Annual Report on Science and Technology Indicators for Belgium

2013

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The Annual Report on Science and Technology Indicators for Belgium is published by the Belgian Science Policy Office.

Belgian Science Policy Office
Avenue Louise 231
1050 Brussels
Belgium
Internet: www.belspo.be

Graphic design : polygraph.be

Edited by André Spithoven
ISSN: 2295-3418
Legal Depot: D/2013/9284/1
November 2013

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Foreword

In the past the Belgian Science Policy Office has provided punctual support to policy makers by offering an overview of indicators on science, technology and innovation. Up to now three editions of Key Data have been produced irregularly since 2001. The current reforms of the Belgian Science Policy Office have paved the way to offer an enhanced effort to monitor the innovation system.

The innovation system of Belgium is seemingly characterized by a paradox. On the input side of the system, as measured by the R&D intensity, the performance fluctuates around the European average. On the output side, however, Belgium belongs to the leading countries when it comes to the number of publications and the quality of research. Although the federal level is responsible for 35% of public means for research and development (R&D), it is acknowledged that the level of funding by the public sector is relatively modest in respect to other countries. A key feature of the innovation system of Belgium is that this federal budget is dispersed over various scientific organisations and administrations. Institutional reforms should remedy the complexities of the system and remove any obstacles to stimulate efficacy at the federal level.

Within the Belgian Science Policy Office reforms have already begun. One of the services concerned is the Scientific and Technical Information Service (henceforth STIS) which is an integrated service with an independent board of governance. Recently, the STIS has been reformed by fusing other activities that resided within the Belgian Science Policy Office. From 2013 onwards the STIS performs two distinct tasks with the aim to inform the science and technology policy at the federal level. First, STIS acts as a collector of data in R&D and innovation that are relevant in the domain of science and technology. Second, STIS acts as an information intermediary between the European Union and the federal scientific institutes.

STIS, as data collector, focuses its attention to collect all relevant data from the regional partners to integrate them into data that represents the efforts on R&D and innovation for Belgium as a whole. The STIS produces the data, always with the input given by the responsible political regional authorities, on (i) the budgetary outlays for R&D; (ii) the data on R&D expenditure and R&D personnel in the business enterprise sector, the government sector, the higher education sector and the private/public non-profit sector; and (iii) the innovative activities. The STIS operates at the federal level in close collaboration with the regional partners that bear the major responsibility in science and technology. STIS co-ordinates the data collection, helps to ensure the application of the internationally agreed methodologies, and communicates these data to international organisations like Eurostat and the OECD.

STIS, as an information intermediary, targets users that are key players in the field of research and innovation. First, it provides information – through the use of websites, newsletters, helpdesk, info sessions and face-to-face meetings – on the European R&D Framework Programme and other related activities (Eurofed). Second, it keeps track of the participation of the Belgian Science Policy Office in projects from the European Research Area (ERAPRO). Third, it provides bibliometric research for external partners, or internal use for the screening of experts for evaluation purposes.

The symbiosis between these two tasks results in a number of policy reports. First, policy reports that tackle the institutional organisation and governance mechanisms of the science and technology domains. In addition, with the insights of international experts, it organises peer review reports on its policy system. Second, data reports on the indicators that are collected aimed at disclosing all data available on R&D activities and innovation. Third, it publishes various research reports: research report series; books; scientific publications; conference proceedings; external and internal research reports.

The STIS supports science and technology policies at national and international levels. First, at the national level it acts as a secretary in the federal cooperation commission on statistics (CFS/STAT); and as a partner in the commission on international collaboration in the inter-ministerial conference for science policy. Second, at the international level it is active in OECD meetings as national experts on STI and in Eurostat task-forces.

This report is a joint effort to inform policy makers and stakeholders of some features of the innovation system. It is hoped that the insights the annual report offers will stimulate an open debate on science, technology and innovation.

Dr. Philippe Mettens
President Belgian Science Policy Office

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CHAPTER 1

A bird's eye view

ANDRÉ SPITHOVEN

1.1. Introduction

Up to now the Belgian Science Policy Office produced three issues of Key Data. The first appeared in 2001 in the framework of the Belgian Presidency of the European Union. The second was published because of the OECD meeting on the internationalisation of R&D in 2005. The third issue, again, found its origin in the triadic Belgian-Spanish-Hungarian European presidency in 2010. Each time Belgium was positioned against a selection of countries.

Because of the growing importance of monitoring the innovative performance of Belgium (e.g. the EU 2020 strategy; National Reform Programmes) the need for recurrent data in the innovation system is making itself felt. Hence the challenge to produce an annual report, not only covering the most recent data, but also putting these data into a perspective figuring on the policy agenda. The annual report on science and technology indicators is, first and foremost, intended to provide a selection of information to policy makers and administrative agencies tackling issues in science policy.

Various aspects contribute to the innovative performance of countries and regions. These aspects are united through the concept of national and regional innovation systems. However, the financial and economic crisis of the recent past is said to have a major impact on the performance of innovation systems. It is acknowledged by businessmen, academics and policy makers alike, that the crisis affected all actors operating in the system. Moreover, due to the idiosyncratic nature of the national innovation system, the consequences of the crisis differ across countries. To capture these consequences an array of indicators is being used, and new ones are developed continually.

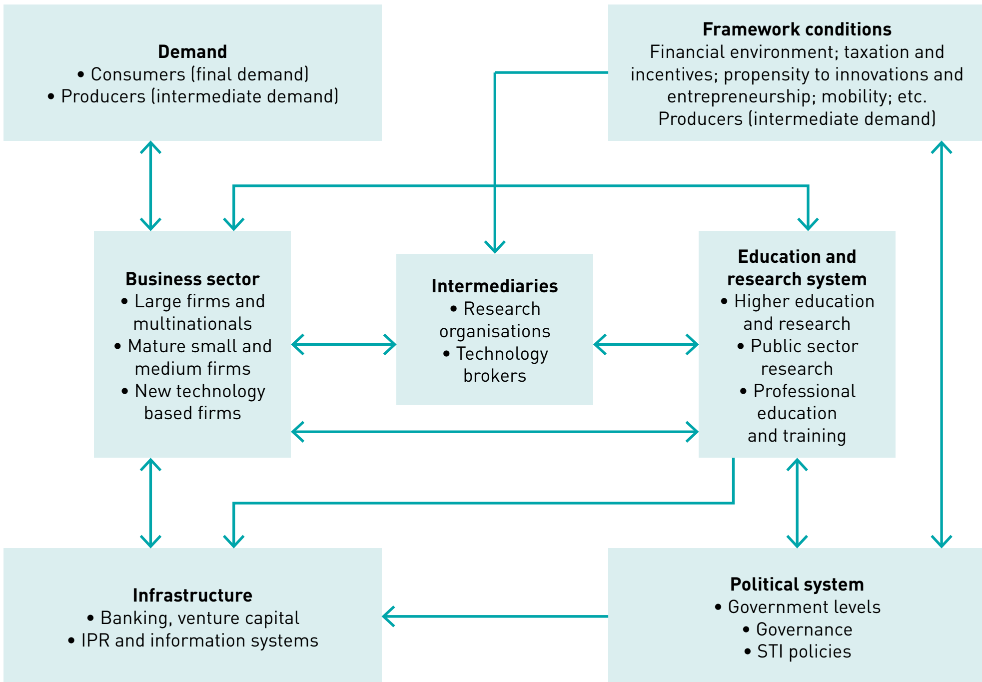
The 2013 issue of the annual report highlights, wherever possible or relevant, the impact of the economic crisis on the functioning of the national innovation system of Belgium. Thus, the idea is not to limit ourselves to a presentation of key data depicting the innovation system, as these are readily available on our website (www.stis.belspo.be/en/stat_stat.asp) as specialised data brochures or extensive databases. Instead, the report aims at offering a more analytical insight into the consequences of the economic crisis by focusing on a key aspect of the system that bears relevance for science policy.

1.2. The national innovation system of Belgium

The national innovation system is defined by the OECD (1997) as a way to acknowledge '*that the flows of technology and information among people, enterprises and institutions are key to the innovative process. Innovation and technology development are the result of a complex set of relationships among actors in the system, which includes enterprises, universities and government research institutes. For policy-makers, an understanding of the national innovation system can help identify leverage points for enhancing innovative performance and overall competitiveness. It can assist in pinpointing mismatches within the system, both among institutions and in relation to government policies, which can thwart technology development and innovation. Policies which seek to improve networking among the actors and institutions in the system and which aim at enhancing the innovative capacity of firms, particularly their ability to identify and absorb technologies, are most valuable in this context*' (OECD, 1997: p.7).

Innovation systems consider the generation, production and funding of various knowledge forms. Producing new knowledge is useful and often serves as an input for other organisations. Together the creation of new knowledge and the diffusion of knowledge open possibilities for the development of wealth and societal needs. The national innovation system can be depicted by a model in which actors interact with each other and in which knowledge flows within and between these actors. The innovation system is an analytical framework capturing the features that are relevant for policy makers to transform knowledge into products and processes for human needs. A key feature of the innovation system is its interactive nature. Actors respond to pressures and incentives and constantly need each other to reach their goals. Figure 1.1 shows a generic national innovation system (OECD, 2005).

FIGURE 1.1 – **Generic national innovation system**

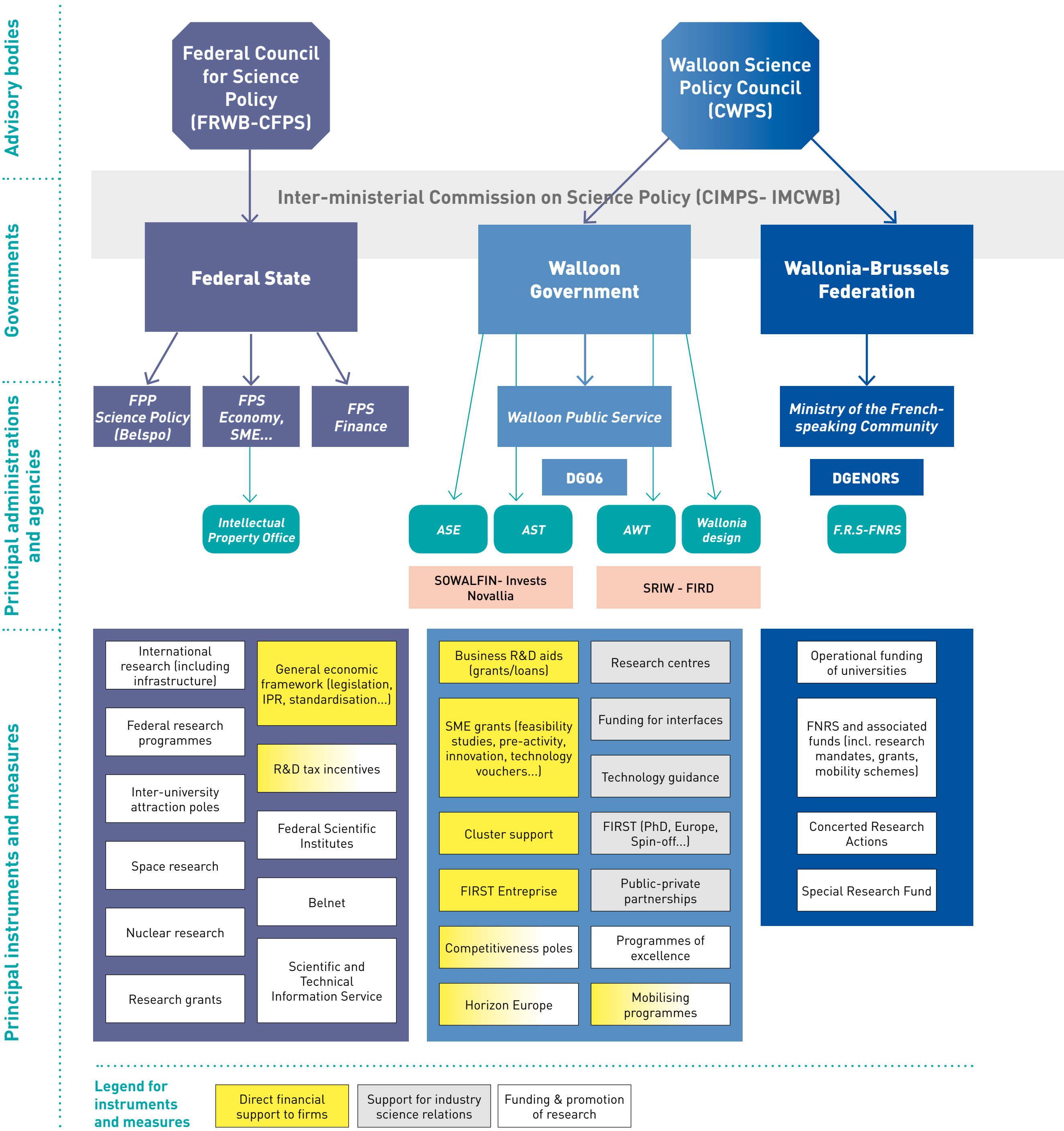


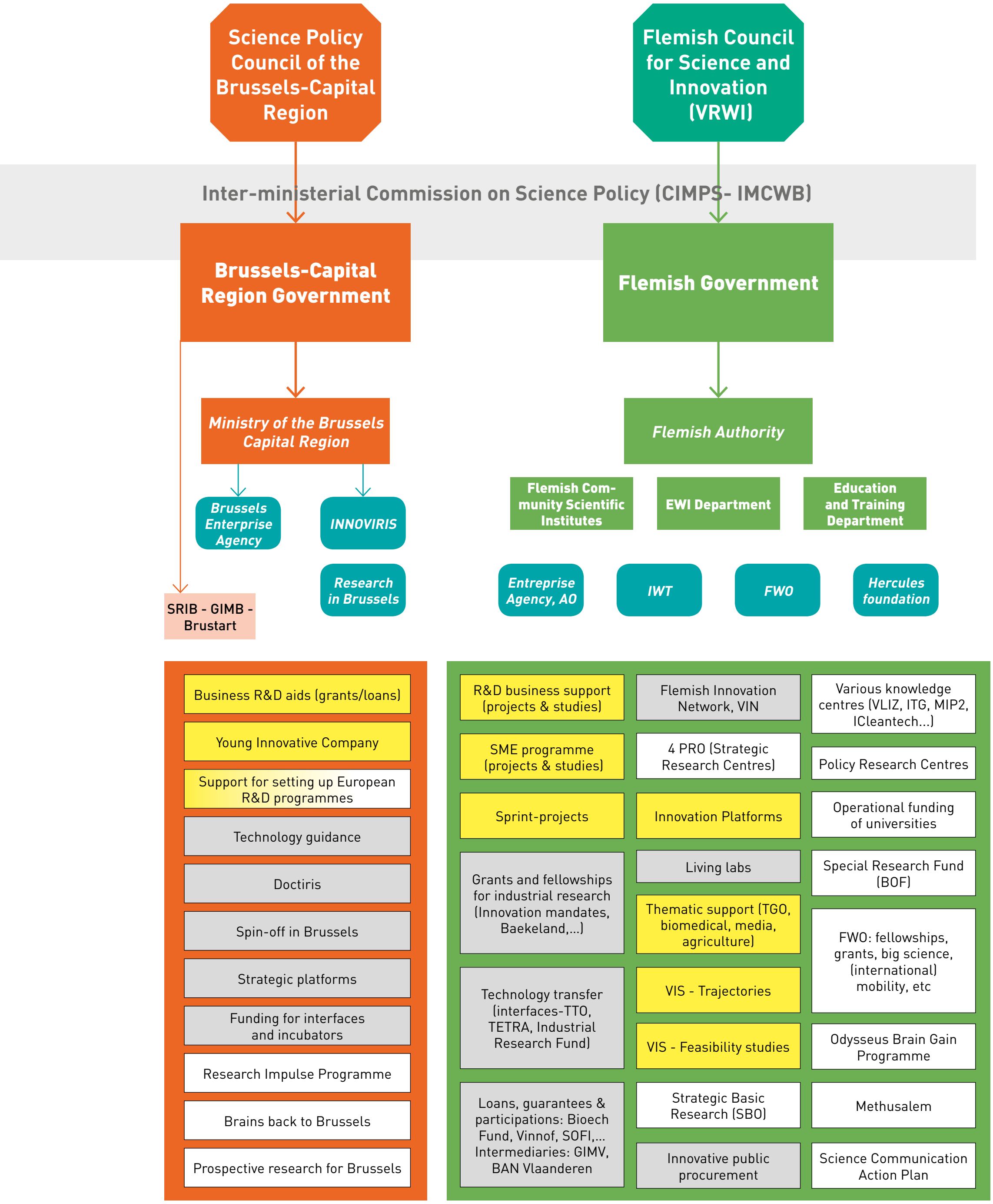
Source: OECD (2005)

As such a national innovation system must not be confused with the institutional profile of countries (Capron and Meeusen, 2000) nor with the policy system for science, technology and innovation (Belgian Science Policy Office, 2010).

The institutional profile is of crucial importance in setting up policy instruments and to enhance framework conditions to stimulate R&D and innovation. Belgium is a federal country with a federal government. The federated entities are communities and regions which bear the primary responsibility for science, technology, education and economic policies. As such they control the main levers for innovation policy. Several responsibilities remain at the federal level: space, international programmes and institutes; fiscal measures (taxes); scientific research institutes regarding its own competences; access to other federal competences (labour market, social security, scientific visa, regulatory framework, etc.). Figure 1.2 pictures the institutional profile for Belgium.

FIGURE 1.2 – **Policy governance of the innovation system**





Source: Reid, A. and Bruno, N. (2012) - where needed adapted by the respective authorities in November 2013.

1.3. Country selection for international comparison

To position a country with regard to innovative performance it is necessary to make comparisons internationally. There are numerous ways in which countries (and regions) may be selected to be compared to Belgium. Because comparison to other counties is part and parcel of the way the Key Data is used by policy makers, the selection is not without relevance. This activity is less innocent as it appears at first sight (see especially chapter 10 of this report). By choosing relative strong innovative countries, the impression can be created that a country is weak and innovation policy is inapt to cope with the challenges to be met. On the other hand, exclusive focusing on less innovative countries strengthens the idea that there are no problems. In a similar vein, the selection of indicators is likewise dangerous in suggesting a (less) favourable picture.

To ensure that every contributor uses a similar set of countries (dependent on data availability), a motivation for the selection has to be made. Because policy makers have opted to promote Belgium as a top performer in the knowledge economy, the selected countries have to excel in some aspect and be comparable to Belgium in respect to its relative smallness (in terms of population) and innovative performance.

For this latter purpose the most recent Innovation Union Scoreboard is used (European Commission, 2013). This Scoreboard makes use of 24 indicators on innovative activities (e.g. R&D, innovation, patents, human resources, entrepreneurship, and economic effects). The position of Belgium in relation to all other European Member States can be seen in Figure 10.3 in chapter 10. The idea is to compare Belgium to countries that are: (i) the most important trade partners; (ii) above the EU-average; and (iii) comparable to Belgium in terms of the number of inhabitants.

Therefore, the list for the Annual Report on Science and Technology Indicators 2013 becomes as follows: Belgium; its key trade partners – France; Germany; Netherlands; and United Kingdom – in Europe; other above EU-average countries – Austria; Denmark; Finland; Ireland; and Sweden. In addition, as in earlier Key Data issues, data on EU27, Japan and the US are also included when available. However, whenever the respective authors in this report feel the need to deviate from this selection to make their point they have the liberty to do so.

1.4. Positioning Belgium through key indicators

Key indicators have grown into an important instrument for policy makers. In the domain of science and technology the most cited indicator is the target to spend 3% of gross domestic product on R&D activities also known as R&D intensity. R&D intensity is a so-called input indicator that provides no automatic guarantees of innovative success. European economies face globalisation and increased competition and its main resource is knowledge. Hence the policy objective in European economies is to become a knowledge-based society. Since R&D is defined as the creation of new knowledge it becomes of key importance.

But indicators must never be seen in isolation. Therefore, a selection is made of twenty indicators that give an idea of the national innovation system. Four phases of the innovation process are reviewed. First, the R&D activities picture the input side of the innovation process. The gross expenditure on R&D (GERD) as a percentage of R&D is the key indicator of R&D intensity. It is this indicator that is to reach 3% by 2020 in the EU27, and many individual member states have also subscribed to this challenge. In most countries R&D is performed by the business sector (BERD). Therefore its contribution to the R&D intensity is depicted. The share of business R&D in total R&D is an indicator of the importance of the business sector in the innovation system (BERD as a percentage of GERD). The involvement of government in the business sector is captured by its funding of R&D activities. The openness of the economy is exemplified by the financing of organisations from abroad. These organisations cover foreign businesses and international organisations such as the European Commission.

