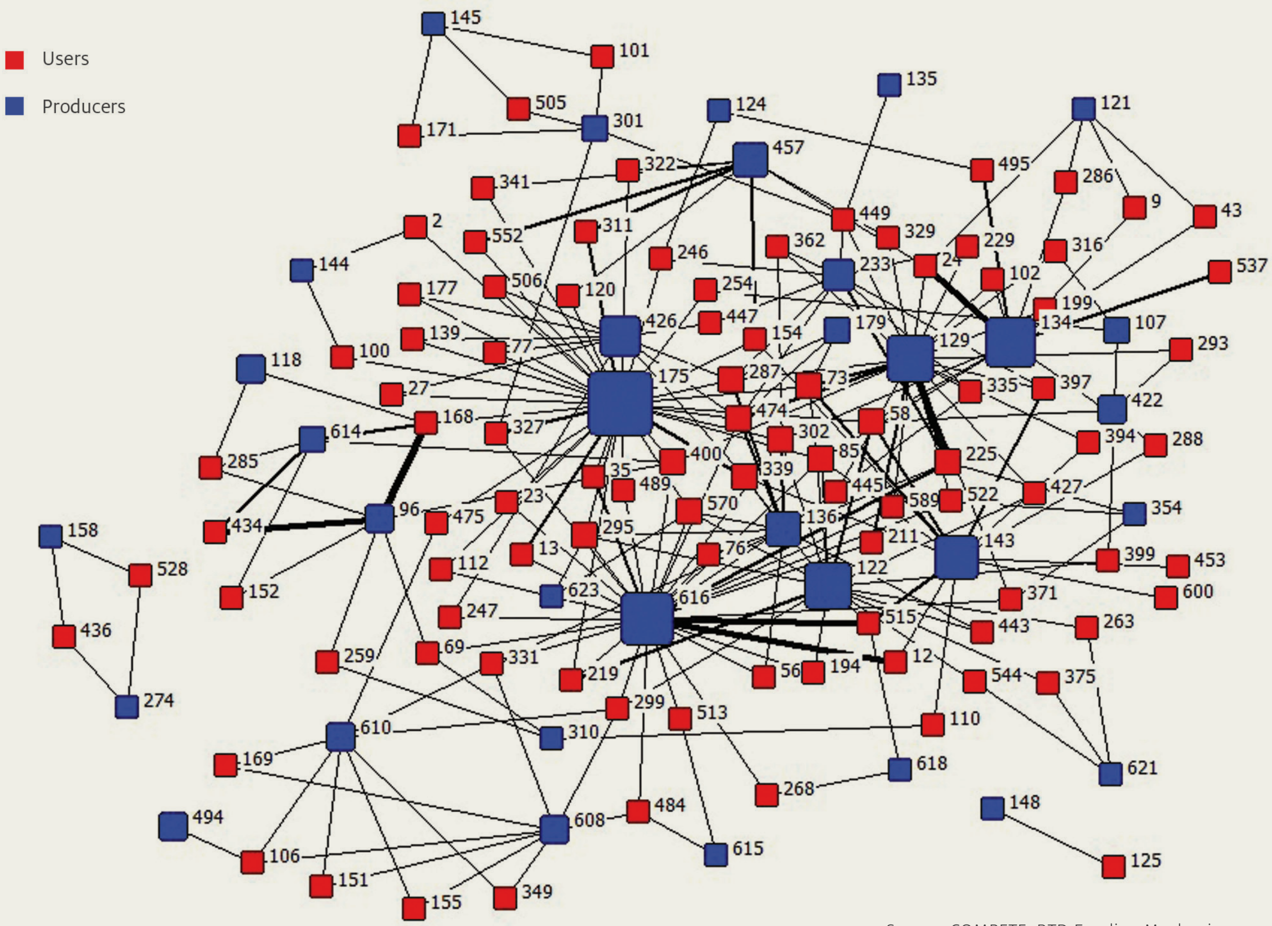
Code	Company	NUT II	CAE (Classification of Economic Activities)	Technological Intensity	Company Type	Number of Links
453	ACTIVE SPACE TECHNOLOGIES, ACTIVIDADES AEROESPACIAIS, SA	COIMBRA / CENTRE	72190 - Other research and development – physical and natural sciences	High-tech knowledge-intensive services	SME	3
221	AMORIM CORK COMPOSITES, SA	SANTA MARIA DA FEIRA / NORTH	16295 - Manufacture of other cork products	Low-tech manufacturing industry	Large Company	3
339	CRITICAL SOFTWARE, SA	LISBOA / LISBON	62010 -IT programming activities	Knowledge-intensive services	Large Company	3
219	EFACEC - ENGENHARIA E SISTEMAS, SA	OEIRAS / LISBON	71120 - Engineering and associated techniques	Knowledge-intensive market services	Large Company	3
211	ISA - INTELLIGENT SENSING ANYWHERE, SA	COIMBRA / CENTRE	71120 - Engineering and associated techniques	Knowledge-intensive market services	SME	3
445	I-ZONE INTERACTIVE MEDIA, SA	LISBOA / LISBON	62010 - IT programming activities	Knowledge-intensive market services	SME	3
474	I-ZONE KNOWLEDGE SYSTEMS, SA	AVEIRO AND COVILHÃ / CENTRE; PORTO / NORTH	70220 - Other consulting activities for business and management	Knowledge-intensive services	SME	3
225	MSFT SOFTWARE PARA MICROCOMPUTADORES, LDA	OEIRAS / LISBON	58290 - Publishing of other computer programmes	Knowledge-intensive services	Large Company	3
188	SETSA - SOCIEDADE DE ENGENHARIA E TRANSFORMAÇÃO, SA	LEIRIA / CENTRE	25734 - Manufacture of metallic moulds	Medium-low-tech manufacturing industry	Large Company	3

Figure V.15 provides a representation of the relationships between knowledge producers and companies. There is a central nucleus to the network, where those institutions with the highest level of centrality can be found. These units, which have the most relationships with companies, are comprised of Universidade de Minho (175), the Engineering Faculty of Universidade do Porto (616), Universidade do Porto (122), Universidade de Aveiro (129), Instituto Superior de Engenharia do Porto (ISEP), Instituto Superior Técnico (134) and the Science and Technology Faculty of Universidade Nova de Lisboa (426).

Universidade de Aveiro (129) and the Engineering Faculty of Universidade do Porto (616) are the entities that establish the strongest collaborations in the network, while Universidade do Minho has the highest number of collaborations.

FIGURE V.15.

Network of Users and Producers



Source: COMPETE, RTD Funding Mechanism – Co-promoted Projects, Mobilisation Projects and Simplified Projects 2012

Looking more closely reveals a specific and autonomous network which is made up of LIP (Instrumentation and Experimental Particle Physics Laboratory) (158), the Science Faculty Foundation of Universidade de Lisboa (274) and two companies: Petsys – Medical Pet Imaging Systems (528) and Hospital Garcia de Orta EPE (436).

Another example of a specific network, but also well connected to the network under study, is the case of the collaboration between the Science Faculty of Universidade do Porto (608), Instituto Politécnico de Bragança and a number of companies in the footwear sector: Procalçado – Manufacture of Footwear Components (106), ICC – Footwear Manufacture and Retailing (151), DCB – Footwear Components (155), Albano Miguel Fernandes LDA (349) and Indinor, Indústrias Químicas LDA (169). These companies also collaborate with the Footwear Technology Centre of Portugal (Figure V.14) as well as the higher education institutions noted (Figure V.15). This facet shows the need for the different actors in the system to have complementary abilities.

As we have seen in the collaborative network analysed above (Figure V.15), the knowledge producing entities in Portugal from the co-promoted projects of the NSRF SI I&DT (the universe of higher education institutions and R&D centres and laboratories) collaborate with a very diverse set of entities. Table V.12 gives precisely that image of sectoral diversity and technological intensity from the collaborations between companies and the knowledge producing entities.

The knowledge producers with the highest level of centrality/ most direct relationship with knowledge users are to be found in the North and Centre of the country. The Engineering Faculty of Universidade do Porto and Universidade de Aveiro stand out because of their strong links and the Universidade do Minho because of the number of collaborative efforts.

In addition, the direct relationship between producers and consumers is characterised by some degree of autonomy and specific networks. These specific networks are located on the periphery and may reflect the scientific and technological specialisation of some of the higher education institutions and laboratories/R&D centres, as well as geographical proximity.

In the case of the co-promoted projects, the knowledge producers create direct relationships with a wide variety of companies, ranging from manufacturing industry with medium-low-technology, to those which are active in more knowledge-intensive sectors. This demonstrates the ability to create direct relationships with companies and industry.

TABLE V.12.
Users with more links to Producers

Code	Company	NUTS 2	CAE (Classification of Economic Activities)	Technological Intensity	Company Type	Number of links
339	CRITICAL SOFTWARE, SA	LISBON / LISBON	62010 - IT programming activities	Knowledge-intensive services	Large company	7
474	I-ZONE KNOWLEDGE SYSTEMS, SA	AVEIRO E COVILHÃ / CENTRE ; PORTO / NORTH	70220 - Other consulting activities for business and management	Knowledge-intensive services	SME	7
287	MAISIS - INFORMATION SYSTEMS, LDA	AVEIRO / CENTRE	62010 - IT programming activities	Knowledge-intensive services	SME	6
302	ALTO - PERFIS PULTRUDIDOS, LDA	MAIA / NORTH	22210 - Manufacture of plastics plates, sheets, tubes and extruded forms	Medium-low-technology manufacturing industry	SME	5
58	AMORIM & IRMÃOS, SA	PORTO E SANTA MARIA DA FEIRA / NORTH; COIMBRA / CENTRE	16293 - Natural cork processing	Low-technology manufacturing industry	Large company	5
295	COLEGIO PAULO VI	GONDOMAR / NORTH	85310 - Lower and upper secondary education	Knowledge-intensive services	SME	5
85	CUF - QUÍMICOS INDUSTRIAIS, SA	LISBON / LISBON; COIMBRA E ESTARREJA / CENTRE	20144 - Manufacture of other primary chemical products (unspecified)	Medium-low-technology manufacturing industry	Large company	5
225	MSFT SOFTWARE PARA MICROCOMPUTADORES, LDA	OEIRAS / LISBON	58290 - Publishing of other computer programs	Knowledge-intensive services	Large company	5
73	SOPORCEL - SOC. PORTUGUESA DE PAPEL, SA	AVEIRO; FIGUEIRA DA FOZ; COIMBRA / CENTRE; PORTO / NORTH	17120 - Manufacture of paper and card (except corrugated)	Low-technology manufacturing industry	Large company	5
570	TECLA COLORIDA - SOFTWARE EDUCATIVO, LDA	PORTO; GONDOMAR; BRAGA / NORTH	63110 - Data processing activities, data warehousing and related activities	Knowledge-intensive services	Microenterprise	5
400	UNICER BEBIDAS, SA	NORTH	11050 - Beer production	Low-technology manufacturing industry	Large company	5
434	BIOSTRUMENT - CONSULTADORIA E DESENVOLVIMENTO DE PORJECTOS BIOQUÍMICOS, SA	PORTO / NORTH	72110 -Research and development in biotechnology	Knowledge-intensive services	Microenterprise	4
299	CEI - COMPANHIA DE EQUIPAMENTOS INDUSTRIAIS, LDA	SINTRA / LISBON	28992 - Manufacture of other assorted machinery for a determined use (unspecified)	Medium-high-technology manufacturing industry	SME	4
331	CURTUMES AVENEDA, LDA	AVEIRO / CENTRE	15111 - Tanning and dressing of leather	Low-technology manufacturing industry	SME	4
449	DEVSCOPE - SOLUÇÕES DE SISTEMAS E TECNOLOGIAS DE INFORMAÇÃO, SA	VILA NOVA DE GAIA / NORTH	62010 -IT programming activities	Knowledge-intensive services	SME	4
168	FRULACT - INGREDIENTES PARA A INDÚSTRIA DE LACTICINIOS, SA	PORTO; MAIA / NORTH	10893 - Manufacture of other assorted food products (unspecified)	Low-technology manufacturing industry	Large company	4
24	ISQ-INSTITUTO DE SOLDADURA E QUALIDADE	OEIRAS / LISBON	72190 - Other research and development – Physical and natural sciences	Knowledge-intensive services	Large company	4

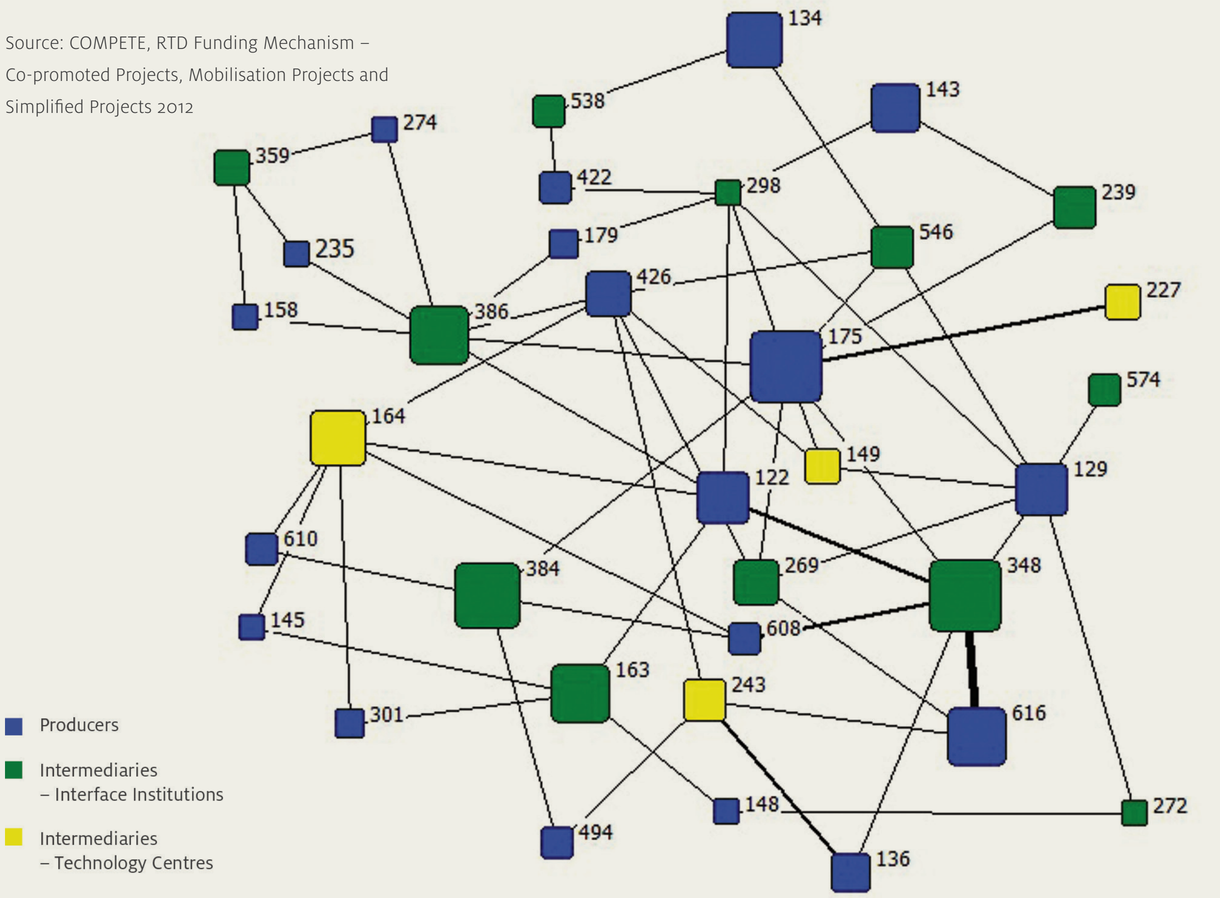
Figure V.16 only shows collaborations between Producers and Intermediaries for co-promoted projects. The relationships between producers and interface institutions are both stronger and more numerous than those between producers and technology centres. Only four technology centres entered into a collaborative effort with knowledge producers under the auspices of co-promoted projects.

These collaborations indicate how the different capabilities necessary for carrying out a project complement each other, as, for example, with industrial research or experimental development inside a company. They are also opportunities for technology centres to update their technological base and for universities and research centres to reinforce their connection to companies and the industrial sector.

FIGURE V.16.

Network of relationships between Producers and Intermediaries – Interface Institutions and Technology Centres

Source: COMPETE, RTD Funding Mechanism – Co-promoted Projects, Mobilisation Projects and Simplified Projects 2012



Universidade do Minho (175) sits in a central location, accumulating the most ties with interface institutions and technology centres.

The collaboration between INESC Porto (348) and the Engineering Faculty of Universidade do Porto can be seen to be among the strongest; INESC Porto is the interface institution on the network with the most connections. In terms of technology centres, the Footwear Technology Centre (164) is the node with the most connections. Interface institutions have more links (and stronger ties) to knowledge producers than technology centres.

Mobilisation Projects

These projects support implementation of the EEC (Collective Efficiency Strategies) anchor projects, which are known as being Hubs for Competitiveness and Technology and Other Clusters (PCT/OC). According to COMPETE they "are characterised by their transversal nature resulting from multiple interests and the mobilisation of diverse scientific and technological competencies, as well as their high level of technological and innovation content. These elements help generate significant impacts in multiple sectors and/or regions, and/or at the level of the particular cluster, making them an essential means for enacting and achieving sustained development strategies of a collective efficiency nature."[9]

They are projects which on average have a far higher number of participants than the co-promoted projects. While the mobilising projects have 311 participations in 14 contracted projects, the co-promoted projects have 1179 participations in 404 contracted projects. This translates into a ratio of 22.21 participations per mobilising project against 2.92 per co-promoted project.

This number of entities reflects the PCT/OCs rationale, engaging the different types of entities identified: producers, intermediaries and users of knowledge. This analysis is based on the mobilisation projects of PCT/OCs, which justifies the low percentage of strong ties found (11.08%) as shown in Table V.13.

TABLE V.13.
General descriptive statistics for the network of Mobilisation Projects (NSRF SI I&DT), 2007-2012

Number of entities in the network	**213**
Number of network ties	**1787**
Number of strong ties (> 1 relationship/project between the same two entities)	**198**
% strong ties (> 1 relationship/project between the same two entities)	**11.08%**

9. http://www.pofc.qren.pt/media/noticias/entity/projectos--

Of the 213 entities that make up the network, most are companies (users – 78.4%). It is as such unsurprising that the average number of ties is larger for the other entities, while also being of very similar magnitudes (41 for producers, 43 for intermediaries, and 46 for users) (Table V.14).

	Producers	Users	Technology Centres	Interface Institutions
Number of entities	24	167	9	13
% entities in the network	11.27%	78.40%	4.23%	6.10%
Number of ties established by the entities with entities of another type	987	1614	414	559
% ties established by the entities	27.62%	45.16%	11.58%	15.64%
Average number of ties per entity	41.13	9.66	46.00	43.00

TABLE V.14.
Descriptive statistics, by type of entity, for the network of Mobilisation Projects (NSRF SI I&DT), 2007-2012

The percentage of collaborations between users and producers (45.6%) is identical to that between users and intermediaries, adding together technology centres and interface institutions (44.7%).

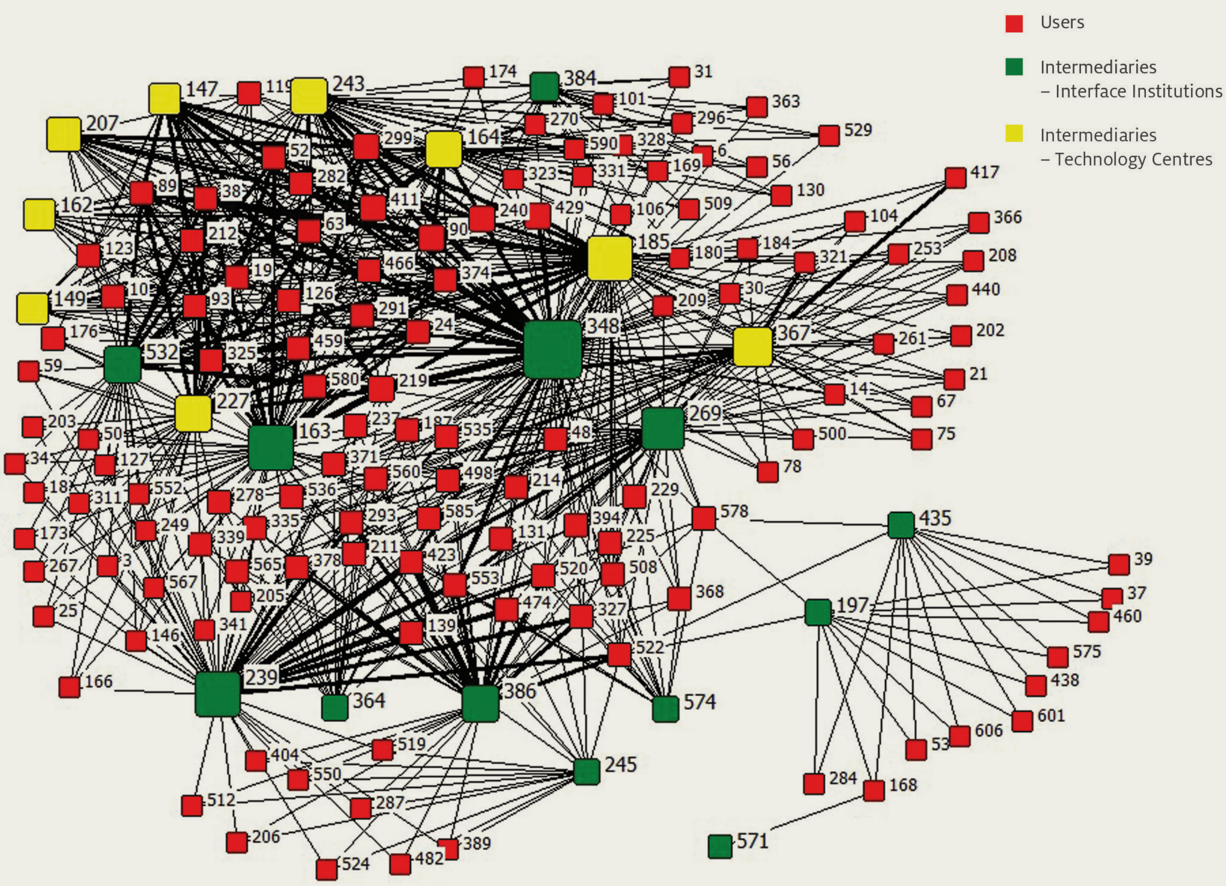
The percentage of ties established for each type of entity is proportional to the number of entities in the network (Table V.14). It is also possible to see that collaboration is fairly equally split between users and the other entities in the system (Table V.15).

Relationships between entities of different types	Weight	Number of ties
Producers – Users	45.6%	814
Producers – Intermediaries (Technology Centres)	3.7%	66
Producers – Intermediaries (Interface Institutions)	6%	107
Users – Intermediaries (Technology Centres)	19.5%	348
Users – Intermediaries (Interface Institutions)	25.2%	452
Total	100%	1787

TABLE V.15.
Number and weight of the relationships for all ties established between entities of different types – Mobilisation Projects (NSRF SI I&DT), 2007-2012

FIGURE V.17.

Network of relationships between Users and Intermediaries – Interface Institutions and Technology Centres



Source: COMPETE, RTD Funding Mechanism – Co-promoted Projects, Mobilisation Projects and Simplified Projects 2012

Figure V.17 shows the pattern of collaboration that exists between users and intermediaries for the mobilisation projects. Four large collaboration sub-networks can be seen to have developed, which we shall refer to by the numbers 1 to 4. Sub-network 1 stands out for its high relational density and is characterised by a restricted group of companies which mainly collaborate with technology centres. INESC Porto (348), CITEVE (185) and INEGI (163) take on the role of gatekeepers, making the connection between the different sub-networks and also having the most ties in the network.

The central intermediary entities of Sub-network 2 are the Pedro Nunes Institute (239) and INESC Inovação (386), which have strong ties with a considerable number of companies, as well as with, to a lesser extent, INTELI (364). Sub-networks 3 and 4 are characterised by a lower relational density and some autonomy compared to the other elements of the network. The main gatekeeper of Sub-network 3 is CEIIA (Centre for Excellence and Innovation in the Automotive Industry) (367) while the principal intermediaries of Sub-network 4 are Biocant (Biotechnology Technology Transfer Association) (435) and AIBILI (Association for Innovation and Biomedical Research on Light) (197). These two sub-networks are examples of specialised sectoral collaboration (automotive and biomedical, respectively) at the heart of the PCT/OCs.

The diversity of the technological intensity which can be seen in Table V.16, which lists users ordered by the number of ties established with technology centres, can be explained by the way that the collective efficiency projects act within a particular context. However, when compared with Table V.17 (the list of users ordered by the number of ties established with interface institutions) it is obvious that interface institutions collaborate predominantly with entities that are active in knowledge-intensive areas.

It can clearly be stated that these two types of intermediaries are different in that technology centres are closer to manufacturing industry, while interface institutions collaborate mainly with companies in the areas of systems engineering and IT, underlining the importance of information and communications technology for research and development in Portugal.

INESC Porto (Institute for Systems and Computer Engineering of Porto), CITEVE (Technology Centre for the Textile and Clothing Industry) and INEGI (Institute of Mechanical Engineering and Industrial Management) are the most central intermediaries in the network of mobilisation projects, with the largest number of strong ties.

Mobilisation projects involve actors from across the whole innovation cycle, with strong ties between them. Interface institutions with in-house R&D are key nodes for the network in contrast with the tendency for direct relationships between producers and users seen in co-promoted projects.

TABLE V.16.

Users with more relations to Technology Centres

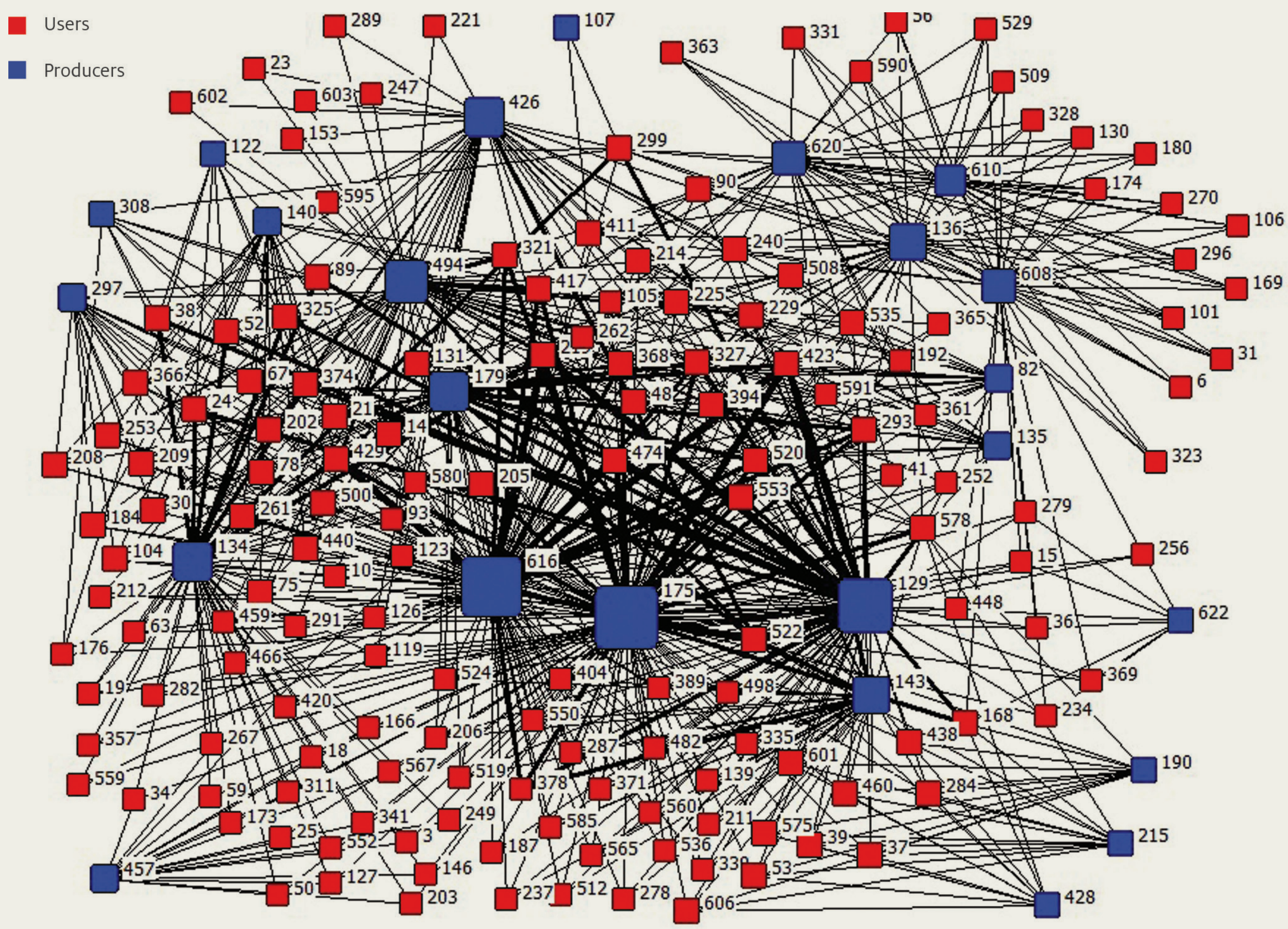
Code	Company	NUT 2	CAE (Classification of Economic Activities)	Technological Intensity	Company Type	Number of Links
219	EFACEC - ENGENHARIA E SISTEMAS, SA	OEIRAS / LISBON	71120 - Engineering and associated techniques	Knowledge-intensive market services	Large company	9
429	CREATIVESYSTEMS - SISTEMAS E SERVIÇOS DE CONSULTADORIA, LDA	S. JOÃO DA MADEIRA / NORTH	46660 - Wholesaling of other office machinery and materials	Less knowledge-intensive services	Microenterprise	9
52	TEGOPI INDÚSTRIA METALOMECÂNICA SA	VILA NOVA DE GAIA / NORTH	25110 - Manufacture of structures of constructed from metal	Medium-low-tech manufacturing industry	Large company	8
89	ADIRA, SA	NORTH	74900 - Other consulting, technical, scientific and similar activities	Knowledge-intensive services	SME	8
38	AZEVEDOS INDÚSTRIA - MÁQUINAS EQUIPAMENTOS INDUSTRIAIS, SA	AVEIRO / CENTRE	28490 - Manufacture of other machine tools	Medium-high-tech manufacturing industry	SME	8
119	BRESIMAR - AUTOMAÇÃO, SA	AVEIRO / CENTRE	46690 - Wholesaling of other machinery and equipment	Less knowledge-intensive services	SME	8
299	CEI - COMPANHIA DE EQUIPAMENTOS INDUSTRIAIS, LDA	SINTRA / LISBON	28992 - Manufacture of other assorted machinery for a determined use (unspecified)	Medium-high-tech manufacturing industry	SME	8
282	COLEP PORTUGAL, SA	LORDELO / NORTH	25920 - Manufacture of light metal packaging	Medium-low-tech manufacturing industry	Large company	8
212	ACONTROL - AUTOMAÇÃO E CONTROLE INDUSTRIAL, LDA	COIMBRA / CENTRE	43210 - Electrical installations		SME	8
19	FELINO - FUNDIÇÃO CONSTRUÇÕES MECÂNICAS, SA	ERMESINDE / NORTH	28930 - Manufacture of machinery for the food, beverage and tobacco industry	Medium-high-tech manufacturing industry	SME	8
123	PRONORMA- PRODUTOS NORMALIZADOS E CONSTRUÇÃO CIVIL, LDA	LISBON / LISBON	43290 - Other building installations		SME	8
466	IDEPA - INDÚSTRIA DE PASSAMANARIAS, LDA	S. JOAO DA MADEIRA / NORTH	13961 - Manufacture of passementerie and tassels	Low-tech manufacturing industry	SME	8
291	PHC 4 PROJECTS, LDA	PORTO / NORTH	62090 - Other activities related to information technology and computers	Knowledge-intensive services	SME	8
411	INOCAM - SOLUÇÕES DE MANUFACTURA ASSISTIDA POR COMPUTADOR, LDA	S.JOAO DA MADEIRA / NORTH; LISBON / LISBON	71120 - Engineering and associated techniques	Knowledge-intensive services	SME	8
24	ISQ-INSTITUTO DE SOLDADURA E QUALIDADE	OEIRAS / LISBON	72190 - Other research and development - Physical and natural sciences	Knowledge-intensive services	Large company	8
126	FORTUNATO O. FREDERICO & Cª, LDA	GUIMARÃES / NORTH	15201 - Footwear manufacture	Low-tech manufacturing industry	Large company	8
90	SILVA & FERREIRA, LDA	S. MARIA DA FEIRA / NORTH	28940 - Manufacture of machinery for the textile, clothing and leather industry	Medium-high-tech manufacturing industry	SME	8
93	MICROPROCESSADOR - SISTEMAS DIGITAIS, SA.	MATOSINHOS / NORTH	33200 - Installation of machinery and industrial equipment	Medium-high-tech manufacturing industry	SME	8
240	OFICINA DE SOLUÇÕES DE INFORMÁTICA, SA	S. JOÃO DA MADEIRA / NORTH	62010 -IT programming activities	Knowledge-intensive services	Microenterprise	8
63	SILAMPOS - SOC. INDUSTRIAL L.M. CAMPOS SA	S. JOÃO DA MADEIRA / NORTH	25991 - Manufacture of metal tableware and articles for domestic use	Medium-low-tech manufacturing industry	SME	8
374	SISTRADE - SOFTWARE CONSULTING, SA	PORTO / NORTH	62010 - IT programming activities	Knowledge-intensive services	SME	8
325	SOFTI9 - INOVAÇÃO INFORMÁTICA, LDA (SOFTI9)	AVEIRO / CENTRE	62010 - IT programming activities	Knowledge-intensive services	SME	8
10	SONAE INDÚSTRIA - PRODUÇÃO E COMERCIALIZAÇÃO DE DERIVADOS DE MADEIRA, SA	ÁGUA LEVADA / NORTH	16211 - Manufacture of wood particle board	Low-tech manufacturing industry	Large company	8
459	VANGUARDA - SOLUÇÕES DE GESTÃO EMPRESARIAL, LDA	MAIA / NORTH	62010 - IT programming activities	Knowledge-intensive services	SME	8
580	KAIZEN INSTITUTE PORTUGAL - CONSULTORIA DE MANAGEMENT, UNIPESSOAL, LDA	VILA NOVA DE GAIA / NORTH	70220 - Other consulting activities for business and management	Knowledge-intensive services	SME	8

TABLE V.17.