Because R&D activities are for the main part performed by human resources, the second set of indicators focus on them. R&D activities are performed by highly skilled people. As input the share of population with tertiary education (mainly masters' degrees and doctorate holders) is considered. New doctorate holders are supposed to guarantee recent knowledge creation. Within organisations the category of R&D personnel contributes to the development of new knowledge. Therefore the share of R&D personnel in total employment is used as a relevant indicator. Within the R&D personnel the function as researcher is key to knowledge creation. This indicator is expressed in terms of full time equivalent (FTE) and headcounts (HC).

Innovation and entrepreneurship, the third set of indicators, guarantee that the newly created knowledge will diffuse itself throughout society. Small and medium-sized enterprises are well-known vehicles to start innovations. Most of them are – in contrast to large enterprises – confined to their region although they increasingly tend to serve international markets. Four indicators focus on the role of SMEs. These range from their in-house innovating capacities to focus on endogenous knowledge creation, to their collaborative agreements which are deemed necessary in a networked knowledge-based economy. Further the SMEs concentrate on the traditional product or process innovations on the one hand, but also increasingly focus on marketing and organisational innovations. Finally, an indicator for all firm sizes looks at the sales that are the results of launching innovations that are new to the market (i.e. radical innovations) and new to the firm (incremental innovations) as a percentage of total sales.

A fourth set of indicators zoom in on innovative output by looking at scientific publications and patents. Public-private academic co-publications give an idea on the scientific output of research collaborations between researchers in enterprises and the public sector. The number of co-publications is expressed per million inhabitants of a country to correct for size. Scientific excellence appears from the share of publications that are among the 10% most cited, and yields an indication of the efficiency of the research system. The economic innovative output is exemplified by patents. Patents are used as an indicator for the creation of new products or the implementation of new processes. The number of patents is often equated with innovation (Jaffe et al., 1993). PCT patents applications are those that are filed at the European Patent Office. The indicator is expressed as a percentage of billion GDP (in PPP €), and per thousand inhabitants. Finally the licence and patent revenues from abroad is an indicator of the openness of a country with respect to trade in technology. It is expressed as a percentage of GDP to correct for country sizes.

Table 1.1 presents an international comparison of the key indicators.

TABLE 1.1 – **International comparison of key indicators**

	Belgium	France	Germany	Nether-lands	United Kingdom	Austria	Denmark	Finland	Ireland	Sweden	EU27
R&D activities											
Gross expenditures on R&D - GERD (as % of GDP)	2.21	2.24	2.88	1.85	1.77	2.75	3.09	3.78	1.70	3.37	1.94
Business expenditures on R&D - BERD (as % of GDP	1.52	1.42	1.94	0.89	1.09	1.87	2.09	2.66	1.17	2.34	1.20
Business expenditures on R&D (as % of GERD)	68.70	63.44	67.33	47.91	61.47	68.09	67.57	70.46	68.98	69.29	61.88
Government financing (as % of BERD)	6.24	8.51	4.46	7.37	8.61	10.97	2.58	2.85	5.93	5.04	7.17
Financing from abroad (as % of GERD	12.96	7.61	3.88	10.85	16.98	15.86	8.73	6.54	20.11	10.86	9.03
Human resources											
Population with tertiary education (as % aged 30-34)	42.6	43.4	30.7	41.1	45.8	23.8	41.2	46.0	49.4	47.5	34.6
New doctorate graduates (per 1000 population aged 25-34)	1.5	1.5	2.7	1.9	2.3	2.3	2.1	2.6	1.6	2.9	1.5
Total R&D personnel (FTE) per thousand employed	13.8	14.7	13.7	11.6	11.4	14.6	20.4	21.7	11.9	17.0	11.4
Total researchers (FTE) per thousand employed	9.4	9.0	8.1	6.2	8.4	9.0	13.4	15.9	8.4	10.6	7.0
Total researchers (HC) per thousand employed	13.9	11.9	12.0	7.5	12.6	14.7	19.4	22.9	12.2	16.3	n.a.
Innovation and entrepreneurship											
SMEs innovating in-house (as % of SMEs)	39.80	29.95	45.25	39.10	n.a.	36.35	40.81	33.18	38.76	37.68	31.83
Innovative SMEs collaborating with others (as % of SMEs)	20.15	11.09	14.01	14.87	22.68	20.52	15.46	16.50	11.93	17.47	11.69
SMEs introducing product/process innovations (% SMEs)	50.34	32.68	57.00	46.02	21.26	42.20	41.60	44.75	45.50	47.38	38.44
SMEs introducing marketing/organisational innovations	41.73	42.80	60.55	36.91	30.64	42.33	42.64	38.89	45.04	42.15	40.30
Sales new to market and new to firm innovations (% total)	14.37	14.73	15.50	10.45	7.31	11.92	14.96	15.29	9.32	8.37	14.37
Innovative output											
Public-private co-publications (per million publications)	97.1	49.0	75.5	128.2	79.5	86.4	179.9	97.9	34.4	147.0	52.8
Scientific publications among the 10% most cited (% total)	13.59	10.33	11.64	15.13	13.28	10.92	14.60	11.48	11.38	12.28	10.90
PCT patent applications (per billion GDP in PPP€)	3.73	4.20	7.42	6.24	3.23	5.11	7.04	8.93	2.76	8.93	3.90
Patent applications to the PCT (per thousand inhabitants)	0.11	0.12	0.22	0.19	0.08	0.16	0.21	0.28	0.08	0.29	0.10
Licence and patent revenues from abroad (as % of GDP)	0.50	0.57	0.40	1.80	0.58	0.19	0.79	1.22	1.80	1.16	0.58

Sources: OECD (2013); European Commission (2013); CFS-STAT (2013).
Notes: R&D: research and experimental development; GERD: Gross expenditure on R&D; BERD: Business expenditure on R&D; GDP: gross domestic product; FTE: full-time equivalents; HC: headcounts; SME: small and medium-sized enterprises; PCT: patent cooperation treaty; n.a.: not available. The year refers to 2011 or the latest available year.

Positions and rankings differ according to the indicators used (European Commission, 2013; Dutta and Lanvin, 2013). This implies that the picture drawn in this section only reflects a partial snapshot of the performance of the innovation system. Comparing Belgium to the European Union (i.e. the average of 27 Member States) gives an optimistic view: Belgium outperforms the EU-27 for all indicators, save for government funding of industry. However, had the 1.1 billion € of fiscal measures (see chapter 9) been included, the picture changes drastically. As for human resources and innovation/entrepreneurship, the Belgium position is well above the European one. Regarding innovative output, the performance is inconclusive: in the case of scientific publications Belgium does all right, but in the case of patents and licence revenues there seems to be a problem in commercialising innovations on the market.

Comparison with trade partners shows that Belgium maintains a median position, despite the problems with the competitive position due to labour market issues. In the case of R&D intensity (i.e. GERD as a percentage of GDP) Belgium is outperformed by Germany and equals France, but leaves the United Kingdom and the Netherlands behind. The relatively privileged position of Belgium is even better in the case of business R&D percentage, which is only preceded by Germany. The innovation system of Belgium depends largely on the behaviour of the business sector as inferred from the high share of this sector in total R&D expenditure (68.7%). The relative openness of the Belgian economy in the case of R&D is also evident from the fact that nearly 13% of all R&D stems from abroad, which is higher only in the United Kingdom. As for the human resources, the Belgian indicators show a blurred picture: in terms of researchers Belgium is in first position compared to its trade partners; but in terms of new doctorate graduates they are in last position (with France). In terms of looking at innovation and entrepreneurship, however, Belgium occupies a relatively high position as it is never far from the trade partners placed at the top. In the case of other types of innovative output – publications and patents – the position of Belgium varies.

First, the position is good with Belgium in second place, following the Netherlands, when both publications are set in terms of co-publications between public and private partners and when considering the overall quality of scientific publications. However, the position is relatively weaker when compared to trade partners when it comes to patent applications, with only the Netherlands performing worse in this respect. Benefitting from patents through financial revenues is, as indicated earlier in comparison to the EU-27, a weakness pointing to commercialisation problems (only Germany struggles with commercialisation as well).

A comparison with the innovation followers that are not key trade partners, gives a slightly different picture. This time, the R&D activities are far less outstanding when it comes to R&D intensity of gross and business R&D (only Ireland performs less than Belgium). Finland, Sweden and Ireland are more reliant on the business sector in their innovation system than Belgium; whereas Austria and Denmark are less. Government financing in Belgium – earlier indicated as weak – now comes out nearly at the top of the list, only preceded by Austria. In the case of openness of the R&D system, Austria and Ireland are more open than Belgium. In terms of human resources the position of Belgium towards non-trade partner innovation followers is relatively weak; particularly in the case of new doctorate graduates. The picture is varied when it comes to innovation activities and innovative output. Belgium either shows top performance – as in SMEs introducing product and process innovations – or weak performance – as in the case of SMEs introducing marketing or organisational innovations; patent applications (gross and per inhabitant); and commercialisation through licence and patent revenues.

The main message given here is that positioning an economy depends, on the one hand, on the indicator that is used; and on the selection of comparative countries on the other.

1.5. Structure of the report

The Annual Report on Science and Technology Indicators for Belgium presents nine chapters which are relevant to the discussion on the national innovation system. Whenever meaningful, the chapters focus on data and indicators with respect to the impact and consequences for R&D activities and to innovation of the economic crisis. In other instances, they focus on a topic that is currently debated in the field.

The second chapter on the budgetary R&D outlays focuses on planned R&D budgets by the public sector. These data differ from the actual public R&D expenditure in several aspects. First, the data on budgets include R&D grants for sources abroad; whereas the R&D expenditures focus on R&D activities performed on the territory of Belgium. Second, budgets devoted to R&D from provinces and municipalities are excluded in the budgetary data, while the R&D funded by these government levels does appear in the data on R&D expenditures. The analysis points to a relative low performance for Belgium in this respect. It shows that the impact of the economic crisis differs according to policy level and, most particularly, a sharp reduction at the federal level. However, these data do not take into account the relative high performance of the fiscal measures.

The third chapter tackles the business R&D expenditures and zooms in on the topic of internationalisation of R&D. Belgium has the reputation of being a very open economy in which foreign-controlled firms are calling the shots. Many firms operate in an international context and are embedded in worldwide networks. This is reflected in the R&D data, where multinational enterprises are more R&D intensive than domestic enterprises.

The fourth chapter looks at the sources of funding of the R&D expenditures by the non-profit sector. This sector consists of higher education institutes, public research organisations and public/private non-profit organisations. Public funding for R&D in both the business sector and non-profit organisations stems for an increasing part from the European Framework Programme on Research and Technological development. R&D in the public sector proves to act counter-cyclical in times of economic crisis.

In the fifth chapter the active part Belgium takes in this Seventh Framework Programme is discussed. The Framework Programme is divided into several thematic areas for which the participation structure and success ratios are examined. The Belgian participation ranks high, although the role of Brussels as the European headquarter for many participants does exert an impact.

Innovation expenditure in relation to the economic crisis is discussed extensively in chapter six. The chapter differentiates between radical and incremental innovators; young and fast-growing SMEs and other firms; strategic considerations in terms of explorative and/or exploitative research; and the permanency of R&D activities in order to capture the impact of the crisis.

Chapter seven concentrates on an aspect of the output side of research. The higher education institutes publish much of their research in international scientific journals that are being cited or referred to. This research is also published in cooperation with the business sector. Information on scientific literature is relevant to understand the structure of the research system in a country.

Chapter eight looks at the doctorate holders as a key element of the input side of the innovation system. More specifically, an array of relevant labour market characteristics of doctorate holders are considered, such as age, gender, type of contract, scientific discipline, sector of employment and occupation, and the mobility of researchers. All these characteristics are studied with respect to gross salary earnings of doctorate holders.

The fiscal measures for R&D knowledge workers that have been taken by the federal authority are the subject of chapter nine. Using an opinion poll directed to enterprises, four aspects of this measure are being investigated: employment effects; effects on R&D projects; decision factors for additional R&D; and what would happen if the fiscal measure did not exist.

Chapter ten zooms in on the most crucial policy issues in the years 2012 and 2013 at European and federal levels. European initiatives are reviewed: Horizon 2020; the innovation union flagship; the Annual Growth Survey; National Reform Programmes; and the development of a new headline indicator. Further, policies at the federal level are discussed: the recovery plan, initiatives within the Belgian Science Policy Office, and the functioning of the Inter-Ministerial Commission for Science Policy.

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Policy priority setting: the government budget on R&D

EMMANUEL MONARD AND ANDRÉ SPITHOVEN

2.1. Introduction

Public policy towards financing research and development makes use of various instruments: direct measures such as subsidies; indirect measures such as tax incentives (see chapter 9); public procurement practices; etc. In this chapter we limit ourselves to the planned R&D budgets which cover to a large extent the planned subsidies given to R&D performers. However, as other policy instruments gain in importance, the R&D budgets capture less of all public involvement in R&D.

Thus policy-making in the innovation system can be captured by two distinct indicators. First, the proposed budget which shows the government's intentions in committing public resources to R&D, and, second, ex post government funding of gross R&D expenditures (see chapter 4). This chapter focuses on the first of these two indicators. The allocation of funds for R&D gives an insight into the political objectives on R&D activities. The government budget appropriations or outlays on R&D, abbreviated as GBAORD, are based on the budget programmes of the federal, regional and community authorities. Some of these are linked to scientific policy and others to budgets assigned to scientific and technological activities. Only the R&D proportion of a budget item is to be taken into account in order to be part of the government budget on R&D. In line with the related OECD and EU Directives, this indicator is not based on real expenditure on scientific and technological activities but on the budget allocations of the aforementioned authorities, and this irrespective of where the money is spent, whether it is within the public sector or not or on the national territory or not.

The ex-ante government budget aggregate differs from, and may not be confused with, ex post government-financed gross R&D expenditures (GERD). There are two main differences between both indicators. First, government-financed expenditures on R&D are based on surveys taken from R&D performers in both the private and public sectors; whereas government budgets on R&D are provisions – drawn from budgetary document information on the commitment of government levels to allocate funds on R&D activities – by governments focused on policy domains related to science and technology. Second, government-financed R&D expenditures cover R&D performed on the national territory; whereas government budgets (GBAORD) also include payment provisions to foreign R&D performers (including international organisations). Therefore, funding of the following international organisations includes the European Organisation for Nuclear Research (CERN), the European Space Agency (ESA), the Consultative Group on international Agricultural Research (CGIAR), the European Synchrotron Radiation Facility (ESRF), the European Molecular Biology Organisation (EMBO), the International Atomic Energy Agency (IAEA), the Co-operation in Scientific and Technical research (COST), and the European Network for Market-Oriented Industrial R&D (EUREKA). The data on budgets derived from funders' reports are considered less accurate than those that are performer reported (OECD, 2013).

The government budget on R&D tells something about the expected or anticipated destination of the R&D investment. It shows trends in the financial involvement and attitude of the public authorities over time towards investment in research and development.

The policy priority setting from the government budget on R&D is captured by so-called socio-economic objectives. Socio-economic objectives are categorised using a nomenclature for the analysis and comparison of scientific programmes and budgets, or NABS for short (OECD, 2002). As such this indicator is particularly valuable for the purposes of international comparison, as it is used by all OECD countries. Alterative classifications can be designed to capture the country's specific institutional structure and organisation of the innovation system. In Belgium, a so-called 'CFS/STAT-nomenclature' is used (see further).

The observed period varies from 2002 till 2011 and the data on government budget appropriations or outlays are based on final budgets. Data for 2012 are not used for international comparison, because they are not available for most countries. And, if available, e.g. in the context of Belgium, they are not used either, because those data are based on provisional budget data and therefore less reliable.

2.2. International comparison of government budgets on R&D

By expressing total government budgets on R&D as a share of gross domestic product (GDP) different countries can be compared to each other. The advantage of this indicator is that it measures R&D budgets as intensity. In this way, the influence of the size of a country is limited. However, international comparison of R&D budget data is impaired by the imprecision in budget appropriations and of the differences of countries when it comes to the amount of R&D being performed and expected in appropriations stage. The indicator shows, in Table 2.1, that Belgium keeps on lagging fairly far behind in Europe throughout the observed period from 2002 to 2011.

TABLE 2.1 – **International comparison of government budgets on R&D (in % of GDP)**

Country	2002	2005	2008	2011
Belgium	0.60	0.59	0.68	0.63
France	1.00	0.97	0.88	0.84
Germany	0.78	0.77	0.80	0.91
Netherlands	0.82	0.79	0.79	0.79
United Kingdom	0.76	0.67	0.65	0.59
Austria	0.67	0.66	0.70	0.77
Denmark	0.73	0.71	0.85	1.02
Finland	0.97	1.03	0.98	1.09
Ireland	0.33	0.46	0.53	0.50
Sweden	0.87	0.86	0.80	0.83
European Union - 27	0.75	0.71	0.72	0.73
United States	0.97	1.04	1.02	0.96
Japan	0.71	0.71	0.71	0.78

Source: OECD (2013); data on EU-27: Eurostat (2013).
Note: The government budgets on R&D and GDP are both measured in national currency.

Compared to the main trade partners, Belgium and Germany are the only ones that increased R&D budgets between 2005 and 2008. The year 2008 showed an important increase of the government budgets on R&D in percentage of the GDP in the case of Belgium. However, this could not be confirmed in recent years, when a slight decrease for Belgium could be noted whereas Germany continued to grow. The main explanation for this evolution might be that Belgium copes with a high debt ratio in terms of its GDP; preventing Belgium – at least at the federal level – to step up its government spending. Belgium is by no means the sole economy in this case (OECD, 2012). The data based on provisional budget data for 2012 seem to confirm this slight decrease or present, in the best case, a status-quo. Hence, of the trade partners, only Germany planned to increase its government budget on R&D between 2008 and 2011.

The government budgets on R&D, when expressed as a percentage of gross domestic product (GDP) for all authorities in Belgium, lie below the EU-27 average and, as such, reveal an underinvestment in R&D by the authorities in Belgium.

Compared to the other selected countries, the increase between 2005 and 2008 for Belgium is followed by Austria, Denmark and Ireland, but not by Finland and Sweden. Countries with already a high R&D intensity did not step up their government budgets on R&D. Yet, except for Ireland, Austria and Denmark did increase their government budgets on R&D up to 2011, as did Finland and Sweden. This is reflected in Table 2.2, by looking at the compound annual growth rates of the government budgets on R&D between the cited years when they are not divided by GDP.

TABLE 2.2 – **Nominal compound annual growth rates of government budgets on R&D (in %)**

Country	2002-2005	2005-2008	2008-2011
Belgium	3.64	9.46	-0.26
France	2.52	0.50	-0.27
Germany	0.95	4.57	6.05
Netherlands	2.07	4.89	0.39
United Kingdom	1.37	3.66	-1.29
Austria	3.36	7.05	5.46
Denmark	3.30	10.36	7.27
Finland	5.14	3.96	4.53
Ireland	20.09	8.39	-5.42
Sweden	3.72	2.49	4.22
European Union - 27			
United States	8.40	3.23	0.00
Japan	0.31	-0.07	0.72

Source: OECD (2013); data on EU-27: Eurostat (2013).
Note: The government budget on R&D is measured in national currency.

Table 2.2 summarises the findings by looking at three different periods. Four patterns are detected. There are countries that have experienced increasing growth rates of their budgets on R&D in the period before and after the economic crisis (Germany and Austria); countries that stepped up the growth rate of their budgets on R&D before the crisis but that were unable to uphold the growth rates of their provisions (Belgium, the Netherlands, the United Kingdom, and Denmark); countries that decreased the growth rate of their budgets before the crisis but increased this growth rate afterwards (Finland, Sweden and Japan); and countries that decreased the growth rate of their budgets before and after the crisis (France, Ireland and the United States).

2.3. Government civil R&D budgets by socio-economic objectives

A meaningful way to gain insights into the policy priority setting of countries is by presenting government budgets on R&D according to their socio-economic objectives. Based on the Frascati Manual (OECD, 2002) all countries should use an agreed Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets, abbreviated as NABS. The remainder of this section exclusively deals with the budgets for civil purposes, thus neglecting the defence which might be significant for some countries. The total government R&D budgets devoted to defence was especially important in some countries (e.g. 56.8% in the US in 2011), but seems to decrease substantially in the United Kingdom (24.2% in 2006 against 14.6% in 2011) and drastically in France (28.8% in 2007 and 6.8% in 2011). However, defence R&D might have significant spillover effects on civil R&D and innovative activities. Table 2.3 introduces the civil R&D budget in monetary terms in 2011 and the nominal compound annual growth rates for three time frames.

TABLE 2.3 – **Government civil R&D budgets in compound annual growth rates (in %)**

Country	2002-2005	2005-2008	2008-2011
Belgium	3.66	9.47	-0.24
France	3.45	0.31	5.51
Germany	0.85	4.47	6.81
Netherlands	1.97	5.00	0.42
United Kingdom	6.25	4.79	1.46
Austria	3.36	7.05	5.46
Denmark	3.22	10.43	7.36
Finland	4.52	4.15	4.62
Ireland	20.09	8.39	-5.42
Sweden	5.53	4.52	6.03

Source: OECD (2013).
Note: The government budget on R&D is measured in national currency.

Table 2.3 shows that in the years preceding the economic crisis, i.e. 2005-2008, the annual growth rates of Belgium were – except for those of Denmark – the highest. But this effort could not be sustained. Ireland and Belgium have opted to pursue a decreased growth rate in the aftermath of the economic crisis between 2008 and 2011, at least in nominal terms. The civil R&D budgets of the Netherlands and to a lesser extent those of the United Kingdom stagnate. Fast growers, with above 5% annual growth between 2008 and 2011, are Denmark, Germany, Sweden, France and Austria.

Each country uses their budgets for the fulfilment of particular socio-economic objectives. The Frascati Manual (OECD, 2002) contains guidelines about 13 specific socio-economic objectives, which can be reduced to six meaningful aggregates in the civil R&D budget. A summarised breakdown of the government civil R&D budget in socio-objectives is presented in Table 2.4.

TABLE 2.4 – **Government R&D budgets by socio-economic objectives in 2011 (in % of civil budgets)**

Country	Economic development	Health and environment	Education and society	Space	Non-oriented research	General university funds
Belgium	40.1	4.8	5.8	8.7	23.8	16.8
France	19.5	11.0	6.1	15.7	20.2	27.6
Germany	24.2	9.4	3.9	4.9	16.9	40.7
Netherlands	19.6	6.8	3.6	3.9	16.8	49.2
United Kingdom	7.9	32.5	4.4	3.4	22.5	29.3
Austria	18.8	8.3	2.5	0.6	13.6	56.2
Denmark	18.6	12.8	6.7	1.3	17.6	43.0
Finland	37.1	9.1	5.9	2.2	18.2	27.5
Ireland	36.5	6.9	2.1	1.7	31.8	20.9
Sweden	15.2	4.4	3.4	0.4	22.5	54.1
European Union - 27	21.6	14.1	4.8	6.1	18.2	35.2
United States	10.5	56.8	2.9	13.9	16.0	0.0
Japan	26.6	7.0	0.7	6.7	21.5	37.4

Source: OECD (2013).
Note: The government budgets on R&D are measured in national currency.
The shares of France, Germany, Sweden and the EU-27 have been adapted to reach 100%.

Table 2.4 reveals that, compared to other countries, Belgium prioritises to fund R&D programmes on economic development (40.1%). This comprises R&D programmes directed towards agriculture, fishery, and forestry, industry, energy, and infrastructure and general planning of land use. This implies that the share of the R&D content of 'block grants' to the higher education sector, as captured by the general university funds, is, with 16.8%, relatively low in Belgium. Like France and the United States, Belgium opted to invest in civil space R&D programmes. Only Sweden intends to carve out a smaller share of its civil R&D budget than Belgium for R&D programmes directed to health and environment covering the protection and improvement of human health, control and care of the environment, and for the exploration and exploitation of earth. Except for Ireland, authorities in Belgium reserve the highest share of civil R&D for research programmes aiming at the advancement of knowledge in general (i.e. non-oriented research).

A further examination of government priorities shows that for six European countries, and for the European Union as a whole, the general university funds are considered the main priority. An emphasis on general university funds reflects the importance attached to university education and academic research in the national innovation system. For three countries – Belgium, Finland, and Ireland – the main policy domain is economic development. Non-oriented research is the second or third most important policy domain for all countries.

2.4. Government budgets on R&D by the different authorities in Belgium

Soon after Belgium became a federal state, policy makers in the Dutch speaking part of Belgium decided to install one authority, the Flemish Government, dealing with 'community' related issues (such as education and health care) and 'regional' related issues (such as industrial policy). The politicians in the French speaking part of Belgium choose to keep two different authorities: French Community and Walloon Region. The data on government R&D budgets of the different authorities in Belgium in the period 2002-2011 pass in review in Table 2.5. Although they all evolve upward, there are some large fluctuations in the course of time.

TABLE 2.5 – **Government R&D budgets on R&D by policy authority (in million constant euro)**

Region	2002	2005	2008	2011
Total for Belgium	1712.4	1787.7	2192.2	2124.1
Brussels-Capital Region	15.0	22.1	23.4	27.9
Federal Authority	510.6	462.5	554.7	505.5
Flemish Government	753.0	898.6	1048.6	1090.2
French Community	237.3	234.7	255.1	271.0
Walloon Region	196.5	169.7	310.5	229.6

Source: CFS/STAT (2013).
Note: Implicit GDP price indices (2005 = 100); OECD (2013).

The differences between the authorities reflect the regional differences in policy R&D strategy. The Flemish Government and, to a far lesser extent the Brussels-Capital Region, constantly augment their government R&D budget. The French Community stagnated at the beginning of the 21st century, but the R&D budgets have been growing ever since. The R&D budget of the Federal Authority fluctuates in nominal terms during the period under consideration due to the contributions made to the space programme. Based on provisional R&D budget data for 2012 there is no evidence of a significant improvement.

As time goes by and policy priorities change, the government R&D budgets change continuously. Similar to the exercise performed earlier, Table 2.6 looks at the evolution of the government R&D budgets by policy authority in terms of the compound annual growth rates in three time segments and in real terms.

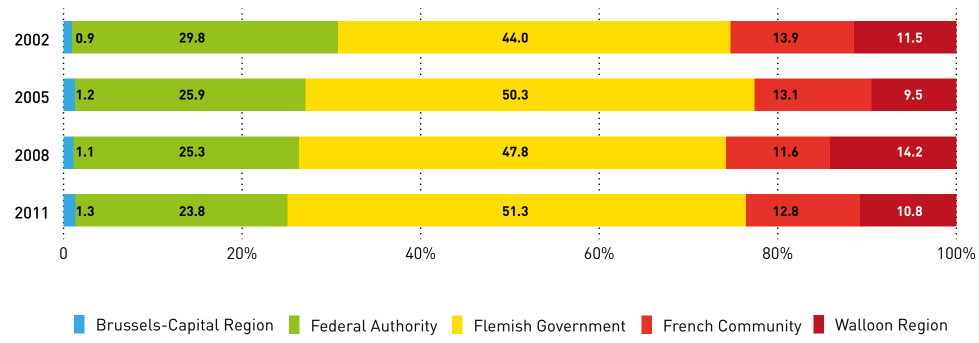
TABLE 2.6 – **Real growth rates of government budgets on R&D by policy authority (in %)**

Region	2002-2005	2005-2008	2008-2011
Total for Belgium	1.44	7.04	-1.05
Brussels-Capital Region	13.79	1.92	6.04
Federal Authority	-3.24	6.25	-3.05
Flemish Government	6.07	5.28	1.31
French Community	-0.37	2.82	2.04
Walloon Region	-4.77	22.31	-9.57

Source: CFS/STAT (2013).
Note: Implicit GDP price indices (2005 = 100); OECD (2013).

Figure 2.1 shows the contribution of each of the political responsible entities within Belgium.

FIGURE 2.1 – **Government R&D budgets on R&D by policy authority (as a share of Belgian total)**



Source: CFS/STAT (2013).
Note: Implicit GDP price indices (2005 = 100); OECD (2013).

Figure 2.1 shows that the regionalisation of science policy, as indicated by the declining share of the Federal Authority in Belgian total, from 29.8% to 23.8%, continuously increases. Federal budgets are mainly reserved for policy domains that remained at national level (e.g. space research; contributions to international organisations). With about three quarters of the total, the majority of government R&D budgets are at regional level. However, this does not account for the global shift from subsidies to tax incentives (see chapter 9).

2.5. Characteristics of government R&D budgets in Belgium

The government R&D budgets in Belgium, 2.1 billion constant euro (2005=100), can be classified according to two additional characteristics following a national specific nomenclature. First, the budgets are classified by institutional and functional destination. Second, the budgets are classified according to the funding mode.

Institutional destinations refer to the organisations themselves: higher education (universities, university colleges) and scientific organisations. Under functional destinations the budgets of particular programmes are targeted. The institutional and functional destination of the government R&D budgets covers seven categories and offers a good insight in the particularity of the national innovation system in Belgium.

TABLE 2.7 – **Government R&D budgets on R&D by destination (in million constant euro)**

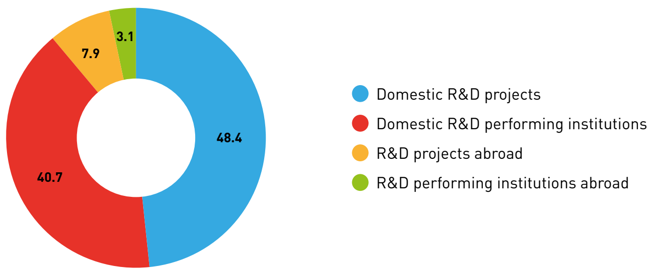
Institutional and functional destination	2002	2005	2008	2011	2011 (in % of total)
Higher education	427	442	499	505	23.8
Scientific institutions	282	256	299	294	13.8
Various credits of R&D	91	96	127	94	4.4
Action programmes	298	306	456	385	18.1
University and basic research funds	172	200	246	243	11.4
Industrial and applied research funds	178	268	244	351	16.5
International actions	264	220	321	252	11.9

Source: CFS/STAT (2013).
Note: Implicit GDP price indices (2005 = 100); OECD (2013).

The category 'Higher education' regroups all financial data related to the block funding of universities and institutions of higher education. The category 'University and basic research funds' regroups all financial data related to the funding of academic research from other sources than block funding. The R&D budget classified in the category 'Industrial and applied research funds' is by far growing the fastest in the observed period (an average of 8% a year). In 2008 it looked as if the category 'Action programmes and organisational systems of R&D' was reaching, in absolute terms, the level of the category 'Higher education', but this tendency did not continue. On the contrary, an important decrease of this category was shown over the recent 3 years.

The second classification was designed a few years ago when the OECD started a pilot project for a new breakdown by funding mode of the government R&D budget data. These indicators are still experimental, but the OECD Working Party of National Experts in Science and Technology Indicators is working to develop methodological guidelines for refining and institutionalising their regular collection. Recently data for Belgium have been provided and are summarised in Figure 2.2.

FIGURE 2.2 – **Breakdown by funding mode for government R&D budget (in %, 2010)**



Source: CFS/STAT (2013).

The data, of all authorities in Belgium combined, are presented for the year 2010 (the only year for which data, according to this new breakdown, have been collected) in million current euro. The data show the 'public funding of R&D' of the R&D budgets in four categories. The funding of domestic R&D, whether performing institutions or projects, represents almost 90% of all public funding. A little more than 10% of the public funding finds its way abroad.

2.6. Conclusion

The chapter on the government budgets on R&D reveals two important messages. First, all authorities in Belgium taken together have, in relative terms, not favoured the policy instrument of subsidies. The growing popularity of the tax incentives for R&D (see chapter 9) and the budgetary constraints are partly responsible for that. Hence, according to the official data, the authorities in Belgium are not the best public investors in R&D in Europe. There is no tendency for a real catching up of Belgium towards the European average regarding subsidies despite efforts; especially by the Flemish Government (average increase of almost 5% over the period 2002-2011) and to a lesser extent by the Walloon Region (average increase of almost 2%). The Federal Authority is the only authority in Belgium that decreased its budgets (very slight) over the period (-0.1%). The year 2008 showed an important increase of the government budgets on R&D of Belgium in percentage of the GDP. However, this could not be confirmed in recent years, when a further slight decrease occurred. This does not imply that federal funding in general decreased. Quite the contrary, since the fiscal measures in 2011 accounted for 1.1 billion €, of which half (i.e. 555 million €) was due to the fiscal measure on R&D knowledge workers.

Second, the Federal authority's share in the government budgets on R&D of the country has known a continuous decline over the last two decades. The share was 43% in 1989. In 2011 it was reduced to 23.8%. This eye-catching change is a good illustration of the growing impact of the regional authorities in the scientific decision making of the country. The Flemish authority's share on the other hand grew to just more than the half of the total government budgets on R&D in Belgium (51% in 2011). As indicated in chapter 9, this evolution reflects the policy choice made at federal level to step up the indirect public aid to R&D through tax measures.

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CHAPTER 3

The internationalisation of business R&D

JULIEN RAVET AND KARL BOOSTEN

3.1. Introduction

In a world based on global supply chains, where parts are produced in one country, shipped across oceans and assembled at the other end of the world, it becomes natural to consider economic phenomena within a network of international trade relations. The advent of new economies and a better educated workforce in developing countries makes it no longer insurmountable to outsource R&D activities to foreign countries.

The internationalisation of R&D activities is nowadays acknowledged as a complex and fundamental aspect of globalisation, which clearly matters for economic development and public policies (OECD, 2005a). As a matter of fact, MNEs account today for most business R&D in the world. The top 700 R&D spenders in the world account for about 50% of worldwide R&D and 70% of business R&D (UNCTAD, 2005). According to the 2012 Industrial R&D Investment Scoreboard, the 1500 world's top investors represented about 90% of the global business R&D in 2011 (European Commission, 2012).

At the firm level, the decision to internationalise R&D activities relies on two main drivers (Kuemmerle, 1997; Dunning and Narula, 1995). On the one hand, firms may adopt a home-base exploiting or asset-exploiting approach by setting up R&D affiliates abroad in order to adapt technologies and products to the local market conditions. On the other hand, home-based augmenting or asset-seeking strategies have grown the most rapidly since the 1980s (Dunning and Narula, 1995) with firms internationalising their R&D activities in order to tap into knowledge and technological resources located abroad. The decision to locate R&D affiliates abroad is affected by several factors, such as the technological strengths of the countries (Patel and Vega, 1999; Le Bas and Sierra, 2002), institutional factors, including public support for R&D, IPR systems, quality of technological infrastructures, and the cost of qualified research (UNCTAD, 2005). These internationalisation strategies may enhance the productivity of R&D activities but they correlate with higher complexity in terms of management, coordination costs and information asymmetries between corporate headquarters and divisional managers (See Cincera and Ravet (2012) for an empirical assessment of the effect of internationalisation on R&D productivity).

This chapter aims at investigating the internationalisation nature of the R&D activities performed by firms located in Belgium. This analysis is highly relevant for a small open economy like Belgium as 66% of the business R&D in Belgium is carried out by foreign-controlled affiliates (CFS/STAT, 2013). Recent data about R&D internationalisation in Belgium are provided by the STIS (Scientific and Technical Information Service) department of the Belgian Science Policy Office. STIS is a public agency responsible for the collection and analysis of scientific and technological data. All data were collected within the framework of international agreements with Eurostat and the OECD to guarantee the reliability and international comparability of the data.

In section 3.2, key figures about R&D internationalisation are reported for Belgium from the financing and the ownership perspective. The purpose of this section is to provide Belgian aggregated figures with an international perspective in order to shed light on Belgian specificities in comparison with other important players in the international innovation playing field.

Section 3.3 is devoted to a microeconomic analysis of the foreign-controlled R&D in Belgium. As most R&D in Belgium is conducted by foreign-controlled affiliates, it is essential to examine the characteristics of these affiliates with respect to their representation in Belgium, their sectoral penetration and the profile of their R&D activities.

While section 3.3 only considers the nationality of the control of the firms, section 3.4 opposes the international nature of the control (i.e. foreign-controlled R&D) to the international structure of the firm (i.e. multinational enterprise) when assessing the R&D efforts of the enterprises. Given size and industry effects, this section examines whether foreign-controlled affiliates are intrinsically more R&D intensive than their Belgian counterparts, being themselves MNE or not. We show that the internationalisation of the structure of the firm matters (i.e. Belgian- or foreign-controlled MNE versus non-MNE) rather than the nationality of the owner.

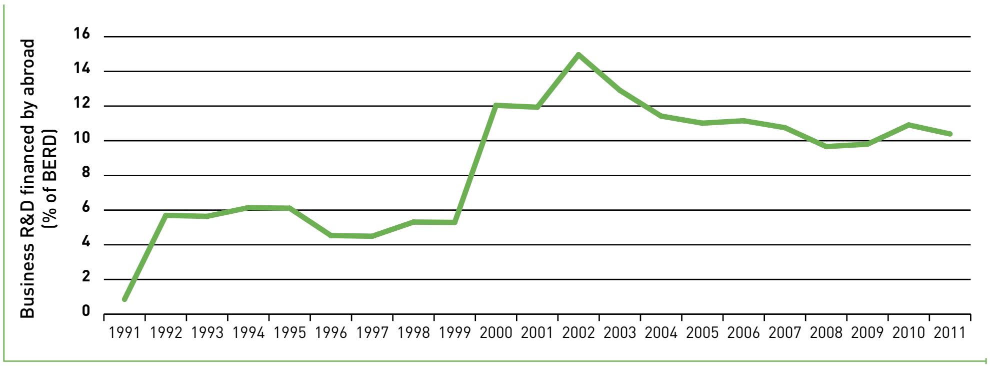
3.2. Internationalisation of R&D in a series of countries

Two approaches may be adopted in order to analyse the internationalisation of R&D in the Belgian business sector. First, R&D investments can be examined from the perspective of the financing source. Since a great share of all R&D investments in the Belgian business sector comes from foreign actors, a thorough understanding of these financing patterns is of vital importance for a better insight into the weaknesses and strengths of the innovation system in Belgium. Disentangling those ties will show how heavily this system depends on foreign capital. The second approach consists in taking into account the strategic ownership of a company. If the decision centre – i.e. the shareholder who owns more than 50% of the company shares and thus has the power to influence the strategic decisions of the company – is located abroad, the company will be regarded as a foreign-controlled affiliate. In the case where the majority of company shares are in hands of a Belgian shareholder we will speak of a domestic or resident-controlled firm. The group of resident-controlled companies can be further divided into companies that have foreign business units under their control and companies that have no foreign companies incorporated in their business structure. Both approaches - the financing source and the ownership - allow us to sketch a global picture of how the branches of the national innovation system are connected with the systems of other countries. As a result of the openness of the Belgian economy, our innovation system becomes more and more integrated into a globalised environment.

Approach 1: internationalisation of R&D from the financing perspective

Capital-intensive and technology-driven companies invest considerable amounts of money in the development of new knowledge. These internal R&D expenses are financed by a wide variety of sources, from capital resources owned by the company to subsidies by public authorities and higher education institutions. A certain share of these investments comes from companies located abroad. These companies can be part of the same business group or can belong to other business groups whose aim is to extend their knowledge stock through cooperation. Financing from abroad also includes public funding by non-Belgian public institutions, which mainly includes EU aids. According to Figure 3.1, the share of these foreign capital investments in R&D activities in Belgium during the period 1991-2002 has risen sharply, from approximately 1% to 15%. After having reached a peak in 2002, figures started to dwindle until they stabilised around the level of 10%. A breakdown of these figures according to industrial sectors reveals that the strong increase between 1999 and 2000 might be explained by changing strategies in a limited number of companies in the pharmaceutical industry.

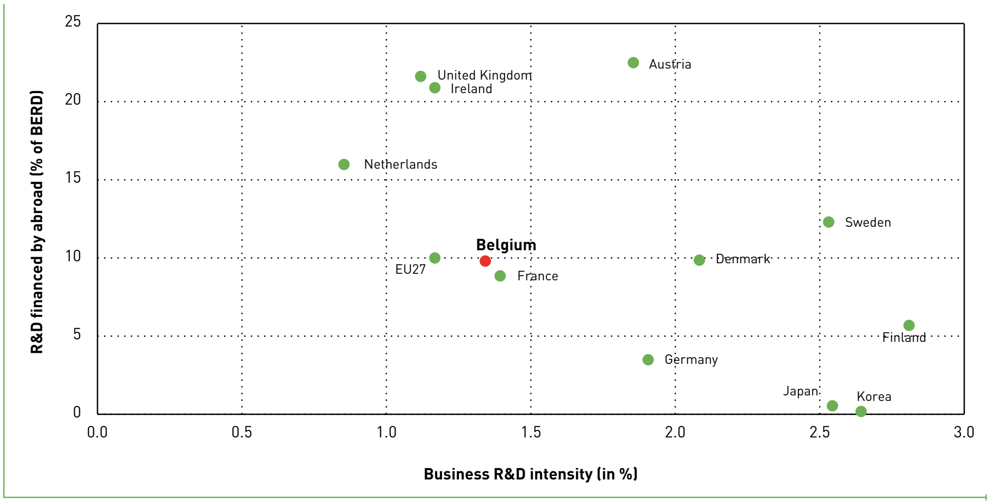
FIGURE 3.1 – **Evolution of the percentage of business R&D financed by abroad from 1991 to 2011**



Sources: OECD (2013) and CFS/STAT (2013).