Users with more ties to Interface Institutions

Code	Company	NUT 2	CAE (Classification of Economic Activities)	Technological Intensity	Company Type	Number of Links
423	METICUBE - SISTEMAS DE INFORMAÇÃO, COMUNICAÇÃO E MULTIMÉDIA, LDA	COIMBRA / CENTRE	62090 - Other activities related to information technology and computers	Knowledge-intensive services	SME	8
522	PLUX - WIRELESS BIOSIGNALS, SA	ARRUDA DOS VINHOS / CENTRE	33140 - Repairs and maintenance of electrical equipment	Medium-low-tech manufacturing industry	SME	8
378	MEDIAPRIMER-TECNOLOGIAS E SISTEMAS MULTIMÉDIA, LDA	COIMBRA / CENTRE	62010 - IT programming activities	Knowledge-intensive services		7
553	PROCESS.NET - SISTEMAS DE INFORMAÇÃO, LDA	PORTO / NORTH	62010 - IT programming activities	Knowledge-intensive services	SME	7
219	EFACEC - ENGENHARIA E SISTEMAS, SA	OEIRAS / LISBON	71120 - Engineering and associated techniques	Knowledge-intensive market services	Large company	7
578	CRITICAL HEALTH, SA	COIMBRA / CENTRE	58290 - Publishing of other computer programs	Knowledge-intensive services	Microenterprise	7
327	INOVAMAIS - SERVIÇOS DE CONSULTADORIA EM INOVAÇÃO TECNOLÓGICA, SA	MATOSINHOS / NORTH	70220 - Other consulting activities for business and management	Knowledge-intensive services	SME	6
474	I-ZONE KNOWLEDGE SYSTEMS, SA	AVEIRO AND COVILHÃ / CENTRE ; PORTO / NORTH	70220 - Other consulting activities for business and management	Knowledge-intensive services	SME	6
520	CRIAVISION, LDA	COVILHA / CENTRE	71120 - Engineering and associated techniques	Knowledge-intensive market services	SME	6
293	EXATRONIC - ENGENHARIA ELECTRÓNICA, LDA	AVEIRO / CENTRE	71120 - Engineering and associated techniques	Knowledge-intensive market services	SME	6
237	OPT- OPTIMIZAÇÃO E PLANEAMENTO DE TRANSPORTES, SA	PORTO / NORTH	63110 - Data processing activities, data warehousing and related activities	Knowledge-intensive services	SME	6
187	AMI - TECNOLOGIAS PARA TRANSPORTES, SA	BRAGA / NORTH	26512 - Manufacture of instruments and apparatus for measurement, control, navigation and other unspecified uses	High-tech manufacturing industry	SME	6
536	UBIWHERE, LDA	AVEIRO / CENTRE	72190 - Other research and development – physical and natural sciences	High-tech knowledge-intensive services	SME	6
335	PONTO C - DESENVOLVIMENTO DE SISTEMAS DE INFORMAÇÃO, LDA	AVEIRO / CENTRE	62010 - IT programming activities	Knowledge-intensive services	SME	6
371	MICRO I/O - SERVIÇOS DE ELECTRÓNICA, LDA	AVEIRO / CENTRE	62010 - IT programming activities	Knowledge-intensive services	SME	6
560	MOVE MILE, SA	COIMBRA / CENTRE	71120 - Engineering and associated techniques	Knowledge-intensive market services	SME	6
585	WIZDEE - SISTEMAS DE GESTÃO DE CONHECIMENTO, LDA	COIMBRA / CENTRE	62010 - IT programming activities	Knowledge-intensive services	Microenterprise	6
498	MONITAR, LDA	VISEU / CENTRE	71120 - Engineering and associated techniques	Knowledge-intensive market services	Microenterprise	6
278	AMBISIG - AMBIENTE E SISTEMAS DE INFORMAÇÃO GEOGRÁFICA	ÓBIDOS / CENTRE	71120 - Engineering and associated techniques	Knowledge-intensive market services	SME	6
211	ISA - INTELLIGENT SENSING ANYWHERE, SA	COIMBRA / CENTRE	71120 - Engineering and associated techniques	Knowledge-intensive market services	SME	6
565	SMARTMOVE	PORTO / NORTH	49310 - TUrban and suburban passenger land transport	Less knowledge-intensive services	SME	6
139	I2S - INFORMÁTICA, SISTEMAS E SERVIÇOS, SA	PORTO / NORTH	62010 - IT programming activities	Knowledge-intensive services	SME	6
339	CRITICAL SOFTWARE, SA	LISBON / LISBON	62010 - IT programming activities	Knowledge-intensive services	Large company	6

FIGURE V.18.
Network of Users and Producers



Source: COMPETE, RTD Funding Mechanism – Co-promoted Projects, Mobilisation Projects and Simplified Projects 2012

Figure V.18 isolates the collaborations between knowledge users and producers. Those entities which display most centrality in the network are Universidade do Minho (175), the Engineering Faculty of Universidade do Porto (616) and Universidade de Aveiro (129). Drawing a second, wider circle of centrality over the network allows us to include Universidade de Coimbra, Universidade da Beira Interior (179), CENTITVC (Centre for Nanotechnology and Smart Materials) (494) and IST - Instituto Superior Técnico (134). It is worth noting that IST is part of a dense sub-network, somewhat detached from the main network of actors and with most of the associated companies in the Lisbon region.

The knowledge producers collaborate mainly with companies involved in knowledge-intensive activities in the services sector (Table V.18).

The producers that are most prominently connected with the mobilisation projects are Universidade do Minho, the Engineering Faculty of Universidade do Porto and Universidade de Aveiro, where they mostly tend to collaborate with companies involved in knowledge-intensive activities.

TABLE V.18.
Users with more ties to producers

Code	Company	Company Type	CAE (Classification of Economic Activities)	Technological Intensity	Number of Links
522	PLUX - WIRELESS BIOSIGNALS, SA	SME	33140 - Repairs and maintenance of electrical equipment	Medium-low-tech manufacturing industry	13
578	CRITICAL HEALTH, SA	Microenterprise	58290 - Publishing of other computer programs	Knowledge-intensive services	13
299	CEI - COMPANHIA DE EQUIPAMENTOS INDUSTRIAIS, LDA	SME	28992 - Manufacture of other assorted machinery for a determined use (unspecified)	Medium-low-tech manufacturing industry	11
423	METICUBE - SISTEMAS DE INFORMAÇÃO, COMUNICAÇÃO E MULTIMÉDIA, LDA	SME	62090 - Other activities related to information technology and computers	Knowledge-intensive services	10
327	INOVAMAIS - SERVIÇOS DE CONSULTADORIA EM INOVAÇÃO TECNOLÓGICA, SA	SME	70220 - Other consulting activities for business and management	Knowledge-intensive services	10
474	I-ZONE KNOWLEDGE SYSTEMS, SA	SME	70220 - Other consulting activities for business and management	Knowledge-intensive services	10
520	CRIAVISION, LDA	SME	71120 -Engineering and associated techniques	Knowledge-intensive market services	10
293	EXATRONIC - ENGENHARIA ELECTRÓNICA, LDA	SME	71120 - Engineering and associated techniques	Knowledge-intensive market services	10
553	PROCESS.NET - SISTEMAS DE INFORMAÇÃO, LDA	SME	62010 - IT programming activities	Knowledge-intensive services	10
219	EFACEC - ENGENHARIA E SISTEMAS, SA	Large Company	71120 - Engineering and associated techniques	Knowledge-intensive market services	10
368	PORTUGAL TELECOM INOVAÇÃO, SA (PT INOVAÇÃO)	Large Company	82990 - Other support service activities supplied to companies (unspecified)	Less knowledge-intensive services	10
429	CREATIVESYSTEMS - SISTEMAS E SERVIÇOS DE CONSULTADORIA, LDA	Microenterprise	46660 - Wholesaling of other office machinery and materials	Less knowledge-intensive services	9
411	INOCAM - SOLUÇÕES DE MANUFACTURA ASSISTIDA POR COMPUTADOR, LDA	SME	71120 - Engineering and associated techniques	Knowledge-intensive market services	9
48	ALCATEL-LUCENT PORTUGAL, SA	Large Company	46520 - Wholesaling of electronic and telecommunications equipment and parts	Less knowledge-intensive services	9
131	CASO - CONSULTORES ASSOCIADOS DE ORGANIZAÇÕES E INFORMÁTICA, LDA	SME	62010 - IT programming activities	Knowledge-intensive services	9
225	MSFT SOFTWARE PARA MICROCOMPUTADORES, LDA	Large Company	58290 - Publishing of other computer programs	Knowledge-intensive services	9
214	GLINTT HS - HEALTHCARE SOLUTIONS, S A	Large Company	62090 - Other activities related to information technology and computers	Knowledge-intensive services	9
394	INTELLICARE - INTELLIGENT SENSING IN HEALTHCARE, LDA	SME	71120 - Engineering and associated techniques	Knowledge-intensive services	9
229	OPTIMUS TELECOMUNICAÇÕES, SA	Large Company	61100 - Wired telecommunications activitiest	Knowledge-intensive services	9
508	CONFORTO EM CASA, LDA	Microenterprise	70220 - Other consulting activities for business and management	Knowledge-intensive market services	9
535	BE ARTIS - CONCEPÇÃO, CONSTRUÇÃO E GESTÃO DE REDES DE COMUNICAÇÕES, SA	Large Company	61900 - Other telecommunications activities	Knowledge-intensive services	9

FIGURE V.19.

Network of relationships between Producers and Intermediaries – Interface Institutions and Technology Centres

Source: COMPETE, RTD Funding Mechanism – Co-promoted Projects, Mobilisation Projects and Simplified Projects 2012

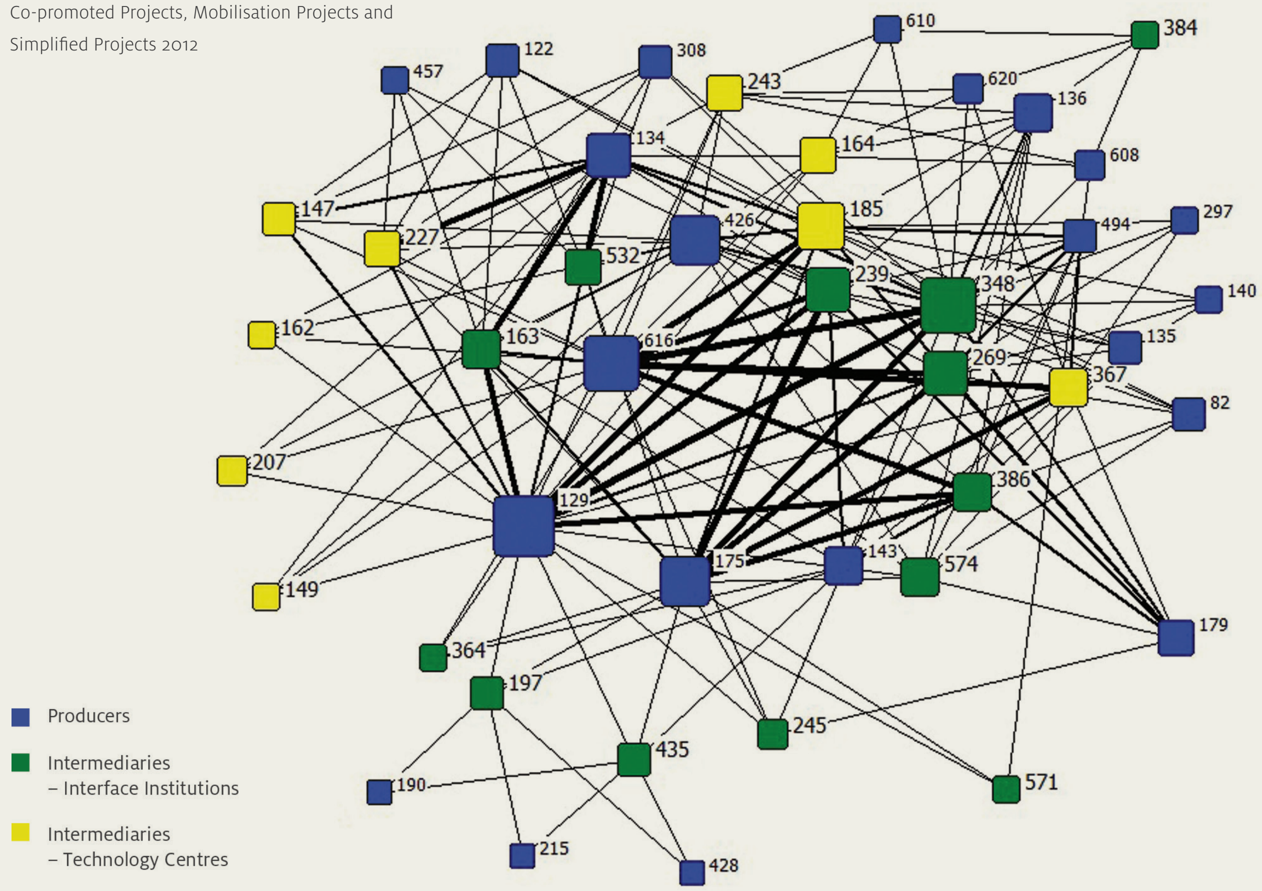


Figure V.19 shows the collaborations between the producers and the intermediaries for the mobilisation projects. The network shows a high density of relationships among a central nucleus of entities. Comparing the collaboration here with that between producers and intermediaries in co-promoted projects (visible in Figure 16) shows the ties to be stronger, resulting from more intense collaboration between these two groups of entities. This phenomenon points to the fact that the collective efficiency rationale encourages collaboration between universities/R&D centres and technology centres/interface institutions.

Interface institutions with in-house R&D represent the group of intermediaries with the strongest links to the knowledge producers. Two technology centres also stand out – CITEVE (185) and CEIIA (367) – as also having strong relationships with universities and R&D centres and laboratories. It should also be noted that a territorial element is at play in the analysis, related to the links identified for Instituto Superior Técnico, which establishes stronger links with those intermediaries with their headquarters or a branch in Lisbon.

Taking the two sub-systems of the incentive mechanisms (co-promotion and mobilisation) together and looking at the top 10 entities ranked by their intermediation ability, produces a list of 7 universities and 3 interface institutions with in-house R&D. These are the institutions which are best placed for acting as gatekeepers, or in other words, they are the main sources of specialised knowledge, assuming network centrality and having a significant ability to influence a large number of actors. By default, they also have the most ties with other entities, the fastest access path to other network actors and a high degree of proximity (relational and/or technological) with other institutions.

If we break down the 10 entities ranked on their intermediation ability by their NUTS II region (Table V.19), we can see that 5 come from the North, 2 from the Centre and 3 from Lisbon. It is worthwhile noting the position of Universidade do Minho, which takes on the role of principal gatekeeper within the context of co-promoted and mobilisation projects.

TABLE V.19.
The top 10 entities ranked according to the level of intermediation

Promoters name	ID	Intermediation value
Universidade do Minho	175	31,610,348.00
Instituto Superior Técnico - UTL	134	23,430,484.00
Faculdade de Engenharia da Universidade do Porto	616	21,017,848.00
Universidade de Aveiro	129	20,260,293.00
Inesc Inovação - Instituto de Novas Tecnologias	386	16,776,711.00
Universidade de Coimbra (UC)	143	12,961,631.00
INEGI - Instituto de Engenharia Mecânica e Gestão Industrial	163	12,196,394.00
INESC Porto - Instituto de Engenharia de Sistemas e Computadores do Porto	348	11,747,692.00
Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa	426	10,273,057.00
Universidade do Porto	122	10,166,507.00
Instituto Pedro Nunes - Assoc. Para a Inovação e Desenvolvimento em Ciência e Tecnologia	239	5,825,595.00

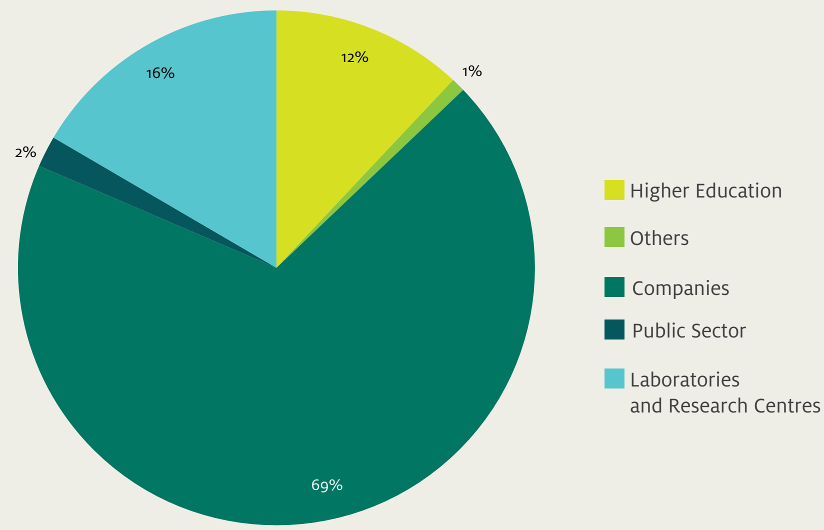
International collaboration in RTD as part of FP7

The 7th Framework Programme (FP7) is one of the main public funding instruments for research and collaborative international development, having a global budget in excess of 50,000 million euros for the period 2007-2013. Any type of legal entity can participate in its projects. However, SMEs are considered to be the main target group, benefitting from a special allotment of 15% of the total budget.

As can be seen in Figure V.20, Portuguese companies prefer to collaborate with other companies and only weak collaboration exists between national companies and other actors in the national scientific system engaged in collaborative international R&D projects (FP7).

FIGURE V.20.

Portuguese companies' profile of collaboration with other national sectors via FP7 Cooperation Programme projects, 2007-2013



Source: GPPQ - Office for the Promotion of the RTD Framework Programme

However, higher education institutions and R&D centres and laboratories are the ones that participate most in FP7 (Table V.20), as well as being responsible for the majority of the funds allocated (Table V.21) both overall and, more importantly, averaged over the different entities.

TABLE V.20.

Number of participations and participating entities, FP7, 2007-2013

	Number of participating entities	Number of participations	Average number of participations per entity
Higher Education	57	519	9
Large Companies	75	187	2
SMEs	194	341	2
Research Centres	68	558	8
Others	76	187	2

Source: GPPQ - Office for the Promotion of the RTD Framework Programme.

	Total amount received by type of entity	Number of partici-pating entities	Average amount received per entity
Higher Education	243,92M€	57	4,279,338.32 €
Large Companies	55,87M€	75	744,984.16 €
SMEs	122,59M€	194	631,916.17 €
Research Centres	233,68M€	68	3,436,440.80 €
Others	56,48M€	76	743,122.52 €

TABLE V.21.

Funding by type of participating entity, FP7, 2007-2013

Source: GPPQ - Office for the Promotion of the RTD Framework Programme.

At this point it is worth noting the low level of collaboration that exists between knowledge producers and users with regard to the RTD initiatives of EU 7th Framework Programme. A healthy level of participation by higher education institutions and R&D centres and laboratories reflects their proper international integration, while their collaboration with companies takes place primarily with foreign companies.

Portuguese participation predominantly comes from higher education institutions and research centres (given that in the classification used by the GPPQ for producing data on FP7 participation, all interface institutions with in-house R&D are included in the category "Research Centres"). They have managed to competitively position themselves in the market for collaborative R&D projects and in the provision of services and technological solutions in projects at an international level.

Certain countries stand out as preferential partners for both producers and users. In other words, comparing preferential international cooperation indicators for these two types of actors from the Science and Innovation System (co-authored academic articles for the producers and the number of collaborations in international projects for the users) we can see that the countries which collaborate most are identical (DE, IT, ES, UK, FR) (Figure V.21 and Figure V.22).

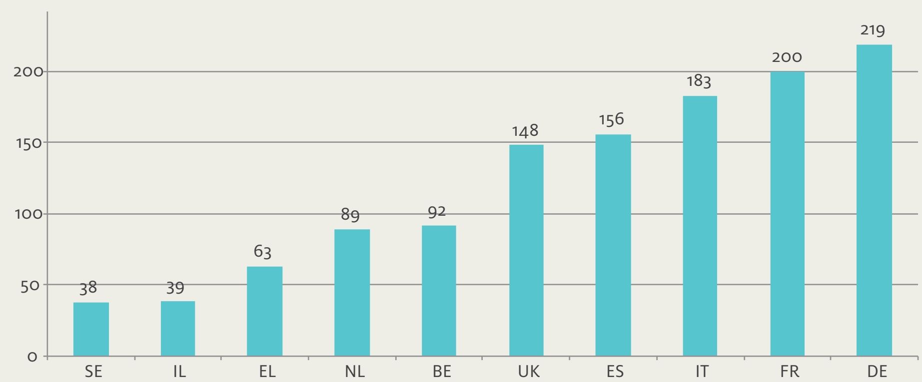


FIGURE V.21.

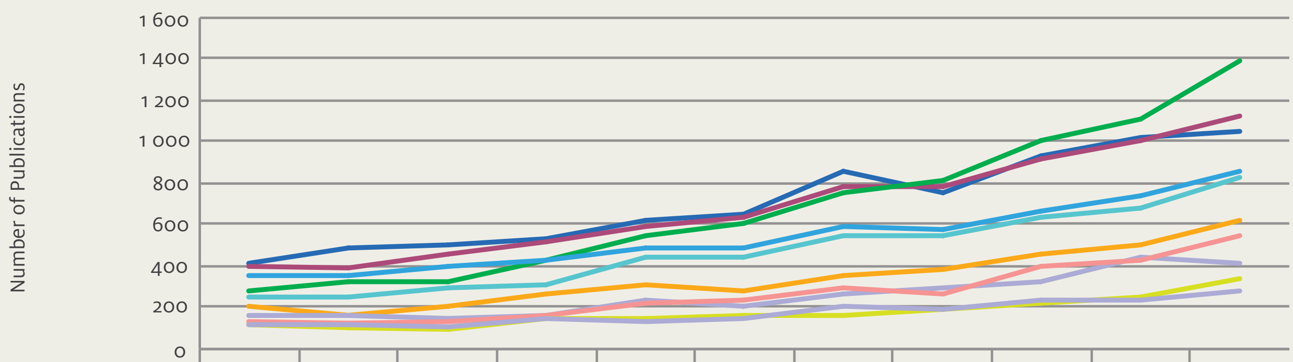
Number of companies involved in FP7 Cooperation Programme projects (per country, 10+)

Source: GPPQ - Office for the Promotion of the RTD Framework Programme

This could signify that there is space for collaboration to increase between knowledge producers and users at a national level, ultimately improving the country's position at an international level.

FIGURE V.22.

Number of co-authored publications, per country



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010*
United Kingdom	413	487	505	533	621	646	857	754	928	1 016	1 057
USA	405	392	460	522	596	632	781	787	921	1 002	1 130
Spain	274	322	325	433	542	606	756	820	1 010	1 117	1 390
France	353	350	395	424	494	491	593	582	671	739	866
Germany	245	247	298	305	438	439	548	545	633	679	826
Italy	203	163	203	268	316	288	359	388	457	501	627
Netherlands	158	159	148	166	235	210	261	291	327	440	421
Brazil	127	125	131	160	218	230	303	264	401	436	544
Belgium	115	102	95	145	152	167	169	194	222	251	336
Sweden	113	124	107	148	138	142	201	191	232	230	277

* Provisonal values

Source: GPEARI - Office for Planning, Strategy, Assessment and International Relations / Ministry of Education and Science and InCitesÔ Thomson Reuters

The relationships established at a national level resulting from funding programmes for science and innovation have not stimulated further collaboration at an international level. A low level of collaboration between knowledge producers and users has been evident, as seen in the number of joint participations in international programmes (FP7).

Conclusions

This chapter has centred on the functions of those actors which specialise in intermediation or knowledge transfer. This was complemented using data on the mobility of doctorate holders as an important proxy for gauging the ability for national companies to absorb technology. In addition, collaboration in the production of codified knowledge was also discussed, drawing on data showing the co-authorship of scientific articles.

The National Research and Innovation System is essentially composed of entities which focus on (i) the production of knowledge (higher education institutions, research centres and laboratories); (ii) the exploitation of knowledge (companies); and (iii) the intermediation of knowledge. Our analysis focuses on this last group (intermediary entities) and on their role in transferring knowledge between people, organizations and industries. In the Portuguese case, five major groups of organisations were identified which are active in the knowledge intermediation space in Portugal: i) Knowledge transfer entities, offices or units; ii) Institutions with an in-house R&D interface; iii) Technology centres; iv) "Competitiveness and Technology Hubs" and Clusters; and v) Technology parks.

By analysing the functions of each of the groups and data from the three main funding instruments of collaborative R&D and innovation (FCT Programmes, NSRF SI I&DT and FP7 Programme) we came to the conclusion that the National Research and Innovation System has all the types of intermediary actors that are potentially necessary for knowledge circulation.

A study of the most recent FCT project funding data (2004-2010) shows only limited collaboration between companies and the other actors in the national research and innovation system. However, this collaboration is more noticeable in the transnational mechanisms that the FCT manages in Portugal (Joint Technology Initiatives, Joint Programming Initiatives and ERA-NETs). The FP7 initiatives also show room for an increase in collaborative ventures between companies and other entities in the R&I system, given that Portuguese companies tend to collaborate more with other national and international companies. When it comes to the co-promoted and mobilisation projects of the NSRF SI I&DT, the other entities (covering both knowledge producers and intermediaries) represent a noteworthy 34% of the total. These data indicate that the objectives and implementation of the funding programmes for research and innovation in Portugal should be better attuned (assuming an entranced complementarity).

It was also seen that the most recent data showing the mobility of doctorate holders shows that Portugal is highly internationalised in Europe. However, it is internally, in the professional employment market, that the differences with other countries are most notable. Portugal has more than 80% of its doctorate holders within the Higher Education sector, and at the same time it is the country with the lowest level of doctorate holders employed in the Business sector. This reflects a poor direct circulation of knowledge from the Producer (doctorate holder /researcher) to the User (company).

6.

Knowledge Exploitation

Introduction

The exploitation of knowledge is central to smart specialisation, given the relevance that innovation and entrepreneurship have for the sustained creation of added value and jobs in companies, regions and countries, as such promoting European competitiveness (European Commission, 2012). In this context there are two concepts which are both different and particularly relevant in characterising knowledge, namely "knowledge exploration", understood to be "the pursuit of new knowledge, of things that might come to be known", and "knowledge exploitation", understood to be "the use and development of things already known" (Levinthal and March, 1993: p105). This chapter focuses on knowledge exploitation in companies, and, in particular, on the use of knowledge given its special relevance for smart specialisation and the difficulty in quantifying and internationally comparing the exploration and development of knowledge.

The Europe 2020 strategy favours policies involving investment in knowledge exploitation. However, the scarcity of resources makes it ever more important that those economic activities and priority areas are identified that can maximise the exploitation of economies of scale, scope and various types of synergies and positive externalities (e.g. knowledge spillovers), where the regional dimension and its up-linking to national and European levels has come to play an increasingly important role (European Commission, 2012). In this context, the policy of investing in research, development, innovation and entrepreneurship is framed by the concept of smart specialisation, based on the identification and exploitation of the specialisation profile and knowledge bases which are specific to each region and on knowledge exploitation associated with the following regional and interrelated strands (McCann and Ortega-Argilés, 2011; European Commission, 2012):

- ***Embeddedness***
  Exploitation of the local bases of economic development – links between the nature of human capital and the regional specialisation profile – by seeking to engage local actors and fostering innovative forms of local entrepreneurship.

- **Relatedness**
  Diversification of the regional specialisation profile, through the exploitation of synergies and positive externalities from the interaction between lower and higher value added economic activities.

- **Connectivity**
  Exploitation of the intra- and inter-regional linkages, including value chains, which involve learning and knowledge spillovers.

As such, these strands are related to the regional exploitation of economies of scale (a significant critical mass of jobs in specific areas), economies of scope (diversity of related economic activities) and of various types of synergies and positive externalities. These concepts underpin the analysis in this chapter, that starts by examining the exploitation of knowledge in terms of business investment in research and development and business innovation (in the second section), and business connectivity (the third section). Following on, the Portuguese specialisation profile and national and regional knowledge bases are characterised in terms of their economic activities, framed by the concepts above (fourth section). The chapter closes by presenting the conclusions.

Research and development and business innovation

Smart specialisation favours the exploitation of knowledge through investment in business R&D and innovation. As such, this section provides a short analysis of these dimensions in Portugal, established in comparison with the average for enterprises in the European Union. Data for this analysis comes from the 2010 Community Innovation Survey (CIS 2010, Eurostat) for the period from 2008-2010. Due to the frequent lack of data for various countries in the European Union, the average for each variable refers only to those countries where data is available. It is worth stating that the sample for Portugal is composed of 20,162 enterprises, where 16,565 are small (82% of the total), 3,155 are medium-sized (16% of the total) and 442 are large (2% of the total). The results of this analysis clearly show how small companies are by far the most numerous in the Portuguese business world. It is also worth noting the lack of homogeneity among countries, with some country samples being more representative than those of other countries.

Moreover, the responses to some questions in the Community Innovation Survey are highly subjective and lack qualification, namely with respect to the nature and degree of innovation--intensity. While there are variables that allow for the identification of the main types of innovation (e.g. training in innovation activities or machinery purchases), there is no information concerning the various degrees of innovation-intensity in each category. Furthermore, the main variables being studied do not distinguish between the various degrees of innovation-intensity in incremental innovation, or between incremental and radical innovation, aggregating, for example, innovation covering the purchase of machinery with radical innovation, such as that associated with the introduction of highly innovative products to the market.

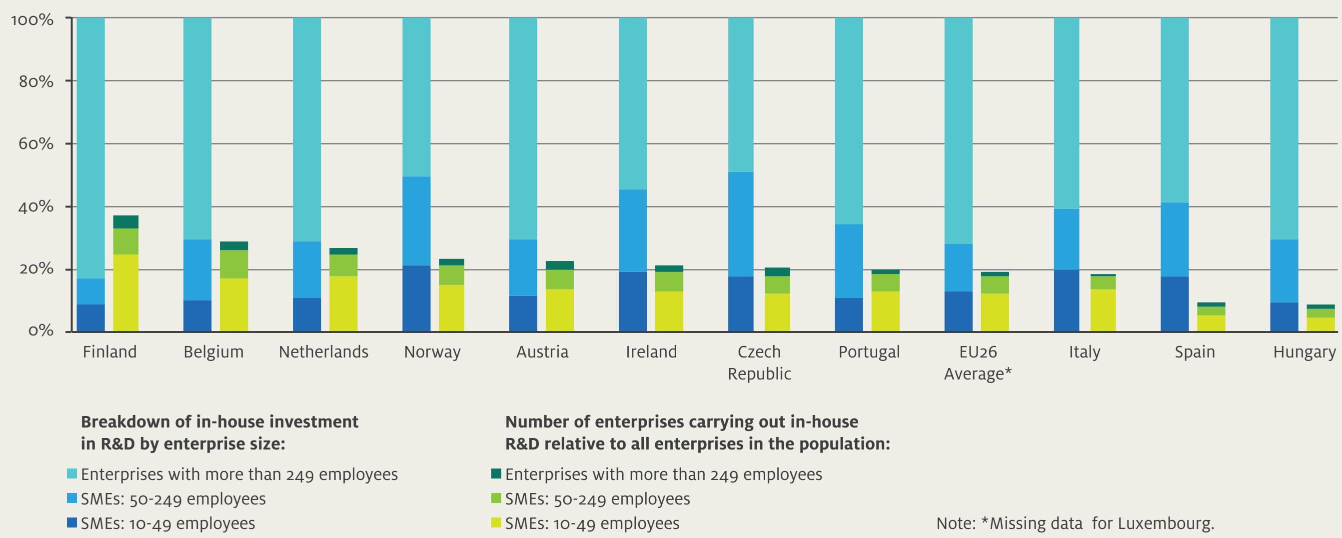
Investment in Research and Development

Between 2008 and 2010, 19.9% of all enterprises in Portugal were carrying out in-house R&D, a figure that is in-line with the European Union average (19.4%). It should be noted, however, that this indicator aggregates a diverse set of activities, thus hampering comparability. On the other hand, the samples collected for some countries are more representative of the total population of enterprises than those of others (the section covering business innovation refers to the smaller population of innovative companies). Small enterprises account for the largest contribution to that percentage in all countries, while large enterprises have a much smaller share. For Portugal, this share is 0.4 percentage points below the EU average (a statistically significant difference) (Figure VI.1).

However, the weight distribution between the contributions of small and large enterprises to total in-house R&D investment is reversed: for all countries studied large enterprises account for the largest contribution to this type of investment, while the share of small enterprises is much smaller. For Portugal, the contribution of large companies is smaller than the average for the EU (5.9 percentage points less, a statistically significant difference), which goes some way to explaining some of the characteristics of the national system in terms of the level of business R&D investment (Figure VI.1).

FIGURE VI.1.