To determine the position of Belgium within an international context, it might be interesting to juxtapose two variables. The first variable is the proportion of foreign-financed R&D investments with regard to the total business R&D investments. The second variable is a measurement of the business R&D intensity of a country. The R&D intensity of a country is calculated by means of dividing the total of business R&D investments by the gross domestic product. The relation between both variables across a range of countries (see chapter 1) is reported in Figure 3.2 and reveals that Belgium occupies a central position. Between countries such as the United Kingdom (a low-R&D intense economy with a high share of foreign R&D investments) and Japan (a high-R&D intense economy with a low share of foreign R&D investments), Belgium has moderate levels with regard to both variables. Particular attention may be given to the location of Belgium and France as both countries occupy more or less the same region in the scatterplot. However, despite these apparent similarities, underlying dimensions may evoke a more divergent reality.

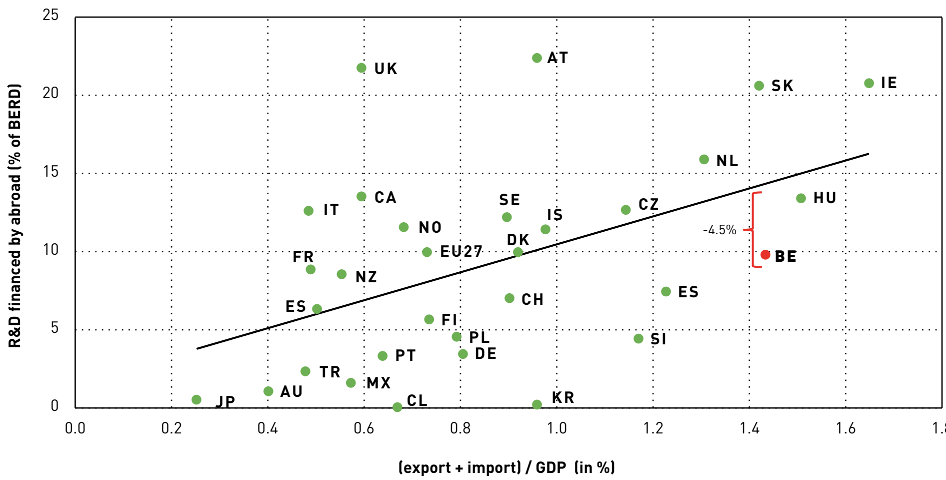
FIGURE 3.2 – **Relation between R&D financed by abroad as a share of BERD and the business R&D intensity of a country in 2009**



Source: OECD (2013).

One of these underlying dimensions is the openness of the economy. Figure 3.3 depicts the relative openness of an economy on one axis and the R&D expenditures financed by abroad as a share of BERD on the other axis using data for a set of OECD countries. Openness is measured here by dividing the sum of export and import figures by the GDP of the country. The regression line suggests a positive relationship between the importance of foreign-financed BERD and the openness of the countries. This regression line indicates that France, which has a more closed economy than Belgium, can count on relatively more financial stimuli from abroad (as a share of BERD) given its degree of openness. Hence, France and Belgium are relocated in opposite directions on this new scatterplot as Belgium receives a rather small amount of foreign investments given its relative open economy compared with the other countries. We will refer again to this finding at the end of the next section where we will point out that this situation will be reversed when the openness of the economy is linked to the proportion of business R&D that is performed by foreign affiliates.

FIGURE 3.3 –**Relation between the openness of the economy and the percentage of internal R&D expenditures of BERD financed by abroad in 2009**

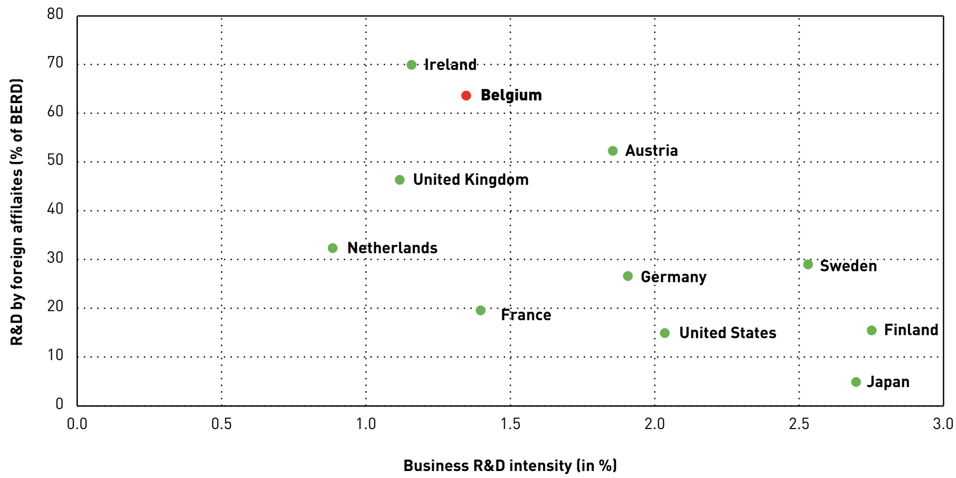


Source: OECD (2013).
Note: Year 2009 except for the financing of Mexico (2007), Chile, Iceland and Switzerland (2008)
Country codes: UK (United Kingdom), AT (Austria), SK (Slovakia), IE (Ireland), IT (Italy), CA (Canada), SE (Sweden), CZ (Czech Republic), NL (Netherlands), HU (Hungary), NO (Norway), IS (Iceland), FR (France), NZ (New Zealand), DK (Denmark), BE (Belgium), ES (Spain), CH (Switzerland), FI (Finland), TR (Turkey), PT (Portugal), PL (Poland), DE (Germany), SI (Slovenia), MX (Mexico), JP (Japan), AU (Australia), CL (Chile), KR (Republic of Korea).

Approach 2: internationalisation of R&D from the ownership's perspective

Another possibility to investigate the internationalisation of R&D is by way of looking at the location of the decision centre of the company. The decision centre is considered as the entity that supervises all strategic business decisions. Figure 3.4 shows the relation between the proportion of R&D expenditures by foreign affiliates with regard to BERD and the business R&D intensity across a number of countries. Countries like Finland, Japan, the US and Germany are characterised by an R&D-intensive economic system which is based on the investments of domestic firms. On the other side of the spectrum are countries like Belgium, Ireland and the UK with a rather moderate R&D-intensity ratio but a higher degree of dependency on foreign-controlled affiliates to maintain their level of R&D investments.

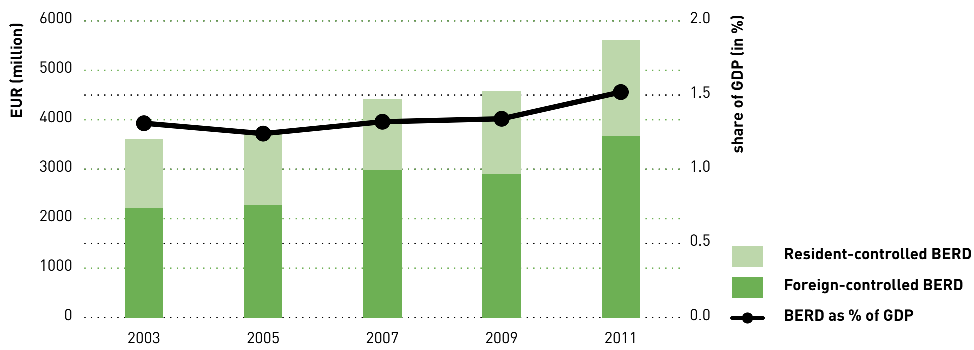
FIGURE 3.4 – **Relationship between R&D of foreign affiliates as a share of BERD and the business intensity of a country in 2009**



Source: OECD (2013).
Note: Year 2009 except data for Japan (2007), Netherlands and Finland (2008).

While Figure 3.4 established an international comparison, Figure 3.5 presents the same elements in a temporal perspective. The evolution of the foreign-controlled R&D in Belgium shows a trend that went upward from 2003 to 2011. Since 2005 this evolution runs synchronously with the R&D-intensity coefficient. After having reached a relative maximum in the period 2007-2009, foreign-controlled R&D figures started to soar again in 2011. Foreign-controlled BERD has always been proportionally more important in comparison with resident-controlled BERD.

FIGURE 3.5 – **Total BERD, foreign-controlled BERD, resident-controlled BERD and total BERD as % of GDP (2003-2011)**



Source: OECD (2013), CFS/STAT (2013).

Analysis of the countries in which foreign R&D investors are located shows that the largest share of investments comes from enterprises whose decision centre is located in the USA. As shown in Table 3.1, neighbouring countries such as the United Kingdom, France and the Netherlands also play a leading role with regard to R&D investments. It is remarkable to notice that Germany plays a rather unimportant role when it comes to R&D investments in Belgium, although it is known as the most important trading partner of Belgium and a leading country in innovation.

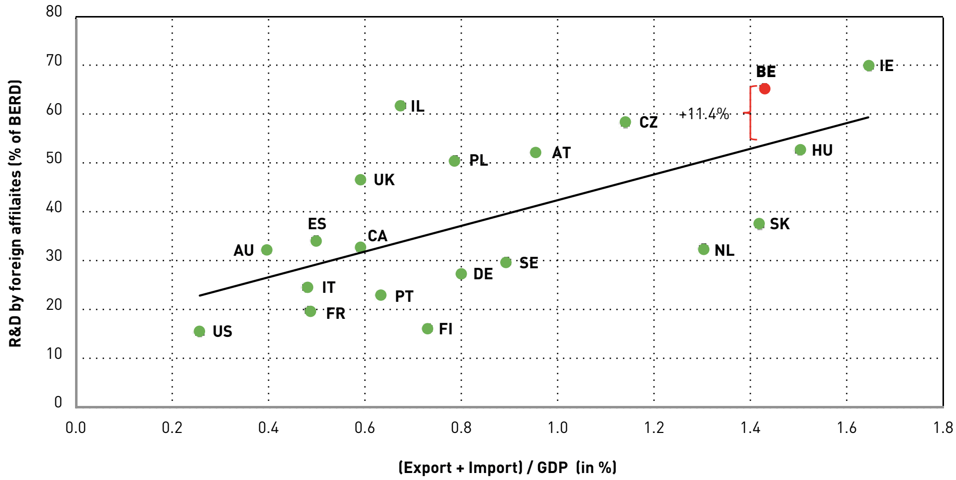
TABLE 3.1 – **Percentage of total R&D investments according to the country of origin in 2011**

Country	% R&D	Country	% R&D
Belgium	34.5	India	0.3
United States	23.6	Austria	0.2
United Kingdom	14.5	Canada	0.2
France	8.6	Australia	0.2
Netherlands	5.5	Denmark	0.2
Germany	4.2	Ireland	0.1
Japan	3.5	Israel	0.1
Luxemburg	1.6	Finland	0.1
Sweden	1.4	Spain	0.1
Switzerland	1.1	Italy	0.1

Source: CFS/STAT (2013).

At this point, the same analysis made earlier about the financing sources of R&D expenditures regarding the openness of the economy is repeated. This time we relate economic openness to the R&D financed by foreign affiliates as a share of BERD. In contrast to the previous result, where Belgium underachieved in terms of foreign investment in R&D activities, Belgium is now positioned above the regression average by 11.4 percentage points, as shown in Figure 3.6.

FIGURE 3.6 – **Relationship between the openness of the economy and the percentage of R&D financed by foreign affiliates as a share of BERD in 2009**



Source: OECD (2009).
Note: Year 2009 except for the R&D by foreign affiliates in Israel, Portugal, Slovakia,Spain (2007), Finland and Netherlands (2008).
Country codes: IL (Israel), BE (Belgium), IE (Ireland), CZ (Czech Republic), UK (United Kingdom), PL (Poland), AT (Austria), HU (Hungary), AU (Australia), ES (Spain), CA (Canada), US (United States), IT (Italy), FR (France), PT (Portugal), DE (Germany), SE (Sweden), FI (Finland), NL (Netherlands), SK (Slovakia).

This implies that Belgium has more foreign-affiliated financed R&D compared with the average that is inferred from an extensive group of industrialised countries. France moved to the other side of the regression line, which is an indication that foreign affiliates established in France are less inclined to do R&D investments than their domestic homologues.

3.3. Foreign-controlled R&D in Belgium

The internationalisation of R&D is presented in this section from the ownership perspective using firm level data, similarly to Teirlinck (2005) and the second approach in section 3.2. The objective is to establish a comprehensive picture at a microeconomic level of the R&D activities located in Belgium that are conducted by foreign affiliates (i.e. inward R&D). Foreign affiliates, or more precisely foreign-controlled affiliates, are identified in accordance with the guidance of the Handbook on Economic Globalisation Indicators (OECD, 2005b). Foreign-controlled affiliates are identified using the recommended criterion of the Handbook on Economic Globalisation Indicators (OECD, 2005b), which is '*whether or not a majority of ordinary shares or voting power (more than 50% of the capital) is held by a single foreign investor or by a group of foreign associated investors acting in concert*' (OECD, 2005b).

The remaining firms in Belgium can be classified as resident-controlled or Belgian-controlled firms. This section analyses the representation of foreign-controlled affiliates in the Belgian technological landscape, their sector penetration and the specificities of their R&D activities according to several dimensions. The R&D intensity according to the nationality of control is examined in section 3.4.

The data are provided by the R&D survey in Belgium conducted in 2012, which covers R&D activities in Belgium over 2010-2011 (CFS/STAT, 2013). This survey is based on a repertory of firms that are considered as regular R&D spenders plus a random sample of firms located in Belgium that are not known as regular R&D spenders but may perform occasional R&D activities. R&D refers to intramural R&D expenditures, unless otherwise mentioned. This section focuses on regular R&D spenders, which represented 91% of the total business R&D in Belgium in 2011. Information on the ownership of R&D is available for 1798 firms that account for 98% of the R&D conducted by these regular spenders.

TABLE 3.2 – **Top R&D spenders in Belgium in 2011**

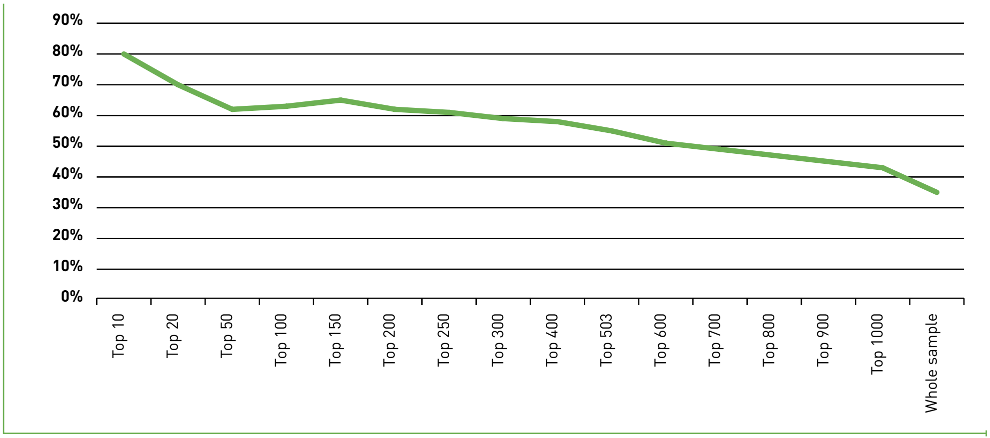
Rank	Control	Country of control	Sector
1	Foreign	United Kingdom	Pharmaceuticals
2	Foreign	United States	Pharmaceuticals
3	Resident		Pharmaceuticals
4	Foreign	United Kingdom	Telecommunications
5	Foreign	United States	Refineries & chemicals
6	Foreign	France	Telecommunications
7	Foreign	France	Refineries & chemicals
8	Foreign	United States	Pharmaceuticals
9	Foreign	Netherlands	Computer & electronics
10	Resident		Metal & metallic products

Source: CFS/STAT (2013).

R&D activities in Belgium are concentrated within a minority of firms. The top ten R&D spenders in 2011 performed about 33% of the total business R&D in Belgium. As can be seen in Table 3.2, only two resident-controlled firms are included in the ten largest R&D spenders in Belgium while the eight foreign affiliates are controlled by firms located in the United Kingdom, the United States, France and the Netherlands. The pharmaceutical sector dominates this ranking with the three largest R&D spenders being pharmaceutical companies. Firms in telecommunications and refineries & chemicals sectors are ranked the highest after the top pharmaceutical firms. If we extend the ranking to the lower R&D spenders, the share of foreign-controlled affiliates decreases to 70% in the top 20 and 63% in the top 100.

However, a look beyond the 100 largest R&D firms indicates that the proportion of foreign firms remains above 60% in the top 300, but is lower for smaller R&D spenders. Indeed, Figure 3.7 suggests that the share of foreign affiliates decreases as the scope of the ranking is extended to smaller firms. While there is still a slight majority of foreign affiliates in the top 700 R&D spenders (51%), the share of foreign-controlled firms is 49% in the top 800. As a whole, 65% of the R&D firms are domestic-controlled, but there is a strong overrepresentation of foreign affiliates within the largest R&D spenders.

FIGURE 3.7 – **Share of foreign affiliates within the top R&D spenders in 2011**



Source: CFS/STAT (2013).

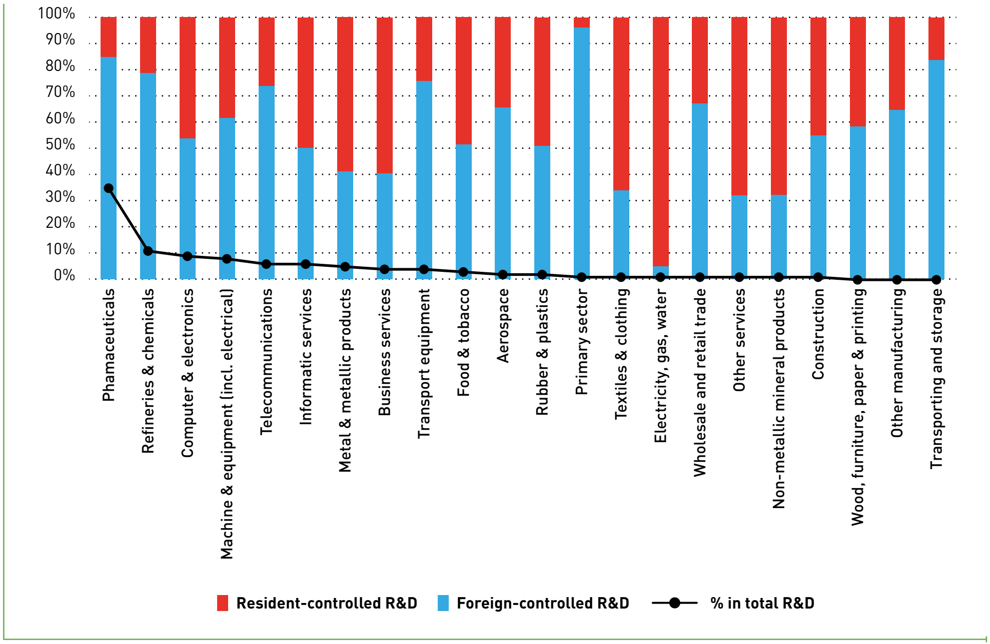
As a result of this overrepresentation, about 68% of the R&D performed by the firms in the dataset is foreign-controlled[1]. The difference in R&D size between foreign-controlled affiliates and resident-controlled firms is definitely large: a foreign affiliate in Belgium spent on average about 4.2 times more for its R&D activities than a resident-controlled firm in 2011. On average, a foreign affiliate spent 6588 thousands euros for its R&D activities in 2011 while a domestic firm spent 1572 thousands euros.

When we refer to the sector for which R&D activities are conducted, this sector is not necessarily the primary sector of the economic activities of the firm. For instance, firms in the 'Research and Development' industry can perform R&D on behalf on the pharmaceuticals sector. Concerning the distribution of R&D across sectors, pharmaceuticals, refineries & chemicals and machines & equipment are the first three leading sectors in terms of R&D size for foreign-controlled affiliates. Pharmaceuticals are also the leading sector for domestic firms while computer & electronics and machines & equipment are respectively the second and third most important sectors in the distribution of resident-controlled R&D.