In-house R&D: breakdown of investment and the number of enterprises by enterprise size, 2008-2010



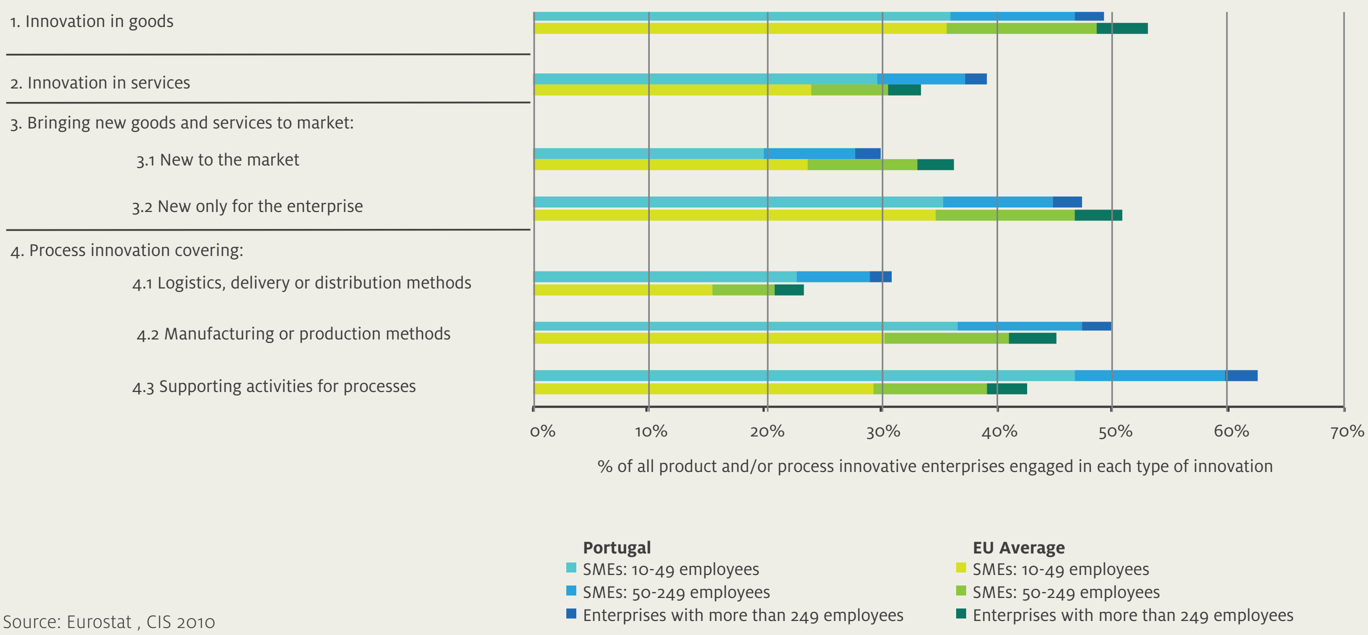
Source: Eurostat , CIS 2010

Business Innovation

Compared with the average for the European Union over the period 2008-2010, Portugal had a smaller percentage of enterprises innovating goods and bringing new products to market (either new for the market or new just for the company). In contrast, Portugal had a higher percentage of enterprises with service innovation and with process innovation (particularly that relating to process support activities), for which the contribution of small enterprises is most expressive. Of course the fact that no consideration is given to the nature and degree of innovation-intensity means that this difference may be mostly due to innovations which are new only to the enterprise, rather than the market, or which have low innovation-intensity. When disaggregating the data on new products brought to market into those that are new to the market and those that are only new for the enterprise, Portuguese enterprises compare less favourably with the European average (Figure VI.2).

When considering the percentage of enterprises engaging in the various kinds of innovation, the share of small enterprises (in Portugal) is relatively greater than the European average. However, this is not the case for the more innovation-intensive products being brought to market that are new to the market. The biggest weakness of Portugal is then not only the relatively small share of large enterprises involved in the various types of innovation, but also the lack of radical and incremental innovation reaching the market. On a positive note, Portugal is more innovative in service innovation than the European Union average (Figure VI.2).

FIGURE VI.2.
Innovation in goods, services and processes, 2008-2010



Source: Eurostat , CIS 2010

The more common innovation activities in Portugal are still of low knowledge intensity. Enterprises mainly engage in the purchase of machinery, equipment and software (66.9% of all enterprises involved in product or process innovation – 4.1 percentage points above the European Union average) and activities designed to improve the firm's potential, such as training for innovation activities (56.6% of firms – exceeding the EU average by 15.5 percentage points, a statistically significant difference) (Figure VI.3).

In-house R&D activity (42.9% of enterprises in Portugal, and 50% for the EU as a whole), bringing innovations to market (26.5% and 31.5% respectively, reinforcing the tendency seen in Figure VI.2) and the acquisition of other external knowledge (13.6% and 20.6% respectively) are clearly behind the EU average. Furthermore, the percentage of enterprises that acquire externally produced R&D and knowledge is relatively low compared to the European average.

On the other hand, it is worthwhile noting the importance of Design in Portugal (36.3% of enterprises, above the EU average of 31.9%) and of other innovation activities (33.1%, compared to the EU average of 26.1%), which includes generic forms of innovation (Figure VI.3).

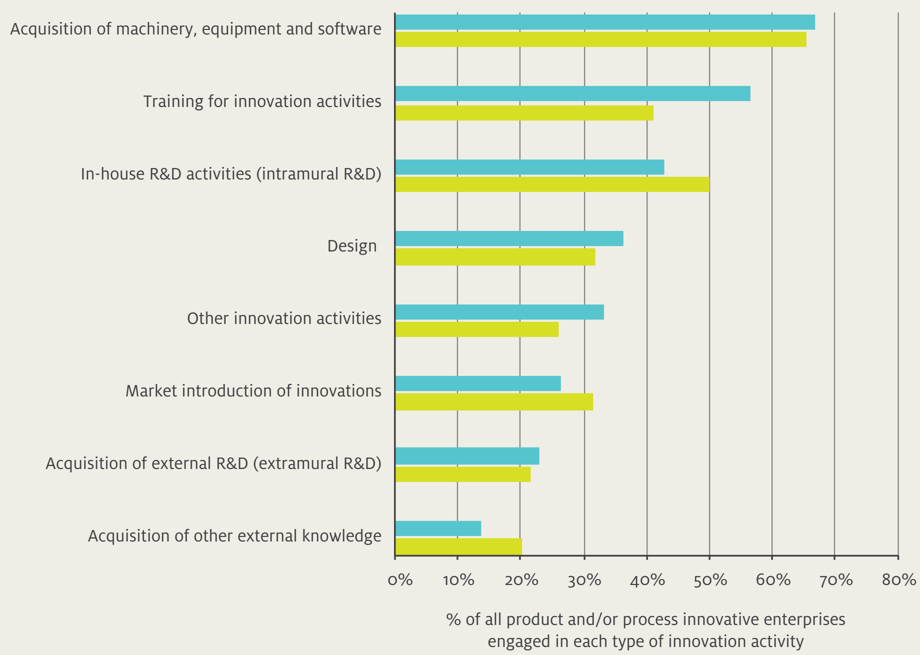


FIGURE VI.3.
Main innovation activities carried out by enterprises, 2008-2010

Source: Eurostat , CIS 2010

Barriers to innovation

Portuguese enterprises consider that they still have to contend with significant obstacles to innovation development that imply both directly associated costs and other more wide-ranging costs. The only obstacle which Portuguese enterprises cite less frequently than their European counterparts is the occurrence of competition from prior innovations. As previously stated, a significant number of innovations in Portugal are new only for the enterprise in question, and not for the market, implying that they are not so affected by innovations that already exist in the market.

As already discussed, large companies in Portugal are relatively few and account for a relatively small share in the various types of innovation and of investment in R&D compared to the average for their European counterparts (see Figure VI.1 and Figure VI.2). This fact may explain why a greater percentage of enterprises in Portugal consider that they have to contend with obstacles to innovation, given that small enterprises, in general, seem to have added difficulties in innovating, due to, for example, greater constraints to investing in R&D, absorbing knowledge, or establishing innovation partnerships.

The obstacles most frequently identified as significant to innovation, are the following:

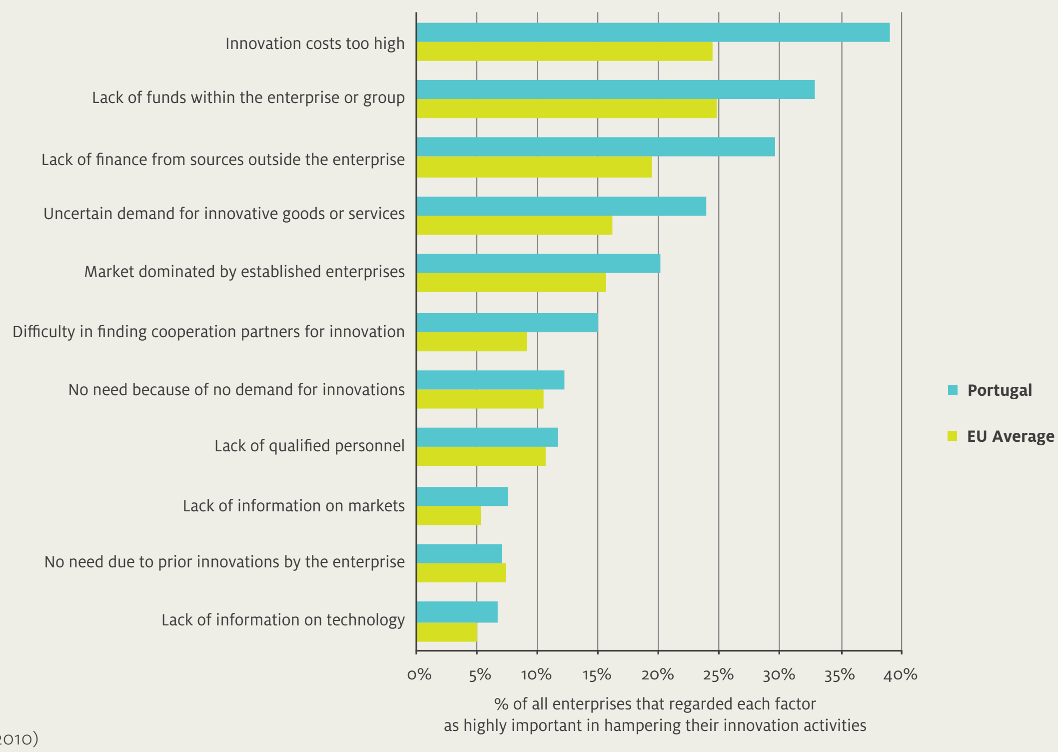
- Excessively high innovation costs – this is an obstacle cited by around 40% of the enterprises in Portugal, substantially more than the European average (24.3%).
- Availability of internal funds – also identified by around one third of the national enterprises, when the European average is 24.7%.
- Difficulties accessing external financing – around 30% of enterprises agreed with this

when only 19.4% of their European counterparts considered it a highly important factor hampering innovation activities; these difficulties may be aggravated by the prolonged financial crisis.

- Access to markets and uncertain demand for innovative goods and services – 24% of enterprises found barriers to market entry, compared with 16.2% for the European average.
- Barriers to entry due to markets being dominated by established enterprises – cited by 20.1% of enterprises in Portugal, against 15.6% for the European average.
- Difficulties in finding cooperation partners for innovation – here 14.9% of Portuguese companies found this to be a significant factor hampering innovation, compared with 9.1% for the European average.

Finally, the lack of qualified personnel was identified as a serious obstacle by only 11.7% of enterprises in Portugal; the average for the EU was 10.7% (Figure VI.4).

FIGURE VI.4.
Main barriers to innovation activities, 2008-2010



Source: Eurostat, CIS 2010)

Knowledge Exploitation and Connectivity

Connectivity is a crucial element for gaining access to information and for searching, transferring, applying and developing knowledge. This may be promoted by infrastructures and adequate means that facilitate the links between actors, through which business learning and innovation occurs. Hence, this section starts by analysing access to broadband internet infrastructures and business use of the internet. Following on, the information sources used by companies for carrying out innovation activities are identified, finishing with an analysis of the importance of the networks established for the innovation process.

Business access to the internet

Business use of the internet and their access to broadband internet infrastructures are important indicators for evaluating the level of business connectivity, as well as the quality of infrastructures that enable and foster the links between actors. The level of internet usage is also indicative of the ability that companies have to benefit from its usage.

In 2009, Portugal was very close to the average of the eight countries in the comparison group for which data was available. This applies both to companies with access to broadband internet and companies which use the internet (Figure VI.5).

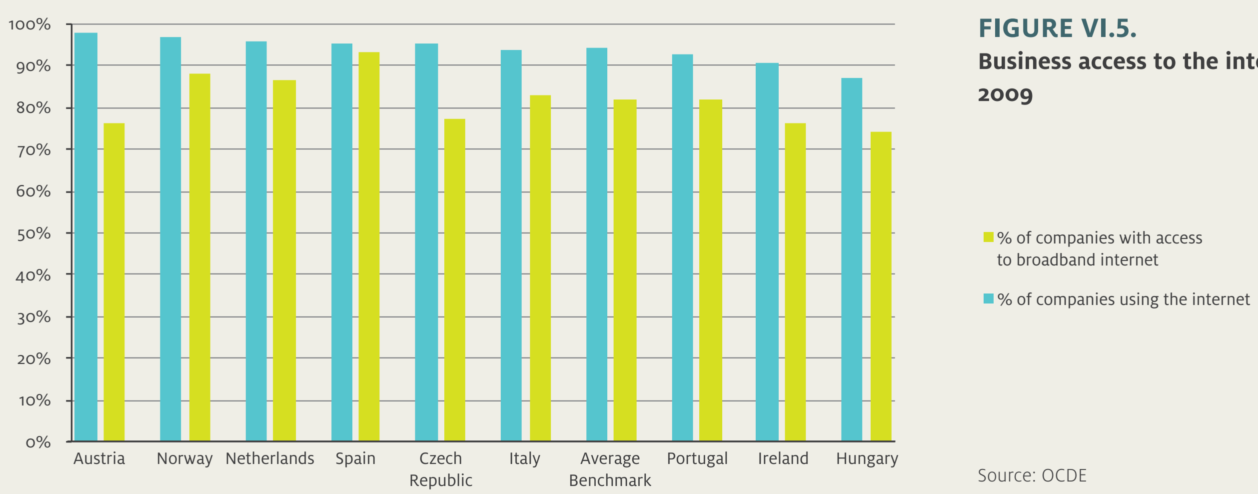


FIGURE VI.5.
Business access to the internet, 2009

Source: OCDE

Access to information sources

The existence of information sources is crucial for companies to maximise the exploitation of their innovation potential. There are conduits via which information flows into the company, ranging from interaction with suppliers and customers, to R&D laboratories and universities or knowledge that is openly made available in scientific publications.

Analysis of the relative importance that Portuguese enterprises attribute to these sources is an important indicator for evaluating their connectivity with the other actors.

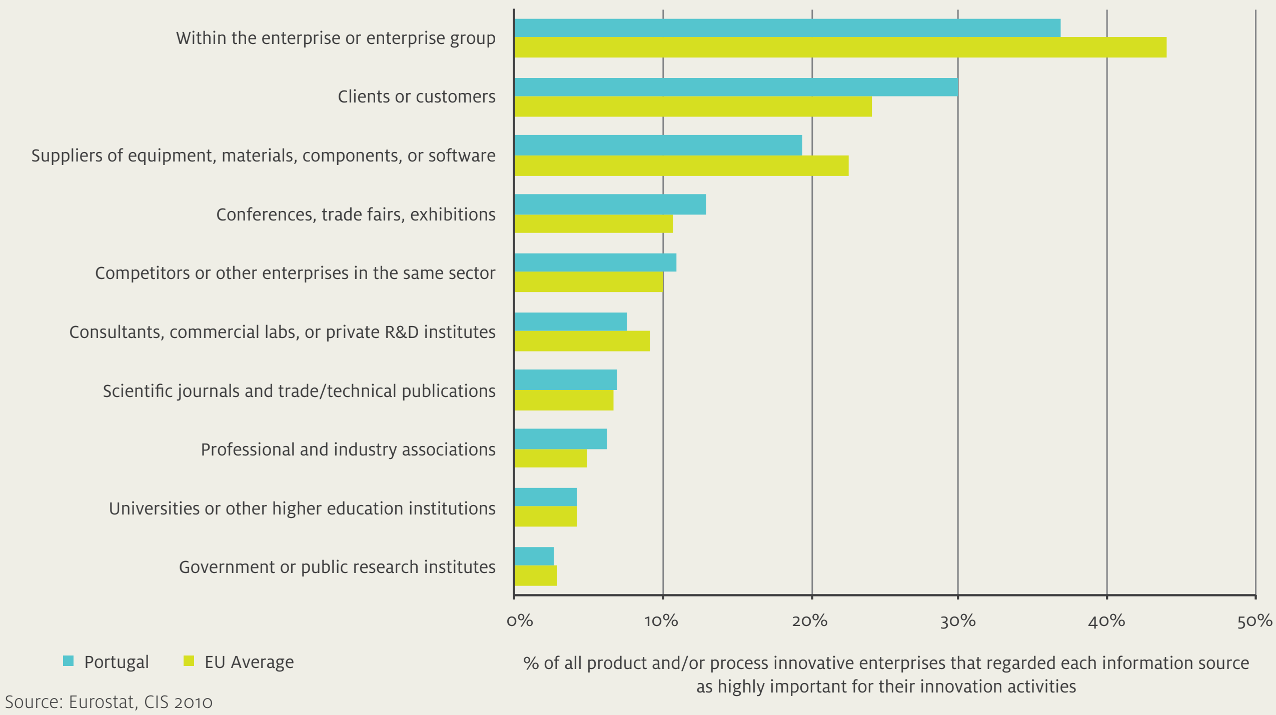
Compared with the rest of Europe, innovative enterprises in Portugal tend to place more importance on information originating with clients or customers (29.9% in Portugal and 24.1% in the EU), while they tend to place less importance on the following sources of information:

i. Information channels within the company, as for example with information arriving through gatekeepers: 36.7% for Portugal and 44% average for the EU;

ii. Information channelled through suppliers: at 19.5%, Portugal finds itself below the EU average of 22.5%.

Professional associations and publications are more important than knowledge producing centres as a means for knowledge diffusion; in this respect Portugal is is-line with the European average (Figure VI.6).

FIGURE VI.6.
Main information sources for innovation activities 2008-2010



Source: Eurostat, CIS 2010

Collaboration on innovation activities

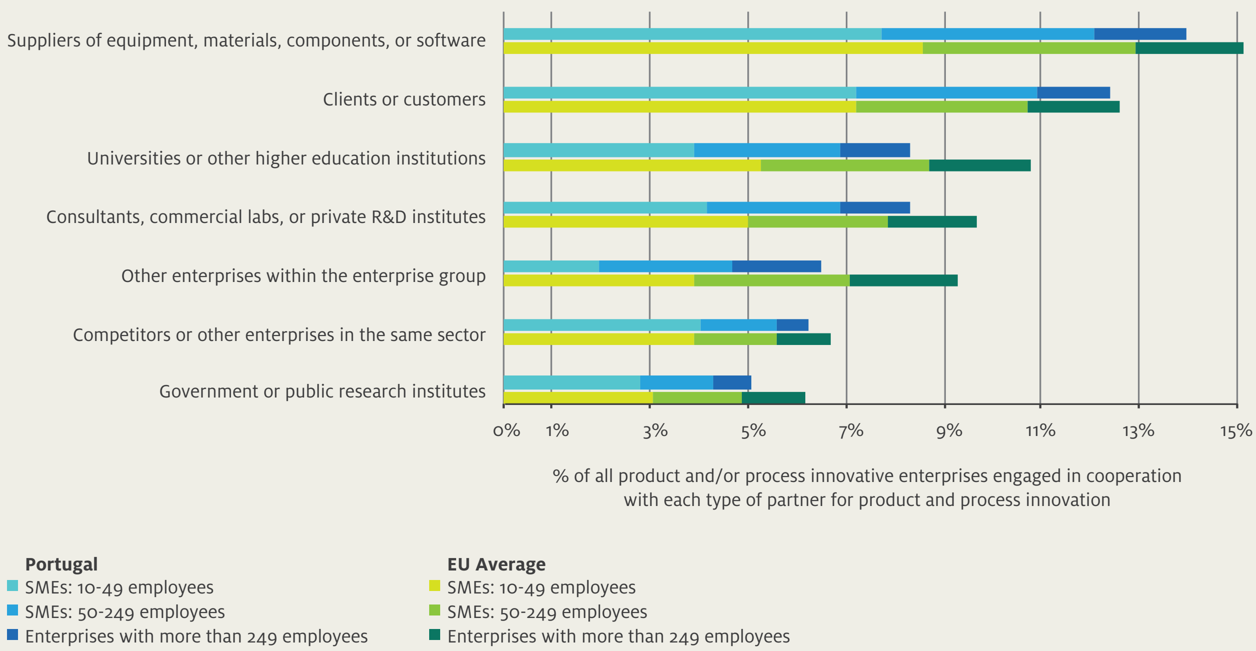
The CIS results covering cooperation for product and process innovation between innovating enterprises and other enterprises or institutions show that Portuguese enterprises collaborated less than the European average (19.5% and 25.5%, respectively). This is the case both for small and medium-sized enterprises and for large enterprises (Community Innovation Survey 2010).

Portuguese enterprises do not stand out from the rest of Europe in relation to their choice of innovation cooperation partners, with preferences which are in-line with the European average: (i) clients and consumers (12.4% and 12.6%, respectively); and (ii) suppliers (14% and 15%, respectively). It should be noted that purchases of machinery, equipment and software is the main innovation activity in Portugal (see Figure VI.7).

The least sought after partners in Portugal, compared to the European Union average, are: (i) "Universities or other higher education institutions" (8.3% and 10.8%, respectively); and (ii) "Consultants, commercial labs, or private R&D institutes" (8.3% and 9.6%, respectively) (Figure VI.7).

Portuguese enterprises' first preference is to collaborate with national partners (58% compared to an average of 47.1% for the EU), followed by European partners (27% and 32%, respectively) and lastly, partners from other countries, such as the United States (5.5% and 8%), and China and India (2.5% and 5.4%) (Community Innovation Survey 2010).

FIGURE VI.7.
Types of cooperation partner for product and process innovation, 2008-2010

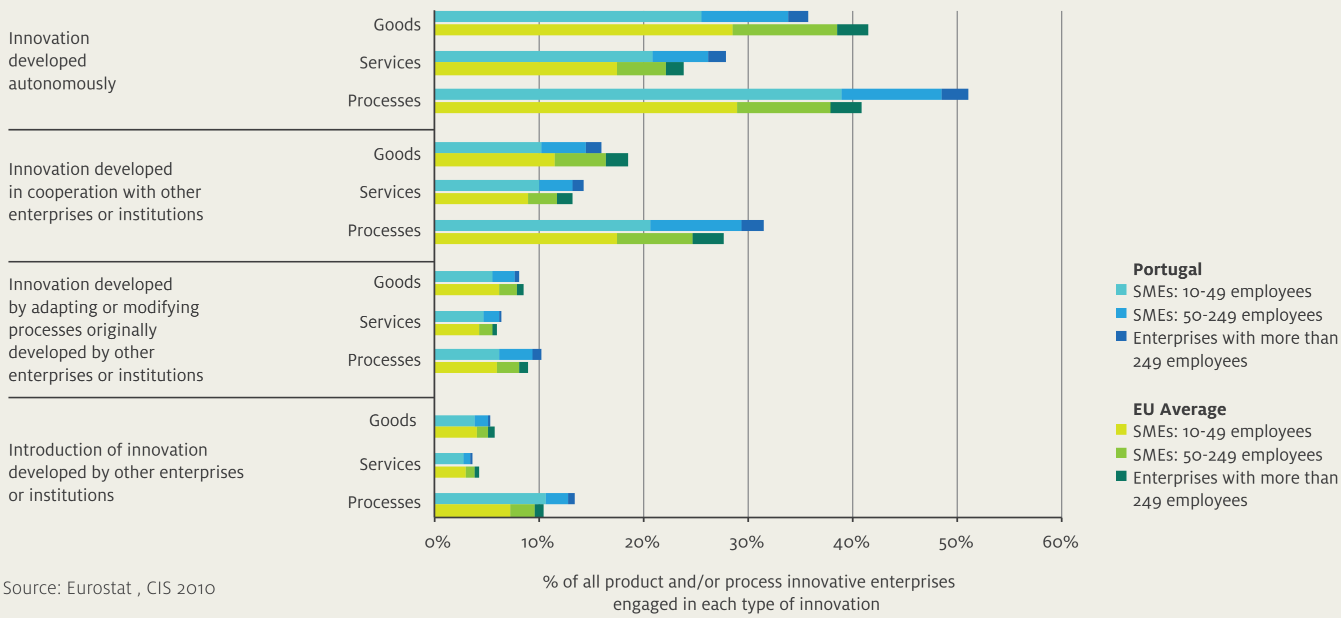


Source: Eurostat , CIS 2010

Business innovations developed autonomously or in cooperation

Portuguese enterprises have a more innovative profile in services and processes than the average for the European Union; this is true for the development of innovation occurring either autonomously or in collaboration with other enterprises and institutions. However, Portugal has a lower percentage of enterprises innovating products, either autonomously or in cooperation with other enterprises or institutions, although that figure is still significant (Figure VI.8).

FIGURE VI.8.
Innovation in goods, services and processes, by developer of innovations, 2008-2010



Source: Eurostat , CIS 2010

National and Regional Economic Specialisation Profiles

Economic specialisation in technology-intensive activities has become increasingly recognised as being a driver of sustained growth of value added and employment at a regional, national and European level. However, the significant technological developments and knowledge gains in recent years have meant that labour-intensive economic activities and sectors – such as textiles, clothing and footwear – have undergone important productivity gains. As such, economic activities and sectors, based in Europe, are still able to successfully compete in the market against countries such as China and India, while continuing to be important employers in the countries and regions of Europe. This success attests that while there is a restrict group of activities whose companies are on average classified as being technology-intensive, it is possible, over a wide range of activities, for enterprises to reach those same levels of technological intensity and as such remain competitive.

The Monitor Group (Monitor Company, 1994: p17-24, known as the Porter report) recommended that Portugal would invest in various forms of industrial upgrading, especially in clusters associated with labour-intensive industries. Priority was given to the following clusters: textiles, footwear, wine, automotive, tourism and wood products (the automotive industry is the only medium-high-technology-intensive industry, with all the others having low-technological intensity, according to the Eurostat classification). In particular, the success of the footwear cluster in Portugal has frequently been used by Porter as an argument in support of his diamond model being applicable not only to activities regarded as technology-intensive, but also to labour-intensive ones (Porter, 1990, 1994; Corte Real, 2008). This strategy for economic development is based on the competitive advantages of industrial agglomerations, drawing on embeddedness (e.g. critical mass of jobs in specific areas, accumulation and development of skills and knowledge), relatedness (e.g. a diverse set of related economic activities, either horizontally or vertically along the value chain) and connectivity (already covered in this chapter). These factors are regarded as fostering flexibility, efficiency gains, learning, innovation and resilience through continued adjustment and adaptation to new challenges (Corte Real, 2008).

As such, it is important to consider not only the main economic activities where Portugal is specialised (Type I), but also to identify those areas of manufacturing industry, of low or medium-low technological intensity, that were capable of surpassing the average productivity levels found in the other countries of the European Union (Type III), setting them apart from those that have below average productivity (Type II). In this way it is possible to establish the existence of relationships between the more and the less productive activities and for each one of the Types II and III, using the most detailed level of the Statistical Classification of Economic Activities (NACE) for which data is available. These relationships constitute an important opportunity for upgrading technology and for exploiting various types of synergies and positive externalities (e.g. knowledge spillovers) which are notably heightened in the case of technology-intensive activities in manufacturing and services (Type IV). These have a significant capacity for driving sustained growth and for leveraging traditional activities, as such representing an important opportunity to diversify and upgrade the productive specialisation profile of the Portuguese economy.

This approach serves as a basis for the following economic activity groupings which structure the analysis of the international specialisation profiles of the Portuguese economy presented in this section:

- **Type I:** Internationally specialised activities (2-digit NACE)
- **Type II:** Internationally specialised, of low or medium-low technological intensity, manufacturing industry activities with low productivity (4-digit NACE)
- **Type III:** Internationally specialised, of low or medium-low technological intensity, manufacturing industry activities with high productivity (4-digit NACE)
- **Type IV:** Internationally specialised, manufacturing and service sector activities, whose 2-digit NACE codes refer to technology-intensive activities (4-digit NACE)

The criteria used to establish these type definitions are based on the Value Added Specialisation Index (international specialisation profile) and the Productivity Ratio (international productivity profile) indicators, calculated for the average of the other 26 countries in the European Union for each economic activity (Table VI.1). The main results from analysing the four Types are presented next.

TABLE VI.1.
Definition of the different international specialisation profile types for the Portuguese economy (for comparison with the remaining 26 countries in the European Union)

Portuguese economy types	Value Added Specialisation Index Portugal/EU26	Productivity Ratio Portugal/ EU26	Economic Activities
I	> =1,3		2-digit NACE
II	> =1,4	< 1	4-digit NACE; Manufacturing industry, except where the 2-digit NACE refers to a technology--intensive activity
III	> 1	> 1	4-digit NACE; Manufacturing industry, except where the 2-digit NACE refers to a technology--intensive activity
IV	> 1		4-digit NACE; Manufacturing and services, where the 2-digit NACE refers to a technology-intensive activity

The types found are described in detail in what follows, identifying their individual components at the activity level.

Type I:
Internationally specialised activities

Portugal is most specialised in economic activities which are characterised by a relatively low international productivity (2-digit NACE) (Figure VI.9 and Figure VI.10). However, there are some exceptions, which have a Productivity Ratio – Portugal/EU 26 above 1:

1. ***Electricity***, *gas, steam and air conditioning supply (Ratio: 2.3)*
2. *Manufacture of coke and refined* ***petroleum products*** *(Ratio: 1.7)*
3. ***Telecommunications*** *(Ratio: 1.6) – the only internationally specialised technology--intensive activity*
4. ***Manufacture of paper*** *and paper products (Ratio: 1.5)*
5. ***Air Transport*** *(Ratio: 1.5)*

Those activities which are ranked highest using the Value Added Specialisation Index are the following (Figure VI.9):

1. *Footwear (Index: 4.1)*
2. *Clothing (Index: 4)*
3. *Air transport (Index: 3)*
4. *Textiles (Index: 2.8)*

The activities covered evolved with different dynamics over the period 2004-2011, as shown by the average annual growth rate in the number of people employed and the number of companies. As such, negative growth rates were observed in Other extractive industries and in the manufacturing industries, notwithstanding the growth seen in the number of companies in the **Beverages** industry (a rise of 161 companies by 2011) which is primarily connected to the **Wine industry** ("Manufacture of wine from grape", a rise of 165 companies).

In contrast, average annual growth rates were positive for the service sector, with the following exceptions: (i) Electricity, gas, steam and air conditioning supply (a drop of 2,788 people employed by 2011); (ii) Construction of buildings (a drop of 18,211 companies and 62,809 people employed); (iii) Food and beverage service activities (a drop of 1,979 companies) and (iv) Security and investigation activities (a drop of 6 companies).

On a positive note, the growth rate in the number of **Telecommunications** companies is quite substantial (22.1% - a rise of 376 companies by 2011). While data is only available for the sub-division of "Wireless telecommunications", this showed a 33.9% rise in employment, or 9,836 people (this data is not included in Figure VI.10). This growth is particularly relevant given the importance of Information and Communications Technologies for economic development.

On this basis, the dynamic performance of the Telecommunications sector and the Beverages industry, linked to the importance of viticulture ("Growing of grapes") for the national economy, stands out, as discussed next (Figure VI.10).

It is worth stating that there are other activities for which no data is available – Financial and insurance activities – or whose available data is not comparable with that shown in Figure VI.9 and Figure VI.10 and as such are not included[1]. Of these, only two have an Employment Specialisation Index for the Portuguese economy, based on the EU26 average, which exceeded 1.3 (Eurostat data for 2010):

1. ***Fishing and aquaculture*** *(Index: 3.35) where the main activity is as follows (data from Eurostat and Statistics Portugal for 2010):*

    a. "Marine fishing, gathering of seaweed and other marine organisms" (89.6% of people employed)

    Fishing and aquaculture grew annually over the period 2004-2011 by an average rate of -0.7% in employment terms and by -0.5% in terms of number of companies (data from Statistics Portugal).

1. Data which are not comparable include all activities in the following Classifications of Economic Activities: Agriculture, forestry and fishing; Public administration and defence; Compulsory social security; Education; Human health and social work activities; Arts, entertainment, sports and recreation activities; Other service activities; Activities of households as employers of domestic personnel; Undifferentiated goods- and services-producing activities of households for own use; Activities of international organisations and other extraterritorial organisations and bodies.

2. ***Crop and animal production**, hunting and related service activities (Index: 2.39), with the following important activities and respective percentages of people employed (data from Eurostat and Statistics Portugal for 2010):*

   a. “Growing of vegetables and melons, roots and tubers” (12.2%)

   b. “Growing of grapes” (10.1%)

   c. “Raising of cattle for milk production” (6.1%)

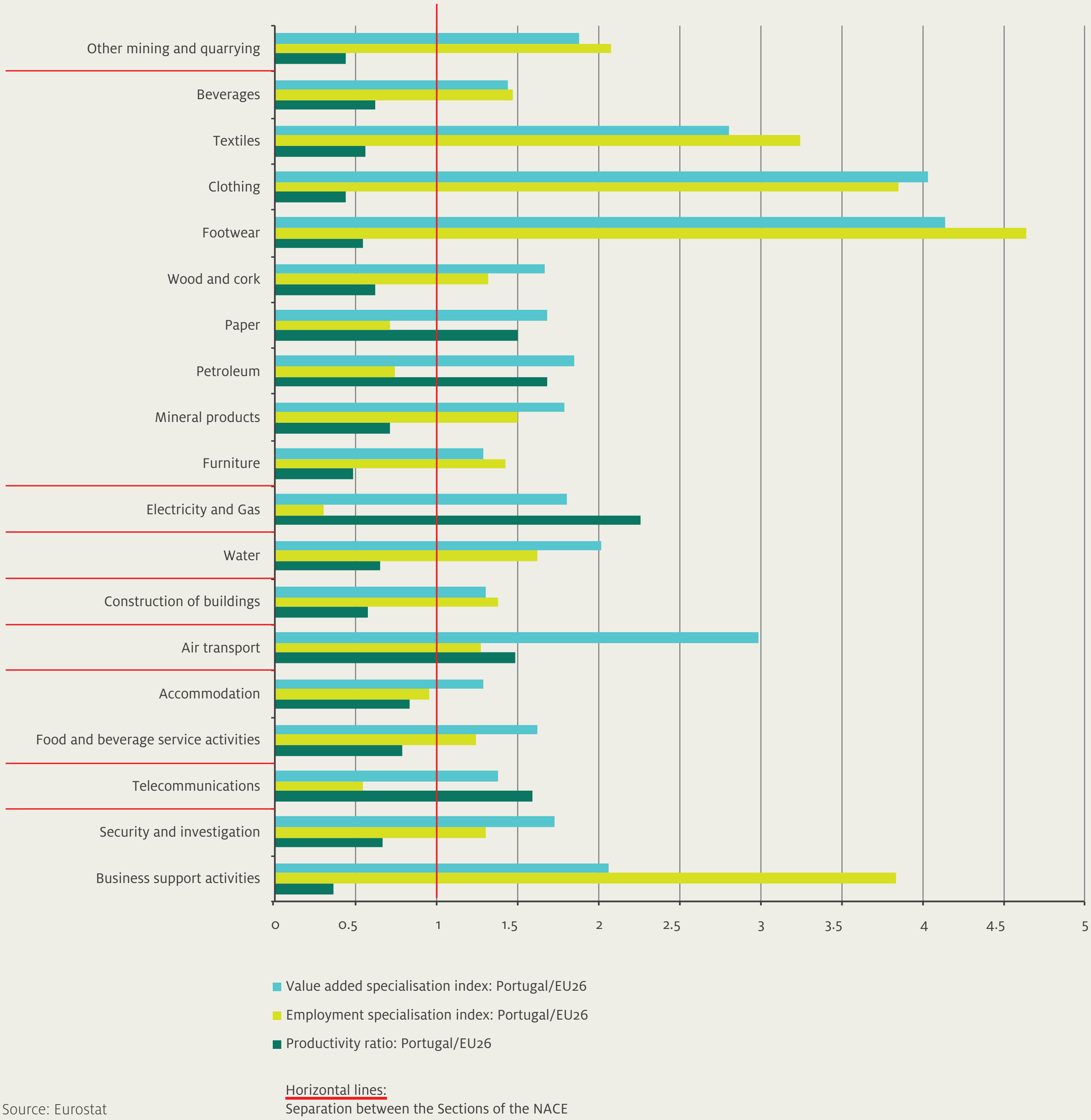
   d. “Raising of poultry” (5.9%)

   Crop and animal production, hunting and related service activities grew annually over the period 2004-2011 by an average rate of 1.2% in terms of employment and by 0.6% in terms of the number of companies. The annual average growth rate of employment in the sub--division of “Growing of vegetables and melons, roots and tubers” is notable (5.2%), as is the growth rate in the number of companies “Growing grapes” (3.1%) (data from Statistics Portugal).

In 2011, the regions of the North and the Centre were the biggest employers of each of the Type I manufacturing industry activities (no data is available for the petroleum industry) – (data from Statistics Portugal).

FIGURE VI.9.

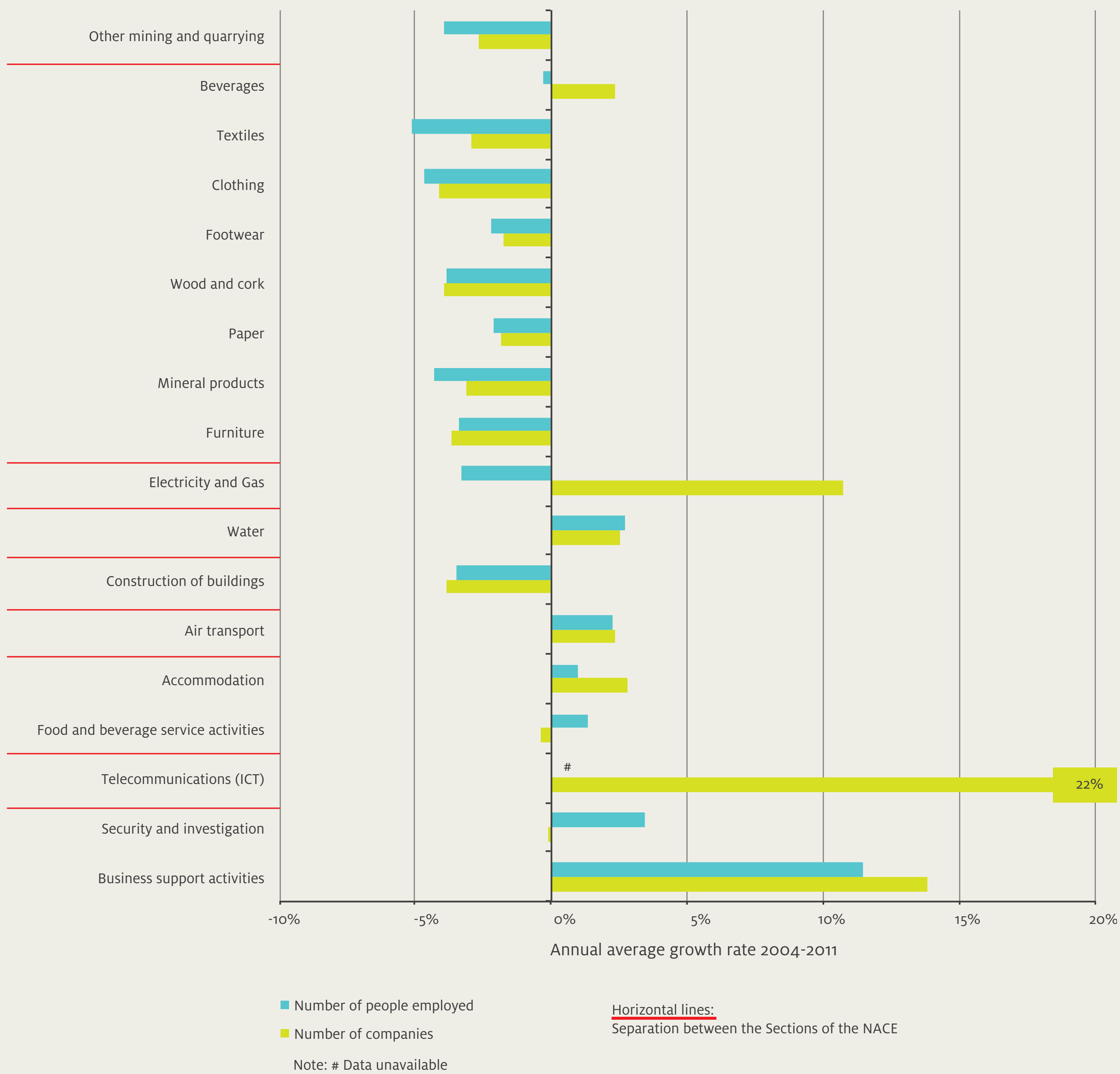
Type I: Internationally specialised activities – Specialisation indices and productivity ratio, 2010



Source: Eurostat

FIGURE VI.10.

Type I: Internationally specialised activities – Growth rates (people employed and number of companies), 2004-2011



Source: Eurostat

There are 31 Type II economic activities – internationally specialised manufacturing activities of the Portuguese economy, of low or medium-low technological intensity and relatively low productivity (4-digit NACE) (Figure VI.11 and Figure VI.12).These 31 activities fall into the following 10 different 2-digit NACE codes (the activities are grouped thematically):

Type II:
Internationally specialised manufacturing activities of low or medium-low technological intensity and low productivity

Food products and Beverages

- Manufacture of food products ("Processing and preserving of poultry meat"; "Processing and preserving of fish, crustaceans and molluscs"; "Manufacture of bakery products"; "Manufacture of prepared feeds for farm animals")
- Manufacture of beverages ("Manufacture of wine from grape")

Textiles, Clothing and Footwear

- Manufacture of textiles, with six different NACE classes (4-digits)
- Manufacture of clothing, with five different NACE classes (4-digits)
- Manufacture of leather and related products, with two different NACE classes (4-digits)

Non-metallic mineral products, particularly Glass and Ceramics

- Manufacture of other non-metallic mineral products ("Shaping and processing of flat glass"; "Manufacture of bricks, tiles and construction products, in baked clay"; "Manufacture of ceramic household and ornamental articles" – main activity; "Manufacture of mortars"; "Cutting, shaping and finishing of stone")

Metal products, such as doors, windows, tanks, cutlery and moulds

- Manufacture of fabricated metal products, except machinery and equipment ("Manufacture of doors and windows of metal"; "Manufacture of central heating radiators and boilers"; "Manufacture of cutlery"; "Manufacture of tools" – including the manufacture of metal moulds)

Forestry based products, particularly Cork and Furniture

- Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials ("Manufacture of assembled parquet floors")
- Manufacture of furniture ("Manufacture of mattresses"; Manufacture of furniture, excluding office, commercial and kitchen furniture)

Media and Print

- Printing and reproduction of recorded media ("Pre-press and pre-media services")

Type II activities are characterised by having a large spread of the Portugal/EU26 Productivity Ratio. The activities with the lowest productivity are the following: (i) Manufacture of various types of clothing; (ii) Manufacture of furniture (excluding office/commercial/kitchen); (iii) "Manufacture of bricks, tiles and construction products, in baked clay"; (iv) "Manufacture of doors and windows of metal"; (v) "Manufacture of bakery products"; and (vi) "Manufacture of footwear".

Those activities with the highest productivity are: (i) "Manufacture of assembled parquet floors"; (ii) "Manufacture of central heating radiators and boilers"; (iii) "Manufacture of wine from grape"; (iv) "Tanning and dressing of leather; dressing and dyeing of fur"; (v) "Manufacture of flat glass"; and (vi) "Manufacture of ceramic household and ornamental articles".

The following activities are of interest due to the fact that they are ranked top in both the Value Added and the Employment Specialisation Indices:

i. "Manufacture of cordage, rope, twine and netting";

ii. "Manufacture of ceramic household and ornamental articles";

iii. "Manufacture of footwear";

iv. "Manufacture of knitted and crocheted fabrics";

v. "Manufacture of outerwear" (except leather clothes and workwear).

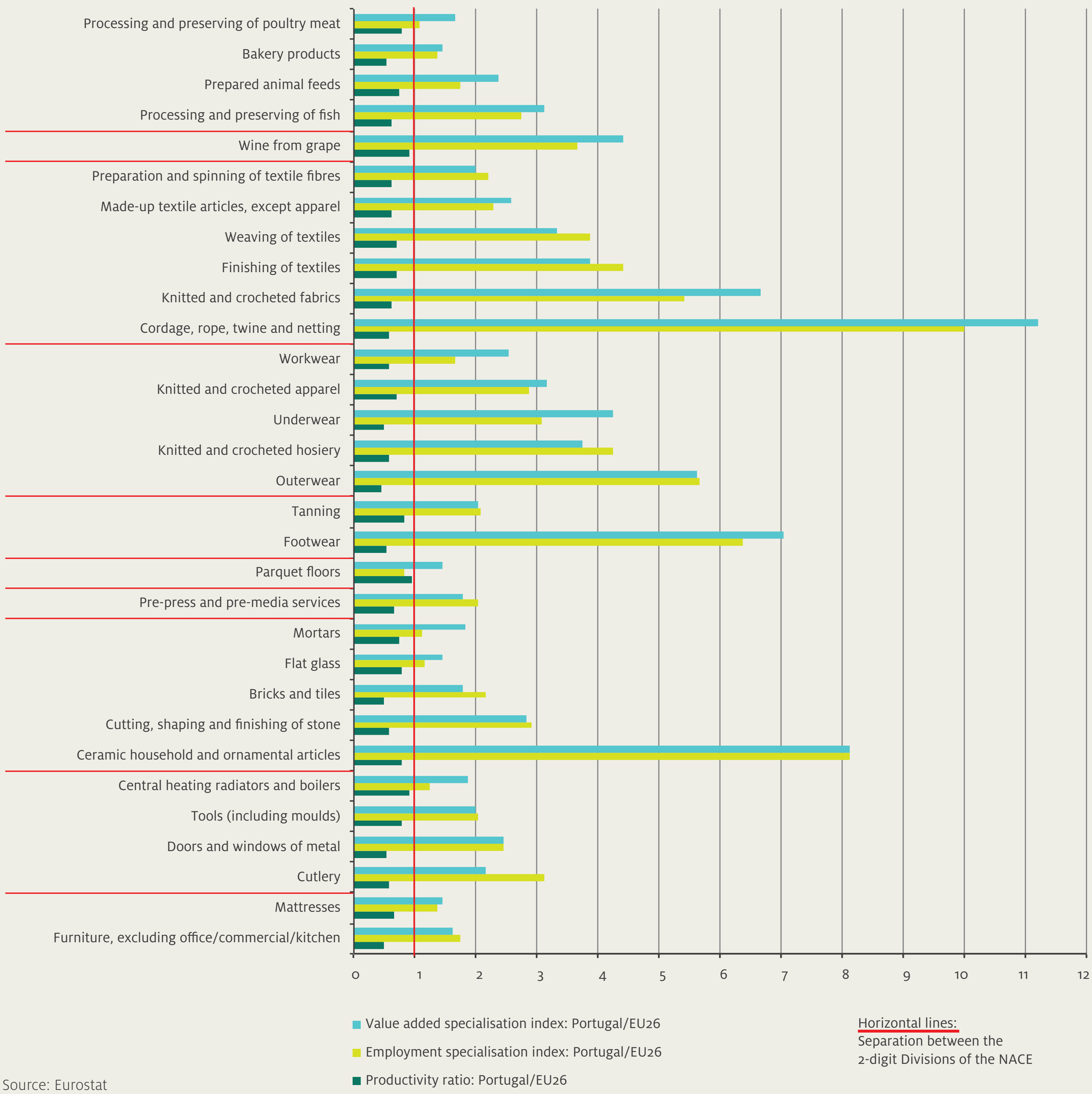
Most of the Type II associated industries have a negative annual average growth rate in the number of companies over the 2004-2011 period, for all activities. Those which did manage a positive growth rate include: (i) "Manufacture of wine from grape" (a rise of 165 companies by 2011); (ii) "Processing and preserving of fish, crustaceans and molluscs" (another 33 companies), (iii) "Manufacture of mortars" (1 additional company), and (iv) "Manufacture of central heating radiators and boilers" (1 additional company) (Figure VI.12).

The annual average growth rate for the number of people employed, over the period 2004-2011, was for the most part negative. Only three stand out in terms of growth: (i) "Processing and preserving of fish, crustaceans and molluscs" (a rise of 1128 people by 2011); (ii) "Processing and preserving of poultry meat" (a rise of 160); and (iii) "Manufacture of bakery products" (a rise of 534) (Figure VI.12).

On this basis, the **Wine industry** ("Manufacture of wine from grape") and the "Processing and **preserving of fish**, crustaceans and molluscs" stand out for their dynamism and entrepreneurship. This last activity was also that which experienced the largest increase both in the number of people employed and in the annual average growth rate of this number.

FIGURE VI.11.

Type II: Manufacturing industry activities in the Portuguese economy – Specialisation indices and productivity ratio (productivity ratio < 1), 2010



Source: Eurostat

FIGURE VI.12.

Type II: Manufacturing industry activities in the Portuguese economy – Growth rates (people employed and number of companies), 2004-2011

Source: Eurostat

Type III:
Internationally specialised manufacturing activities of low or medium-low technological intensity and high productivity

Type III activities are internationally specialised manufacturing activities of the Portuguese economy, of low or medium-low technological intensity and relatively high productivity (4-digit NACE) (Figure VI.13 and Figure VI.14).

There are 16 Type III activities, falling into 9 different 2-digit NACE codes (the activities are grouped thematically):

Food products and beverages

- Manufacture of food products ("Operation of dairies and cheese making"; "Processing of tea and coffee")
- Manufacture of beverages ("Manufacture of beer")

Non-metallic mineral products, particularly glass and ceramics

- Manufacture of other non-metallic mineral products ("Manufacture of hollow glass"; "Manufacture of ceramic tiles and flags"; "Manufacture of ceramic sanitary fixtures" - main activity; "Manufacture of cement"; "Manufacture of lime and plaster")

Forestry based products, particularly paper, cork and furniture

- Manufacture of paper and paper products ("Manufacture of pulp" - main activity; "Manufacture of paper and paperboard")
- Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials ("Manufacture of articles of cork"; Manufacture of products of wood, straw and plaiting materials, except veneer sheets and wood based panels, parquet flooring, builder's carpentry and wooden containers)

Fabricated metal products

- Manufacture of fabricated metal products, except machinery and equipment ("Manufacture of steam generators, except central heating hot water boilers")

Petroleum products

- Manufacture of coke and refined petroleum products ("Manufacture of coke and refined petroleum products")

Rubber and plastics

- Manufacture of rubber and plastic products ("Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres")

Repair of machinery and equipment

- Repair and installation of machinery and equipment ("Repair and maintenance of ships and boats")

The following activities stand out as being the most productive: (i) “Manufacture of paper and paper products”; (ii) “Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres”; (iii) “Manufacture of coke and refined petroleum products”; (iv) “Manufacture of hollow glass”; and (v) “Manufacture of pulp”.

The industries which are ranked top according to the Value Added Specialisation Index are:

i. “Manufacture of **pulp**”;

ii. “Manufacture of coke and refined **petroleum** products”;

iii. “Manufacture of **ceramic** sanitary fixtures”;

iv. Manufacture of articles of **cork**”;

v. “Manufacture of hollow **glass**”.

Portugal is specialised in all of the above activities, except for the “Manufacture of hollow glass”, as identified by the Employment Specialisation Index.

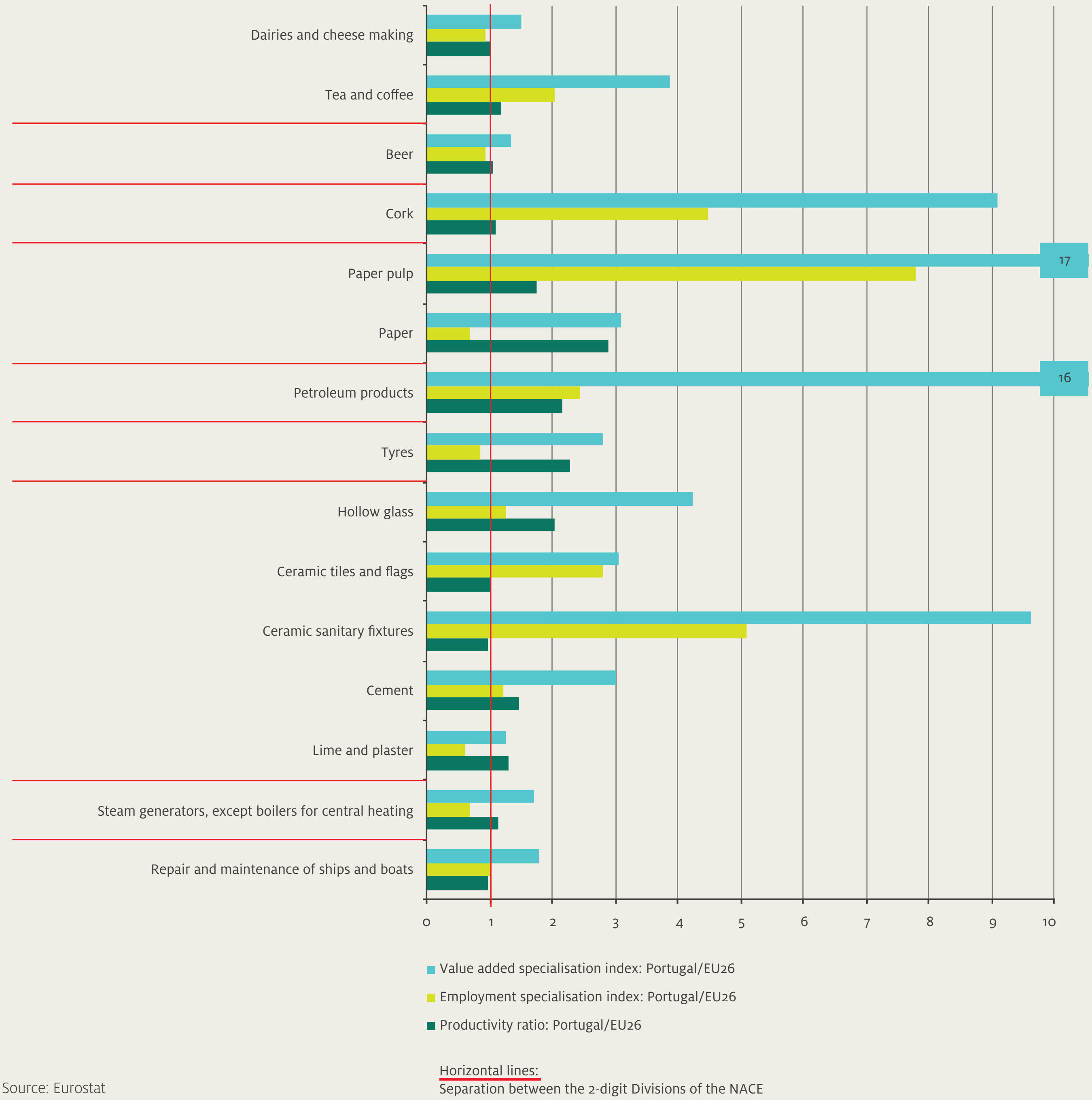
The average annual growth rate in the number of companies over the period 2004-2011 was in general negative. There were only five activities where it was positive: (i) “Manufacture of coke and refined petroleum products” (8 more companies by 2011); (ii) “Manufacture of pulp” (another 5 companies); (iii) “Manufacture of beer” (another 3 companies); (iv) “Manufacture of cement” (another 2 companies); and (v) “Repair and maintenance of ships and boats” (another 41 companies) (Figure VI.14).

On the other hand, there were only three activities with a positive average annual rate of growth in the number of people employed over the period 2004-2011: (i) “Processing of tea and coffee” (another 1428 people by 2011); (ii) “Manufacture of lime and plaster” (another 28); and (iii) “Repair and maintenance of ships and boats” (another 5). Data was not available for the number of people employed in the “Manufacture of coke and refined petroleum products” in 2004 (Figure VI.14).

On this basis, it should be noted the dynamism of the **“Processing of tea and coffee”** industry, along with the general lack of growth in the number of companies and the number of people employed in Type III activities.

FIGURE VI.13.

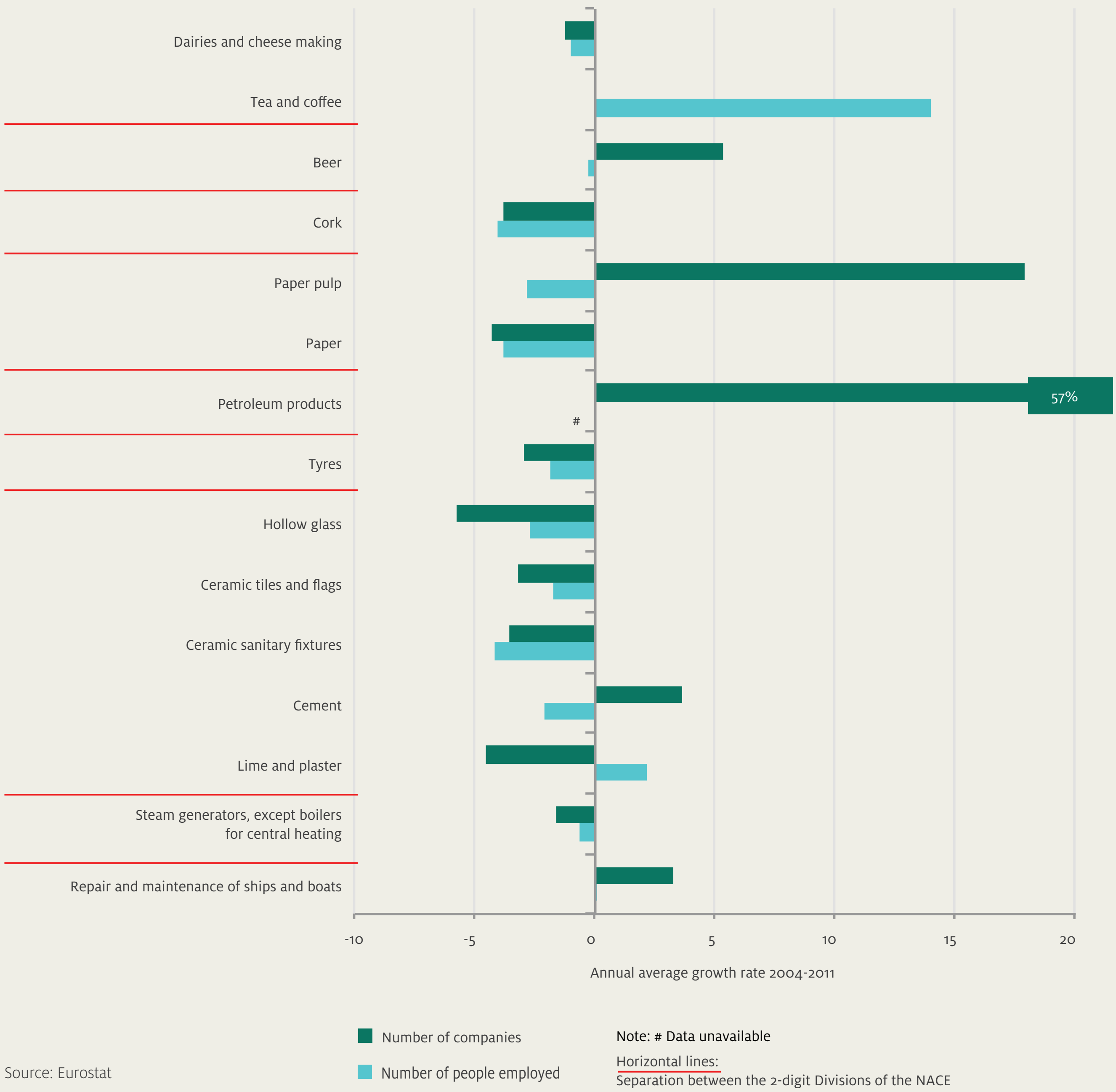
Type III: Manufacturing industry activities in the Portuguese economy – Specialisation indices and productivity ratio (productivity ratio > 1), 2010



Source: Eurostat

FIGURE VI.14.

Type III: Manufacturing industry activities in the Portuguese economy – Growth rates (people employed and number of companies) , 2004-2011



Note: # Data unavailable

Horizontal lines:
Separation between the 2-digit Divisions of the NACE

Source: Eurostat

Type IV activities are internationally specialised manufacturing and service sector activities, whose 2-digit NACE codes refer to technology-intensive activities (Figure VI.15 and Figure VI.16).

Type IV:
Internationally specialised manufacturing and service sector activities intensive in technology

There are 19 Type IV activities (9 from manufacturing and 3 from services), which fall into the following 7 different 2-digit NACE codes (the activities are grouped thematically):

Chemical industry

- Manufacture of chemicals and chemical products ("Manufacture of industrial gases"; "Manufacture of paints, varnishes and similar coatings, printing ink and mastics")

Manufacture of electronic, electrical and transportation equipment, particularly that associated with the automotive industry

- Manufacture of computer, electronic and optical products ("Manufacture of consumer electronics")

- Manufacture of electrical equipment ("Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus"; "Manufacture of other electronic and electric wires and cables" – except fibre optic cables; "Manufacture of non-electric domestic appliances")

- Manufacture of motor vehicles, trailers and semi-trailers ("Manufacture of electrical and electronic equipment for motor vehicles"; "Manufacture of other parts and accessories for motor vehicles")

- Manufacture of other transport equipment ("Manufacture of bicycles and invalid carriages")

Information and Communication Technologies (ICT)

- Telecommunications ("Wired telecommunications activities"; "Wireless telecommunications activities")

Consulting, scientific and technical activities

- Scientific research and development ("Research and experimental development on social sciences and humanities")

Only five out of all these activities have a Portugal/EU26 Productivity Ratio above 1, with three coming from manufacturing and two from the service sector:

i. "Manufacture of **electric motors**, generators, transformers and electricity distribution and control apparatus";

ii. "Manufacture of non-electric domestic **appliances**";

iii. "Manufacture of industrial **gases**";

iv. "Wireless **telecommunications** activities";

v. "Wired **telecommunications** activities".

The Manufacture of consumer electronics is the activity with the highest Employment Specialisation Index (Figure VI.16).

As with the other types, the majority of activities within the manufacturing sector experienced a negative average annual growth rate in the number of companies over the period 2004-2011. However, telecommunications services stand out with significantly high growth rates: (i) "Wired telecommunications activities" (another 141 companies by 2011), and (ii) "Wireless telecommunications activities" (another 29 companies by 2011) (Figure VI.16).

There were only four activities that had a positive annual average rate of growth of the number of people employed over the period 2004-2011: (i) "Manufacture of other electronic and electric wires and cables, except fibre optic cables" (another 1,482 people by 2011), (ii) "Manufacture of industrial gases" (another 215), (iii) "Manufacture of bicycles and invalid carriages" (another 249) and (iv) "Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus" (another 762) (Figure VI.16).

Overall, these four activities experienced strong growth in the number of people employed, while the technology-intensive area of telecommunications services showed very positive entrepreneurial dynamics.

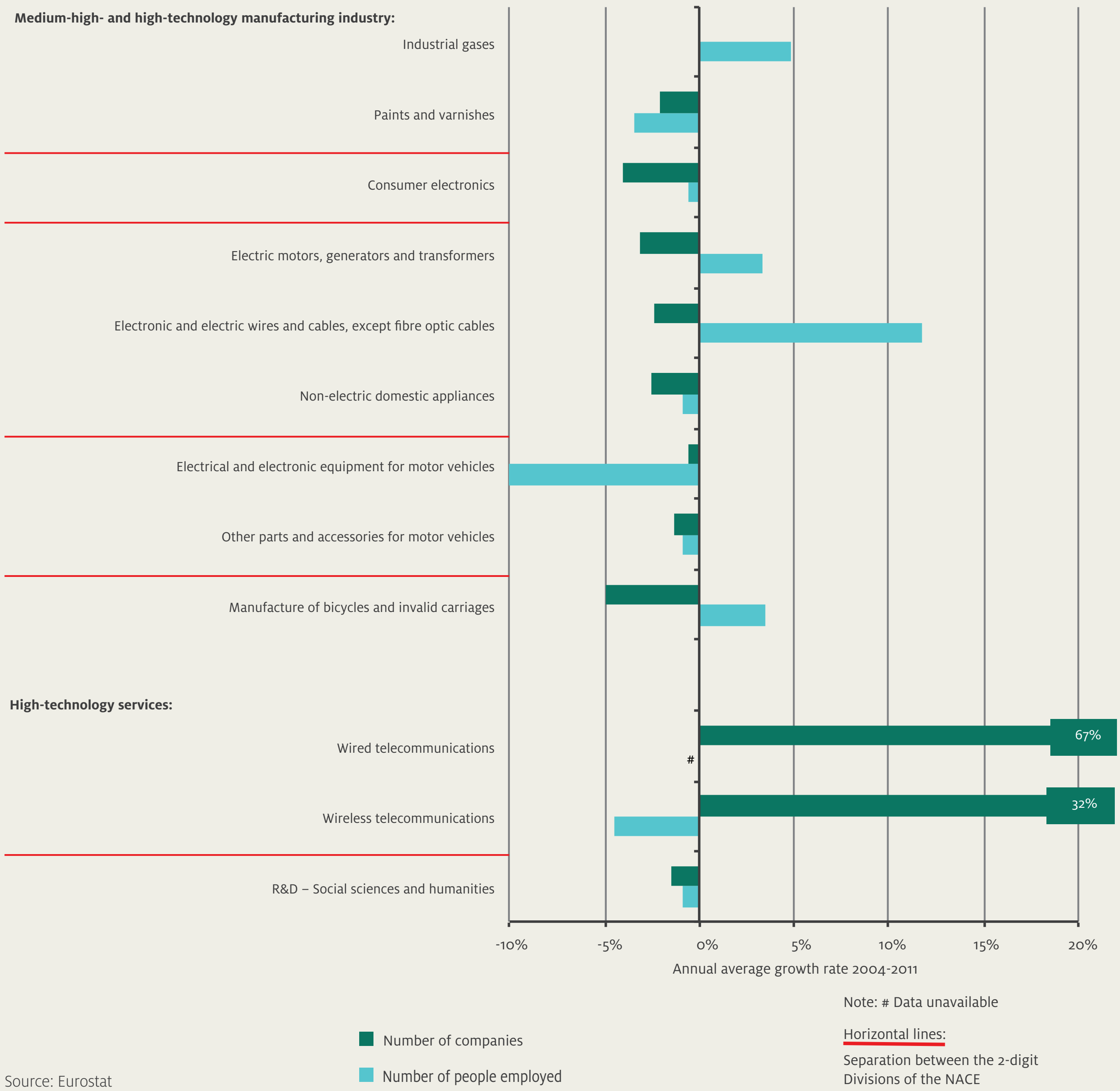
FIGURE VI.15.

Type IV: Manufacturing and service sector activities in the Portuguese economy whose 2-digit NACE codes refer to technology-intensive activities – Specialisation indices and productivity ratio, 2010

Source: Eurostat

FIGURE VI.16.

Type IV: Manufacturing and service sector activities in the portuguese economy whose 2-digit NACE codes reflect to technology – intensive activities – growth rates (people employed and number of companies), 2004-2011



Source: Eurostat

Types of specialisation profiles and clusters of economic activities

The internationally specialised activities of the manufacturing industry (NACE 2-digit divisions) as identified by the Value Added Specialisation Index are all of Type II and Type III:

Type II

- **Textiles**
- **Clothing**
- **Footwear**
- **Furniture and Mattresses**
- **Media and print**

Types II and III

- **Food products,** particularly preserving of fish (Type II), Dairies and cheese making, tea and coffee processing (Type III)
- **Beverages**, particularly Wine (Type II) and Beer (Type III)
- Non-metallic **mineral products**, particularly Cutting, shaping and finishing of stone (Type II), Glass and Ceramics (Types II and III) and Cement (Type III)
- **Wood and cork**, particularly Parquet flooring (Type II) and Cork (Type III)
- **Metal products**, such as doors, windows, tanks, cutlery and moulds (Type II) and steam generators (Type III)

Type III

- **Paper**
- **Petroleum products**

The scientific specialisation profile of Portugal may enhance the resilience of these low and medium-low technology-intensive activities. In point of fact, comparing the scientific fields where Portugal is most specialised (Chapter 4) with the activities here shows some clear areas of overlap:

i. The Food products cluster: the fields of Food Science and Technology and of Agronomic Engineering;

ii. Textiles cluster: the field of Materials Science – Textiles;

iii. Ceramics cluster: the field of Materials Science – Ceramics;

iv. Paper, Furniture, Wood, and Cork clusters (forestry based industries): the fields of Materials Science – Paper and Wood and of Forestry and Logging.