At the Belgian level, the pharmaceutical sector is clearly the leader in terms of R&D size, with about 35% of the Belgian R&D conducted by pharmaceutical companies. This industry is largely dominated by foreign affiliates with about 85% of the pharmaceutical R&D being foreign-controlled. According to Figure 3.8, the majority of the R&D activities are systematically performed by foreign affiliates in the six largest R&D sectors (pharmaceuticals, refineries & chemicals, computer & electronics, machine & equipment, telecommunications and informatics service). These top sectors account for 74% of the total R&D. On the whole, foreign-controlled R&D dominates sectors that represent together 88% of the total R&D. At the bottom of the ranking, domestic firms are more present than foreign affiliates in four of the last nine sectors. Resident-controlled R&D is dominant in sectors that individually account for less than 5% of the total R&D in the economy (metal & metallic products, business services, textiles & clothing, electricity, gas & water, other services and non-metallic products).

(1) Section 3.2 reports that 66% of BERD is foreign-controlled. The slight difference is due to two reasons. First, this section only focuses on regular R&D spenders. Second, the dataset does not include collective research centres, which are included in the BERD statistics for Belgium and are exclusively resident-controlled.

FIGURE 3.8 – **Share of foreign-controlled and domestic-controlled intramural R&D by sector in 2011**

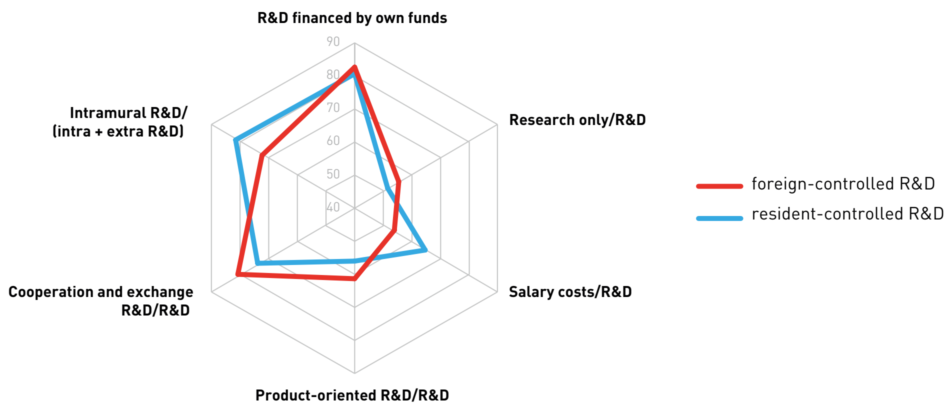


Source: CFS/STAT (2013).

The profile of the R&D carried out by foreign-controlled affiliates and resident-controlled firms in Belgium can be established according to several dimensions. Figure 3.9 presents such an R&D profile by implementing indicators related to the financing, nature and objectives of the R&D activities performed in Belgium by foreign affiliates and domestic firms. Concerning the financing of R&D, foreign-controlled R&D and domestic-controlled R&D both rely mainly on the firms' own funds, with about 80% of the R&D that does not involve external funding. However, foreign affiliates and domestic firms differ with respect to their propensity to subcontract or outsource R&D. Indeed, extramural R&D expenditures represent 28% of the total, i.e. intramural and extramural, R&D of the foreign-controlled affiliates while they account for only 18% of the total R&D of the resident-controlled firms. The openness of foreign-controlled affiliates to third-party actors is also illustrated by a larger share of R&D that is performed by firms with cooperation and exchange activities. About 80% of the foreign-controlled R&D can be attributed to firms that develop or exchange technological knowledge with other firms, research centres or higher education institutions. Nevertheless, the commitment of resident-controlled firms to partnerships is still large with 74% of domestic-controlled R&D being performed by firms with cooperation activities.

Another difference lies in the nature of the R&D activities. While a slight majority of R&D in Belgium is globally dedicated to research activities and the rest to experimental development, foreign-controlled R&D appears to be more research-oriented than resident-controlled R&D. Research activities represent 56% of the intramural R&D performed by foreign affiliates and 51% for domestic firms. The difference in research-only activities is not explained by differences in applied research efforts, but rather by a larger share of expenditures by foreign affiliates that is focused on fundamental research.

FIGURE 3.9 – **Profile of R&D by foreign-controlled affiliates versus resident-controlled firms in 2009**

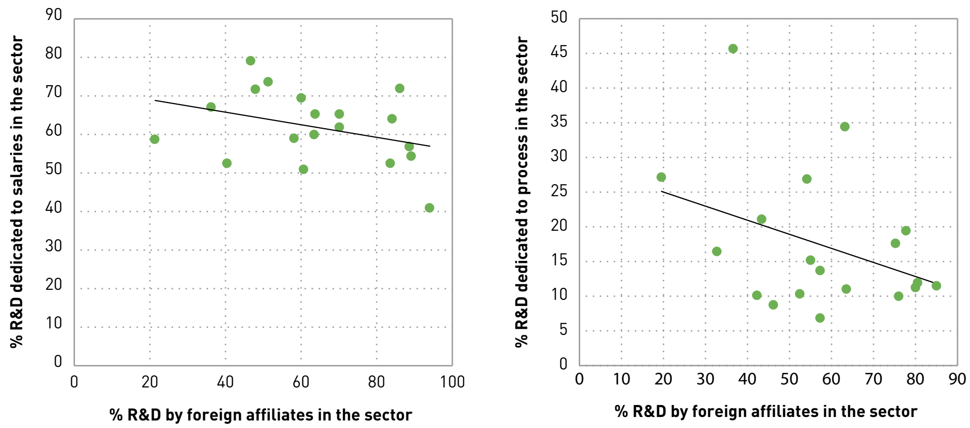


Source: CFS/STAT (2013).
Note: R&D refers to intramural R&D unless otherwise mentioned. Figures are expressed in percentage terms.

As regards the different types of R&D costs, about two thirds of domestic-controlled R&D costs are salary costs while this type of costs accounts for 54% of the R&D performed by foreign affiliates. The latter seems to spend relatively more money for organisation costs related to laboratory materials, furniture, overhead costs and internal consultancy. The shares of foreign-controlled and domestic-controlled R&D related to investment costs are similar. As regards the product- or process-oriented R&D activities, foreign-controlled R&D seems to be more product-oriented than domestic-controlled R&D.

The differences in cost-related and product-related R&D are also illustrated at the sector level, which implies that these differences are partly explained by sector specificities. Hence, according to Figure 3.10, there is a decreasing relationship between the share of R&D performed by foreign affiliates in a sector and the share of R&D dedicated to salary costs. The larger share of R&D by foreign affiliates that is dedicated to product-activities can be related to the decreasing relationship between the share of foreign-controlled R&D and the importance of process-oriented R&D in a given sector. Patterns at the sector level are less pronounced for the other indicators of the R&D profile, meaning that the role of the sector characteristics is less relevant.

FIGURE 3.10 – **Share of foreign-controlled R&D and share of R&D dedicated to salaries and process activities at the sector level in 2009**



Source: CFS/STAT (2013).

In terms of employment, foreign affiliates also account for a considerable proportion of personnel related to R&D activities, which implies that the recruitment of R&D employees in Belgium is highly sensitive to the decisions and strategies of multinational enterprises with foreign ultimate owners. As shown in Table 3.3, 60% of the R&D personnel in Belgium and 62% of the researchers are actually employed by foreign-controlled affiliates. The share of employees that is assigned to R&D activities is about 10% for firms with R&D activities, and it is higher for foreign affiliates (11%) than for domestic firms (8%). Researchers represent 7% of total employment in R&D active foreign-controlled affiliates and 5% in resident-controlled firms.

TABLE 3.3 – **R&D personnel by foreign affiliates and domestic firms in 2011 (in %)**

	Foreign-controlled	Resident-controlled
R&D personnel/total employment in R&D active firms	11	8
Researchers/total employment in R&D active firms	7	5
Share of Belgian R&D personnel	60	40
Share of Belgian researchers	62	38

Source: CFS/STAT (2013).
Note: R&D refers to intramural R&D unless otherwise mentioned.

3.4. R&D intensity, foreign control and multinational enterprises

Section 3.4 disentangled the characteristics of foreign-controlled R&D according to several dimensions. This section is dedicated to the analysis of the R&D intensity of the firms. When restricting the dataset to R&D active firms only, the R&D intensity of the subset of foreign-controlled firms is 16%, which is larger than the R&D intensity of resident-controlled firms (10%). R&D intensity in this case is computed as the ratio of intramural R&D expenditures to value added. One can argue that foreign-controlled affiliates with R&D activities are more likely to be overrepresented in sectors that are more R&D intensive, especially when the decisions of the foreign owner are driven by home-base augmenting or asset-seeking strategies. This is illustrated in Figure 3.11, which indicates a positive relationship between the presence of foreign affiliates in a sector (in terms of R&D size) and the R&D intensity. This relationship suggests that Belgian high-tech sectors are strongly dominated by foreign-controlled R&D. However, it is not clear whether this is due rather to the capability of Belgian high-tech industries to attract the interest of foreign firms, or to the impact of the presence of foreign affiliates in a given sector.

FIGURE 3.11 – **Share of foreign-controlled R&D and R&D intensity at the sector level in 2009**

Source: CFS/STAT (2013).

In order to measure whether foreign control does intrinsically correlate with higher R&D intensity, industry effects and size effects must be implemented in the analysis. Indeed, foreign-controlled affiliates may strongly differ from resident-controlled firms according to these dimensions, which are known to affect R&D intensity. Griffith et al. (2004) report that foreign-controlled affiliates in the United Kingdom tend to be larger than the British domestic firms, but smaller than the British-owned multinationals. These categories of firms differ in the same direction with respect to their R&D intensity. We conduct a standard regression analysis with the logarithm of the R&D intensity as a dependent variable. Control variables for size and industry are implemented with employment (in full-time equivalent) and 22 industry dummies as explanatory variables. We also control for the age of the firm.

Furthermore, while all foreign-controlled affiliates are multinational enterprises, they are not the only MNEs in Belgium. Belgian-controlled enterprises with affiliates abroad also have direct access to resources abroad and are also considered as multinational companies. It can be argued that foreign-controlled affiliates in Belgium are more R&D intensive because they actually are MNEs, not because they are foreign-controlled. The internal R&D networks that exist within MNEs may keep these structures a step ahead of their non-MNE competitors. On the one hand, foreign affiliates that integrate an internal R&D network within their MNE conduct relatively more R&D (Zander, 1999). On the other hand, the R&D performed by foreign affiliates relies on the existing R&D activities by the parent company (Sadowski and Sadowski-Rasters, 2006). We want to test whether or not the structure of the firms (i.e. MNE versus non-MNE) affects the R&D intensity within firms located in Belgium. Hence, we classify firms according to four categories, which are reported in Table 3.4.

TABLE 3.4 – **Classification of the firms**

	Without controlled affiliates abroad	With controlled affiliates abroad
Belgian-controlled enterprise	non-MNE	Belgian-controlled MNE
Foreign-controlled (FC) affiliate	FC affiliate without affiliates abroad (MNE)	FC affiliate with affiliates abroad (MNE)

Only one category does not include MNEs: the resident-controlled enterprises without affiliates abroad. The dataset with available information for the variables in the model includes 634 non-MNEs, 276 Belgian-controlled MNEs, 291 foreign-controlled affiliates without affiliates abroad and 164 foreign-controlled affiliates with affiliates abroad.

Table 3.5 reports the estimates of four different specifications measuring the determinants of R&D intensity. Overall, the coefficients for the employment variables suggest that size has a negative effect on R&D intensity for small firms while the effect is positive for larger firms. The coefficient of age is negative and significant, which illustrates a higher R&D intensity within younger firms. Industry effects are jointly significant in determining the R&D intensity of the firms in the dataset.

The impact of foreign control on R&D intensity is tested in Model 1. The effect is positive and significant, which implies that, given size, industry and age effect, foreign-controlled affiliates are still more R&D intensive than Belgian controlled-firms.

This result must be compared with the estimates of Model 2 as specification in Model 2 separates non-MNEs from resident-controlled MNEs. The three MNE categories from Table 3.5 are included in the regression, with non-MNEs as a reference group. The estimates show that the three coefficients associated with these MNE categories, including the Belgian-controlled MNEs, are positive and significant. Furthermore, the coefficients are not significantly different. This result indicates that foreign-controlled affiliates are not significantly more R&D intensive than Belgian-controlled MNEs. However, non-MNEs are significantly less R&D intensive than MNEs. This implies that R&D intensity is determined by the international structure of the enterprise, which may be resident- or foreign-controlled, rather than the nationality of the control.

TABLE 3.5 – **R&D intensity determinants**

	Model 1	Model 2	Model 3	Model 4
Constant	1.421** (0.582)	1.450** (0.576)	1.773*** (0.518)	1.882*** (0.529)
log (*employment*)	-0.697*** (0.084)	-0.730*** (0.087)	-0.677*** (0.192)	-0.741*** (0.194)
log (*employment*)^2	0.048*** (0.010)	0.048*** (0.010)	0.054*** (0.021)	0.056*** (0.021)
log (*age*)	-0.262*** (0.055)	-0.265*** (0.055)	-0.277*** (0.103)	-0.308*** (0.104)
Foreign-controlled affiliate	0.256*** (0.072)			0.229** (0.112)
• *without affiliates abroad*		0.375*** (0.092)		
• *with affiliates abroad*		0.415*** (0.102)		
Belgian-controlled MNE		0.308*** (0.085)		0.449*** (0.124)
%R&D financed by abroad			0.009** (0.004)	0.009** (0.004)
Industry	Yes***	Yes***	Yes***	Yes***
R^2	0.36	0.36	0.31	0.32
Adjusted R^2	0.35	0.35	0.28	0.29
Number of observations	1365	1365	572	572
Akaike info criterion	4186	4177	1697	1687
Schwarz info criterion	4322	4323	1810	1809

Source: CFS/STAT (2013).
*Notes: Dependent variable: log(RD/value added). Dataset of R&D active companies located in Belgium. Symbols ***, **, * refer to statistical significance at 1%, 5%, 10% levels, respectively. OLS estimates including a set of industry dummies (22 categories). Heteroskedastic-consistent standard errors are in brackets. Industry dummies are jointly tested for significance level.*

Specifications in Model 3 and Model 4 include the share of R&D that is financed by non-Belgian investors in order to test how the first approach in section 3.2 – i.e. internationalisation of R&D from the financing perspective – correlates with R&D intensity (the sample size decreases to 572 observations because of the availability of this information). As a result, firms that benefit from more foreign support appear to be more R&D intensive. However, the causality is unclear. On the one hand, financing from abroad may stimulate R&D activities if firms are financially constrained by local funding (own funds, external private funding or public aids in Belgium). On the other hand, more R&D intensive firms may more likely benefit from European aid or direct support from their parent company for strategic reasons. For instance, the Seventh Framework Program of the European Commission applies a more favourable reimbursement rate of the total eligible costs related to R&D activities for small and medium enterprises, which include start-ups that are highly R&D intensive (European Commission, 2013). Nevertheless, Model 4 still indicates that MNEs are significantly more R&D intensive than non-MNEs, even when taking into account foreign funding.

3.5. Conclusion

This chapter highlights several features about the internationalisation of R&D in Belgium. 66% of the business R&D activities of Belgium are conducted by foreign-controlled affiliates. The main countries of control are the US, the UK and France. While the importance of foreign-controlled R&D in a small open economy like Belgium can be expected, we showed that there is an overrepresentation of foreign-controlled R&D in Belgium compared to other OECD countries given the openness of the Belgian economy.

Foreign-controlled affiliates are the largest R&D spenders in Belgium. They also dominate the industries that account for most R&D in the economy. In particular, 85% of the R&D in the top R&D sector (pharmaceuticals) is carried out by foreign affiliates. Furthermore, their R&D activities rely more on cooperation, exchange, outsourcing and subcontracting than their resident-controlled counterparts.

When limiting the dataset to R&D active firms only, we observe that the aggregated R&D intensity of foreign-controlled affiliates is higher. This is partly explained by the concentration of foreign-controlled R&D in industries that are more R&D intensive. By taking into account size, industry and age effects, foreign-controlled affiliates also appear to be intrinsically more R&D intensive. However, we show that R&D intensities at the firm level do not differ between foreign-controlled affiliates and Belgian-controlled multinational enterprises. This result suggests that, given the international structure of the firm (i.e. MNE or non-MNE), there is no difference in R&D intensity due to the nationality of the ownership. However, MNEs are significantly more R&D intensive than non-MNEs, even when controlling for size effects, which suggest that the internationalisation of the structure of the firms correlates with higher R&D intensities.

As the innovation system of Belgium largely depends on investments made by foreign business units, it is essential to assure a smooth continuation of this inflow of foreign capital and to attract new foreign R&D investments. In a general sense this could be realised by offering enterprises long-term investment perspectives. Several policy suggestions might be helpful in achieving this goal: R&D investments could be made less risky by improving the return on investment through fiscal measures; the presence of an extensive pool of highly skilled labour force in science and engineering is an absolute necessity for making the internal market attractive to foreign high-tech companies; the creation of opportunities to transform R&D results in tangible products and services should be highly supported. This could be achieved in practice by the establishment of private-public partnerships between companies and universities/public research centres and the development of marketing strategies for testing consumer responsiveness to new products and prototypes.

Economic literature on the internationalisation of R&D has demonstrated that outsourcing of R&D activities to foreign markets is not necessarily associated with a detriment of jobs in the home market. There is evidence that foreign R&D investments of domestic firms give rise to new R&D investments in the home market (Blomström et al., 1997; Barba Navaretti et al., 2006; Hijzen et al., 2009; Cockburn and Slaughter, 2010). The implicit assumption in this reasoning is that the investments of domestic firms in non-domestic markets bring back a certain amount of the knowledge stock created abroad to domestic R&D activities. Potential steps that might help in realising this goal consist in establishing bilateral trade agreements with emerging economies, improving the visibility of Belgian high-tech and medium-high-tech companies abroad, and encouraging Belgian entrepreneurs to explore the growth potential of foreign markets.

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R&D funding of the public sector in times of economic crisis

ANDRÉ SPITHOVEN AND ELENA PHALET

4.1. Introduction

The financial crisis morphed into an economic crisis which broke out in full force in 2008 and has had severe implications on the real economy (OECD, 2011; Paunov, 2012; OECD, 2012; Archibugi et al., 2013). The first six months of 2013 showed signs of a worldwide economic recovery. It is too early to point to the exact role economic policy played in this scenario. Economic policy of many high-income economies, like Belgium, is directed to fine-tuning the balance between demand stimulus and debt reduction (Dutta and Lanvin, 2013).

In view of the limited number of academic papers on innovation and the recent crisis, one would suppose that innovation theorists feel less concerned. This is somewhat awkward since Schumpeter himself, the economist who drew attention to the role of technical change in an economy, was well aware of the link between crisis and innovation. A process of 'creative destruction' would induce a period of growth based on technical changes. Each innovation system is made up of the interplay between different actors: enterprises and non-profit organisations (Lundvall, 1992; Nelson and Winter, 1982). The key assumption in this chapter is that organisations in the non-profit sector are not immune to the consequences of the economic downturn regions and countries have been facing. Moreover, the R&D efforts deployed by the non-profit organisations have an impact in the total level of R&D spending in a country, and hence affect the economy.

Public intervention in the innovation system has often been justified (OECD, 2005). While worldwide academic research is estimated to yield a 10 to 28% rate of return, a Canadian longitudinal study of research based academic spin-off companies in Canada points to an impact of 3.3 to 4 times the government funding for non-medical natural sciences, and 4.3 to 6.5 for physics (Mansfield, 1998). Even when only spin-offs are taken into account, government funding of R&D is quantitatively justified, while other impacts, potentially larger but harder to quantify, can be considered a sizeable bonus.

Governments will not only work through budget allocations (see chapter 2), but also enact policies in order to maximise the economic potential of R&D activities through encouraging spin-offs, technology transfers, patenting and licencing, contract research, competitive instead of institutional grants, mobility of researchers and internationalisation. The public sector thus plays a crucial role in innovation systems, both by performing R&D activities and by providing financial means. This chapter deals with both dimensions – performance and funding – against the background of the recent economic downturn.

R&D expenditure in Belgium exceeded 8 billion euro in 2011, which counted for 2.21% of GDP. The public sector in Belgium accounted for almost one third (30.4%) of this investment with R&D activities performed in public research organisations and higher education institutes. On the other hand, the public sector in Belgium covers 26.3% of total R&D funding. With foreign public bodies included, like e.g. the European Commission, the share of public R&D funding rises to 29.6%.