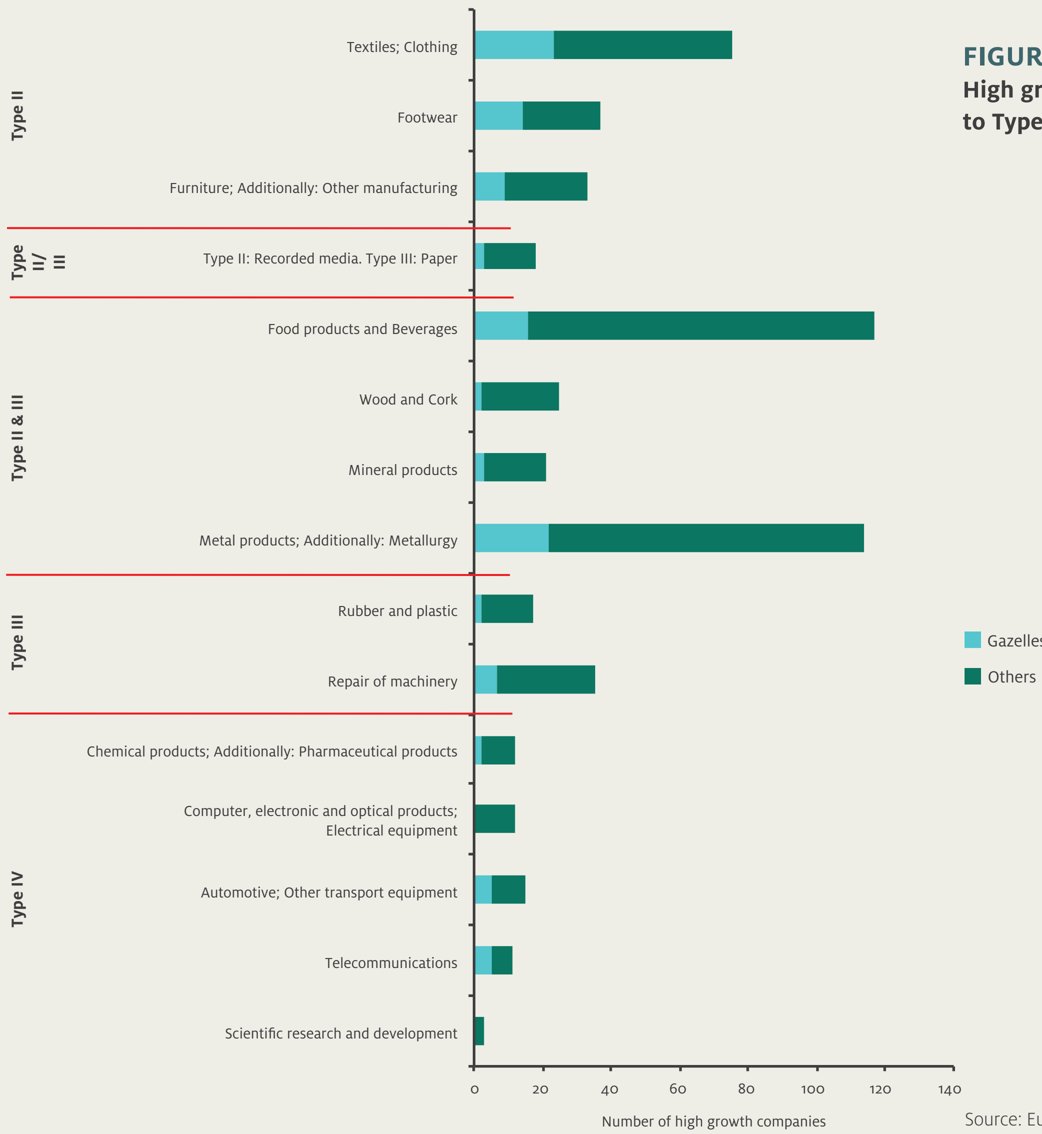
This scientific specialisation benefits industry in several ways. Examples of these benefits include: training offered by universities in areas associated with the clusters; joint applications for European funding of R&D projects; and other types of partnerships, as identified in Chapter 5, which involve Universities, Technology Centres and Industries, including among others, Cork, Paper, Beverages, Food Products, Footwear and Moulds. Moreover, the manufacturing industry generally benefits from the Portuguese scientific specialisation that exists in more cross-cutting areas, such as (i) Materials Science – Composites; (ii) Materials Science – Biomaterials; (iii) Chemical Engineering; (iv) Manufacturing Engineering; (v) Industrial Engineering; and (vi) Operations Research and Management Science, among others.

The resilience of the activities that were identified at the beginning of this section can also benefit from the relationships between the constituent competitive sub-activities. It is the case that each of the 2-digit NACE divisions identified has at least two 4-digit NACE classes where the Portuguese economy exhibits international specialisation (Value Added Specialisation Index), with the only exceptions being Media and Print and Petroleum Products. The sub-activities of each 2-digit NACE division reveal a gamut of productivity performance, with examples both above and below the average for the other EU countries, with the notable exception of the Textiles, Clothing and Footwear sector where the productivity is consistently below average. However, it is noteworthy that this sector is composed of a very large number of companies (around 16,000 by 2011) and very diverse levels of productivity. Many of these companies display high levels of productivity, technological intensity and qualified labour, which has been a contributing factor towards the significant resilience of the sector in the face of intensifying competition from Asia, Eastern Europe and Brazil, among others (see, for example, Corte-Real, 2008, for a detailed analysis of the changing competitiveness factors and international framework of the Portuguese footwear industry). Textiles, Clothing and Footwear is the industrial sector employing most people in Portugal and enjoys the highest ranking in the international Value Added Specialisation Index (Figure VI.9). Compared to other activities, it also has a significant number of high-growth companies, particularly gazelles (companies started less than five years ago) (Figure VI.17 – data from 2009). As previously stated, the fact that both the definition of technology-intensive activities and the productivity calculation are based on averages hides these resilience and industrial upgrading factors which are particularly valued by the Porter models (1990, 1994).

This resilience also occurs in the other clusters of low and medium-low technological intensity, where activities exist with higher productivity than the European average and significant employment levels. The Food Products and Beverages industries stand out, not only due to the large number of high-growth companies compared to the other activities (Figure VI.17 – data from 2009), but also because between 2004 and 2011 the Food Products and the Beverages sectors raised the number of people employed by 146 and 161 respectively, in the midst of adverse international conditions.

The performance of the following industries stands out: Processing and Preserving of Fish (supported by strong activity in the area of Marine Fishing); Dairies and Cheese Making; and Processing of Tea and Coffee. The most notable activities in the Beverages industry include the "Manufacture of wine from grape" (strongly supported by national activities in the viticulture, glass and cork industries) and the "Manufacture of beer" (Figure VI.12 and Figure VI.14). It is also worth noting the relatively large number of high growth companies and gazelles in industries associated with metal products and metallurgy (Figure VI.17).

FIGURE VI.17.
High growth companies in Type II to Type IV activities, 2009



Source: Eurostat

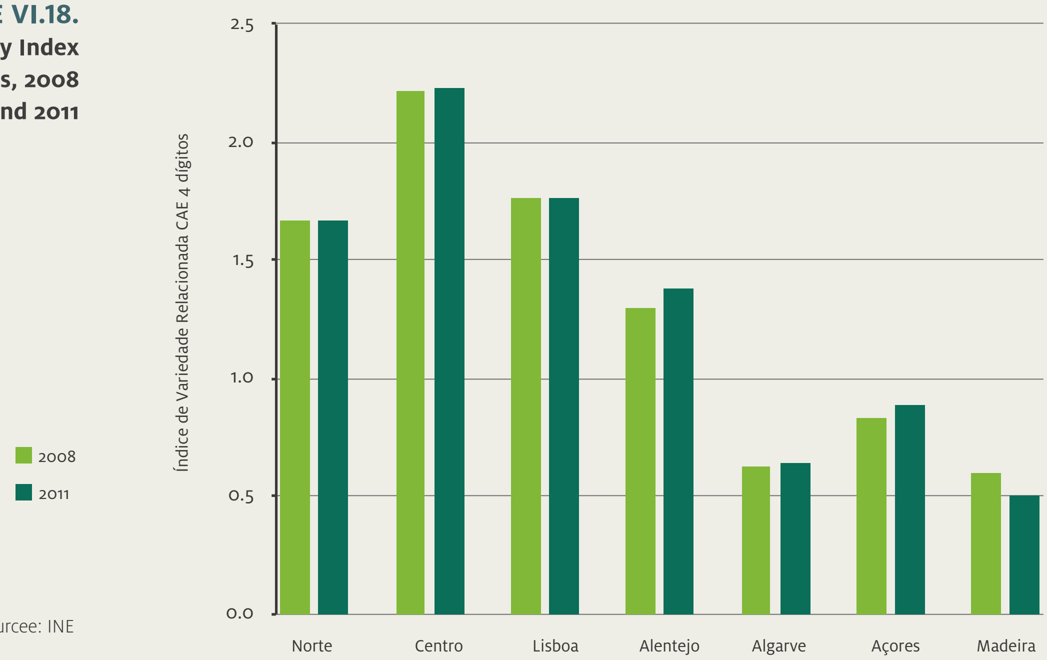
This backdrop provides significant potential for the exploitation of knowledge spillovers between sub-activities – 4-digit NACE classes – as these happen primarily among companies that sell related products (Frenken et al., 2007: p689). While the profile of the Portuguese economy is clearly specialised in low or medium-low technology-intensive activities, their significant size, resilience and the existence of a large variety of related sub-activities, with a wide range of levels of performance, constitute an important window of opportunity for the exploitation of sizable economies both of scale and scope, as well as various types of synergies and positive externalities (knowledge spillovers) associated with the regional levels of related variety and the geographical concentration of the economic activities.

One of the most interesting aspects of this potential relates to technology-intensive manufacturing and service sectors sub-activities. The Portuguese economy is internationally specialised in only one technology-intensive 2 digit NACE division, namely that of Telecommunications. However, various sub-activities (4-digits) do exist where this is also the case (Figure VI.15 – Type IV). The analysis in the previous section shows that various sub-activities have productivity levels above the European average and high average annual growth rates over the period 2004-2001, both in terms of the number of companies and the number of people employed (Figure VI.16 – Type IV).

The Related Variety Index is designed to measure the variety of the sub-activities (4-digits) of each 2-digit NACE division, taking into account the different relative levels of employment (Frenken et al., 2007). In 2011, the Centre had the highest Index level in the country, followed by Lisbon, the North and the Alentejo, which shows an upward trend. The Centre is able to achieve this position in large part due to the clusters in the areas of Food products, Glass and Ceramics and Metal products, while the North benefits form clusters in the areas of Textiles, Clothing, Food products and Metal products (Figure VI.18).

The potential benefits from related variety are not only restricted to the sub-activities of the 2-digit NACE divisions. Indeed, it is the case that important links exist between the 2-digit NACE divisions – (i) Food products and Beverages; (ii) Forestry based products; (iii) Textiles, Clothing and Footwear; (iv) Electronic, electrical and transport equipment, particularly that associated with the automotive sector – and, most importantly, bridging activities with lower and higher technological intensity, thus offering a significant potential for leveraging and economic gro-

FIGURE VI.18.
Regional Related Variety Index using 4-digit NACE classes, 2008 and 2011



Sourcee: INE

wth. However, increased variety does not only indicate significant potential, but also suggests that regions become more resilient when faced with external shocks that affect some activities more than others (European Commission, 2012; Frenken et al., 2007: p689). The Diversity Index (refered to by Frenken et al., 2007, as the Unrelated Variety Index) seeks to measure the diversity at this level of disaggregation, while not, however, taking into account the possible relationships between the 2-digit NACE divisions. Lisbon, the Centre and the North are the regions which have the most diversified profile of different 2-digit NACE activities, followed by the Alentejo, the Algarve, Madeira and the Azores (Figure VI.19).

It must be stated that these two indices were constructed using all the manufacturing activities and only high-technology services, in-keeping with the analysis in this chapter; these activities are considered to be more likely to generate knowledge spillovers, innovation and sustained economic growth.

The regional indices of Related Variety and Diversity indicate that the North, Centre and Lisbon regions have a significant advantage. As it stands, these regions are particularly well placed to benefit from agglomeration economies, resulting from the regional concentration of a significant number of economic activities and sub-activities. In 2011, the North and Centre had the highest levels of employment intensity, when compared to the EU26 average, in each activity of low and medium-low technological intensity identified at the beginning of this section. The North had the highest ratio for all the activities, with the exception of Mineral products (where the Centre had the highest concentration of Ceramic and Glass industry) and Media and Print (highest concentration in Lisbon). Ratios for the Food products industry in the North and the Centre were similar, as they were for the Petroleum Products industry in the North and the Alentejo (data from Eurostat).

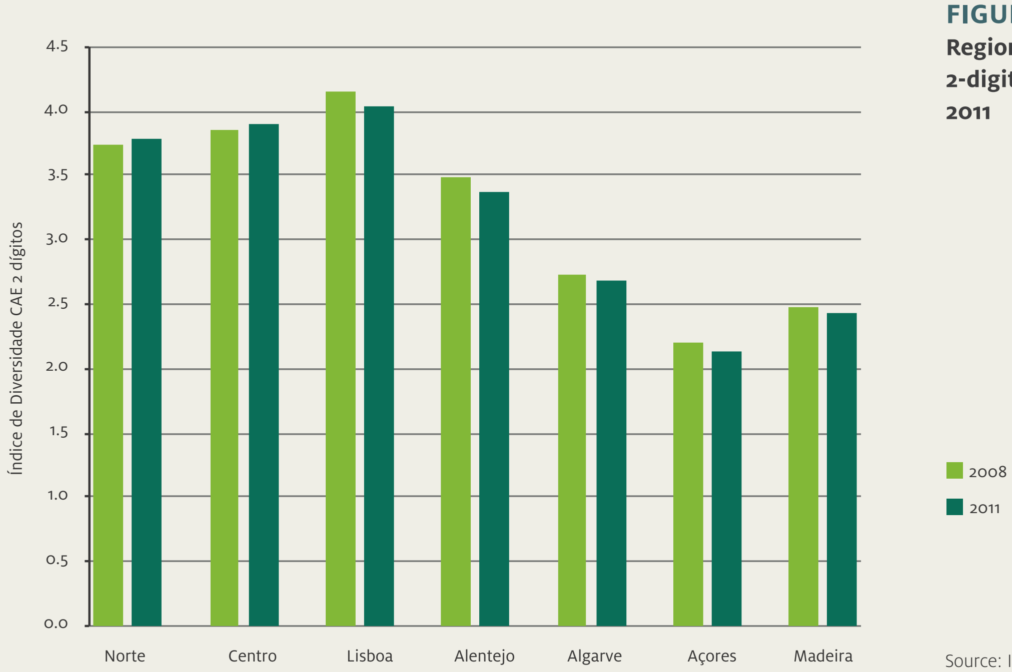


FIGURE VI.19.
Regional Diversity Index using 2-digit NACE divisions, 2008 and 2011

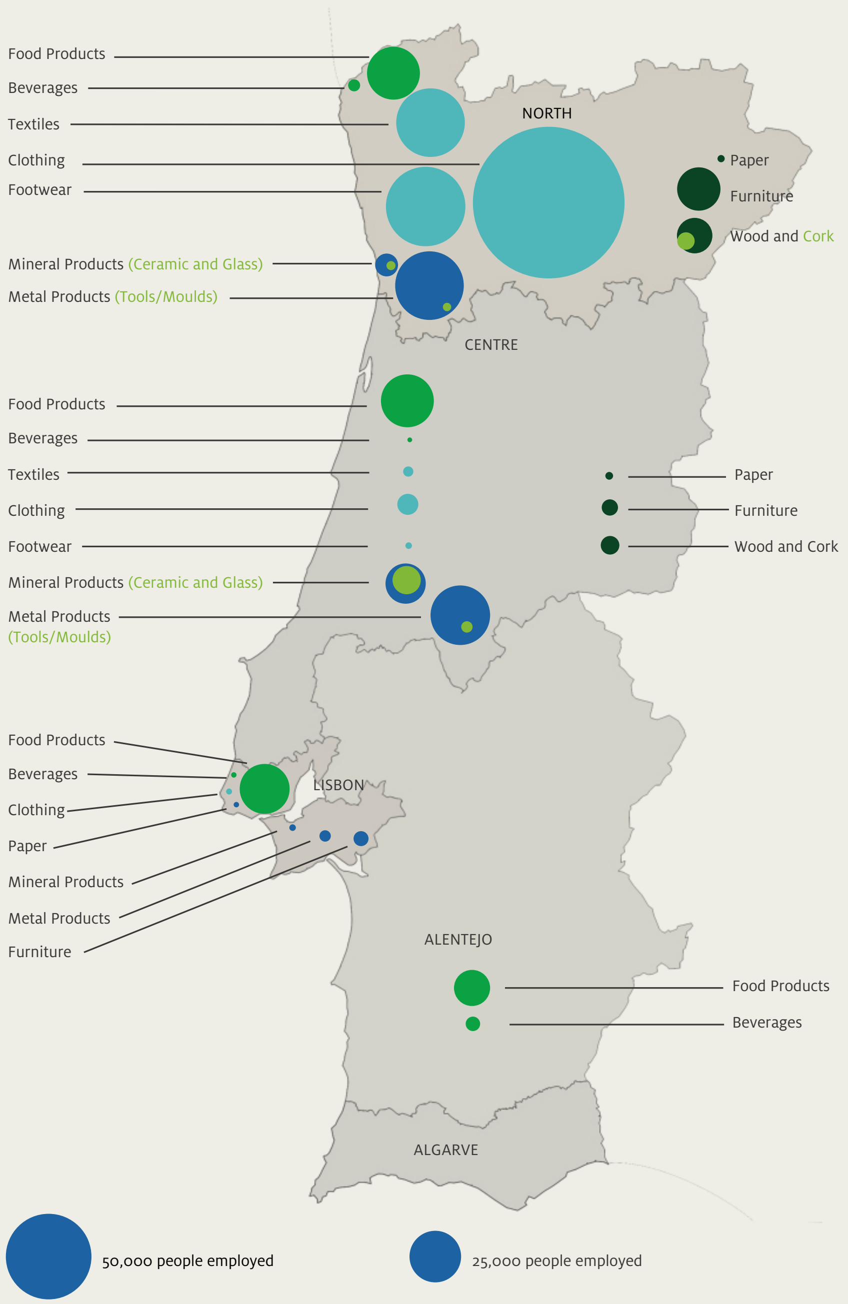
Source: INE

Figure VI.20 shows a regional map of the internationally specialised, manufacturing industry activities of low or medium-low technological intensity (using Value Added). The North clearly stands out in terms of the number of people employed. The Food industry is particularly important in Lisbon and the Alentejo, while Beverages are very significant in the Alentejo. The Azores, Madeira and the Algarve have no activities that appear on the map, given that they have no activities with an employment intensity over 0.06, considered here to be the minimum level for identifying significant critical mass (employment intensity for an economic activity is the ratio between the employment level for a region and the average value for the other 26 countries in the European Union – data from Eurostat).

Activities involving technology-intensive manufacturing and service sector activities are more highly concentrated in Lisbon, where IT, Telecommunications, Automotive and Pharmaceuticals stand out (Figure VI.21). In the North, Machinery and Equipment, Automotive (particularly Components) and IT are especially notable. As a result of the Type IV analysis, it has been seen that various activities exist with high growth that have important connections to various national clusters and have the potential to play a significant role in the economic development of the country.

The Algarve exhibits relatively low employment intensity in the areas of manufacturing and high-technology services, being as it is a region which is specialised in tourism. The Alentejo, on the other hand, reaches critical mass in various industrial activities, such as Food products and Investment in Research and Development.

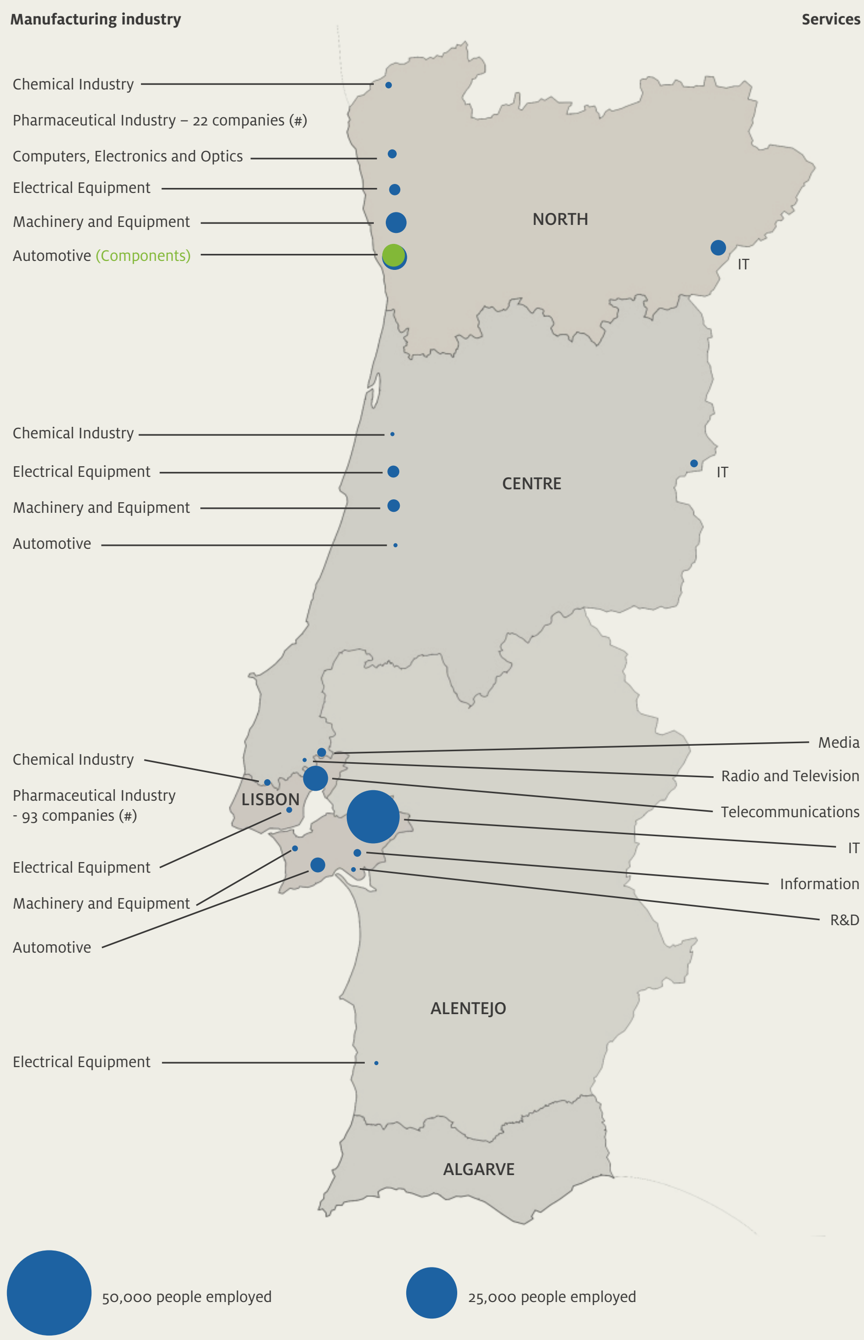
FIGURE VI.20.
Clusters of internationally specialised manufacturing activities in the Portuguese economy, of low and medium-low technological intensity, 2011



Source: Statistics Portugal

Note: Placement on the map is only indicative of the region.

FIGURE VI.21.
Technology-intensive manufacturing and service sector activities in the Portuguese economy – people employed in 2011



Source: Statistics Portugal

Notes: Placement on the map is only indicative of the region.
(#) missing data on the number of people employed

Conclusions

Investment in Research and Development

The percentage of Portuguese companies that invest in in-house Research and Development is similar to the European Union average, with small companies accounting for most of these. Large companies, which tend to be more innovation-intensive, account for the largest share of investment; there are, however, relatively few of these in Portugal.

Business innovation and barriers to innovation

Compared to the European Union average, Portugal has a higher percentage of innovative enterprises engaged in service innovation and process innovation, and a lower percentage of innovative enterprises involved in product innovation and bringing new products or services to market. In this respect, the innovation performance of these enterprises in Portugal compares unfavourably to their European counterparts, as far as bringing new goods and services to market is concerned, that are either new to the market or new only for the enterprise or for both.

The most common innovation activities among innovating enterprises in Portugal include the acquisition of machinery, equipment and software and training for innovation activities, linked to a low level of innovation-intensity. Relative to the European average, there is a significantly higher percentage of enterprises engaged in innovation training activities and a significantly lower percentage involved in (i) carrying out in-house R&D, (ii) bringing innovations to market, and (iii) the acquisition of external knowledge.

The main obstacles to the development of innovation activities are related to the associated costs, funding and financing, as well as market uncertainty and the power of established companies. There is a significantly higher percentage of enterprises in Portugal that are confronted with the main obstacles to innovation than the average for the European Union.

Collaboration on innovation activities, access to information sources and innovations developed autonomously

Portuguese enterprises collaborate less, with other enterprises or institutions, for product and process innovation than the average in the European Union. In particular, those partners that are relatively less sought after in Portugal are the “Universities or other higher education institutions” and the “Consultants, commercial labs, or private R&D institutes”. Collaborations occur more frequently with “Suppliers of equipment, materials, components, or software” and with “Clients or customers”. Innovating companies in Portugal tend to place more importance on information coming from clients or customers than their European counterparts.

Portugal has a greater percentage of enterprises than the European average developing service and process innovations, both autonomously and in cooperation with other enterprises and institutions. However, Portugal’s profile is less innovative with respect to product innovation, either carried out autonomously or in cooperation with other enterprises or institutions.

National and regional economic specialisation profiles compared to other European Union countries

The Portuguese economy can be seen to have a clear international specialisation profile based on activities of low or medium-low technological intensity, dominated by the following clusters: (i) Textiles, Clothing and Footwear; (ii) Food products and Beverages; (iii) Glass and Ceramics; (iv) Forestry based products (Paper, Furniture, Wood and Cork); and (v) Metal Products. These clusters have a significant potential to benefit from sizable economies of scale and scope, as well as positive externalities and synergies (knowledge spillovers) and leverage effects, boosting economic growth. This is strengthened by the following factors:

i. National scientific specialisation in the cluster areas;

ii. Regional concentration of these activities in the North and Centre of the country (high levels of the regional indices for Related Variety and Diversity), with the significant presence of critical masses in employment and technology-intensive activities;

iii. The existence of internationally specialised sub-activities in each 2-digit NACE division which is part of each cluster;

iv. Each 2-digit NACE division, which is part of each cluster, has different sub-activities, which at the same time have productivity levels both above and below the EU26 average, with the exception of Textiles, Clothing and Footwear.

The Textiles, Clothing and Footwear sector is the most specialised in terms of employment and value added, with a highly significant weighting in the Portuguese economy. While the respective sub-activities have productivity below the average of the European Union, the dynamism of the sector has been important, with a significant number of high growth companies and, in particular, gazelles. The sector is characterized by a highly heterogeneous set of companies regarding the levels of productivity, technological intensity and qualifications of the workforce.

The technology-intensive activities, particularly services, are more concentrated in the region of Lisbon and the Tagus Valley. There is a clear specialisation profile associated with the Automotive Industry, including Electronic, Electrical and Transportation equipment, while there are important competitive advantages and the potential for significant growth in the areas of Telecommunications, and the Chemical, Pharmaceutical and IT industries, amongst others, such as Research and security (activities related to security systems); Computers, Electronics and Optics; Media, Radio and Television; and Information. The links between these activities and the more traditional clusters have the ability to play an important role in the development of the country.

7.

Public Policies for Research and Innovation

Introduction

The innovation process results from the transformation of existing information from various sources into useful knowledge, which is then embodied into new or transformed products, processes and services, successfully brought to market. This process is effective when the knowledge networks act as vehicles for collecting and transforming information into output. In this way, a shared culture is created, deepening the systemic relations in the innovation system (Freeman, 1991; 1995).

As previously noted, we define in this work the research and innovation system as a set of components, relationships and attributes. The components are the actors that act on and operationalise the system be they people, organizations, or physical and technological elements, as well as institutions, legislative and statutory regulatory systems and also traditions and culture. The innovation system has different dimensions depending on the emphasis that is placed on delineating the frontier defining the relationships between the components. In this report the national dimension is connected with the regional, in order to formulate a national research and innovation strategy, with a view to mobilising what Furman et al. (2002) call the national innovative capacity providing the basis for the production and commercialisation of the flow of knowledge and innovative technologies.

The national innovative capacity depends on the existing potential of the national innovation infrastructure and its ability to pervade the economy. In addition, it depends on the existence of a favourable climate to innovation and the intensity of the relations between the components, along with the ability to benefit from organised and diverse economies of agglomeration. Just like the national dimension, the regional dimension is based on the network of interactions between the actors, the strength of the institutions, and the capacity to overcome the existing market or system failures (Laranja et al., 2008). Therefore, the public intervention that exists is necessary to solve these failures, helping provide the country with a solid innovative capacity for conducting innovation, either focusing on a regional or national level, or even a combination of the two. In this respect, public intervention consists of adopting a panoply of instruments and political measures that act on the supply-side of the system (production of knowledge, regulation, infrastructure and resources), known as 'technology push', or over the demand-side (strengthening the knowledge exploitation and interactions between producers and users, or through public procurement), known as 'technology pull'.

The previous chapters analysed the way in which knowledge is produced in Portugal and how it is embedded in the system and shaped by the characteristics of the national economy, as well as the way knowledge circulates and enhances the relationships between system components. Finally, an analysis was made of how knowledge is put into use, bringing new products, processes or services to market or improving existing ones. This chapter concludes the analysis of the system, focusing on its structure and governance, as well as on the formulation and implementation of public policy for knowledge, over the period 2000-2012.

The comparison with the benchmark countries, in this chapter, only takes place to contextualise the progress achieved in Portugal towards meeting the targets set for its policy measures, by comparing the evolution of the respective indicators. This choice was made because system structure and public policy approaches are connected with the history, culture and institutional trajectories of each country.

As such, this chapter is organised as follows: Firstly, the institutional trajectories on the basis of the current system configuration and governance model are analysed. Secondly, a brief analysis is made of the rationales used by the national authorities to justify public intervention. The chapter closes by taking stock of progress towards the political objectives set out for the decade as well as the trends in that progress over the period.

The structure of the system and its governance

The institutional trajectories and the structure of the national research and innovation system

The research and innovation system in Portugal has undergone considerable development, as demonstrated in the previous chapters. The research gap with the European Union average is closing and good progress has occurred in the innovation component. International reports produced by the European Union and the OECD have recognised the fact that the gap with the European average has narrowed (European Commission, 2012; OECD, 2012)[1] . The continued growth of the system is rooted in the continued investment in the long--established institutional trajectories.

The characteristics of the national research and innovation system in Portugal reflect the specific path of its evolution (Conceição and Heitor, 2003; Henriques, 2006; Godinho and Simões, 2009). Expansion was centred on the growth of quasi-public organisations which were created and funded by national programmes, frequently adopting the legal status of private Non-Profit Institutions - NPIs (Kastrinos and Romero, 1997; Laranja, 2009) that have populated the space known as the 'intermediary layer' (Rip and Van der Meulen, 1996; Van der Meulen and Rip, 1998). The intermediary layer is the space that bridges the relations between the top levels of policy and funding, and the main pillars of the research performing sectors (Business, Higher Education, and Government). These institutions are for the most part strategically and financially autonomous, and are interwoven with the traditional performing institutions, namely universities, national Laboratories, or companies.

The importance of the intermediary layer is verifiable, for example, by the growth rates of R&D expenditure of the private non-profit sector in Portugal, which clearly show an expansion – between 1982 and 2000 the sector had the highest annual average rate of growth at current prices out of all the performing research sectors (23%)[2]. The creation and expansion of the NPIs was mainly promoted and consolidated by previous Community Support Frameworks (CSF), with a significant component of infrastructure creation, namely through the Operational Programmes CIENCIA and PEDIP of the CSF I (1990-1993), and PRAXIS XXI and PEDIP II from the CSF II (1994-1999). This was in addition to the strategic funding for the centres and institutes of public sector research (Higher Education, Government and NPIs) that received the FCT Label, following international research evaluation, and which are designated FCT research units or associated laboratories. These units and laboratories are currently the primary locus for knowledge production in Portugal, representing 75% of the total national scientific production (FCT/CWTS, 2013). These organisations have, among others, an important intermediation function in the circulation of knowledge, as the analysis in Chapter 5 suggests.

The institutional trajectories, centred on the growth of those hybrid organisations, are visible through the evolution of the structure of the system through time. The three figures below – Figure VII.1, Figure VII.2 and Figure VII.3 - illustrate well that evolution, representing a macro overview of the configuration of the system at three distinct points in time: 1972, 1990

1. http://ec.europa.eu/enterprise/policies/innovation/files/ius-2011_en.pdf. OECD, 2012. Science, Technology and Industry Outlook, OECD, Paris.

2. Quadros_Globais82_031408007vf.xls, accessed at www.oces.mctes.ptwww.oces.mctes.ptwww.oces.mctes.pt, 15-09-2007.

and 2012: (i) the year 1972 was chosen as it is prior to the April 1974 Revolution and reflects the structuration of the system driven by the national effort centred in the nuclear energy programme; (ii) 1990 is an important year of institutional creation, driven by European structural funds with the implementation of the first Community Support Framework (1989-1993), with direct investment both in research and development (R&D) and technology and, (iii) 2012 represents the state of the play of the system.

At the beginning of the 1970s[3], research in Portugal accounted for only 0.37% of the Gross National Product and was mainly concentrated on the national Laboratories (Figure VII.1). The national Laboratories, which came into being at the end of the 19th century, structured research in Portugal, as elsewhere, according to the national missions: public health, hygiene and tropical medicine; prospection and mapping of natural resources; delineation of the overseas territories borders; mineral exploitation; and industrial technologies. In contrast to the majority of developed countries, research by the business sector in Portugal was minimal, leading to an oversized Government sector. At that time, the latter accounted for almost half of all R&D expenditure (45%) and almost two thirds of all researchers (4,725 FTE R&D personnel, representing 61.7%). The Private Non-profit sector was already relevant, with R&D expenditure totalling 15.3% of the total. This sector benefitted from the important contribution of the newly created Instituto Gulbenkian de Ciência, in spite of having limited R&D personnel (240 FTE staff).

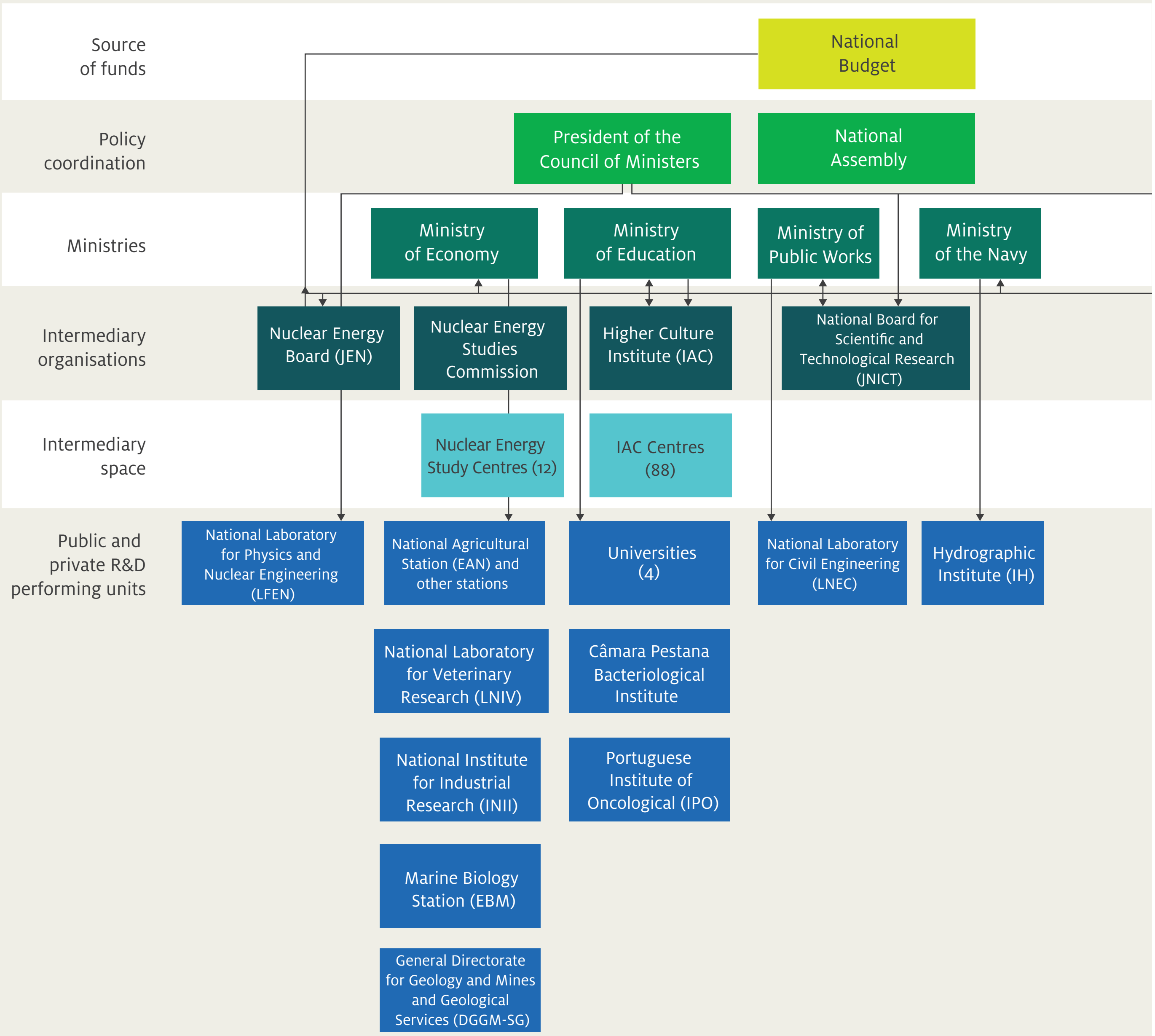
Like in the other Southern European countries, the Higher Education sector in Portugal was of limited importance in the system (14.6% of R&D expenditure and 1,401 FTE personnel, representing 18.3%). The four universities of the time, located in Lisbon, Coimbra and Porto, had limited research activity. This fact is explained by the organisation of university research around the research centres (88 study centres) of the Institute for Higher Culture, and the nuclear energy study centres (14), created and funded directly by the Nuclear Energy Board. Although these centres were located on university campuses and buildings, they had financial and scientific autonomy from their university host. Many of the R&D units and associated laboratories that are nowadays supported by the FCT can trace back their origins to these centres.

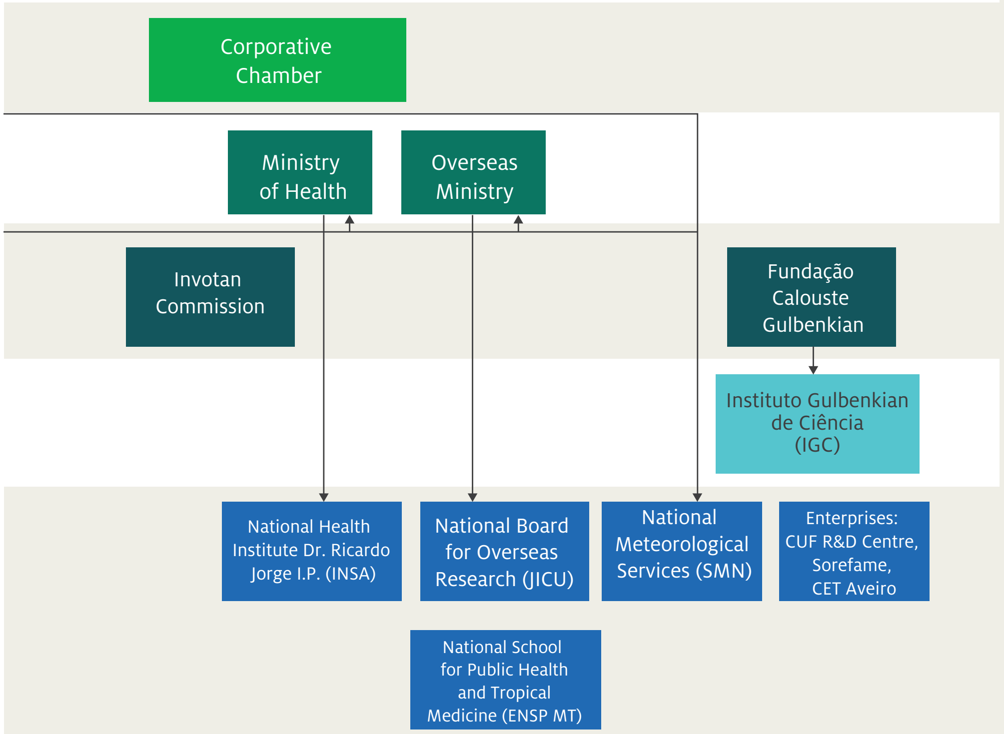
The Business sector was of marginal importance in the system compared to the size of the same sector in other countries, representing only 25.1% of R&D expenditure and 16.8% of R&D personnel (1,287 people – FTE). Few companies had research units because the economic fabric was mainly composed of small and medium-sized enterprises (Moura, 1973). Few large companies, with scale and influence, had R&D centres or performed R&D activities. There were however some large business R&D centres worth mentioning: the Research Centre of the CUF Group, closed before 1974; the Sorefame and MAGUE centres; and the success case of CET in Aveiro, founded by the CTT (the Portuguese Postal Service) and that originated PT Inovação.

The research and innovation system expanded in size and scope over the following 20 years (Figure VII.2) with the growth in public investment mainly co-financed by the European structural funds, the reorganisation of the national Laboratories and the creation of many centres and institutes. Most of these centres and institutes are quasi-public, and were funded by the CIENCIA and PEDIP programmes. In addition, increasing linkages were created between the different actors, namely between the Government and Business sectors. The

3. This historical account is based on Henriques (2006). The dynamics of a national system of innovation and the role of the non-profit space: Portugal as a Research Laboratory, Centre de Sociologie de l'Innovation. École Nationale Supérieure des Mines de Paris, Instituto Superior de Economia e Gestão da Universidade Técnica de Lisboa, Paris, Lisbon.

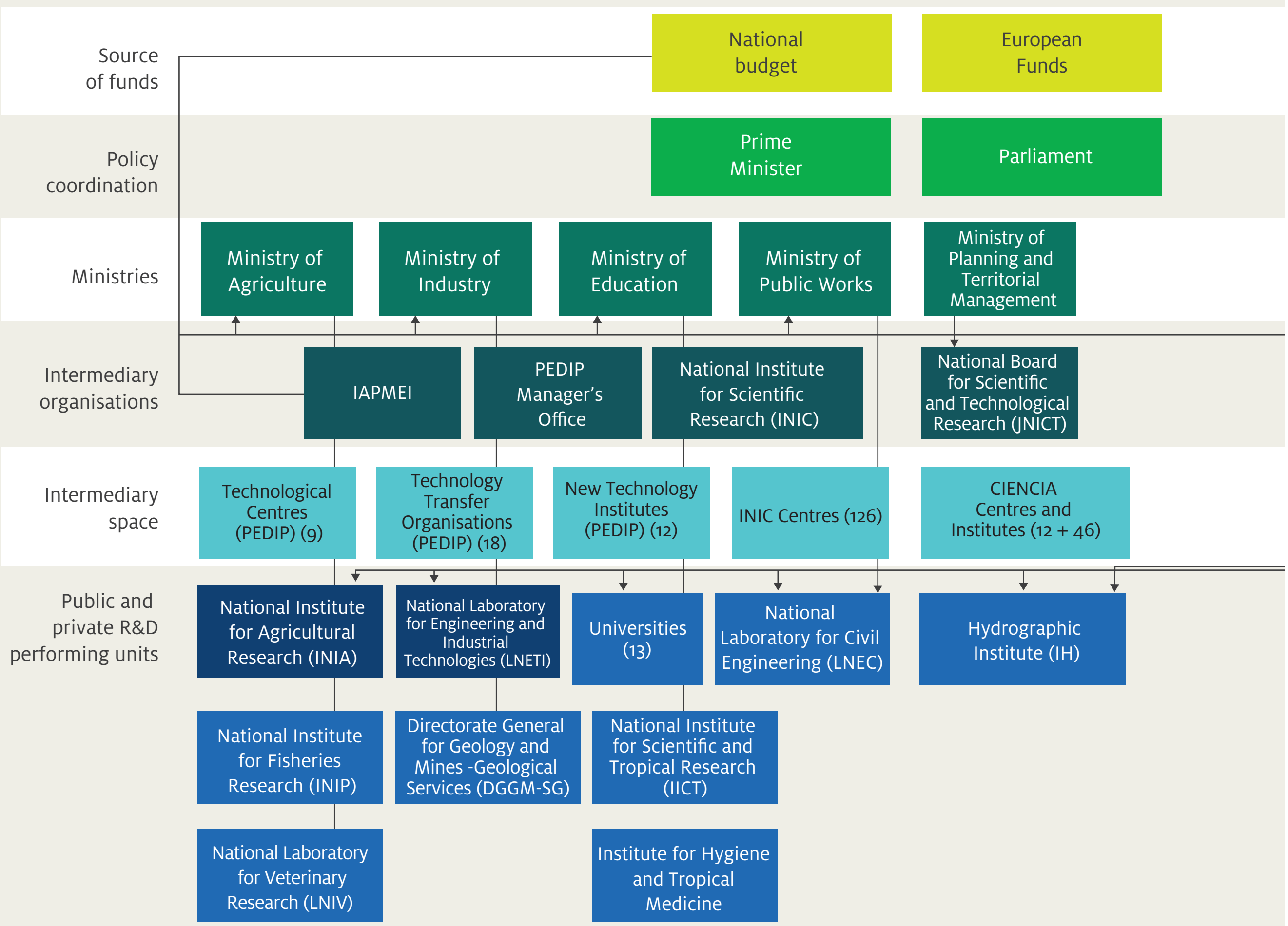
FIGURE VII.1.
Organization chart of the innovation system in 1972




Corporative Chamber
Ministry of Health
Overseas Ministry
Invotan Commission
Fundação Calouste Gulbenkian
Instituto Gulbenkian de Ciência (IGC)
National Health Institute Dr. Ricardo Jorge I.P. (INSA)
National Board for Overseas Research (JICU)
National Meteorological Services (SMN)
Enterprises: CUF R&D Centre, Sorefame, CET Aveiro
National School for Public Health and Tropical Medicine (ENSP MT)

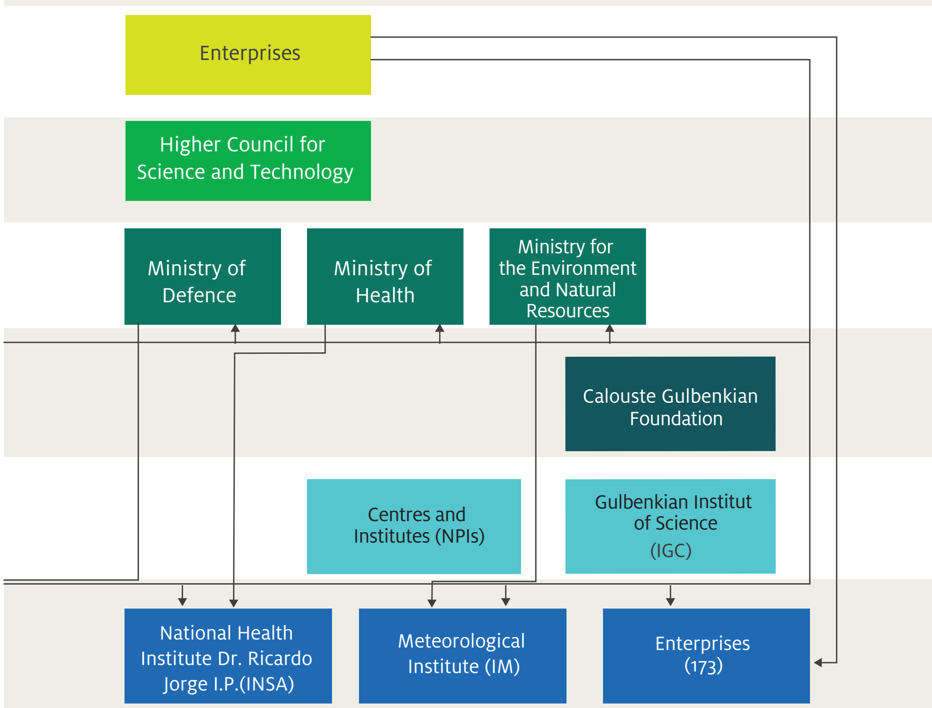
human and financial resources almost doubled, reaching 13,448 people (FTE) in 1992, while expenditure grew by 28% to a level of 0.65% of GDP. By 1992, Higher Education had become the major performing sector, concentrating almost half (46.5%) of the research personnel and 43% of the R&D expenditures. The Government sector significantly reduced its role in the system, being left with only one third of the human resources and 22.1% of R&D expenditure. Business also saw its importance fall, accounting for 21.7% of expenditure and 14% of research personnel, even though the number of companies engaged in R&D rose substantially (173 companies). The Private Non-profit sector in 1992 was responsible for 13.2% of

FIGURE VII.2.
Organization chart of the innovation system in 1992



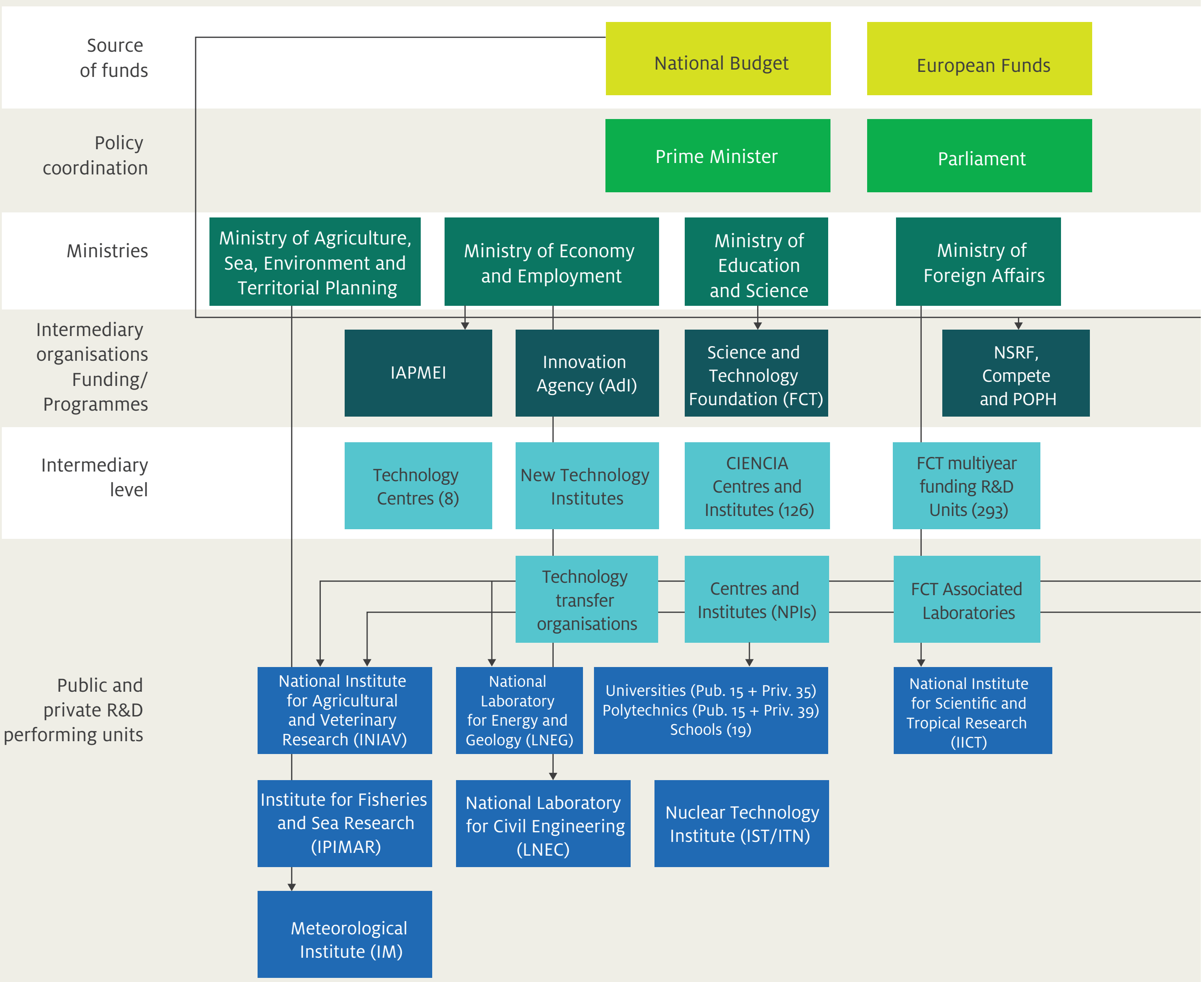
the expenditure and 1,362 R&D personnel (10.1%); in reality, its importance is larger in terms of personnel given that many NPIs share human resources with the traditional performing sectors.

By 2012 (Figure VII.3), the system has gained maturity and scale with research intensity reaching 1.69% of GDP. The objective set out by the government in the 1960s to attain 1% of GDP was finally achieved in 2007, reaching 1.21%. This result was influenced by sizable levels of public investment and the poor performance of the country's GDP from 2000 onwards.

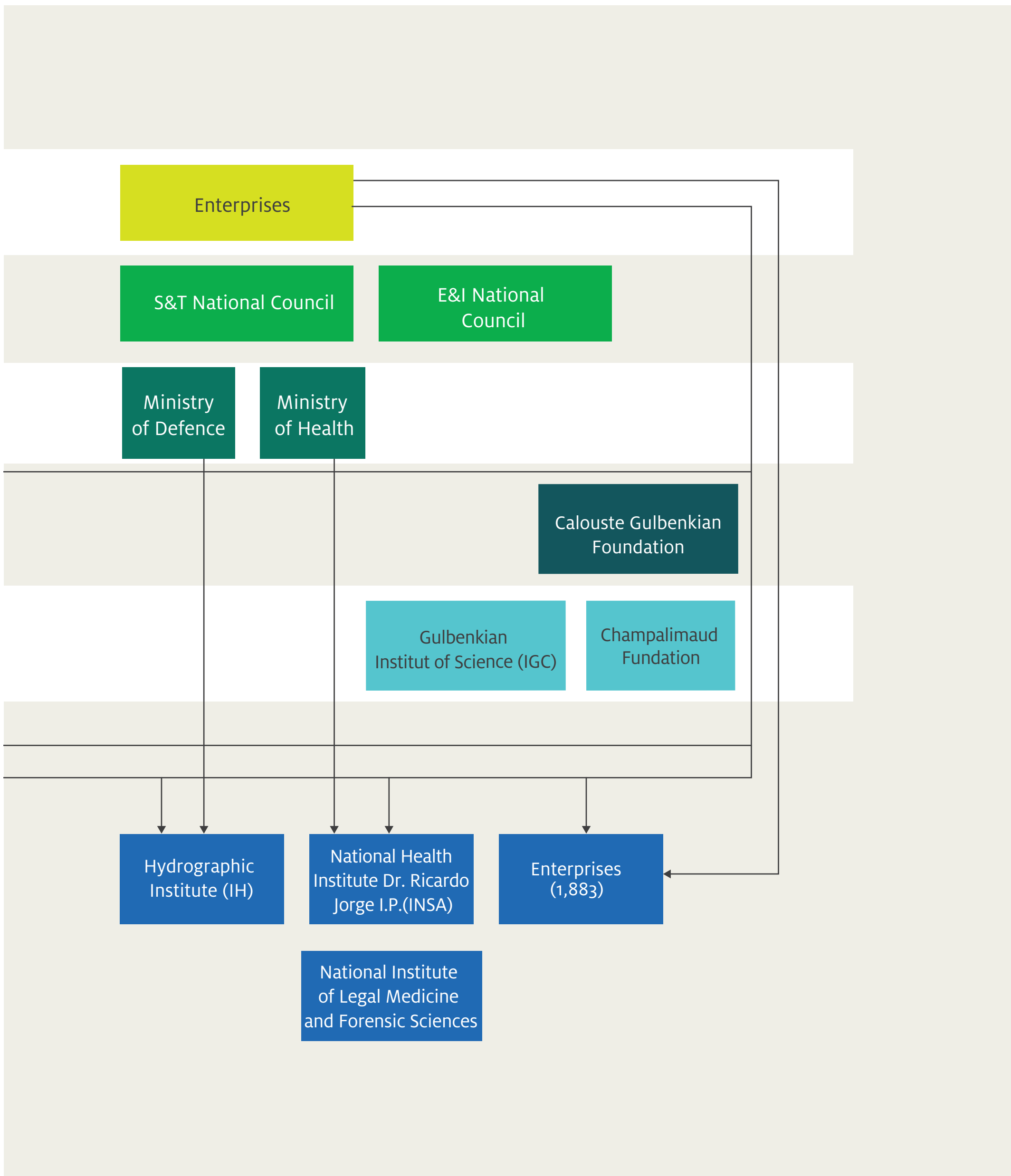


Another objective achieved in this period was the Business sector becoming the central actor in the system, with its share in the total R&D expenditure reaching 51% in 2007, similar to the centrality it has in the systems of developed countries. However, this trend towards a reversal of the system structure has not yet been consolidated, as business investment fell and its share declined to 45% of the total in 2011. Despite this reduction, the Business sector shows a new dynamic and has reached a significant scale, with the number of companies with in-house R&D activities doubling between 1992 and 2010.

FIGURE VII.3.
Organization chart of the innovation system in 2012



At the same time, the Higher Education and Private Non-profit sectors maintain their almost dominant traditional position, representing almost half of the total R&D expenditure (47%), while the Government sector is clearly marginal in the system. Over the course of a decade this sector lost 10% of expenditure share, despite, or because of, the transfers of responsibilities and institutions to the Higher Education sector and the instability resulting from a long period of restructuring of the national Laboratories which started in 1998 and has not yet been concluded.



In conclusion, the research and innovation system in Portugal evolved centred on its most dynamic actors, namely the quasi-public institutions acting as mediators of traditional actors. Public policies actively promoted their proliferation, with the objective of filling both the organisational and functional gaps in the system. This development path led to a substantial reduction in the role of the public and semi-public sector in the system, curtailing its excessive weight in the system in 1972 (78%) to almost half of the total (54%) in 2010.

The composition of the public and semi-public sector changed substantially over the period under study. The national Laboratories, which were the main actors in the system for many decades, became marginalised, representing only 7% of the total expenditure in 2011. Universities and R&D units, centres and institutes consolidated their position as the most dynamic and visible part of the public sector research. The Business sector has gained centrality and became a major player in the system (45% of expenditure in 2011), although it has still not yet achieved leadership capacity.

System governance: the actors and functions

The governance of the national research and innovation system has many specificities inherent to the way the organisational and functional public policy model was institutionalised in Portugal. These particularities derive from the fact that the model defining and managing the national policy for research and development (R&D) has, to the present day, remained incomplete, in contrast to the other European countries. The functions and associated implementing structures were institutionalised and working rarely since the 1960s, when the national R&D policy started to be established following the example of the other OECD member countries. However, contrary to other countries, Portugal only had a government member responsible for R&D from the mid-1980s onwards. Up to that point, coordination was mostly carried out at the intermediary level.

The culture and tradition of each country and its idiosyncrasies are intrinsically linked to the governance model, the policy design and the way that the different actors interact (Elzinga and Jamison, 1995). It is based on this rationale that the OECD, for example, has never proposed an explicit model for R&D policy, while at the same time deliberately engaging in its promotion and, encouraging the member countries to adopt explicit R&D policies, independent of culture or education policies.

According to Henriques and Laredo (2013), the model diffused by the OECD, that made the science policy explicit and autonomous, is characterised by a set of policymaking functions with particularities that distinguish it from the functions of the other sectoral policies. These functions are the following:

- Horizontal coordination at a ministerial level with a centralised decision making process. This implies policy coordination of all sectors that include science and technology activities part of the national budget, under the responsibility of the prime minister, an interministerial commission, or a minister responsible for the S&T sector;

- Advice is given by an advisory body to the government authority, preferably composed of recognised scientists from the public sector and the business world;

- Medium term planning, as part of the national plan, including foresight activities, formulated in coordination with the authorities responsible for the national plan;

- The existence of the Research Budget, which, as part of the national budget, specifies the investment in the area, and, if possible, is discussed in detail in the national parliaments;

- Priority setting, according to the national methodologies for determining the themes and structural resources to be included in the national plan as targets for priority funding, with their own budget. These priorities should be preferably selected with wide stakeholder participation.

- Competitive allocation of resources distributed on a project basis, whose selection involves a peer-review process to evaluate the merit of the proposals submitted;

- Finally, the administration of the policymaking process should be carried out by a body responsible for supporting the entire policymaking process and staffed by personnel with competences in S&T management.

More recently, another function was added to this list: the ex-post evaluation of policies, normally done by external evaluators, which are tasked with the assessment of policies that have already been implemented, and with providing recommendations for designing the next cycle of public policy.

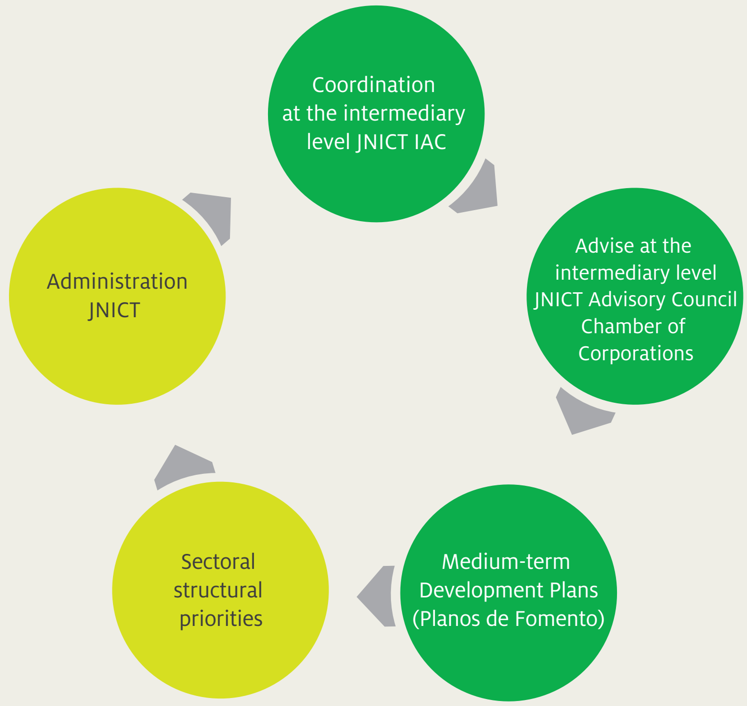
In Portugal, the essential functions were only implemented relatively recently, and some of the functions have never stabilised due to their irregular operation. The same three years were chosen to illustrate the instability in the public policy model (Figure VII.4, Figure VII.5 and Figure VII.6). This comparison aims to provide an integrated vision of the structure and governance of the research and innovation system.

The governance model configured in 1972 was the first model established following the creation of the National Board for Scientific and Technological Research (Junta Nacional de Investigação Científica e Tecnológica – JNICT) as the policy coordinating body. The 1990 configuration constitutes a break with the model institutionalised in 1986, while it coincides with the implementation of the first Community Support Framework Programme for Portugal and the ensuing changes (structural funds). Finally, 2012 represents the current governance model. Each one of the Figures only shows those functions with regular activity in the year under analysis; the different colours, in the model, show the relative dominant role of each function in the design and implementation of public policy.

Portugal had a late full institutionalisation of science policy and its governance mechanisms (Figure VII.4). The horizontal coordination function was not done, at policy level, by a minister for Science and Technology, but was in the remit of the intermediary organisation JNICT, acting as an administrative body under the Prime Minister. The horizontal coordination of JNICT was centred on two sectors of performance – Government and Business – given that Higher Education was under the auspices of the Higher Culture Institute (Instituto de Alta Cultura). The two institutions disputed the coordination of academic research.

Neither the research budget nor the competitive allocation of resources were implemented at the time. The governance system was centred on coordination and advice, managed by the interconnected advisory councils of the various intermediary organisations, in association with their planning structures.

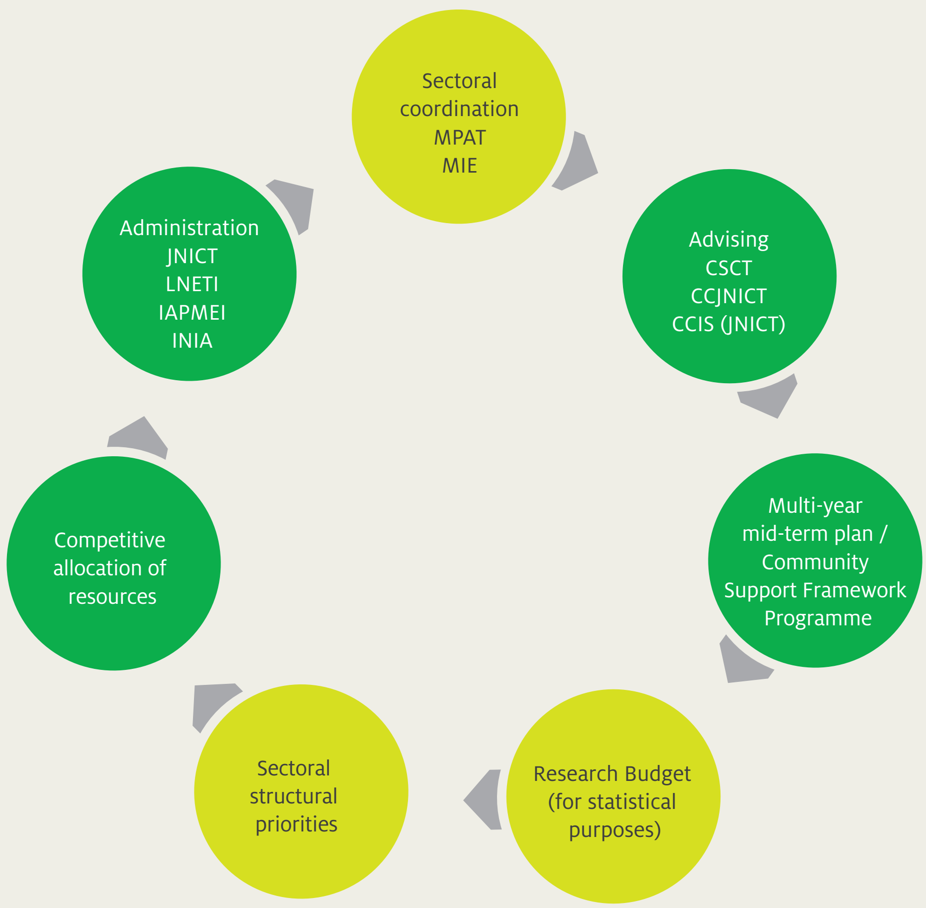
FIGURE VII.4.
R&D policy cycle functions (1972)



The governance structure of the system remained centred on the intermediary level, which was populated with organisations tasked with programming and funding functions, as well as with advisory bodies. These latter bodies had a thematic or general nature and were composed of reputed researchers from academia and business and high-level representatives. Although a Secretary of State for Scientific Research was appointed in 1985 – in the pre-accession period to the European Communities – coordination remained with a vertical nature: R&D policy part of the portfolio of the Ministry of Planning and Territorial Management (Ministério do Plano e da Administração do Território), while technology policy came under the remit of the Ministry for Industry and Energy (Ministério da Indústria e Energia).

This period was characterised by significant progress both in terms of institutional change and in the size of funding resources allocated to R&D and technology. In institutional terms, the period was marked by the approval of the Scientific and Technological Research Law (Law nº 91/88 13 August, a parliamentary initiative) setting out the complete model for the governance of research policy (Figure VII.5). The mechanisms and structures included in the law had eventually to be disregarded, as they overlapped with the programming mechanisms associated with the Community Support Framework Programme. In this way, the emergent institutional framework implemented as a result of the new law was not crystallised. This fact is clearly specific to Portugal, given that the Science Law is the basis for the governance of R&D and innovation policies in most countries. For example, the Science Law in Spain has been considered as a major driver in the scientific and technological development that occurred in the country, due to the agreement between the two major political parties on its application (Sanz-Menéndez, 1995; Menéndez, 2005).

FIGURE VII.5.
R&D policy cycle functions (1992)



The governance remained vertical, based on pillars, with multiple decision-making centres according to the remit of the targeted sectors: science, agriculture, health or industry. The focus was placed on competitive allocation of funds and on the medium-term programming of the Community Support Framework Programme, as well as on the sectoral advice based on the assessment of the merit of the proposals (peer-review) (Silva and Henriques, 1995; Pereira, 2004). During the 1980s and beginning of the 1990s, the advisory bodies were instrumental in formulating the programmes and increasing the awareness and visibility of R&D in the political agenda of Portugal, a function neglected during the 1970s and in part of the late 1980s. Advice was mainly given to JNICT, whose advisory council had an important role in strategic coordination, with additional contributions from the research coordination commissions (CCIs) (Caraça, 1982, 1999; Henriques, 1999).

Although the research budget had been approved (Resolution of the Council of Ministers 4/87, 28-01-1987), it has never been possible to implement a functional classification for R&D activities in the National Budget. The research budget has never been discussed in Parliament during the discussion and voting of the national budget. The research budget in Portugal is, as such, even today, limited to a posteriori collection of data covering expenditure and investment by Central Government for merely statistical purposes[4] .

The integration of a systemic approach to innovation policy into the political discourse in Portugal dates from 2000, the year in which PROINOV was launched which also coincided with the launch of the Lisbon Strategy (see Rodrigues et al., 2003). Even though it has been consistently reduced, the division between research policy *lato sensu* and innovation policy persists, given the creation of an inter-ministerial coordination mechanism for the management of the structural funds (NSRF), in addition to the integration of the operational programmes under a common umbrella with cross-cutting general themes, in contrast to the previous sectoral organisation (see ERAWATCH[5]).