In the domain of R&D the non-profit sector is made up of three sectors of performance: the higher education institutes, the public research organisations and the private-public non-profit organisations. The higher education institutes comprise universities and university colleges located in Belgium. The public research organisations, or government organisations, are a diverse set, as can be inferred from their heterogeneous R&D intensity.

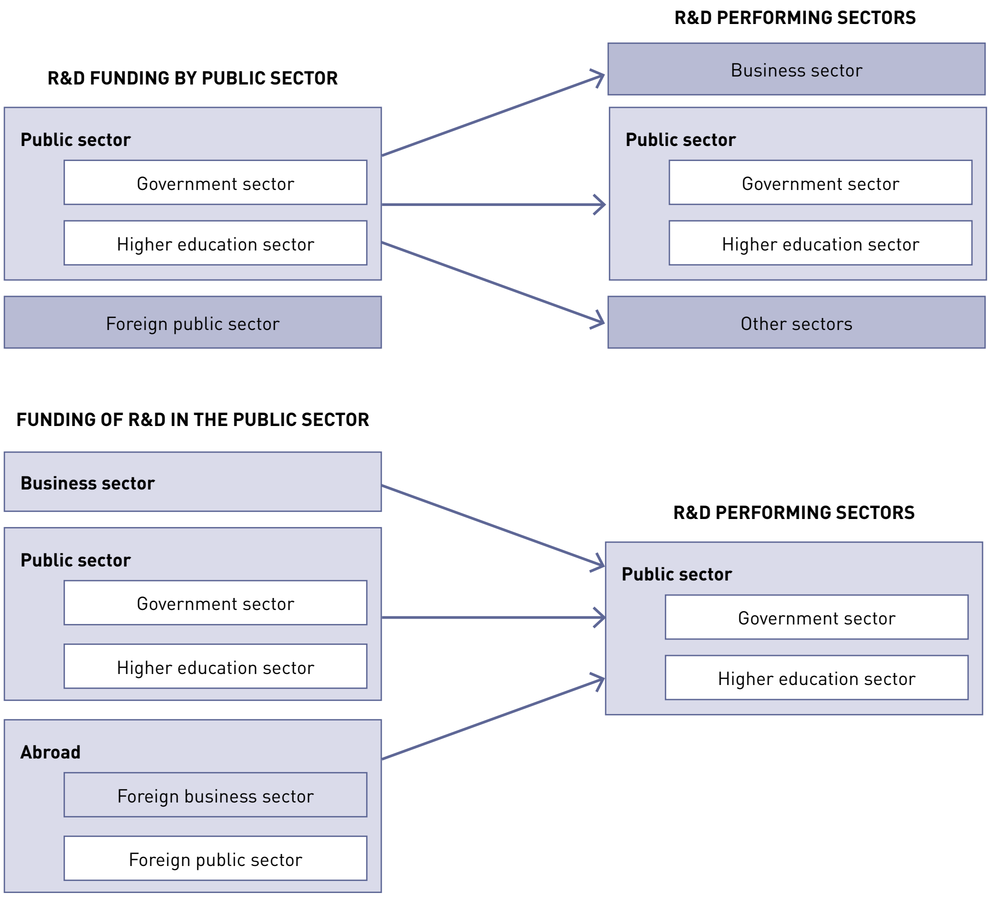
First, there are the specialised research centres (e.g. IMEC in microelectronics; SCK in nuclear energy) which focus on one separate technology or research domain. Second, the scientific organisations (e.g. INBO on safeguarding nature; CRA/CEA on agricultural research) are also specialised in R&D activities but are less research driven as they are targeted towards applied research domains. Third, the public organisations consist of museums and public administrations which perform R&D tasks related to other key activities (e.g. the Royal Belgian Institute of Natural Sciences). These also include lower government levels (e.g. provincial initiatives).

The private-public non-profit organisations are an amalgam of charity organisations (e.g. cancer research) and international organisations that could not be classified elsewhere (e.g. Von Karman Institute). Due to their limited weight in the innovation system, with a share of R&D expenditure of less than 1% of gross R&D expenditure in 2011, these public-private non-profit organisations receive only limited attention. This chapter also excludes the collective research centres as a category of non-profit organisations. These centres are not for profit research centres that perform R&D on behalf of, and on demand from, specific business sectors (Spithoven et al., 2009). But because collective research centres are privately owned by their member firms, their R&D data are comprised in the business sector (OECD, 2002).

In what follows, R&D in the non-profit sector is looked at from two perspectives. First, the focus is on the non-profit sector as a performer of R&D activities. Second, the emphasis is placed on the role of the non-profit sector in terms of R&D funding. In this chapter non-profit is limited to the public sector, which in turn has two independent composites: the government sector and the higher education sector.

All sectors in the innovation system – the private as well as the public sectors – are assumed to be touched by the economic downturn. Schematically these approaches are summarized in Figure 1.

Figure 4.1 – **R&D IN THE PUBLIC SECTOR: PERFORMANCE AND FUNDING**



4.2. Public R&D expenditure

A major indicator capturing the knowledge-based economy is the R&D intensity, which is defined as the share of R&D expenditure in gross domestic product. Reaching an R&D intensity of 3% is generally subscribed to as a policy target, not only at the European level but also at the national and regional levels. Equally agreed upon is the target to finance 1% of this R&D from public sources; although not limited to government and higher education.

First and foremost the impact of the crisis on public R&D expenditure has to be examined. Table 4.1 shows the evolution of the shares of the non-profit organisations in terms of gross expenditure on R&D and in terms of non-business expenditure on R&D.

TABLE 4.1 – **R&D expenditure of the public sector**

A. Public sector	Share of gross expenditure on R&D (in %)			R&D expenditure (in million €)
	2005	2008	2011	2011
Higher education R&D expenditure	23.2	21.8	22.3	1825.5
Government R&D expenditure	7.1	8.9	8.1	658.6
B. Non-profit sector	**Share of non-business expenditure on R&D (in %)**			
	2005	2008	2011	
Higher education R&D expenditure	69.8	68.8	71.4	
Government R&D expenditure	26.1	28.1	25.7	
C. Public sector	**Public R&D intensity (as a share of GDP – in %)**			
	2005	2008	2011	
Higher education R&D expenditure	0.41	0.43	0.49	
Government R&D expenditure	0.15	0.18	0.18	

Source: CFS/STAT (2013).

The bulk of R&D expenditure of the non-profit sector stem from the higher education institutes: 22.3% of gross R&D expenditure of Belgium in 2011, or 71.4% of the total R&D expenditure in the non-profit sector.

An evolution occurred in these shares. In terms of gross R&D expenditure, in panel A of Table 4.1, the shares of higher education have gone down from 23.2% over 21.8% in 2008, to rise again to 22.3% in 2011, totalling 1.8 billion €. This evolution is partly attributable to a relatively slower growth in the R&D expenditure of the business sector. The evolution of the shares of the government sector mirrors the previous one: the share of gross R&D expenditures starts from 7.1% in 2005, rises to 8.9% in the crisis year of 2008, and diminishes to 8.1% in 2011. All in all, higher education was 3.3 times as large as the government sector in 2005 and 2.8 times as large in 2011. Looking at non-business expenditure on R&D, in panel B of Table 4.1, the share of higher education since 2005 is seen to decrease in 2008, and gains 2.6 percentage points in 2011. As expected – because of our reasoning in shares – the government sector mirrors this evolution

Panel C of Table 4.1 refers to the contribution of the non-profit organisations to the so-called Lisbon target of spending 3% of gross domestic product (GDP) on R&D. The R&D intensity of higher education is rising. This might be attributed to the public financial support that is given through the fiscal measure when employing highly skilled R&D knowledge workers (see chapter 9).

In 2011, the total R&D intensity in Belgium amounted to 2.21%, with the higher education covering more than one fifth of the R&D intensity. The R&D intensity of public research organisations has risen steadily until 2008. After that, even in times of budget constraints, the R&D intensity is kept stable. Again, this might be partly attributed to the existence of the fiscal measure on behalf of the knowledge workers.

A particularity of the non-profit organisation is that a distinction is made between the fields of science in which R&D is being performed. Based on the Frascati Manual (OECD, 2002) there are six scientific disciplines: exact sciences, applied sciences and engineering, medical sciences, agricultural sciences, social sciences and human sciences. Table 4.2 looks at these scientific disciplines and the crisis impact.

TABLE 4.2 – **R&D expenditure of government and higher education by fields of science**

Share of R&D expenditure in 2011 (in %)			
Fields of science	**Public sector**	**Governments**	**Higher education**
Exact sciences	17.0	10.2	19.4
Applied sciences and engineering	31.3	70.0	17.3
Medical sciences	21.7	1.1	26.2
Agricultural sciences	9.9	10.5	9.6
Social sciences	12.4	2.6	15.9
Human sciences	7.7	5.7	8.5

Compound annual growth rate (in %)						
	Public sector		**Governments**		**Higher education**	
Fields of science	**2005-08**	**2008-11**	**2005-08**	**2008-11**	**2005-08**	**2008-11**
Exact sciences	5.0	2.1	17.3	-4.7	2.7	3.6
Applied sciences and engineering	4.6	4.0	4.3	3.0	5.2	5.4
Medical sciences	6.6	4.6	0.1	-0.2	6.7	4.7
Agricultural sciences	3.9	3.1	11.7	-3.2	0.6	6.1
Social sciences	2.6	4.6	17.5	-4.7	1.7	5.2
Human sciences	4.5	7.2	8.8	-1.4	3.2	9.7
Total R&D expenditure	4.8	4.0	7.0	0.9	3.9	5.2

Source: CFS/STAT (2013).
Notes: Growth rates are calculated in constant prices (2005=1.000).

The top half of Table 4.2 looks at the share of R&D expenditure in 2011 by the public sector and its two composites: the government consisting of public research centres, museums, etc. and the higher education sector composed of universities and university colleges.

About one third (31.3%) of all public R&D is performed in applied sciences and engineering. One fifth (21.7%) of R&D expenditure goes to medical sciences and over one sixth (17%) to exact sciences. Together with one tenth (9.9%) or R&D being performed in the agricultural sciences, it is clear that the bulk (79.9% or four fifths) of all public R&D is carried out in research intensive 'natural' sciences. The remaining fifth (20.1%) of public R&D is performed in the social and human sciences. These shares are by no means a reflection of the enrolled student population, which implies that sustained efforts in disciplines with high R&D shares might encounter domestic human capital bottlenecks and stimulate an incoming mobility of foreign trained scientists.

However, within public R&D, governments' research centres and higher education institutes have a different pattern of R&D shares by fields of science. The majority of government R&D expenditure is concentrated in the applied sciences and engineering. This is due to the deliberate policy of creating specialized research facilities with a high critical mass in terms of research capacity, e. g. the renowned inter-university research on microelectronics (IMEC), or the centre on nuclear energy (SCK). A similar reasoning applies to the agricultural sciences (10.5%) due to the initiative on biotechnology (e.g. VIB).

The R&D shares in the fields of science in higher education institutes range less widely. Most R&D is done in medical sciences (26.2%) comprising research in university hospitals; least in human sciences (8.5%) This is partially explained by the high cost of research infrastructure in medical sciences, with 38.5% of total R&D expenditures in 2011, the highest of all the fields in science.

The negative effect of the crisis on public R&D expenditure is exemplified by columns (2) and (3) in the bottom half of Table 4.2. In sum, the annual growth in real terms declines from 4.8% between 2005 and 2008 to 4.0% between 2008 and 2011. Except for R&D expenditure in the social sciences and humanities, the annual growth in the post-crisis years is lower than in the pre-crisis period. For the exact and agricultural sciences, the growth rates in the post-crisis period lie below the average (4.0%) for that period. However, R&D expenditure in the government sector reacted differently from the higher education sector. The relatively high pre-crisis annual growth rates of the government sector (7.0%) stagnate to nominal annual growth rates of only 0.9%. In three fields of science a decline of R&D expenditure is recorded: exact, agricultural and social sciences. Only the applied sciences and engineering demonstrates above average growth rates, although these are still moderate compared to pre-crisis levels.

The picture changes when higher education is considered. Annual growth rates are slightly higher in the post-crisis period: 5.2% versus 3.9% in the pre-crisis period. The growth rates have declined in the applied sciences and engineering and in the medical sciences, but both fields of science already enjoyed high shares of R&D expenditure. For all other scientific disciplines, the growth rates in the post-crisis period exceeded those of the pre-crisis years. In case of the human sciences, the annual growth rates more than doubled compared to the pre-crisis period. This might point towards a catching up movement, because the share in overall R&D expenditure was small.

The governments and the higher education sectors clearly show considerable differences. This might be related to the fact that both enjoy tax incentives for certain types of highly qualified R&D personnel, and are obliged by law to reinvest the proceeds in new R&D personnel. The business sector can apply for the tax benefit as well, but are not obliged to reinvest in new personnel, which means that the extra income more often than not disappears from the R&D data. In the case of government research centres, the share of personnel costs in 2011 amounts to 55%; whereas this was 66% in the case of higher education. By implication, higher education institutes benefit more from the tax incentive, which might explain at least partially the divergent growth paths within the public sector.

A comparison of the growth rates of the R&D expenditure in the non-profit sectors with those of the profit sector, made in Table 3, reveals some differences between sectors of performance.

TABLE 4.3 – **Annual nominal growth rates of R&D expenditure in the non-profit and profit sector – in %**

	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Government R&D expenditure	0.2	5.3	16.1	3.6	-3.1	2.3
Higher education R&D expenditure	-0.4	3.9	8.4	9.2	5.0	1.6
Public R&D expenditure	-0.2	4.3	10.5	7.5	2.8	1.8
Business R&D expenditure	6.2	5.2	3.0	-2.8	7.7	9.4
Gross R&D expenditure	4.3	4.8	4.9	0.4	6.0	7.0

Source: CFS/STAT (2013).

Business R&D expenditure follows the economic cycles since its annual growth rates were negative in 2008-2009. This finding confirms the pro-cyclicality of R&D expenditure in the enterprise sector (Barlevy, 2007; Broda and Weinstein, 2010). The financial crisis and concurrent global recession starting in 2008 caused the private sector to revise R&D expenditure downwards. However, R&D is not something that can simply be left off and picked up again when the economic outlook recovers. Because a continuing R&D effort is important for long term growth, governments will increase their efforts to try and offset the reduced investment by the business sector.

R&D expenditure in higher education institutes proves to be counter-cyclical because it increased less in economic peak moments, but has shown a significant growth rate since 2007. A reason for the counter-cyclical behaviour might be the existence of the tax incentive, totalling 555 million € in 2011, from the federal government since 2003 (see chapter 9). Since the bulk of R&D expenditure go to wage costs, the federal financial stimulus might be, at least partially, held responsible for these high counter-cyclical growth rates. This reasoning brings us to the topic of the funding of public R&D.

4.3. Funding of R&D by the public sector

The current economic downturn has consequences for government budgets as revenue diminish due to reduced tax revenue, combined with higher costs due to increased unemployment rates. The result is less budgetary room to stimulate the economy, and forces the public sector to cut spending because of budgetary pressure. As R&D is deemed a crucial ingredient for economic recovery, the question is how governments react with respect to public R&D funding. Two distinct hypotheses are framed: public R&D expenditure might be pro-cyclical or contra-cyclical (Makkonen, 2013).

To capture the consequences of the financial crisis, the period between 2005 and 2011 is divided in two separate but equal time-frames. The first three-year period, from 2005 to 2008, covers the period before the crisis. The second period runs from 2008 to 2011 and deals with the post-crisis period.

TABLE 4.4 – **Public R&D funding by sector of performance**

	Total R&D	Enter-prise sector	Public sector	Govern-ments	Higher education
Million € funding in 2011 (1)	2417.3	386.5	1983.2	416.5	1566.7
Share of public funding in total R&D of sector in 2011 (2)	29.6	6.9	79.8	63.5	85.8
Share of foreign public funding in total public funding in 2011 (3)	11.1	9.4	9.7	14.2	8.5
Growth of total public funding (4)					
• 2005-2008	3.38	3.02	3.68	2.68	3.96
• 2008-2011	4.27	2.31	4.42	3.65	4.63
Growth of domestic public funding (5)					
• 2005-2008	3.22	2.48	3.36	2.13	3.69
• 2008-2011	4.58	7.09	4.11	3.00	4.39
Growth of foreign public funding (6)					
• 2005-2008	4.59	5.17	7.25	6.87	7.42
• 2008-2011	1.91	-21.79	7.55	7.97	7.36

Source: CFS/STAT (2013).
Notes: Rows (1)-(3) are in current prices; rows (4)-(6) are compound annual growth rates in constant prices where 2005=100.

The top row (1) of Table 4.4 shows the public R&D funding from domestic and foreign sources in 2011 in the various sectors of the innovation system: enterprises and public sector. Domestic public sources in Belgium comprise the federal authority, the regional governments (regions and communities) and the higher education sector. Foreign public sources are, in descending order of importance as R&D funders, the European Union, international organisations, foreign government agencies, and foreign higher education institutes. Total public R&D funding amounts to 2417.3 million euro in 2011, of which 16% goes to the enterprise sector and 82% to the public sector (the remaining 2% is devoted to public-private non-profit organisations). Within the public sector, 80% of the funds are destined for higher education and 20% finances government research centres.

The share of public funding in total R&D activities of the sector of performance is cited in row (2). Almost one third (29.6%) of R&D is financed by the public sector. However, this is largely sector-dependent since 6.9% of total business R&D is financed through public means and almost 80% of R&D in the public sector. Even within the public sector the share of public involvement differs: 63.5% of R&D in the government sector enjoys public funding. For the higher education sector, this rises to 85.8% in the higher education sector. Contrary to a belief that universities are financed to a large extent from private funds, it only accounts for 14.2% of university funding; whereas this share is markedly higher (36.5%) in government research centres, like IMEC.

Funding from abroad is always important for a small open economy in the European Research Area. About one tenth (11.1%) of gross R&D expenditure is funded from foreign public sources, as exemplified in row (3). This share proves to be only slightly higher in the public sector (9.7%) than in the private enterprise sector (9.4%). The reason why the share in gross R&D expenditure is higher than both these percentages is due to the fact that foreign public funding of the public-private non-profit organisations amounts to 85.7% (not in Table 4.4).

Notwithstanding the economic crisis, row (4) of Table 4.4 shows a positive evolution of total public R&D funding in real terms from 3.38% annually in the three years before the crisis to 4.27% annually in the three years after the outbreak of the crisis. It seems that this is mainly due to the efforts of the public sector in general and to the higher education institutes in particular. As expected from the pro-cyclicality of business R&D funding, the growth rate, although still positive, has declined.

Public funding for R&D stems from domestic and foreign sources captured by rows (5) and (6) of Table 4.4. As can be readily seen, all domestic sources show positive growth rates which are even higher in the post-crisis period. Annual growth of foreign public funding, however, declines in the post-crisis years. Apparently this is because of the negative involvement of foreign enterprises, even with a stable growth in funding from foreign higher education sector.

Table 4.4 indicates that public funding is counter-cyclical: in economically hard times public funding grows more than in prosperous times. Only foreign public funding of enterprises decreases significantly, even to such an extent that any possible positive effect of increased domestic public funding is annihilated.

4.4. Funding of R&D performed by the public sector

The public sector has five separate sources of funding (OECD, 2002): business enterprises, governments, higher education institutes, private/public non-profit organisations, and sources from abroad. This last category can be divided between funding from business (73.2% in 2011) and non-profit organisations – e.g. government agencies such as the European Commission (22.2% in 2011) and international organisations (2.5% in 2011) – that are not located on the territory in which the R&D is performed. In the tables below the international sources of funding have been redistributed among the other players in the innovation system (i.e. enterprises, governments, higher education, and private/public non-profit organisations).

Table 4.5 investigates the funding of the public R&D expenditure by looking at shares and growth rates. We compare data from 2005-2008, before the economic and financial crisis hit, with data from 2008-2011 in order to estimate the effect the crisis has had on funding public R&D.