As Figure VII.6 shows, all the functions associated with policymaking are present and in force in 2012. Some of these are pivotal to the policy cycle, as is the case of the competitive allocation of resources and the medium-term programmes co-funded by the European structural funds, which are object of ex-ante and ex-post programme evaluation, as was already the case in 1990. During 2000s, there was a trend of moving towards horizontal coordination, through the creation of interministerial commissions, such as the Technology Plan[6]. The higher advisory bodies, at a governmental level, were reactivated, with the creation of two national councils - one for science and technology and the other for innovation and entrepreneurship - composed of leading figures from research and business communities, to advise directly the Prime Minister. Policy advisory bodies to the Government were not active since 1995, with the exception of a limited period of activity of the Higher Council of Science, Technology and Innovation (2003-2005), and the Advisory Council to the Technology Plan. The latter met regularly and kept the general public informed of its activities[7].

The Interministerial Commission for Coordination is associated with planning through multiple sectoral or national plans like the National Development Plan, the National Reform Programme and the medium-term plan for the European structural funds (NSRF), as well as the Technology Plan, which was part of the growth and competitiveness component of the National Action Programme for Growth and Employment that applies the Lisbon Strategy priorities to Portugal. The Technology Plan was structured on three pillars: knowledge, technology and innovation (2005-2010). It can be assumed that the Strategic Programme for Entrepreneurship and Innovation (+e+i) has inherited the function of the Technology Plan, with a greater emphasis on the promotion of entrepreneurship. The administration and implementation of policy were streamlined and redesigned the funding agencies for research and innovation. The number of sectoral funding agencies was reduced, concentrating this function in only two main agencies under the remit of two ministries - the Fundação para a Ciência e a Tecnologia (FCT) and the Institute for Support to Small and Medium-Sized Enterprises and Innovation (Instituto de Apoio às Pequenas e Médias Empresas e à Inovação – IAPMEI) -, and also in the management authority for the NSRF, and the innovation agency (AdI).

4. Calculation of the GABORD indicator (Government Budget Appropriations or Outlays for Research and Development).

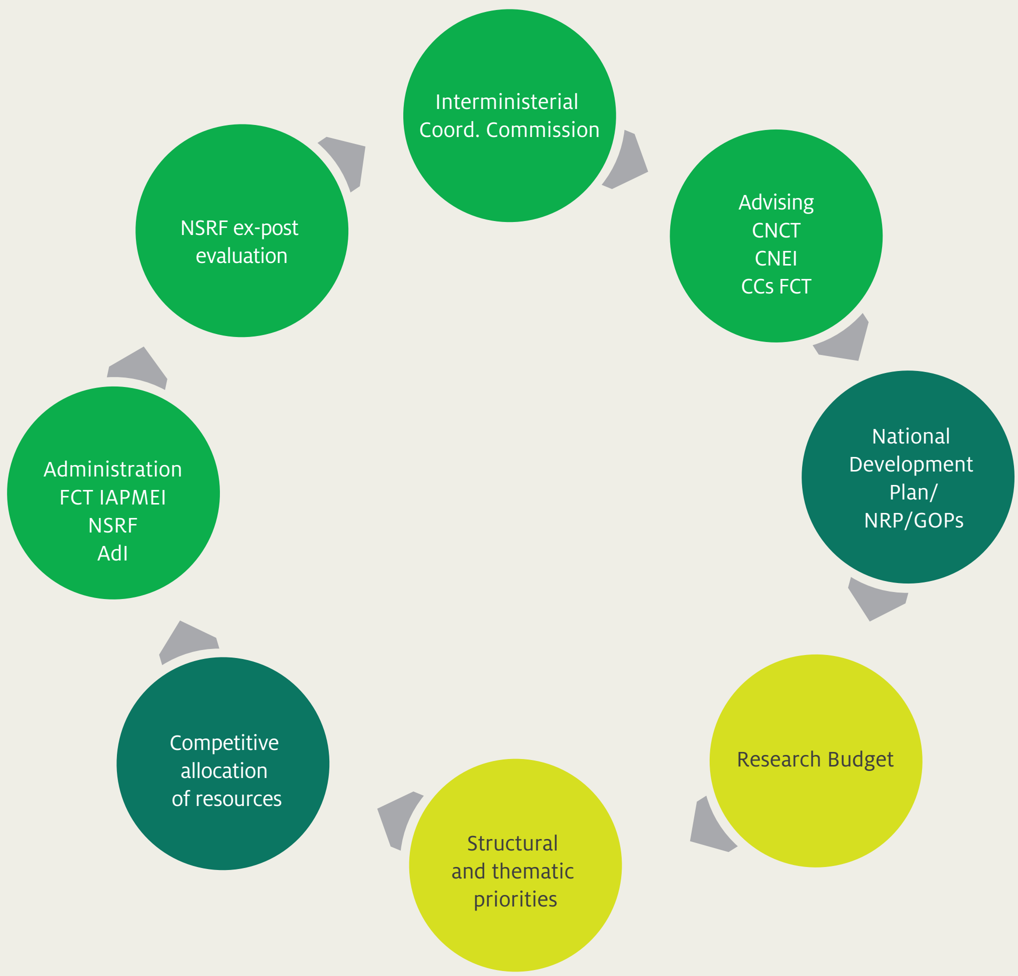
5. http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/pt/country?section=GovernanceStructures&subsection=GovernmentPolicyMakingAndCoordination

6. See http://www.planotecnologico.pt

7. See for example http://www.planotecnologico.pt/document/ccpt20090709imprensa.pdf which details the council members.

In addition to the evaluations of R&D policy carried out by the OECD in the 1980s and the 1990s, ex-post evaluation of programmes and policies in Portugal has been done only as a requirement of European structural funds. This type of evaluation has been coordinated by the NSRF Observatory, and has been centred in a small number of specialised consulting companies in that segment of the market. Portugal has neither participated in nor requested an evaluation of the innovation policies and systems that the OECD is carrying out in the majority of its member countries – nor has it been part of the mutual learning processes that occur as part of ERAC (European Research Area and Innovation Committee) of the European Union. The last evaluation by the OECD of a national policy for research and innovation was in 1993. In fact, Portugal is one of the few OECD member countries that have not had their innovation policy evaluated by the OECD in the first decade of this century.

FIGURE VII.6.
R&D policy cycle functions (2012)



One of the important challenges of public policy is to consolidate the process where policy-making functions are made irreversible, in order to ensure the regular functioning of the functions and of its implementation structures, independently from the government cycle. Other important challenges for the formulation of policies are to ensure an effective, rather than 'ceremonial' (Meyer, 1977), stakeholder participation in the different phases of the policymaking cycle, from the strategic coordination and collective identification of priorities and choices, to the developing of shared visions and scenarios. One of the most used mechanisms involves stakeholder participation in the advisory councils of the bodies responsible for implementing and formulating policy, along with public consultations and forums for discussion.

The participation of key actors, either public or private, has been marginal in policy design and programme formulation, in Portugal (ERAWATCH, 2012). From the middle of the 1990s onwards, the national advisory councils, such as the Higher Council for Science and Technology or the scientific and technological councils of the bodies responsible for policy funding and implementation, have not functioned on a regular basis. Public consultations, as well, are rare and have little impact on the design of policies and national programmes (Glynn et al., 2003; Pereira, 2004). Those that have occurred have typically taken the form of open conferences with only half a day to a day of presentations. Little or no debate took place at these events, which are often scheduled to coincide with the preparatory phase of the multi-year funding programmes with European structural funds support.

The justification for public intervention

The rationale for public intervention in research and innovation in Portugal is based on the market failures argument, established in the literature as a justification for the public investment in the production of public and collective goods. The reason behind is to avoid sub-investment by the private sector, since the value of these goods cannot be determined by the market, given their non-excludable and non-rival characteristics . The Technology Plan (2005-2009) explicitly mentions market failures in the description of its rationale. At the beginning of this millennium, national policies begin to use innovation system and cluster promotion approaches, associated with the traditional Portuguese policy intervention based on the internationalisation and the promotion of university-industry partnerships.

Portuguese public policy explicitly adopted the concept of an innovation system in 2001; this may have been encouraged by the Lisbon strategy and by the construction of the European Research Area. For the first time in Portugal, an interministerial programme - the Integrated Innovation Support Programme – PROINOV (2001-2003) - adopted the concept of innovation system as a rationale for action, centred on firms and competitiveness as the basis for innovation.

The adoption of the national innovation system (NIS) concept was inscribed in the Resolution of the Council of Ministers No. 53/2001, which approved the PROINOV programme. It defined as the objective of policy to "… develop the innovation system, defined as a set of interlinked institutions that contribute towards the creation, development, absorption, utilisation and sharing of economically useful knowledge for a particular national territory. As such, besides companies, the innovation system is composed of higher education, training, R&D, interface and business support and funding institutions, located both inside and outside of national borders, towards a growing internationalisation." Following this Resolution, most policy documents in Portugal, from plans to programmes, also adopted the NIS concept as a rational.

This fact can be seen in the Strategic Initiative Knowledge and Innovation, which replaced PROINOV. The former programme had the same approach, promoting an integrated innovation policy designed to foster a knowledge-based economy (2004-2006). This approach is also adopted in the Technology Plan (2005-2009), which co-existed with the action plan of the Ministry for Science and Higher Education, designated as "Commitment to Science" and more specifically focused on the science component.

The strategic vision for science and innovation in Portugal of the first decade of the new millennium, focused on closing the capacity gap in the research and innovation system, over the course of a generation, (PROINOV). This objective to reduce the capacity gap has existed since the beginning of the policy intervention in Portugal, and had become explicit in the CSF III, in the NSRF that followed, and in the subsequent medium-term plans. The Commitment to Science, the policy agenda of the Ministry of Science, Technology and Higher Education (MCTES), explicitly describes this vision with the title 'Closing the scientific and technological gap'. The capacity gap was assumed as a market failure, which should be addressed through significant levels of public expenditure in R&D, to reach the target of 1% of GDP (Technology Plan). Public investment should focus on training and internationalisation, particularly on the science component of the policy.

Internationalisation of the system has always had an important role in public intervention in Portugal. Initially, internationalisation was chosen as the basis for the training of the future leaders and modernisation of the research system. Later, internationalisation was fostered through the mobilisation of the intergovernmental research organisations, where accession to CERN became a role model for the development of specific research topics in the country and for access to modern large specialised infrastructures. More recently, from 2006 onwards, internationalisation has been based on the promotion of partnerships between Portuguese institutions and prestigious organisations in other countries, namely the United States of America, to promote thematically focused joint-programmes (international partnerships).

In the making of the fabric of the system and fostering the knowledge-based economy, public intervention has always primarily been centred on the promotion of links between producers and users of knowledge, either via partnerships between universities/research institutions and firms, or via intermediary organizations. There were few programmes or policies that funds directly and exclusively business R&D. The particular exception was the program for the creation of Centres for Research and Technological Development in the Business Sector (NITEC), whose aim was to promote the creation of R&D laboratories in companies. As a matter of fact, the public funding of R&D in the Business sector has mainly occurred through the promotion of partnerships with universities and research institutes.

The rationale for the cluster policies in Portugal gained momentum at the beginning of the 1990s, when a study was commissioned by the then Ministry for Industry and Energy to one of the founders of the concept, Michael Porter[8] . The study was applied and followed-up in particular clusters, namely via private initiatives, as it was the case of the "wine cluster"[9]. The National Plan for Economic and Social Development (2000-2006) refers to the importance of economic clusters, namely for improving the positioning in the value-chains. However, the cluster policies were only formally put in place, in Portugal, in 2007, with the implementation of specific funding instruments for the creation and development of clusters and technology hubs, under the NSRF, and for the creation of industry groupings, designed to maximise the benefits from proximity, under the Collective Efficiency Strategies (Decree-Law nº 287/2007 of 18 August).

8. Porter, M., 1994. Construir as vantagens competitivas de Portugal (Constructing the competitive advantages of Portugal), CEDINTEC.

9. http://www.viniportugal.pt/index.php?option=com_content&task=view&id=12&Itemid=27

Setting agendas for research and innovation policies

Setting research agendas and priorities for public research take place through inclusive processes involving the main actors of the system – the stakeholders –, namely from the Business sector and Civil Society. At the same time, in general, authorities apply scenario and foresight methods and techniques, among others, to build visions of the future (OECD, 2003).

In the last seven years, in Portugal, the advisory councils had a minimal or almost inexistent activity, as discussed in the previous section, with the exception of the scientific councils of the FCT -reformulated in 2009-2010 - and the advisory council for the Technology Plan. Public consultation and meetings for strategic reflection have also been scarce, as well as the use of experts for supporting the policy design process. Agendas are set mainly based on results from ex-ante and ex-post evaluation, which is carried out by consultants or university teams as part of the Community Support Framework Programme[10]. Formally, the Associated Laboratories of FCT should also be consulted in matters of public policy but rarely happened, beyond the annual sessions usually organised by the Committee of the Associated Laboratories, in cooperation with the MCTES, where the research results of these laboratories were presented, and in some other occasional interventions[11].

With the purpose of identifying the level of involvement of stakeholders in the discussion of the strategic agendas and formulation of plans and programmes for public policy, a web search, with keywords, and an analysis of all the relevant official programmes and plans were carried out, The survey identified the type of debating forum, as well as the organisation that took the initiative: government or its agencies (top-down); or the scientific community (bottom-up) (Table VII.1).

10. http://www.qca.pt/acessivel/n_qca/avaliacao.asp

11. http://www.snesup.pt/cgi-bin/getinfos pl?EEVVApukVyZVwaKIHZ, the webpage of the Council of Associated Laboratories is no longer available.

TABLE VII.1.
Stakeholder participation in the formulation of plans and programmes in Portugal (2000-2010)

Plan or programme	Year	Methodology	Initiative
S&T White Book	1999	Thematic working groups and presentation of results in a short-seminar	*Top down*
Engineering & Technology 2000-2020	2000	Sectoral forecasting reports, organised by the IST, INETI, Engineering Academia and the Order of Engineers	*Bottom-up*
Funding Model for FCT R&D Units	2004	Web forum	*Top down*
II Meeting of Innovation, Science and Technology	2004	Seminar organised by a commission composed of researchers	*Bottom-up*
Knowledge and Innotation Initiative	2005	Thematic plans for Innovation (ICTs, Biotechnology, Sea, Nanotechnology) prepared by experts or working groups	*Top down*
National Innovation Plan	2005	Working group (composed of 5 people)	*Top down*
Portugal Innovation – Europe 2020 (ME/AdI/COTEC)	2011	Conferences in the major cities of the country (300 participants in total)	*Top down*

No formal participation of the Business sector was found in the formulation process of the research or innovation policies. Companies, however, can influence the design of policy through the work developed by COTEC Portugal – Associação Empresarial para a Inovação[12] (Business Association for Innovation) and AIP – Associação Industrial Portuguesa[13] (The Portuguese Association for Industry). Overall, and in line with the conclusions of the ERAWATCH reports, the public authorities have largely defined the research agenda, without relevant input from other sectors, namely the Business sector (Godinho and Simões, 2009, 2010, 2011).

In addition, the role of Parliament in the discussion of research and innovation policy has been centred mainly on parliamentary 'hearings' (seven occurred during the last legislature[14]) - normally prompted by questions, raised by interest groups and associations, on controversial public issues - and in the promotion of science cafés, as well as reports by the members of the Parliament. There are neither inscriptions of parliamentary activity on legislative initiatives, nor on policy design. There is both an absence of analysis of science and technology issues during the discussion of the national Budget and of technology impact assessment activities.

In Portugal, the space for stakeholder participation in the formulation of research and innovation policies is fragmented, sparsely populated, and still emergent. This space has been formed out of ad-hoc initiatives, focused either on the preparation of the proposals for the multi-year programme to be negotiated with the European Commission concerning the structural funds, or on the debate arising from the dynamics of change in the government cycle.

The strategy and research and innovation policy options

As previously mentioned, Portugal has adopted the innovation system as the framework for innovation policies since the first decade of this millennium. Coordination between the various public policies of the knowledge triangle is slowly being implemented using dedicated implementation structures, such as the interministerial commissions for research and innovation issues, and the new approach of the NSRF, which created a rupture with the tradition of autonomous sectoral policies, with little coordination, as referred to above.

Since the last decade, a complex system exists of sectoral and thematic plans following the demands of the national processes and commitments associated with European integration. The medium-term planning of research and innovation policy is framed within the national planning system, dating back to the Mid-Term Development Plans (Planos de Fomento) up to the 25th of April, 1974. Figure VII.7 provides a global overview of how the process is organised, drawing on all the official planning and programme documents related to R&D and innovation. The planning for the national system has, according to law, its foundations on the national economic and social development plan, and the other strategies or sectoral plans follow in cascade.

Following on from the Lisbon Strategy, and in accordance with the commitments made to the European Union, every two years Portugal submits the National Reform Programme (NRP) to the European Commission. The NRP contains the structural reforms proposed by the country for scrutiny by its partners and monitoring by the community authorities. R&D and innovation are one of the developmental axes, within the smart growth priority[15] .

12. http://www.cotecportugal.pt/index.php?option=com_content&task=blogcategory&id=69&Itemid=109

13. http://www.empreender.aip.pt/irj/go/km/docs/sitemanager/www_empreender_aip_pt/conteudos/pt/centrodocumentacao/Centro%20de%20

14. According to the report available at http://www.parlamento.pt/actividadeparlamentar/documents/relatorio_atividade_comissoes_parlamentares/racomissoes%20_xiileg_1%C2%AAsl.pdf#page=203 Documenta%C3%A7%C3%A30/Vis%C3%A30%20do%20Empreendedorismo%20e%20da%20Inova%C3%A7%C3%A30.pdf.

15. http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/priorities/smart-growth/index_en.htm

The National Plan for Economic and Social Development (PNDES) (MEPAT, 1999) was the guiding plan for the period 2000-2006, organising the integration into the national framework of the thematic and sectoral plans. For the period 2007-2015 the national plan was designated as the National Strategy for Sustainable Development, less ambitious then the first one and mainly focused on integrating the multiple plans, strategies and targets in existence in Portugal (APA, 2008).

FIGURE VII. 7.
Research and innovation policy planning and programmes in Portugal: levels and linkages (2000-2012)

National Plans or Strategies for Economic and Social Development	• PNDES (2000-2006) – Government/Parliament/President of the Republic - CSF III (2000-2006) • OP POCTI – Operational Programme Science, Technology and Innovation • OP ECONOMIA/PRIME – Operational Programme Economic Modernisation • National Sustainable Development Strategy (2006-2015) - NSRF (2007-2013) • POPH – Operational Programme for Human Potential • OP COMPETE – Operational Programme Thematic Factors of Competitiveness - National Reform Programme (2008-2010) - Portugal 2020 (2011-2020)
Medium-term Plans	• GOP (2005-2009) • GOP (2010-2013) • GOP (2012-2015) • GOP (2013-2015)
Annual Plans (GOP)	• GOP 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010
Innovation, Technology and Science Plans	• PROINOV (2001-2003) • Strategic Initiative for Knowledge and Innovation (2004-2010) • Technology Plan (2005-2009) • Commitment to Science (2005) • Strategic Programme for Entrepreneurship and Innovation (2012-...)
Sectoral and Thematic Plans	• Aeronautics and Space: 1999, GOP (2000, 2001, 2002, 2009, 2010), 2005 • ICT: GOP (2001, 2002), 2005 • Biotechnology: 2005 • Research and Innovation for Sustainable Development: 2005 • Sea Programme: 1999, GOP (2000, 2001, 2002, 2009, 2010), 2004, 2005 • Computational Programme for the Portuguese Language: 1999 • Energy • GRID Initiative: GOP (2005-2009)

The key documents for the multi-year planning and programming, in the first planning period, which provided the framework for most of the investment in the Portuguese public policy, were: (i) the PNDES (2000-2006); (ii) the Community Support Framework Programme III; (iii) the Operational Programme (OP) for Science, Technology and Innovation (POCTI), reformulated in the interim programming period in December 2004, to include Higher Education and renamed as the Programme for Science and Innovation (POCI); and (iv) the OP Economia was reformulated and renamed as Programme for the Economic Modernisation (PRIME), centred on promoting technology and innovation policy for the Business sector and fostering links between the public sector, the semi-public R&D sector and the private sector.

For the following period, 2007-2015, the reference documents were: (i) the strategic plan, Sustainable Development Strategy; (ii) the National Strategic Reference Framework Programme, QREN (2007-2013) –which created a rupture with the traditional organisational structure based on sectoral operational programmes; (iii) the thematically structured operational programmes, with one programme for R&D and innovation covering the factors of competitiveness (COMPETE), and the other to promote advanced training and skills – the OP for Human Potential (POPH).

The Framework Law for National Planning (Law 43/91 of 27 July) states that annual and triennial Government Planning Options (GOP) should be presented alongside with the submission of the National Budget. These two important documents are subject to review and recommendations by the Economic and Social Committee (CES). The GOP always has a section devoted to S&T and innovation, describing the objectives of the governmental actions included in the National Budget for the given period. It should be recalled that the National Budget in Portugal does not have a functional classification allowing for the identification of the Research Budget, its activities and autonomous scrutiny.

Medium-term plans and national strategies for research and innovation are scarce and not institutionalised in the policymaking process. However, since 2003, there are programmes or plans formulated to coordinate the sectoral measures promoted by the different ministries and agencies. In fact, after the 1990 experiment on the formulation of a multi-year S&T plan (MPAT/SECT, 1991), the Integrated Innovation Support Programme (PROINOV) has been the first programme that sought to reinforce the systemic consistency of the national innovation system, as previously mentioned, and has required the coordination of five ministries with responsibilities in the area of innovation (European Commission, 2003). The plan ended, following a change in the Government, and was substituted by the National Innovation Plan, also with a short life span. The latter plan contained proposals for thematic programmes, covering, for example, space, nanotechnology and the sea, etc. (MCES, 2004).

The Technology Plan (2005-2011) was the only plan that came to fruition – the plan survived due to the stability of the government and its implementation framework. The Technology Plan built on the previous strategic innovation planning outlined in PROINOV and its successor, and kept the objectives of consolidating the innovation system and its components[16] . The plan consisted of a diverse set of ideas, some of them specific and others horizontal in nature, managed by several implementation structures, under the coordination and management of the Technology Plan Office.

16. http://www.planotecnologico.pt/default.apx

The Programme for Entrepreneurship and Innovation (+e+i) is currently being implemented; to some extent it continues the activities of the Technology Plan, while placing a stronger emphasis on promoting entrepreneurship[17]. In any case, the creation of a national research and innovation strategy – an essential instrument for innovation policy in European and OECD countries – continues to be a project worth developing for Portugal as a nation.

Objectives, priorities and targets set

GOP policy measures

The plans and the strategic visions of the public policies are operationalised through a set of instruments and policy measures. The implementation of the national public policy is, at the policy level, framed by the Government Planning Options (GOP). The GOP define the objectives and the policy measures in order to implement the choices or priorities and are the basis for the distribution of national resources in the National Budget. At intermediary and implementation levels, public policy is operationalised by 'purely' national programmes and by programmes referred to as being 'coordinated' with the European Commission because they are negotiated and approved by the European Commission, as part of the European Cohesion Policy, and the co-funding sourced, into a large extent, by the European regional funds.

In order to identify the choices of the Portuguese public policy for research, development and innovation, an analysis of the Government Planning Options (GOP) was carried out for the 2000-2015 period. The objectives laid down in the GOP were organised into major thematic groups, allowing a comparison with the targets defined in the operational plans and programmes. Some of these political objectives have long been part of the GOP, as for example: advanced training; support for internationalisation, encouraged by the integration into international R&D organisations; support for developing intellectual property rights and patents applications; incentives for cooperation between universities and industry, and support for entrepreneurship.

Over the period 2000-2013, the Government Planning Options for research and technological development and innovation were, broadly speaking, organised into several major dimensions designed to enhance the innovation system: strengthening capacity building; the reorganisation of the institutional fabric, encouraging its connectivity; and, finally, stimulating knowledge exploitation and its context, in structural terms. The Portuguese research policy has important specificities, such as the selection of priorities that are mostly general in nature – there are few thematic priorities -, and the mobilisation of intergovernmental research organisations and foreign research institutions for the catching-up process.

The choices made in the plans mentioned in Table VII.2 can be organised into six categories, according to the rationale and motivation for the public intervention and its time horizon. The motivations range from the need to (i) assure a proper functioning of the research and Innovation system - one of the public missions -; (iii) overcome bottlenecks or encourage emerging dynamics; (iii) foster changes in the strategic direction of the actors towards relevant themes or promote their concentration to achieve critical mass; (iv) reduce duplication or increase the diversity of the system; and (v) enhance the context of the system or promote a favourable environment for innovation activities.

17. http://www.ei.gov.pt/index/

TABLE VII.2.

Policy measures included in the Government Planning Options (GOP) 2000-2013

Policy objectives	Measures Envisaged	GOP
1. Reorganisation of the R&I System Governance	Re-launch of the Higher Council for Science, Technology and Innovation	2003, 2004
	Creation of the National Council for Science and Technology	2013
2. Enhancing Human Capital, Mobility and Employability	Advanced Training of Human Resources for S&T	2000, 2001, 2002, 2004, 2005, 2006, 2007, 2009, 2010, 2011, 2012, 2013
	Promotion of Doctoral Programmes	2008, 2013
	Training for Technicians	2010, 2011, 2012
	Researchers Mobility	2000, 2001, 2003, 2004
	Attraction of Talent	2008, 2010, 2011, 2012
	Promotion of employment in science – FCT Researcher contracts and recruitment support	2001, 2005, 2006, 2007, 2008, 2013
	Excellence Awards	2004
3. Completing the Institutional Fabric of the Public Research Sector and Promoting its Reorganisation	Creation of the Biomedical Research Institute (Funding Agency)	2000
	Research Institutes and Centres multi-year funding	2000, 2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2013
	Creation and Funding of FCT Associated Laboratories	2000, 2001, 2005, 2006, 2007, 2008, 2009
	Reform of public research laboratories (national Laboratories)	2000, 2005, 2006, 2007, 2008, 2009
	Critical Mass creation and development of competences through institutional thematic networks	2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012
4. Enhancement of Infrastructures and Reorganising of the Equipment Network	Modernisation of Equipment and the Infrastructures Network	2000, 2001, 2004, 2010, 2011, 2012
	Support for Libraries and Repositories	2001, 2004
5. Galvanizing Quality R&D Activities	Competitive General Funding for RTD Projects	2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009
	Competitive General Funding for RTD Projects, by type	2013
6. Thematic Programmes	Sea Programme	2000, 2001, 2010, 2011, 2012
	Space Programme	2000, 2001, 2010, 2011, 2012
	Science, Technology and Society	2003, 2004
	Digital Portugal	2000
	Portuguese Participation in the GRID Network	2005, 2006, 2007, 2008, 2009
	Information and Communication Technologies and the Information Society	2000, 2001
7. Promotion of Links between the Actors of the Innovation System	Promotion of Inter-institutional Cooperation	2001, 2003, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012
8. Valorisation of Knowledge	Network of Industrial Liaison Offices	2000
	Economic Development Centres	2000, 2003, 2008
	Technology Transfer (Vouchers)	2010, 2011, 2012
	Creation of the GAIN Network	2013
9. Improving the financing of Innovation	Encouraging Venture Capital	2000, 2010, 2011, 2012
10. Stimulating the Business Sector	Support for Creating New Companies	2008
	Support for Entrepreneurship	2013
11. Development of Intellectual Property Rights	Support for Patents and their diffusion	2008
12. Supporting Integration into the European Research Area and Enhancing the European Competitiveness of National RTD	Further Integration into the European Research Area	2003
	Support for Participation in the European RTD Framework-Programme	2000, 2003
	Creation of the Office for Promoting the RTD Framework-Programme (GPPQ)	2005, 2006, 2007, 2008, 2009
	Promoting Iberian Cooperation on R&D through the creation of Iberian R&D Centres and of National Programmes	2005, 2006, 2007, 2009, 2010, 2011, 2012
13. Promoting the Internationalisation of the Research and Development System	Accession to European Intergovernmental Organisations for Research and Other International Scientific Organisations	2001, 2004, 2008, 2010
	Fostering International Cooperation	2003, 2004
	Programme of International Partnerships between Foreign Research Organisations and Portuguese Thematic Networks	2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012
	Ex-post evaluation of International Partnerships with American Universities, to support the decision for continuation	2013
	Promoting the UNESCO-CPPLP Centre	2011, 2012
14. Dissemination of Scientific Culture	Creation of the network of Ciência Viva Centres	2000
	Support to Ciência Viva	2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012

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The GOP, over the period in question, were organised according to the dimensions mentioned above:

1. Measures with a permanent nature for the development of the national endogenous capacities aiming at the regular functioning of the system. These measures include the following dimensions:

   a. Support for 'Human Capital Formation' involving generalised support for advanced training through the provision of fellowships for ISCED level 6 qualifications and post-doctoral training;

   b. 'Core' funding of research centres and institutes. Up to 1994 this funding was not competitive; allocation was the responsibility of the National Institute for Scientific Research (INIC);

   c. Support for research activities, through generic competitive funding of projects (typically three year projects), covering all scientific fields;

   d. Support for scientific culture, through the Ciência Viva programme.

2. Measures, of a temporary nature, chosen at the political level to eliminate institutional bottlenecks in the system. This type of measures includes:

   a. The recreation of the Science and Technology Higher Council – a fundamental body for the proper functioning of public policy, which has only functioned sporadically;

   b. Reform of the national laboratories; a measure that has been present in the Government Planning Options since 1998, when the process began;

   c. The creation of B-on, to provide the system with an on-line library, complementing the existing libraries and facilitating and enlarging access by academia to the scientific and technical information system;

   d. Proposal for the creation of a funding agency for medical sciences in Porto, which has never been implemented;

   e. The creation of a network of Valorisation of Research Centres, or networks of Industrial Liaison Offices and, for 2013, the GAIN network;

   f. The creation of the Office for Promotion of the RTD Framework-Programme (GPPQ), helping Portuguese teams become more competitive in obtaining funding from the European Framework Programme;

3. Measures to stimulate the dynamics of concentration, by reducing fragmentation or by increasing diversity:

   a. Reorganisation of the institutional fabric through a network of units, centres and research institutes, with 'core' / programmatic funding provided by FCT. The creation of a network of thematic Associated Laboratories to create critical mass at thematic level in the country and to support public policy. In the same logic, it was envisaged the creation of Thematic Networks covering Associated Laboratories/ University Centres and national Laboratories.

4. Measures to influence the behaviour of R&D performers:

   a. The creation of strategic partnerships between national thematic networks and American universities/European institutions to improve the quality of post-graduate training and to enhance mission-oriented research, problem solving, and university-industry linkages;

   b. The promotion of training of technicians and enhancement of researchers mobility, which are inconspicuous measures in its implementation. The funding of doctoral schools, which has only been recently implemented;

   c. Stimulation of research labour market, through the recruitment of researchers by laboratories and centres, based on contracts between the FCT and the researchers, promoting, in this way, the retention of talent. The opening-up of public research jobs has not been implemented, although it is a target set in the national plans;

   d. The development of Iberian and international cooperation and incentives to attract European funds, and support to the diversification of the funding sources of R&D institutions;

   e. Support for the creation of start-ups, while fostering entrepreneurship;

   f. The promotion of patent applications and diffusion of best practices for intellectual property rights.

5. Measures to support emerging fields; these measures have been few and are restricted to a small number of priorities identified and selected at government level. The ones selected are:

   a. Programmes in the fields of Sea and Space, and more recently to promote GRID networks;

   b. Support for nanotechnologies through the creation of an Iberian institute;

   c. Support for particular scientific areas by providing access to large European infrastructures.

6. Measures to promote a favourable environment for innovation; these measures have been few over the last decade, and include:

   a. The promotion of venture capital financing;

   b. Strengthen the systemic cohesion of the innovation system, through the reinforcement of linkages between the different innovation system components, , included in the Technology Plan and in funding programmes based on structural funds (e..g. the NSRF), such as the recent clusters policy.

From the analysis of the six dimensions of public intervention, in the last decade, it can be concluded that only one of them falls, to a certain extent, on the demand-side, which is in-line with the traditional supply-side oriented formulation of Portuguese public policies, namely for the development of generic capacities. Policy instruments acting on the knowledge demand side have only rarely been formulated or implemented. For example, only in few occasions public procurement has been used to support innovation, the same happened to measures of a regulatory nature. Even when these measures exist, they are centred mainly on funding instruments, intellectual property rights, or visas for scientists.

Achieving the targets defined in the different plans and programmes

In the last decade, national public policy included mechanisms to monitor policy results, from national programmes, which are centred on structural thematic objectives. In order to analyse the progress made towards achieving the objectives set in the plans and strategies, a methodology was applied inspired by Scorecards[18], based on measuring the progress of each indicator selected by the national authorities, in the approved strategic plans, and agreed targets.Scorecards help evaluate the progress, or lack of it, of each indicator with respect to the defined targets, as well as the trend (progress, stagnation, or regression) seen over the period under analysis.

The 13 objectives defined in the National Plan for Growth and Jobs (PNACE), Technology Plan (PT), Commitment to Science and the National Strategy for Sustainable Development (ENDS) for the period 2005-2010 are displayed in Table VII.3. In some cases, each plan selected more than one target, and respective indicator, for the same objective. For example, for the objective to increase national scientific production there are three different targets, and respective indicators, even though each of them can be a proxy for that objective. Because of that, there is a certain inconsistency in the targets set for the objectives due to the lack of coordination between the plans. The ENDS 2015 attempted to provide a synthesis of those indicators, having proposed alternative ones in some cases (DPP, 2011). Table VII.3 shows the targets set, identifying also the respective indicator and the plan where the target was defined. In addition, the difference was calculated between the value of the indicator in 2005 and in the target year (2010), showing whether the target was successfully reached (+) or not (-).

The objectives whose targets were achieved are the following:

- System outputs – internationally referenced scientific production;
- Education and Training – graduates in S&T areas (doctorate holders), aged between 20 and 29 years old; number of doctorate degrees awarded annually;
- System Resources – human resources and researchers;
- Knowledge exploitation – venture capital.

18. Inspired by the methodology used for strategically managing organisations, an adaptation is employed here of the methodology developed in the report by Deloitte for the DG Research and Innovation "Monitor human resources policies and practices in research – The Researchers Report 2012, Scorecards".

The objectives whose targets were not reached are the following:

- System outputs – internationally registered patents;
- Education and Training – graduates in Engineering Sciences (first stage of tertiary education); new doctorates aged between 30 and 34 per thousand population; and the share of doctorate holders in Engineering Sciences;
- System Resources – financial resources;
- Knowledge exploitation – technology intensive sectors and exports.

Overall, the research and innovation system has achieved the targets regarding the outputs in tertiary education and publications, as well as the increase in the human resources in the system. However, the objectives were not met concerning the technological outputs, the growth in the technology intensity of the economy, as well as the level of financial resources invested in the system. The exception was the increase in venture capital investment.

The attainment of objectives and targets should be put into context by comparing the performance of Portugal with that of the benchmark countries in order to identify convergent or divergent trends towards those countries. For each dimension, the most significant indicator was chosen for the comparison, in the period 2005-2010, or the last year where data was available. The progress achieved was then calculated, providing a quantification of the tendency for the objective over the period being studied.

Objective 1 – Increasing internationally referenced national scientific production

For the objective of increasing the volume of scientific production, it was selected the indicator for the number of internationally referenced publications, normalised for the population size. The political targets defined, as shown in Table VII.4, sought an increase in this indicator by 50%. Portugal largely exceeded this target, showing an excellent level of performance with respect to the knowledge production objective. Moreover, Portugal was the country that showed the greatest progress in this indicator (when compared with the benchmark countries), despite the fact that it finds itself alongside Hungary as one of the countries with the lowest level of scientific output. By 2010 the national values were closer to those of its neighbour, Spain.

TABLE VII.3.
Research and innovation policy indicators for the period 2005-2010 (or last available year)

Objective	Plan	Duration	Targets
Knowledge Production (Publications)			
1	PNACE & PT	2005-2008	Increase by 50% internationally referenced scientific publications
1	C. to Science	2006-2009	Increase by 50% (600 publications/per M pop./year) internationally referenced scientific publications
1	ENDS 2015	2006-2015	Increase the no. of scientific pub. (Scopus) to 650 per M pop.
Knowledge Production (Patents)			
2	PNACE & PT	2005-2008	Triple the no. of patents registered
2	C. to Science	2006-2009	Triple the no. of patents registered at the EPO and USPTO
2	ENDS 2015	2006-2015	Increase the no. of patent applications to the EPO per M pop. (12)
2	ENDS 2015	2006-2015	Increase the no. of USPTO patents per M pop. (12).
Human Resources for R&D (ISCED 5-6 Education)			
3	C. to Science	2006-2009	Increase by 50% the no. of new engineering sciences graduates
3	PT ENDS 2015	2006-2015	Increase the flow of new graduates, aged 20-29, in S&T into the population (12/1000)
4	ENDS 2015	2006-2015	Increase the no. of new doctorates, aged 30-34, in S&T as a proportion (‰) of the population (0.45)
4	PNACE & PT	2005-2008	Increase the no. of doctoral degrees awarded in Portugal and abroad to 1500 per year
4	C. to Science	2006-2009	1500 doctoral degrees per year, and to increase the relative weight of doctoral degrees in engineering sciences
Human Resources for R&D (Stock)			
5	PNACE & PT	2005-2008	Increase human resources in R&D activities by 50%
6	PT	2005-2009	Increase the number of researchers in Portugal to reach 5.3 per thousand population
6	C. to Science	2006-2009	Reach 5.5 researchers (FTE) per thousand labour force
6	ENDS 2015	2006-2015	Increase the no. of researchers (FTE) per thousand labour force (6 per thousand)
Financial Resources for R&D			
7	ENDS 2015	2006-2015	Total expenditure on R&D as a % of GDP (3%)
8	PNACE & C. to Science ENDS	2005-2008	Triple the private contribution in business R&D (0.8%)
8	C. to Science	2006-2009	Increase business R&D in GDP to 0.8%
9	PNACE & PT and C. to Science ENDS 2015	2006-2015	Double the public investment in R&D (1% of GDP)
Knowledge Exploitation (Innovation)			
10	ENDS 2015 & C. to Science	2006-2015	Increase the share of employment in medium- and high-techology sectors in total employment (4.7%)
11	ENDS 2015	2006-2015	Increase the share of employment in high-tech services in total employment
12	ENDS 2015 & C. to Science	2006-2015	Increase the share of high-tech products exports in total exports (11.4%)
13	ENDS 2015	2006-2015	Increase the share of investment in venture capital in GDP (0.15% by 2010)

Indicator	Source	Divergence from Target
No. of Publications in the WoS	DGEEC/MEC	+17,5 pp
No. of Publications in the WoS /per M pop./year	DGEEC/MEC	+15,9 pp
No. of Publications in Scopus /per M pop./year	SCIMAGO/Eurostat	+ 605.25
No. of registered patents – USPTO, EPO, INPI	Eurostat	-0,9
No. of registered patents – USPTO, EPO	Eurostat	-1,95
No. EPO patents /per M pop.	Eurostat	-1,63
No. USPTO patents/per M pop.	Eurostat/USPTO	-1,48
Graduates (ISCED 5) in Eng. – 2004/5 and 2008/9	DGEEC	-0,13
Graduates (ISCED 5-6) in scientific and tech. areas per thousand population	ENDS	+2,40
Doctorate holders (ISCED 6), aged 25-34, per thousand population	ENDS	- 1.45
No..of Doctoral degrees awarded or recognised in Portugal per year	DGEEC	+166
No. of Doctoral degrees awarded or recognised in Portugal in Engineering sciences per year - 2004/5 and 2008/9	DGEEC	-0,03
No. of human resources in R&D activities	DGEEC	+92 p.p.
No. of researchers/average annual population * 1,000 population	Eurostat	+3,75
Researchers/labour force*1,000	Eurostat	+3,77
Researchers/labour force*1,000	Eurostat	+3,77
R&D Expenditure/GDP	Eurostat	-1,41%
Business expenditure in R&D/GDP	Eurostat	-0,2 p.p.
Business expenditure in R&D/GDP	Eurostat	-0,1 p.p.
Government expenditure in R&D/GDP	Eurostat	-0,1 p.p.
Employment in medium- and high-tech industries/total employment (2005-2008)	ENDS	-0.01pp
Employment in the knowledge intensive service sector/total employment	ENDS	-0.1pp
Venture Capital Investment/GDP (2007-2011)	Eurostat	- -8.40pp
Exports of high-tech products/total exports (2007-2011)	Eurostat	+0.07pp

TABLE VII.4.
Scorecard: International publications per million population

Source: Scimago, Eurostat (February 2013)

Country	2005	2010	Progress	Trend
Portugal	690,36	1.255,25	82%	↗
Austria	1.472,68	1.931,04	31%	↗
Belgium	1.660,08	2.072,62	25%	↗
Spain	960,52	1.333,91	39%	↗
Finland	2.136,88	2.560,00	20%	↗
Netherlands	1.915,61	2.427,94	27%	↗
Hungary	670,66	771,59	15%	↗
Italy	922,17	1.151,25	25%	↗
Ireland	1.470,93	2.182,70	48%	↗
Norway	1.897,59	2.688,86	42%	↗
Czech Republic	888,50	1.345,79	51%	↗

Objective 2 - Increasing the level of national patenting with the EPO

In relation to the objectives of tripling the number of patents in Portugal and of increasing the number of patents registered internationally (EPO, USPTO), once again, an indicator was chosen that could be normalised by population size, to allow, as in the previous case, comparison with other countries. The chosen indicator for patenting was the number of patents registered at the EPO per million population. Portugal always had very low numbers of patents registered internationally, and the progress achieved so far is not signalling a turn in the current situation, as both the growth and target deviation are negative. However, it should be noted that the same negative tendency in the growth in the number of patents was visible not only in Portugal, but in most of the benchmark countries. Only four countries registered a significant level of growth: Hungary, Austria, Ireland and the Czech Republic (Table VII.5).

TABLE VII.5.
Scorecard: Number of patents registered with the EPO per million population
e) estimated value

Source: Eurostat (February, 2013)

Country	2005	2009 (e)	Progress	Trend
Portugal	10,95	10,30	-6%	↙
Austria	184,72	193,74	5%	↗
Belgium	143,76	133,83	-7%	↙
Spain	31,51	31,22	-1%	↙
Finland	252,53	227	-10%	↙
Netherlands	214,03	203,17	-5%	↙
Hungary	13,33	19,28	45%	↙
Italy	83,71	76,42	-9%	↙
Ireland	66,88	72,22	8%	↙
Norway	106,21	88,99	-16%	↙
Czech Republic	10,62	22,98	116%	↙

The national plans include five objectives for increasing the level of tertiary education qualifications in Portugal. Two of these objectives focused on increasing the number of technology first degrees and the other on the general increase in the number of new degrees awarded (ISCED 5 and ISCED 6) to young adults; the other three objectives centred on increasing the number of doctoral degrees awarded in Portugal and abroad. The indicator chosen to measure the variation in the qualifications of the Portuguese population was the number of new doctorate holders per thousand labour force, aged 25-34, allowing a comparison with the European counterparts (Table VII.6).

Objective 3 - Increasing tertiary level qualifications in the population aged 25-34

Country	2005	2010	Progress	Trend
Portugal	2,50	1,90	-24%	↙
Austria	2,00	2,30	15%	↗
Belgium	1,20	1,50	25%	↗
Spain	0,90	1,20	33%	↗
Finland	3,10	2,60	-16%	↙
Netherlands	1,30	1,90	46%	↗
Hungary	0,70	0,80	14%	↗
Italy	1,10	1,60	45%	↗
Ireland	1,20	1,60	33%	↗
Norway	1,30	1,90	46%	↗
Czech Republic	1,10	1.30	18%	↗

TABLE VII.6.
Scorecard: Number of doctorate holders per thousand labour force, aged 25-34

Source: Eurostat, 2008

Surprisingly, Portugal, after many years following a positive trend in this indicator, started to decline in 2008, regressing to 2002 levels by 2010. Thus, the tendency over the second half of the decade was for the decline in the number of new doctorate holders per thousand of the labour force. This decline only occurred in Portugal and Finland.

One of the ever-present objectives of Portuguese public policy has been the expansion of the system through the growth of the number of researchers. Two targets were laid down in this respect: one proposed a 50% increase in human resources in R&D, and the other an increase in the number of researchers per thousand labour force. The latter was the chosen indicator. Over the 2005-2010 period, Portugal more than doubled the number of researchers in the labour force, exhibiting the strongest growth of all the benchmark countries. In general, all countries showed a positive trend in the growth of the number of researchers in the system (Table VII.7).

Objective 4 – Increasing the share of researchers in the labor force

TABLE VII.7.
Scorecard: FTE Researchers per thousand labour force

Country	2005	2010	Progress	Trend
Portugal	3.80	8.20	116%	↗
Austria	7.10	8.50	20%	↗
Belgium	7.20	7.30	1%	↗
Spain	5.30	5.80	9%	↗
Finland	15.10	15.50	3%	↗
Netherlands	5.60	6.10	9%	↗
Hungary	3.80	5.00	32%	↗
Italy	3.40	4.10	21%	↗
Ireland	5.70	6.60	16%	↗
Norway	8.90	10.20	15%	↗
Czech Republic	4.70	5.60	19%	↗

Source: Eurostat

Objective 5 – Increasing the research intensity of the economy

The Lisbon Strategy set a target of 3% for the share of R&D expenditure in GDP (GERD/GDP). This target was agreed upon at the Barcelona Summit and was carried over into the Europe 2020 strategy, which introduced more flexibility for the individual countries. Portugal registered a sizable level of growth over the last decade. The R&D intensity of GDP has been increasing in all the countries under comparison, except the Netherlands, which saw a slight decrease (Table VII.8).

TABLE VII.8.
Scorecard: R&D expenditure as a share of GDP

Country	2005	2010	Progress	Trend
Portugal	0.78	1.59	104%	↗
Austria	2.46	2.79	13%	↗
Belgium	1.83	2.01	10%	↗
Spain	1.12	1.39	24%	↗
Finland	3.48	3.90	12%	↗
Netherlands	1.90	1.85	-3%	↙
Hungary	0.94	1.17	24%	↗
Italy	1.09	1.26	16%	↗
Ireland	1.25	1.71	37%	↗
Norway	1.51	1.69	12%	↗
Czech Republic	1.35	1.55	15%	↗

Source: Eurostat (2013)

Objective 6 – Increasing Business R&D effort in the GDP

Objective 6 is linked to the previous objectives given that the anticipated increase in the R&D intensity of GDP should result in a 2% share in GDP of R&D expenditure financed by the Business sector, with this sector representing two-thirds of total R&D expenditure. The progress shown in Portugal of business R&D expenditure, over the last decade, was notable, with the largest growth out of all the benchmark countries (which for the most part was positive) (table VII.9)

TABLE VII.9.
Scorecard: R&D expenditure financed by the Business sector as a share of GDP

Country	2005	2010	Progress	Trend
Portugal	0.30	0.73	143%	↗
Austria	1.72	1.90	10%	↗
Belgium	1.24	1.33	7%	↗
Spain	0.60	0.72	20%	↗
Finland	2.46	2.72	11%	↗
Netherlands	1.01	0.89	-12%	↙
Hungary	0.41	0.69	68%	↗
Italy	0.55	0.70	27%	↗
Ireland	0.81	1.17	44%	↗
Norway	0.81	0.87	7%	↗
Czech Republic	0.86	0.96	12%	↗

Source: Eurostat

Objective 7 – Increasing the share of public funding in the R&D expenditure

The effort applied in funding business R&D, concurs with the increase in public sector funding (1%). The tendency in Portugal has been positive, approaching the target, and with values in-line with most of the countries under comparison. Of these, only Finland managed to reach the target. In contrast to the positive trend shown by most countries for this indicator, the Netherlands stagnated and Hungary and Italy saw their position worsen (Table VII.10).

TABLE VII.10.
Scorecard: Public sector funding as a share of total R&D expenditure

Country	2005	2010	Progress	Trend
Portugal	0.43	0.72	67%	↗
Austria	0.88	1.08	23%	↗
Belgium	0.45	0.51	13%	↗
Spain	0.48	0.65	35%	↗
Finland	0.89	1.00	12%	↗
Netherlands	0.74	0.74	0%	-
Hungary	0.47	0.46	-2%	↙
Italy	0.55	0.53	-4%	↙
Ireland	0.40	0.50	25%	↗
Norway	0.66	0.83	26%	↗
Czech Republic	0.55	0.62	13%	↗

Source: Eurostat

Objective 8 – Increasing technology intensive sectors' share in employment

The objective of increasing the weight of technology intensive sectors in manufacturing industry cannot be measured in terms of the trend up to 2010, because of a break in the data series - technology intensive manufacturing and services sectors were merged into a single indicator. Employment in technology intensive sectors did not show any change until 2008. Most benchmark countries experienced an increase in this area, especially in the case of Hungary and the Czech Republic. Only four countries saw a decline in this indicator: Austria, Belgium, Italy and Ireland (Table VII.11).

TABLE VII.11.

Scorecard: Employment in technology intensive sectors (medium- and high-technology) as a share of total employment

Country	2005	2008	Progress	Trend
Portugal	3.29	3.30	0%	-
Austria	6.29	5.78	-8%	↙
Belgium	6.52	6.25	-4%	↙
Spain	4.67	4.78	2%	↗
Finland	6.76	6.95	3%	↗
Netherlands	3.29	3.36	2%	↗
Hungary	8.34	9.26	11%	↗
Italy	7.51	7.27	-3%	↙
Ireland	6.02	5.24	-13%	↙
Norway	4.12	4.28	4%	↗
Czech Republic	9.52	11.64	22%	↗

Source: Eurostat

Objective 9 - Increasing knowledge intensive service sectors' share in employment

Employment in knowledge intensive sectors, in Portugal, experienced a relatively modest growth. Despite of the importance of the tertiary sector in the Portuguese economy (see Chapter 1), it is the country where knowledge intensive services have the lowest share. Most of the countries in the comparison group are in-line with Portugal, following a positive trend; the exception here is Belgium, which saw a small fall over the period (Table VII.12).

Country	2005	2008	Progress	Trend
Portugal	22.86	23.79	4%	↗
Austria	31.09	31.50	1%	↗
Belgium	38.88	38.50	-1%	↙
Spain	26.86	28.89	8%	↗
Finland	40.53	41.06	1%	↗
Netherlands	41.96	42.66	2%	↗
Hungary	28.22	28.73	2%	↗
Italy	30.17	31.02	3%	↗
Ireland	34.02	36.22	6%	↗
Norway	45.52	46.75	3%	↗
Czech Republic	25.09	25.63	2%	↗

TABLE VII.12.
Scorecard: Employment in knowledge intensive service sectors as a share of total employment

Source: Eurostat

Objective 10 – Increasing the share of high-tech products in exports

The increase in the share of total exports attributable to technology intensive sectors was one of the indicators that showed a steep decline. In this case, data is only available for the period 2007-2011. Exports in technology intensive sectors not only failed to grow, but actually saw their share of the total fall by more than half. Ireland, Holland and Hungary were countries in the group that also saw a fall in this indicator, although less significant than in Portugal. The other countries have shown a positive trend in this area (Table VII.13).

Country	2007	2011	Progress	Trend
Portugal	6.80	3.00	-56%	↙
Austria	11.10	11.20	1%	↗
Belgium	6.60	7.70	17%	↗
Spain	4.20	4.80	14%	↗
Finland	40.53	41.06	1%	↗
Netherlands	18.30	17.30	-5%	↙
Hungary	21.40	20.80	-3%	↙
Italy	6.00	6.40	7%	↗
Ireland	25.70	20.70	-19%	↙
Norway	3.30	4.00	21%	↗
Czech Republic	14.10	16.20	15%	↗

TABLE VII.13.
Scorecard: Technology intensive sectors exports as a share of total exports (2007-2011)

Source: Eurostat (2013)

Objective 11 – Increasing venture capital investment

The last of the public policy objectives relates to venture capital investment as a percentage of GDP. Data up to 2011 show Portugal following a positive trend in relation to this objective and target, in-line with only two countries: Hungary and the Czech Republic. The other countries saw a significant fall in this indicator (Table VII.14).

TABLE VII.14.
Scorecard: Venture capital investment as a share of GDP

Country	2007	2011	Progress	Trend
Portugal	0.13	0.22	72%	↗
Austria	0.13	0.04	-68%	↙
Belgium	0.30	0.16	-48%	↙
Spain	0.26	0.21	-20%	↙
Finland	0.47	0.22	-52%	↙
Netherlands	0.61	0.34	-44%	↙
Hungary	0.05	0.08	53%	↗
Italy	0.11	0.08	-32%	↙
Ireland	0.17	0.03	-81%	↙
Norway	0.26	0.14	-45%	↙
Czech Republic	0.05	0.12	134%	↗

Source: Eurostat

The analysis of the progress towards meeting policy targets shows, in comparative terms, the tendencies of each of these indicators in the countries closer to the Portuguese reality, and has quantified the progress achieved. It can be concluded that overall Portugal has kept pace with the rest of the comparison group, except with respect to the positive development in venture capital investment; and with respect to the negative development in terms of technology and knowledge intensive exports and the number of new doctorate holders per thousand labour force aged between 25 and 34 years old.

Conclusions

In conclusion, the evolution of the research and innovation system in Portugal has been centred on its most dynamic actors, namely the quasi-public institutions that act as mediators for the traditional actors. The Business sector is positioning itself at the centre of the system, although it is not yet leading the national research and innovation system. At the same time, the Government sector has been reducing its role to a marginal level. The last decade is characterised by the adoption of a more systemic approach to innovation in public policy, although public intervention has, for a long time, been centred on the creation of linkages between producers and users of knowledge, either by way of partnerships between universities/ research institutions and companies, or by way of intermediary organisations.

One of the important challenges faced by public policy is to consolidate the process where policymaking functions are made irreversible, in order to ensure the regular operation of implementation structures and in the functions, independently from the government cycle. Other important challenges for the formulation of policies are to ensure stakeholder participation in the different phases of the policymaking cycle, from the strategic coordination and collective identification of priorities and choices, to the development of shared visions and scenarios. Public consultations are rare and have little impact on the design of policy in national programmes.

Finally, it is worthwhile emphasising the importance of carrying out international evaluations of the policies and programmes as well as of participating in mutual learning exercises, or other similar exercises involving specialised entities, that would allow for an independent and informed opinion to complement the activities being implemented.

Over the period 2000-2013, the Government Planning Options for the research and technological development and innovation sectors were, broadly speaking, organised around several major dimensions that include; enhancing the innovation system; strengthening capacity building; the reorganisation of the institutional fabric, encouraging its connectivity; and stimulating knowledge exploitation, and its context, in structural terms. There are few thematic priorities for investment. The mobilisation of international organisations, namely intergovernmental research organisations and foreign research institutions, for the promotion of the R&D system is a distinctive feature of the national catching-up process.

In general terms, the research and innovation system has achieved the targets set for growth in its outputs in tertiary education and publications, as well as in its human resources. The same cannot be said for technological outputs and the technological intensification of the economy; or even the financial resources for investment in the system, where the goal of closing the gap with the European average is still to be achieved. The challenge will be to maintain and consolidate the growth of the R&D component and to enhance the effectiveness of technology oriented policy, including improved coordination between knowledge production and exploitation. It can be concluded that Portugal is in-line with the evolution observed in the benchmark countries for those indicators selected as targets for public policy.

General Conclusions

The analysis of the last decade of the Portuguese research and innovation system, presented in this report, is focused on the system's potential dynamics in relation to the processes and functions associated with the production and exploitation of knowledge. Characterising the structure of the system by identifying the actors and the relationships established between them provided a basis for analysing the key functions associated with the evolution of the system. Prior to this, an analysis was made of the socioeconomic context surrounding the system. Knowledge production, circulation and intermediation, along with its economic exploitation, were identified as functions of the system, with the accompanying functions of mobilising physical, human and financial resources and their associated public policies. At each stage of the report a comparison was made with either the average of the European Union (27) or the group of 10 countries selected for benchmarking.

The main objective of the study was to identify the strengths and weaknesses, opportunities and threats associated with each of the system functions. This then serves as a starting point for a strategic reflection on the trends and desirable scenarios, so as to choose agglomerating themes covering various activities, including scientific and technological, as well as economic themes, that drive discussion with the main stakeholders. It is through this dialogue that substantiated choices can be made regarding the priorities and design of the National Research and Innovation Strategy for Smart Specialisation.

Portugal is geographically a small country, located at the western corner of Europe and bordering Spain at its northern and eastern sides. The fact that it is far from the centre of Europe, and does not border onto central regions, means that both in economic terms and scientific and innovation terms, the country can neither benefit from being close to the major centres of knowledge, nor from gains due to externalities and spillovers that result from cross-border collaboration (Varga, 2006). However, this geographical localisation has a vast exclusive economic zone of 1.7 million km^2, 18 times its land area and with a great potential for developing a future blue economy.

Portugal has an average population density, unevenly distributed between the coastal and inland regions, with high degrees of concentration in urban areas and with an aging population, and facing a threat of decline, This is associated with a poorly qualified population, compared to the European average, namely in the older generations. These factors, among others, have contributed to Portugal diverging from the European average in terms of wealth over the last decade.

The economic structure is highly concentrated in the service sector, and only around 40% is technology intensive. Manufacturing industry focuses mainly on low and medium-low technology sectors (77.6% of GVA), although some of these sectors have recorded high levels of technological sophistication, as is the case of textiles and footwear, for example.

The dynamism of the research and development sector, and the increase in the business innovation capacity fostered a positive Technological Balance of Payments (for the first time in 2007), with a contribution to the sales of R&D services abroad and a reduction in technology imports due to an increased capacity to produce technology endogeneously.

The evolution of the research and innovation system in Portugal is centred on its most dynamic actors, namely the quasi-public institutions that act as mediators for the traditional actors. The composition of the public and quasi-public sector also changed significantly over the period under study, with the consolidation of the universities, and units, centres and institutes together representing the most dynamic and visible part of the public sector. The Business sector is moving into the core of the system, although it does not yet have the ability to lead the national research and innovation system. Conversely, it is notable the marginal weight of the Government sector, which has had an average negative growth of 4.3% for the whole decade.

The Portuguese Research and Innovation System has been growing at an annual average growth rate of 8% per year, in a fast convergence process with the EU27 average in terms of financial and human resources, while a favourable trend has also been shown in indicators such as GERD as a % of GDP and the number of higher education graduates in scientific and technological areas per 1,000 population for the 20 to 29 years old age group.

The system is characterised by being concentrated in three main regions, which are also more traditionally associated with R&D and innovation – Lisbon, the Centre and North – although a sizable growth is visible in all regions of the country.

For the R&D and innovation system today, the density of actors and the linkages between them is within reach of the one of the most developed systems. The system can claim to have all types of intermediary actors that are potentially necessary for knowledge to circulate (the space between production and exploitation), with their own specialised knowledge and distinct capabilities.

There are a large number of collaborations between companies and universities or R&D Centres (Producer-User), a facet especially visible in data from the COMPETE incentives scheme, that represents direct circulation of knowledge, helps to drive innovation. There is yet space to increase collaboration between companies and other system entities in the context of the actions supported by FP7.

By the end of this decade, the path covered and the interactions that were established between the different actors laid down the key framework conditions for improving the innovation performance of companies. While to be expected are the economic results - in terms of the contribution to GVA and to exports of more technologically intensive industries and services - do not yet fully reflect the transformation process observed for the system in the last decades. In other words, the scientific and technological base of the system has achieved a maturity and density capable of enhancing an increasing dynamism and adequate knowledge exploitation, with ensuing effects on the economy.

In Portugal, companies mainly concentrate on the performance and financing of more applied activities, with only a minor percentage of effort being directed to more basic research (1.6%) – the smallest amount of any of the countries in the benchmark group. A distinctive element of the system is the existence of a layer of private NPIs focused on basic research (49.9% of R&D expenditure of the private non-profit sector), whereas in the benchmark countries this sector is predominantly associated with applied research. Two thirds of R&D investment in Portugal is channelled into four main socioeconomic objectives: Promoting productivity and industrial technologies (24%); General advancement of knowledge (20%); Transports, telecommunications and other infrastructures (19%); and Health (13%).

The resources mobilised for R&D investment are highly concentrated on Engineering and Technology, namely enabling technologies (and in particular Information and Communication Technologies), largely as a result of the importance of these technologies for the Business sector. In terms of financial flows, the Government and Business sectors together fund 89% of total R&D expenditure in the country. Companies are more likely to self-finance their R&D activities, given that 94% of R&D expenditure by the Business sector were financed directly from their own funds. The private NPIs also tend to rely largely on self-funding (43.9%). Linked to the limited amount of funds flowing, both into and out of companies, is the indirect funding by Government via tax incentives. In fact, Portugal is part of a small group of countries that rely predominantly on tax incentives for stimulating R&D in the business sector, including the Netherlands, Belgium and Ireland (0.14% of GDP).

Doctorate holders in Portugal are mainly employed in Higher Education, reflecting a low level of inter-sectoral mobility. Portugal is one of the European countries with a lowest percentage of doctorate holders employed by companies (6.5%), compared to levels around 30% for countries such as the Netherlands or Belgium.

The increase in the system capacity, both in terms of human resources and in terms of financial and structural resources, enabled a significant growth in the outputs of the system through the creation of a critical mass effect. In particular, Portuguese scientific production has recorded notable rates of growth (an AAGR of 14%), having almost tripled in overall terms. This growth effort caused Portugal to rise from 16th to 15th position between the 2000 and 2010 world rankings. However, the improvement in the scientific production and productivity still leave the country in one of the last places when ranked against the countries in the comparison group. Despite the significant growth observed, Portugal has continued to perform below its potential (namely if we consider the above average level of FTE researchers in the country). For the group of countries under comparison, Portugal was the country with the second highest level of growth in European patent requests. Nevertheless, such growth was not sufficient to redress the very low level of patenting in the country.

Despite the significant growth observed in the outputs and quality of scientific production, Portuguese universities have remained in the bottom half of the three major international rankings: Academic Ranking of World Universities – 2012 (above the 300th position), the SIR (above 270) and Leiden (above 259).

Scientific production involving international cooperation tripled over the period under study, reflecting a growing internationalisation and integration in collaborative science networks. Collaboration concentrates its efforts on just a few countries, namely the United Kingdom, the USA, Spain, France, Germany, Italy, the Netherlands, Brazil, Belgium and Sweden.

Comparising between the profile of Portuguese scientific production with that of the ten countries in the benchmark group, highlights Portugal´s specialisation in Exact Sciences, Engineering and Materials Science, as well as Biological Sciences and Agriculture, and Environmental Sciences. Although Portugal is neither specialised in Medicine nor the related Medical and Health Sciences at a European level, these areas have shown the highest rate of growth out of all fields in terms of the number of publications over the last decade. By 2010, Medical and Health Sciences had become the field with the most publications, overtaking Exact Sciences.

In terms of scientific competitiveness, as evidenced by the scientific specialisation index, Portugal was found to be highly specialised in Marine Sciences over the period 2000-2010. Even though the specialisation of scientific production declined in the second half of the decade, areas such as Fisheries and Marine and Freshwater Biology, Oceanography and Oceans Engineering consolidated their activity in this period. It is worth drawing attention to the importance of Food and Beverages, Agricultural Sciences and Biotechnology, as well as the Environment and Biology, given the national clusters in these areas. Assembling the areas of greater specialisation by thematic proximity allows groups to be identified that correspond to clusters of a technological or economic nature, as is the case of the Sea, Biotechnology and Health, Production engineering, Civil Engineering, Materials and Transports.

The profile of the Portuguese scientific production structure by NUTS 2 region is diversified, with each region contributing in a specific way to the national make-up. As such, the field with the most publications in each region was: Materials Science – Multidisciplinary, in the North; Electronic and Electrical Engineering, in the Centre and Lisbon; Environmental Sciences in the Alentejo; Freshwater and Marine Biology, in the Algarve and Azores; and lastly, Applied Physics, in Madeira. Looking just at the ten fields which have the most publications per region reveals Engineering fields at the top in Lisbon and the North; Exact Science fields in the Centre and Madeira; and Natural Science fields (excluding Exact Sciences) in the Algarve, Alentejo and Azores.

In what concerns the impact of Portuguese scientific production, the following fields were identified has having above world average impact: Space Science, Physics, Agricultural Sciences, Plant and Animal Sciences, Neurosciences and Clinical Medicine. However, comparisons using the h-index show that Portugal does not occupy any top position for the 27 scientific fields analysed.

The leading sectors in 2010 in terms of the number of patent requests include Pharmaceutical Products, Civil Engineering and Fine Chemicals. Taking into account the distribution of all patent requests (registered at the EPO) by field of technology for the period 2000-2008, activity was concentrated in areas of Information Technology, Pharmaceutical Products, Biotechnology, Medical Technology, Renewable Energy and Environmental Management. The level of patents granted through the EPO has remained very low over the last decade.

In business innovation, Portugal has a significant advantage (compared to the European Union average) in service and process innovation, and process innovation in the area of business support activities. The country rates poorly in terms of product innovations brought to market. The most common innovation activities in Portugal are: purchases of machinery; equipment and software; training for innovation activities; and carrying out in-house R&D activities. The percentage of enterprises involved in training for innovation activities is significantly above the European average, while the percentage involved in in-house R&D activities is significantly below the European average. It should also be noted that a relatively small percentage of enterprises outsource their R&D or other knowledge, either within Portugal or the European Union.

The main barriers to developing innovation activities are related to the associated costs, funding and financing, as well as with market conditions - uncertainty and power of the incumbent companies. There is a higher percentage of enterprises in Portugal, than in the average for the European Union, citing such barriers as being highly important factors hampering innovation.

The Portuguese economy shows a clear specialisation profile based on manufacturing industry activities of low or medium-low technological intensity, particularly concentrated in the North and Centre of the country. The capacity to benefit from significant economies of scale, of scope/related variety and knowledge spillovers in each sector is enhanced by the regional concentration of these activities in the North and Centre of the country, by the national scientific specialisation in the areas of each sector, and by employment in Research and Development. These sectors have shown a substantial dynamism of firm growth in terms of employment.

Regional clusters of manufacturing industry were identified as having significant potential to benefit from economies of scale, scope and various types of synergies and positive externalities. These clusters favour knowledge transfer and technology upgrades in sectors of lower technological intensity, such as those associated with i. Food products and Beverages; ii. Textiles, Clothing and Footwear; iii. Mineral products; iv. Metal products; and v. Forestry based products; as well as of higher technological intensity, such as those associated with vi. Chemical products (except pharmaceutical); and vii. Electronic, Electrical and Transportation Equipment, particularly related to the automotive industry.

Opportunities to deepen specialisation in technology-intensive activities and to develop sectors that show significant potential for growth were also identified, such as: i. Automotive Industry, including Electrical, Electronic and Transportation equipment; ii. Telecommunications; iii. Research and security (activities related to security systems); iv. Pharmaceutical industry; v. Chemical industry; vi. Computers, Electronics and Optics; vii. Information Technology; viii. Media, Radio and Television; and ix. Information.

By cross-referencing the analysis of the scientific and economic specialisations, it was possible to identify a significant degree of scientific specialisation in several areas of economic specialisation, namely the following clusters: i. Food products cluster / the fields of Food Science and Technology and of Agronomic Engineering; ii. Textiles cluster / the field of Materials Science - Textiles; iii. Ceramics cluster / the field of Materials Science - Ceramics; and iv. Paper, Furniture, Wood and Cork clusters (forestry based industries) / the fields of Materials Science – Paper and Wood and of Forestry and Logging.

The analysis based on the Related Variety Index, which seeks to measure the variety of the sub-activities (4-digits) of each 2-digit NACE division, taking into account the weight of employment in each of them, concludes that in 2011, the Centre had the highest Index level in the country, followed by Lisbon, the North and Alentejo, which shows an upward trend.

The Diversity Index, measuring the diversity across various types of activities at the 2-digit NACE level, shows that Lisbon, the Centre and North regions have the most diversified profiles, followed by the Alentejo, Algarve, Madeira and the Azores.

The explicit adoption of the concept of an innovation system by Portuguese public policy began in 2001, although the focus was placed on building up the fabric of the system and promoting a knowledge-based economy. Public intervention has always centred on the creation of links between producers and users of knowledge, either by way of partnerships between universities/research institutes and companies, or by way of intermediary bodies.

Between 2000 and 2013, the Government Planning Options in the research and technological development and innovation sectors were broadly structured around the following areas: stimulating the innovation system; strengthening the creation of capacities; reorganising the institutional fabric, while promoting connectivity; and generally stimulating knowledge exploitation and its surrounding environment in structural terms. The number of choices identifying thematic priorities for investment has been very limited. The catch-up process underway for the national R&D system makes particular recourse to mobilising international organisations, namely intergovernmental, research organisations and foreign research institutions, to stimulate the R&D system.

Overall, the research and innovation system has achieved the targets set out with regard to improving its outputs in tertiary education and publications, as well as the increase in the human resources allocated to the system. However, it was not able to reach the targets regarding the technological outputs and the technological intensification of the economy, and the level of financial resources invested in the system.

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