TABLE 4.5 – **Public R&D funding by sector of performance – in %**

A. Funding sector	Share of public R&D funding			Compound annual growth rate		
	2005	2008	2011	2005-2008	2008-2011	Difference
Business sector	10.4	10.8	9.4	11.1	2.6	-8.5
Public sector	74.9	71.9	72.1	8.1	7.8	-0.3
Government sector	66.4	62.4	62.7	7.4	7.8	0.4
Higher education	8.5	9.5	9.4	13.7	7.5	-6.2
Abroad	13.2	15.8	16.8	16.3	10.0	-6.3
Business sector	7.0	9.4	9.1	21.0	6.8	-14.3
Public sector	6.2	6.4	7.7	10.6	14.5	3.9
Total funding public R&D	100.0	100.0	100.0	9.6	7.7	-1.9
B. Funding sector	**Share of government R&D funding**			**Compound annual growth rate**		
	2005	2008	2011	2005-2008	2008-2011	Difference
Business sector	9.2	10.8	9.6	17.8	-18.4	-36.2
Public sector	58.7	51.5	51.2	4.5	4.8	0.3
Abroad	31.5	37.5	38.8	15.6	5.1	-10.5
Business sector	24.1	28.0	30.5	17.4	3.8	-13.6
Public sector	7.3	9.4	8.3	9.3	9.9	0.5
Total funding government R&D	100.0	100.0	100.0	9.4	2.7	-6.8
C. Funding sector	**Share of funding R&D higher education**			**Compound annual growth rate**		
	2005	2008	2011	2005-2008	2008-2011	Difference
Business sector	10.9	11.3	11.1	5.4	7.4	2.0
Public sector	80.9	78.5	79.3	6.1	6.2	0.1
Abroad	6.4	7.6	7.2	10.0	14.2	4.2
Business sector	0.2	0.2	0.2	16.1	107.8	91.8
Public sector	6.2	7.4	7.0	9.9	9.2	-0.6
Total funding R&D higher education	100.0	100.0	100.0	6.3	7.1	0.8

Source: CFS/STAT (2013).
Notes: Growth rates are calculated in constant prices (2005=1.000).
The sums of shares differ from 100% because the public-private non-profit organisations have been discarded.

Public R&D expenditure in 2011 amounted to 2.4 billion € and rose steadily from 1.3 billion € in 2000. In 2011 16.8% of public R&D funding came from sources abroad. More than half of these sources, 53.9%, stem from foreign located enterprises, and about 40% (38.2%) came from foreign government levels or agencies (mostly from the European Commission).

In 2011 1.7 billion €, or 70.4%, of public R&D is funded by governments, i.e. the European Commission, federal authority, regional authorities. Public R&D funding rose continuously for all sectors. However, the share of government public R&D funding diminishes gradually from 2000. From 2004, the share of enterprise funding of public R&D rose until 2008 and declined in 2009. In monetary terms, the amount of enterprise funding still grew in 2011 to reach 460 million €.

Panel A in Table 4.5 shows the funding of public R&D by each sector of performance. In 2011 the bulk of funding, 72.1%, stems from the domestic public sector; whereas 9.1% comes from foreign public sources, bringing total public involvement to well over 80% (81.2%). The remainder of the public R&D funding comes from domestic (9.4%) and foreign (9.1%) enterprises, implying that the attractiveness of public R&D is about equally divided between Belgium and abroad. This is related to the fact that many government research centres, such as IMEC, do not limit their activities to national boundaries. However, the evolution of the shares of public R&D funding by the business sector varies. First, the domestic business sector grew steadily between 2005 and 2008 (from 10.4% to 10.8% at a rate of 11.1% annually), but the economic crisis reduced public R&D funding by business by 8.5 percentage points to an annual growth rate of 2.6% in order to realise a share of funding of 9.4%. Foreign firms showed a similar pattern, although the growth rates in the post-crisis period remained high. Since business R&D is cyclical, these reductions of growth rates were to be expected.

Within the public sector as a funder the roles of government and higher education differ. Government funding of public R&D amounts to about two thirds. Yet, its growth rates remain at high levels, 7.4% between 2005 and 2008 and 7.8% between 2008 and 2011. The higher education has a more moderate share in funding public R&D, but its growth rate declined in the post-crisis period to 7.5%.

A special case is the funding by the foreign public sector, which consists mainly of the European Commission. Its share has risen from 6.2% in 2005 to 7.7% in 2011. This clearly shows that R&D is a key issue in the policy objectives at the European level, as stated in the Lisbon strategy. this explains why growth rates in the post-crisis period are 3.9 percentage points higher than those before the outbreak of the crisis, and that the annual growth remains in double digits, even when expressed in real terms.

Panel B in Table 4.5 zooms in on the funding of government organisations in particular. The domestic business sector funds slightly less than 10% of R&D in government research centres. But in the case of foreign businesses, this share rises to 30.5%. The remainder of the R&D in the government sector is financed by public means (51.2%). This shows that much of the R&D performed in government research centres serves to stimulate applied R&D that is of interest for enterprises in order to be developed further. Since business R&D reacts pro-cyclically, the growth rate in the post-crisis period is far less (-18.4% for domestic firms and 3.8% for foreign firms) than the one before the crisis. The involvement of the public sector, on the other hand, has risen slightly: from 4.5% to 4.8% for the domestic agents and 9.3% to 9.9% in the case of foreign agents. However, the final upshot is that, in real terms, the growth rates of funding government research organisations in the post-crisis period is only 2.7% annually, as opposed to 9.4% per annum in the pre-crisis period.

Panel C in Table 4.5 focuses on the higher education institutes. These institutes are mainly funded by the public sector, with the shares around 80%. Their growth rates remained stable throughout the economic crisis. Funding from the domestic business sector did even rise, to 7.4% annually in the post-crisis period, even though the business sector seemed more reluctant to fund public R&D. This might point to the need for domestic firms to tap into basic research and knowledge at universities in order to innovate and build up a competitive edge. One tenth of the R&D funding in the higher education comes from domestic businesses. The involvement of the foreign business sector is far less outspoken. They are assumed to tap into the knowledge stock of their home universities. Their small shares also account for the extraordinary growth rates. In sum, the higher education sector did not seem to suffer from the crisis. As indicated earlier, this might be partly explained by the fact that they received additional public funding through the fiscal measure. But it could also be explained by the fact that society and science policy are confident that the crisis might be tackled by investing more in basic research performed at universities.

4.5. International comparison of R&D in the public sector

This section compares Belgium to a selection of other countries in terms of R&D activities. The central focus is on the place of the public sector in the innovation system and its reaction to the economic crisis.

Table 4.6 gives an overview of the evolution of gross domestic product (GDP) of the selected countries as an indication of the extent to which the crisis has had an impact. After all, this is the background against which one of the most important indicators – the R&D intensity – has to be interpreted, in conjunction with the evolution of R&D expenditure.

TABLE 4.6 – **Compound annual growth rates of GDP and gross R&D expenditure (in %)**

	Gross domestic product			Gross expenditure on R&D		
	2005-2008	2008-2011	Difference	2005-2008	2008-2011	Difference
Belgium	2.2	0.4	-1.7	4.7	4.4	-0.3
France	1.7	-0.6	-2.3	1.9	1.3	-0.7
Germany	1.3	-0.2	-1.5	3.7	2.2	-1.5
Netherlands	2.7	-1.3	-4.0	0.1	0.2	0.1
United Kingdom	2.2	0.0	-2.2	3.4	-0.1	-3.5
Austria	2.5	0.3	-2.2	5.4	1.3	-4.1
Denmark	2.0	-1.0	-3.0	7.1	1.7	-5.4
Finland	3.3	-1.1	-4.3	5.5	-0.3	-5.8
Ireland	0.8	-5.5	-6.3	6.2	-0.6	-6.8
Sweden	2.6	1.2	-1.4	3.9	-1.8	-5.7

Source: OECD (2013).
Notes: Growth rates are calculated in constant prices (2005=1.000). Netherlands 2010 instead of 2011.

Based on the annual growth rates in Table 4.6, the impact of the crisis may be interpreted according to the differences between pre- and post-crisis periods. Belgium started from an annual growth rate in real terms of 2.2% of GDP between 2005 and 2008, which stagnated to 0.4% between 2008 and 2011. Compared to its nearest trade partners – France, Germany, the Netherlands and the UK – the Belgian economy performs relatively well. The impact of the crisis was, with -1.7 percentage points, relatively modest. Only Germany and Sweden had a similar impact. Since GDP and R&D expenditures are linked, those are bound to experience an impact of changing growth performance in GDP (European Commission, 2011). The fact that the correlation between the differences of GDP and gross R&D expenditure is 0.43 is partly due to the existence of a time lag, but also to the fact that the policy level gives high priority to the issue of R&D since it is explicitly stated as one of the Lisbon targets. Notwithstanding the importance of R&D, the annual growth rates are lower in the post-crisis period, which is shown in the last column of Table 4.6. Comparing the growth rates of the gross expenditure on R&D clearly reflects the negative effect of the financial and economic crisis: for all selected countries (except for the Netherlands) the annual growth rates are lower than before the outbreak of the crisis. Belgium, however, scores, with -0.3%, relatively well in this respect, especially since its annual growth rates were already high in the pre-crisis period (4.7%).

Table 4.7 zooms in on the role of the public sector in the innovation system. Two indicators are used for this: the share of public R&D expenditure in the country total; and the composition of the public sector.

TABLE 4.7 – **The public sector in the innovation system**

	Share of gross expenditure performed by the public sector (in %)			Composition of the public sector: size of higher education versus government		
	2005	2008	2011	2005	2008	2011
Belgium	30.7	30.8	30.4	2.7	2.4	2.8
France	36.6	36.0	35.3	1.1	1.3	1.5
Germany	30.7	30.8	32.7	1.2	1.2	1.2
Netherlands	47.1	49.9	52.1	2.8	3.2	3.4
United Kingdom	36.3	35.7	36.1	2.4	2.9	2.9
Austria	29.9	30.3	31.4	4.7	4.7	4.9
Denmark	31.1	29.8	32.0	3.8	10.4	13.8
Finland	28.6	25.2	28.8	2.0	2.1	2.3
Ireland	34.5	35.3	31.0	3.7	4.4	5.3
Sweden	26.9	25.8	30.4	4.4	4.8	6.0

Source: OECD (2013).
Notes: Netherlands 2010 instead of 2011.

The share of public R&D expenditure in gross expenditure, in columns (2) to (4) varies for the selected countries in 2011 between 28.8% in Finland and 52.1% in the Netherlands. Higher shares are a proxy for more heavy public involvement in the innovation system. In Belgium, almost one third of R&D is done in the public sector: 30.4% in 2011 and remaining relatively stable through time. Compared to the neighbouring trade partners, this is relatively modest. The public sector involvement in the UK and France is also markedly higher than the Belgian one, which might be attributed to a larger defence sector. The difference in percentage points with other selected countries is smaller, and only Finland – a country with one of the highest R&D intensities – has a lower share than Belgium.

The last three columns in Table 4.7 capture the composition of the public sector in a single measure: R&D expenditure in higher education versus that of government organisations. For Belgium, higher education is almost three times as large as the government sector (2.8 times in 2011). Generally, the public sector changes only marginally over time. However, in Sweden, Ireland, the Netherlands and especially in Denmark, R&D in higher education becomes gradually more important than the R&D efforts of public research organisations. With the exception of Denmark, this shift took place in the post-crisis period.

Table 4.8 gives the compound annual growth rates for public expenditure on R&D.

TABLE 4.8 – **Compound annual growth rates of R&D expenditure in the public sector (in %)**

	Public R&D expenditure			R&D expenditure in governments			Public R&D expenditure in higher education		
	2005-2008	2008-2011	Diffe-rence	2005-2008	2008-2011	Diffe-rence	2005-2008	2008-2011	Diffe-rence
Belgium	4.8	4.0	-0.8	7.0	0.9	-6.1	3.9	5.2	1.3
France	1.4	0.6	-0.8	-1.6	-2.8	-1.3	4.1	3.2	-0.9
Germany	3.8	4.3	0.4	3.5	3.7	0.1	4.0	4.7	0.7
Netherlands	2.1	2.4	0.3	-1.1	-0.8	0.3	3.2	3.4	0.2
United Kingdom	2.8	0.3	-2.5	-1.4	0.3	1.7	4.4	0.3	-4.1
Austria	5.8	2.5	-3.3	6.3	1.3	-5.0	5.7	2.8	-2.9
Denmark	5.6	4.2	-1.4	-20.8	-4.4	16.4	10.7	4.9	-5.8
Finland	1.1	4.2	3.1	-0.5	2.9	3.4	1.9	4.8	2.9
Ireland	7.0	-4.8	-11.8	1.7	-9.5	-11.3	8.4	-3.8	-12.2
Sweden	2.4	3.8	1.4	0.1	-2.6	-2.7	2.9	5.0	2.1

Source: OECD (2013).
Notes: Growth rates are calculated in constant prices (2005=1.000). Netherlands 2010 instead of 2011.

The public R&D expenditure in Table 4.8 can be compared to Table 4.6. This shows that the variation, i.e. the difference between pre- and post-crisis annual growth, is larger in the case of public R&D expenditure for the UK, Austria and Ireland. For all other countries, GDP decreases more in percentage points than public R&D expenditure. The reason is that R&D is central to science policy, whereas GDP is a resultant of the functioning of a whole economy.

Table 4.8 further reveals some adjustments when the details of the sector of performance are taken into account. As to the annual growth rates for the R&D expenditure of the government sector, many countries display lower growth rates in the aftermath of the economic crisis. This is especially the case in Belgium where the annual growth stagnates in the post-crisis period (0.9% per annum, as opposed to 7.0% in the period before the crisis). Only Ireland, which was severely hit by the crisis, has known a bigger break in series. In some countries, the evolution has become negative in the post-crisis period: France (-2.8%), the Netherlands (-0.8%), Ireland (-9.5%) and Sweden (-2.6%) have even turned negative. Denmark has also encountered negative growth rates (-4.4%), but these were even more negative in the period before the crisis and point to deeper changes in their innovation system, as corroborated by Table 4.8. Only four countries show higher growth rates of government R&D expenditure after the crisis. For the Netherlands, the United Kingdom and Finland this might be due to relatively low levels of growth rates before the outbreak of the crisis. Only Germany experienced a pre-crisis growth rate of 3.5%, and maintained it at 3.7% in the post-crisis period. Germany, however, succeeded in coping relatively well with the crisis (see Table 4.6).

Looking at the R&D expenditure in the higher education sector, some real annual growth rates are even higher than before the crisis in the case of Belgium, Germany, the Netherlands, Finland and Sweden. Except for the Netherlands, these countries have relatively high R&D intensities. Only in Ireland, which was hit severely by the economic crisis, the growth rate of the higher education sector has become negative.

A popular indicator in this respect is the already cited R&D intensity – the share of R&D expenditure in gross domestic product – because it corrects according to country size. This R&D intensity is calculated for each of the two performance sectors in the non-profit: government research organisations and the higher education sector. Table 4.9 summarizes the findings.

TABLE 4.9 – **R&D intensities by sector of performance (in %)**

	Government R&D intensity			Higher education R&D intensity		
	2005	2008	2011	2005	2008	2011
Belgium	0.15	0.18	0.18	0.41	0.43	0.49
France	0.37	0.34	0.32	0.40	0.43	0.48
Germany	0.35	0.38	0.42	0.41	0.45	0.52
Netherlands	0.24	0.21	0.22	0.66	0.67	0.75
United Kingdom	0.18	0.16	0.16	0.44	0.47	0.48
Austria	0.13	0.14	0.15	0.61	0.67	0.72
Denmark	0.16	0.07	0.07	0.60	0.77	0.92
Finland	0.33	0.30	0.33	0.66	0.64	0.76
Ireland	0.09	0.09	0.08	0.34	0.42	0.44
Sweden	0.18	0.16	0.15	0.78	0.79	0.88

Source: OECD (2013).
Notes: Netherlands 2010 instead of 2011.

In the case of government R&D intensity, Belgium's performance proves to be relatively stable. Although the level of R&D intensity is quite modest when compared to the most important trade partners, it progressed positively before the crisis broke out, at which time the Belgian efforts stagnated. Yet, only Germany and Austria outperformed Belgium by showing higher R&D intensities than before the crisis. The situation deteriorated in the case of France, the United Kingdom, Denmark (which is reorganising its innovation system), and Sweden. A U-shaped pattern – declining R&D intensities before the outbreak and rising ones after the crisis – is found in the Netherlands and Finland.

The evolution of the R&D intensities in the higher education differs considerably from those of government organisations, pointing to its specific role in the innovation systems. Higher education contributes to basic research in all fields of science; whereas R&D in government organisations is often mission oriented in specific scientific fields. In Belgium, the R&D intensity keeps rising, from 0.41% in 2005, over 0.43% in 2008, to 0.49% in 2011. The success of the tax incentive to lower R&D costs and the obligation for higher education to reinvest the freed money (see Chapter 9) goes some way towards explaining this. A similar pattern is found in all other countries, highlighting the pivotal role of the higher education institutes in their striving towards a knowledge-based economy.

4.6. Conclusion

It is acknowledged that public involvement in the innovation system – be it through education, research infrastructures, public-private partnerships, or other means – is a widely accepted practice in modern day science policy. In Belgium, public R&D expenditure is largely targeted towards mission oriented strategic research centres and towards research at universities of both basic and applied nature.

The impact of the crisis on R&D expenditure of the public sector is largely counter-cyclical where public funding is concerned, with the gross expenditure for R&D in both the higher education sector and public research centres going up steadily between 2005 and 2011, but not really sufficiently to offset the unavoidable decrease in the important contribution of private sector investment to R&D in the non-profit sector in Belgium.

In real terms, the crisis affected higher education and government research centres differently, with the compound annual growth rate of the higher education sector suffering less than those of the public research centres, which do enter into the negative. This difference is due to two factors. First, public research centres specialise in areas in a limited range of scientific fields, while the higher education sector relies for one third on medical sciences, which was already heavily subsidised and consequently suffered less than exact sciences, applied sciences and engineering. A second reason is that the tax advantage on the wages of researchers benefits the higher education sector more, because personnel costs add up to 66% of its total expenditure on R&D, as opposed to only 55% for the public research centres.

In real terms, public funding for R&D follows a positive trend from 3.18% for 2005-2008 to 4.27% for the crisis years of 2008-2011. One third of all R&D in Belgium is financed by public means, for a total amount of almost 2.5 billion euro in 2011, distributed unevenly between the business sector R&D (6.9%) and public sector R&D (80%). As for the Lisbon target of public funding of R&D, the picture is not promising. The target is set at 1% public R&D funding by 2020; but in 2011, this percentage is still limited to 0.65%. This means that public funding should, in terms of GDP in 2011, rise an additional 1.3 billion euro. However, the above considerations do not account for the efforts made by the federal governments completely, because these data take other measures into account in an insufficient manner. In 2010, however, a staggering 1.1 billion euro of forgone taxes due to R&D measures is recorded (see chapter 9), which implies that when all efforts are taken together, the governmental bodies in Belgium are on track.

Within the public sector, 63.5% of public research centres receive public funds, while this number goes up to 85.8% in the higher education sector. The contribution of private funds in university budgets accounts for only 14.2%, and in public research cent budgets for 36.5%.

Financing from abroad accounts for 11.1% of gross R&D expenditure in Belgium and benefits mainly the public-private non-profit sector, with the remaining funds distributed almost equally between the public and private sector (9.7% and 9.4% respectively).

A closer look at the public sector as a performer of R&D shows that 16.8% of its funding comes from abroad, both from the business sector and from government agencies.

Seventy per cent (70.4%) of all public R&D in 2011 was funded by the government on all different levels: regional or community governments, the federal government and foreign governmental agencies. The European Commission's share herein has steadily risen from 6.2% in 2005 to 7.7% in 2011. Its annual growth rates, even in real terms, remain in double digits, demonstrating that R&D is an important European policy objective.

About one fifth (18.5%) of public R&D is funded by sources in the private sector, equally distributed between domestic enterprises (9.4%) and foreign enterprises (9.1%). Foreign business funding mainly goes to the government sector. This relatively high involvement of the foreign business sector follows from the fact that the scope of operation of many public research centres is international. This business sector share in public sector R&D increased between 2005 and 2008 and decreased afterwards for both domestic and foreign enterprises, as a result of the pro-cyclical nature of business investment.

When we compare developments in R&D budgets in Belgium with neighbouring countries, a clear impact of the crisis on both growth rates of GDP and gross expenditure on R&D is obvious, but in the case of Belgium relatively limited. R&D intensity has remained stable in the public sector without real changes for the public research centres, but steadily increasing for the higher education sector even in the post-crisis years of 2008 - 2011. R&D tax incentives, lowering the wage cost of certain types of highly qualified knowledge workers, with an obligation to reinvest the freed funds in R&D, have undoubtedly contributed to this.

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Participation to the Seventh Framework Programme

KRISTOF VLAEMINCK

5.1. Introduction

This chapter offers a statistical overview of the participation of Belgian project participants to the Seventh Framework Programme (FP7) and it has two sections: the Seventh Framework Programme for Research and Technical Development and the Seventh Framework Programme of the European Atomic Energy Community for nuclear research and training activities (EURATOM). The aim is to get an idea of the Belgian performance for every thematic area and compare some of the results with the other member states. The dataset used for this chapter is the e-Corda database of the European Commission with an update from 19 June 2012.

FP7 is with 50.5 billion euro for the period 2007-2013 the biggest programme that funds research and technical development (RTD) in Europe. In order to accomplish the programme's objectives, there are four types of activities: trans-national cooperation on policy-defined themes in the 'Cooperation' programme with a budget of 32.4 billion euro; investigator-driven research based on the initiative of the research community in the 'Ideas' programme with a budget of 7.5 billion euro; support for individual researchers in the 'People' programme with a budget of 4.85 billion euro; and support for research capacities in the 'Capacities' programme with a budget of 4.1 billion euro. FP7 also supports the non-nuclear direct scientific and technical actions carried out by the Joint Research Centre (Official Journal of the European Union, 2006).

The Seventh Framework programme is structured in four thematic areas. The first is 'Cooperation' which '*supports all types of research activities carried out by different research bodies in trans-national cooperation and aims to gain or consolidate leadership in key scientific and technology areas*' (European Commission, 2013). This thematic area includes eleven sub-themes: (i) health; (ii) food, agriculture and fisheries, and biotechnology; (iii) information and communication technologies; (iv) nanosciences, nanotechnologies, materials and new production technologies; (v) energy; (vi) environment (including climate change); (vii) transport (including aeronautics); (viii) socio-economic sciences and humanities; (ix) space; (x) security; and (xi) general activities[1]. The second theme is 'Ideas'. The objective of this specific thematic area is '*to reinforce excellence, dynamism and creativity in European research and improve the attractiveness of Europe for the best researchers, both from European and third countries, as well as for industrial research investment, by providing a Europe-wide competitive funding structure, in addition to, and not replacing, national funding, for "frontier research" executed by individual teams*' (European Commission, 2013). The third theme is about 'People' with the 'Marie Curie Actions'. The 'Marie Curie Actions' have '*been particularly successful in responding to the needs of Europe's scientific community in terms of training, mobility and career development*' (European Commission, 2013). The fourth theme deals with 'Capacities' which '*aims at enhancing research and innovation capacities throughout Europe and ensure their optimal use*' (European Commission, 2013) and has seven sub-themes: (i) research Infrastructures; (ii) research for the benefit of SMEs; (iii) regions of knowledge; (iv) research potential of convergence regions; (v) science in society; (vi) support for the coherent development of research policies; and (vii) activities of international cooperation.

This chapter includes the Seventh Framework Programme of the European Atomic Energy Community (EURATOM) for nuclear research and training activities. EURATOM is legally separated from the European Community (EC) and has its own Framework Research Programme, managed however by the common Community institutions. For the implementation of this programme, 2.751 billion euros are foreseen for the period 2007-2011 (Official Journal of the European Union, 2007).

(1) 'General activities' is a sub-theme only used in the e-Corda database and it colletcs mainly ERANET calls for proposals.

5.2. The e-Corda database

The data used in this chapter are related to the number of project partners, not to the number of projects. One project usually has at least three project partners from at least three different countries, but several project partners from the same country are quite common. When the number of project partners is considered instead of the number of projects, a stronger Belgian presence in FP7 is quantified. The downside of this choice is that the contribution of the partner becomes irrelevant and a very small project partner has the same effect on the project outcomes as the project coordinator. A statistical analysis of the budget of Belgian project partners might give an overview of the contribution, but the financial data in the e-Corda database is less reliable.

The e-Corda database provides a wide range of detailed information on all project partners involved in a FP7 project proposal. The subdivisions relevant for this chapter are the following categories (terminology used by the European Commission). The term 'Programme' designates the thematic area such as space, environment (including climate change), people, ideas, infrastructures, ... The term 'EC decision' is based on the feedback of evaluators, the European Commission (EC), and provides a ranking list which is used to categorize the projects into: (i) main listed: these projects are invited for negotiations; (ii) reserve listed: the back-up list in case one or more negotiations from the main list fail or in case additional funding is available; (iii) rejected: the quality of the projects is not sufficient and therefore these projects will not be funded; (iv) ineligible: the project proposal does not fulfil one or more of the eligibility criteria and therefore this project will not be taken into consideration; and (v) withdrawn: a project proposal was withdrawn before the deadline to submit proposals.

For this chapter, successful project partners are project partners involved in a main listed project proposal. Although in general, a main listed project will become a funded project after negotiations, there is still a difference between the two. As mentioned above, the negotiations with the EC can collapse, or a project proposal from the reserve list might be funded. Taking into account the long negotiation process and to ensure the information is as up-to-date as possible, the project partners involved in main listed project proposals, and not the project partners involved in funded projects, are used as an indicator of success, or lack of it. A lapse of two and a half years between the official publication of a call for proposals and the publication of a database with funded projects is the general rule rather than the exception.

In the case of most project proposals it is clear for which programme they were submitted. One exception is the call for proposals 'The Ocean of Tomorrow'. The three topics of this call are implemented jointly by the thematic areas 'Food, Agriculture and Fisheries, and Biotechnology'; 'Energy'; 'Environment (including Climate Change)'; 'Transport (including Aeronautics)' and 'Socio-economic sciences and Humanities'. The project proposals submitted for this call are assigned to the thematic area by taking the proposal title into account.

Appointing a project partner to a certain country is based on the geographic location of the official postal address of the partner. This is not unusual, of course, but it has to be kept in mind when interpreting the figures, and certainly for the figures of Belgium, because they are influenced by the so-called 'Brussels-effect'. Many institutions or (lobby) groups have their main office in Brussels, close to the European Commission, but the actual work is performed elsewhere in Europe. Even more important are the institutes and agencies allied to the European Union. The best example is the Joint Research Centre in the Flemish region (Geel), a project partner involved in many FP7 project proposals. Obviously Belgium is not the only country facing this shortcoming, but the presence of the European Commission in Brussels entails that many of these institutes and agencies be located in Belgium.

5.3. Participation to FP7 in Belgium

In this section the Belgian participation to the Seventh Framework Programme will be looked at in closer detail. First, the participation for every thematic area will be examined. As stated before, there are six possible outcomes: 'main listed', 'reserve listed, 'rejected', 'ineligible', 'withdrawn' and 'not decided yet'. Table 5.1 gives an overview of the number of framework partners in Belgium by thematic areas and their subdivisions. Second, the success ratios for projects, with at least one participant from Belgium, are mentioned. Third, the coordinators of projects are considered for every thematic area.

TABLE 5.1 – **Overview of the number of FP7 project partners in Belgium**

Theme	Main listed	Re-serve listed	Re-jected	Ineli-gible	With-drawn	Not decid-ed yet	Total
Cooperation							
Health	379	65	912	53	2	0	1411
Food, agriculture and fisheries, and biotechnology	344	495	245	19	0	3	1106
ICT	599	116	2177	36	4	0	2932
Nanosciences, nanotechnologies, materials and new production technologies	375	76	626	4	0	1	1082
Energy	171	55	275	7	1	7	516
Environment (including climate change)	243	71	604	28	0	0	946
Transport (including aeronautics)	517	172	810	35	0	0	1534
Socio-economic sciences and humanities	104	42	490	22	0	1	659
Space	99	36	112	0	0	0	247
Security	138	37	413	8	0	0	596
General activities	11	0	2	0	0	0	13
Ideas	89	32	480	17	4	312	934
People	471	97	1848	10	0	108	2534
Capacities							
Research Infrastructures	119	18	163	5	0	0	305
Research for the benefit of the SMEs	222	40	613	38	0	164	1077
Regions of Knowledge	19	13	48	2	0	0	82
Research Potential of Convergence Regions	0	1	10	2	0	0	13
Science in Society	80	21	183	6	0	0	290
Support for the Coherent Development of Research Policies	13	0	5	0	0	0	18
Activities of International Cooperation	32	8	52	1	0	0	93
EURATOM	109	52	48	6	0	0	215
Total projects (as a share)	**4134 24.9 %**	**1447 8.7%**	**10116 60.9%**	**299 1.8%**	**11 0.1%**	**596 3.6%**	**16603**

Source: e-Corda Common Research Datawarehouse of the European Commission.

The coordinator of a project is generally the most important project partner as the coordinator is (one of) the biggest beneficiaries; he puts the most effort in the project and is the key figure in keeping the project running. A country with more project coordinators may be considered as one with a more important position within the scientific research community. Finally, the participation is compared according to the different thematic areas. This gives an idea as to which thematic areas are important for the research community in Belgium.

Based on Table 5.1, it is easy to tell that the most popular thematic areas are, by far, 'Information and Communication Technologies' and 'People'. With some margin, the top five is completed by 'Transport (including aeronautics)', 'Health' and 'Research for the benefit of the SMEs'. Due to the nature of certain thematic areas, some of them have hardly any Belgian participants involved. These are 'General activities' (projects limited to participation of specific participants such as public administration), 'Research potential of convergence regions' ('*helping the less advanced regions remote from the European core of research and industrial development to fully exploit its research potential*' (European Commission, 2007a)) and 'Support for the coherent development of research policies' ('*the development of effective policies to leverage public and private research investments to accelerate the transition towards a competitive knowledge-based economy*' (European Commission, 2007b)).

Another observation is the high number of undecided projects where partners from Belgium are involved for the thematic areas 'Ideas' and 'Research for the benefit of the SMEs'. To a lesser extent, this also applies to the thematic area 'People'.

5.4. Number of project coordinators

Table 5.2 gives an idea on how many project coordinators in Belgium are involved in FP7 projects. The project coordinator is the most important partner because he takes the lead on the project and oversees the work that has to be done. In most cases he is also the main contributor for writing the proposal, so most credit for a main listed project proposal goes to the coordinator.

For the interpretation of the data in Table 5.2, the thematic areas 'General activities', 'Research potential of convergence regions' and 'Support for the coherent development of research policies' are not taken into consideration due to the low number of project partners involved. The thematic areas with the most coordinators involved are, by far, 'Ideas' and 'People', followed by 'Space', 'Health' and 'Nanosciences, nanotechnologies, materials and new production technologies'. The large number of coordinators in thematic areas 'Ideas' and 'People' is no surprise since these projects have generally a limited number of partners; even a sole coordinator is no exception. This is not the case for the other thematic areas where collaboration between at least three parties from different member states of the European Union or associated countries is an eligibility criterion. Initiatives with a high percentage of coordinators can be considered as thematic areas that are important for the Belgian research community and where a certain level of excellence is demonstrated. A high percentage is around 10% or higher.

TABLE 5.2 – **Overview of the total number of project partners from Belgium, the number of project coordinators and the percentage of project partners that is also a project coordinator**

Theme	Total number of project partners in Belgium	Total number of project coordinators in Belgium	Percentage of Belgian project partners with a role as coordinator
Cooperation			
Health	1411	200	14.17
Food, agriculture and fisheries, and biotechnology	1106	105	9.49
ICT	2932	371	12.65
Nanosciences, nanotechnologies, materials and new production technologies	1082	151	13.96
Energy	516	55	10.66
Environment (including climate change)	946	71	7.51
Transport (including aeronautics)	1534	157	10.23
Socio-economic sciences and humanities	659	89	13.51
Space	247	37	14.98
Security	596	38	6.38
General activities	13	5	38.46
Ideas	934	819	87,69
People	2534	919	36,27
Capacities			
Research infrastructures	305	19	6.23
Research for the benefit of the SMEs	1077	95	8.82
Regions of knowledge	82	4	4.88
Research potential of convergence regions	13	4	30.77
Science in society	290	37	12.76
Support for the coherent development of research policies	18	7	38.89
Activities of international cooperation	93	9	9.68
EURATOM	215	24	11.16
Total	**16603**	**3215**	**19.36**

Source: e-Corda Common Research Datawarehouse of the European Commission.
Note: A single project can have more than one Belgian project partner involved. As a consequence, column 4 of Table 5.2 does not represent the percentage of coordinators in Belgium leading a project, but rather gives an idea of the percentage of project partners in Belgium that are responsible for leading the project.

5.5. Success rate of project partners in Belgium

Success is defined as a project that has been selected on the 'main list'. Projects on the main list are invited for negotiations by the European Commission. This does not necessarily mean that these projects will be funded, although that will generally be the case. For example, negotiations may collapse or the project may fail during the security scrutiny procedures. On the other hand, projects on the 'reserve list' may become a subsidized project as well, in case additional funding opportunities are found.

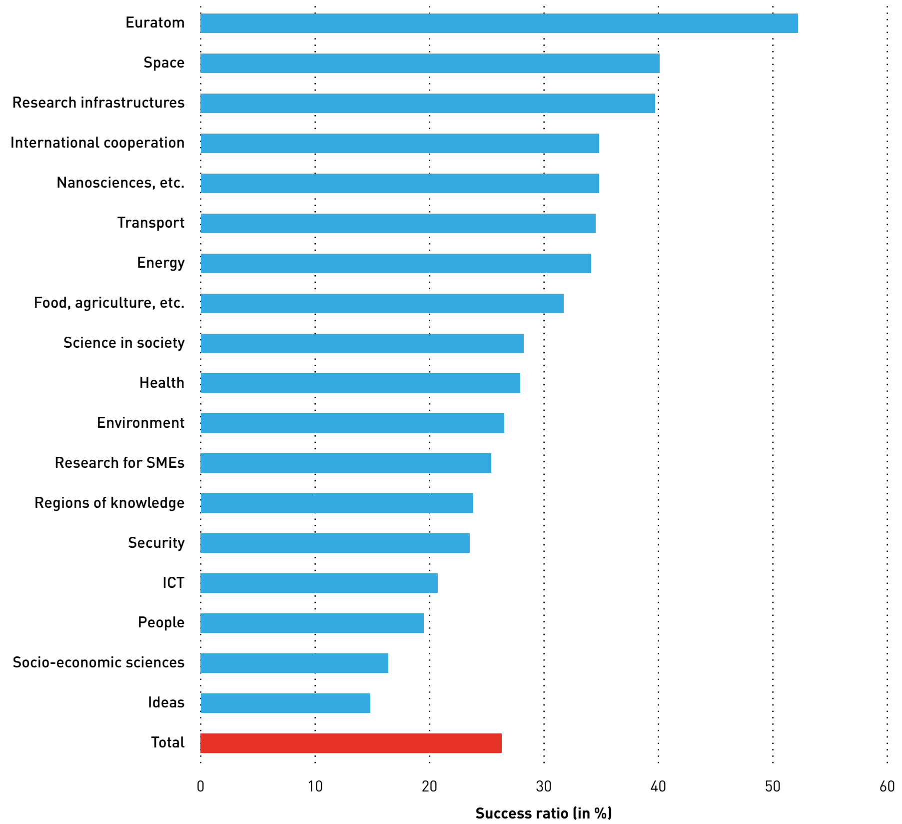
The number of funded projects from the 'reserve list' outnumbers the number of projects from the 'main list' that did not receive any funding. This means that the success ratio mentioned in Table 5.3 below, underestimates the success ratio when taking the actual funded projects into consideration.

TABLE 5.3 – **Overview of the Belgian success rate for the participation to FP7 in general and for the Belgian project coordinators**

Theme	Main listed	Total	Success ratio Belgian project partners (in %)	Main listed Belgian project coordinators	Total number of Belgian project coordinators	Success ratio Belgian project coordinators (in %)
Cooperation						
Health	379	1356	27.9	40	168	23.8
Food, agriculture and fisheries, and biotechnology	344	1084	31.7	33	101	32.7
ICT	599	2892	20.7	88	361	24.4
Nanosciences, nanotechnologies, materials and new production technologies	375	1077	34.8	29	150	19.3
Energy	171	501	34.1	18	48	37.5
Environment (including climate change)	243	918	26.5	13	63	20.6
Transport (including aeronautics)	517	1499	34.5	55	153	35.9
Socio-economic sciences and humanities	104	636	16.4	11	86	12.8
Space	99	247	40.1	14	37	37.8
Security	138	588	23.5	14	37	37.8
General activities	11	13	84.6	4	5	80.0
Ideas	89	601	14.8	79	532	14.8
People	471	2416	19.5	215	904	23.8
Capacities						
Research Infrastructures	119	300	39.7	3	16	18.8
Research for the benefit of the SMEs	222	875	25.4	20	75	26.7
Regions of Knowledge	19	80	23.8	0	4	0.0
Research Potential of Convergence Regions	0	11	0	0	2	0.0
Science in Society	80	284	28.2	12	36	33.3
Support for the Coherent Development of Research Policies	13	18	72.2	7	7	100.0
Activities of International Cooperation	32	92	34.8	3	9	33.3
EURATOM	109	209	52.2	11	22	50.0
Total projects	**4134**	**15697**	**26.3**	**669**	**2816**	**23.8**

Source: e-Corda Common Research Datawarehouse of the European Commission.
Note: To define the success rate, only the main listed, reserve listed and rejected projects are taken into account.

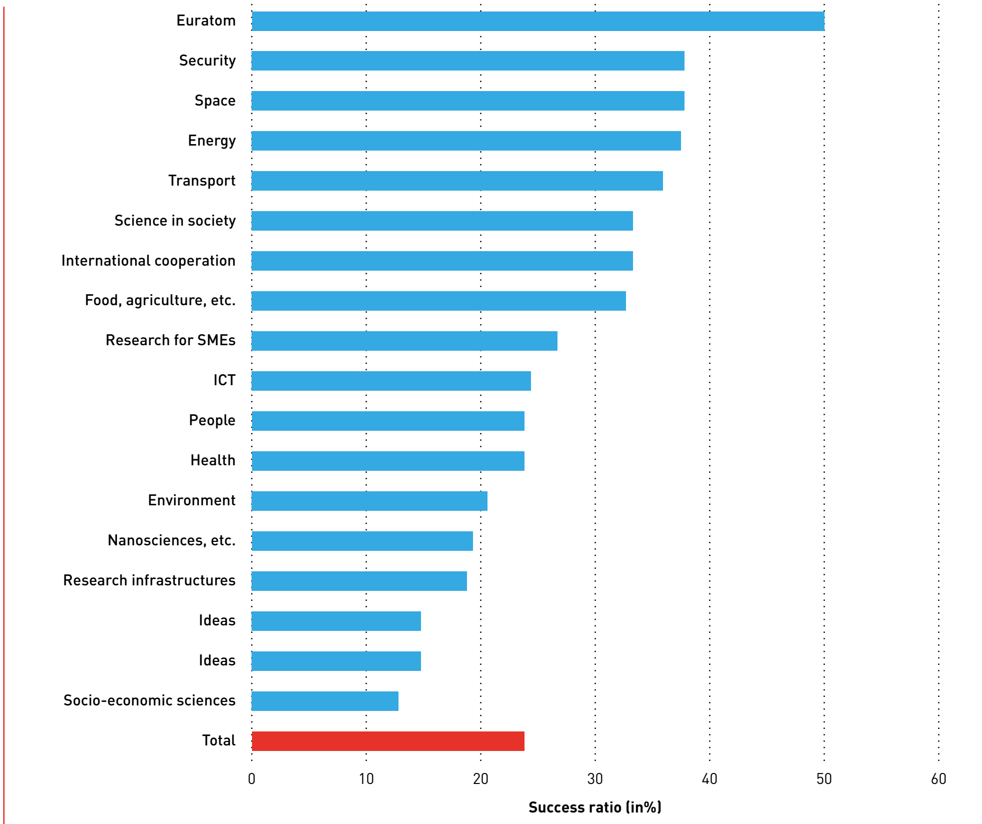
FIGURE 5.1 – **Success ratio of the project partners in Belgium per thematic area and the total success ratio**



Source: e-Corda Common Research Datawarehouse of the European Commission.
Notes: For the discussion on the success rates, the thematic areas 'General Activities', 'Research Potential of Convergence Regions' and 'Support for the Coherent Development of Research policies' are not taken into account due to the limited number of submitted project proposals. In these cases, one main listed project proposals less or more would change drastically the success rate.

The success rate for the Seventh Framework Programme of the European Atomic Energy Community for nuclear research and training activities (EURATOM) is high. One out of two project partners in Belgium got funding for their research. The fact that the targeted researchers for this framework programme are limited must be taken into consideration but the result is, nevertheless, extraordinary. Three other remarkable results are the success rate of the thematic areas 'Space', 'Research Infrastructures' and 'Nanosciences, nanotechnologies, materials and new production technologies'. For these activities the success rates surpass the global success rate of all the FP7 project participants by at least 10%. On the other side of the spectrum the result of the activity 'Ideas' is situated at a success rate of less than 10%. This is no surprise since the competition for ERC grants in this field is generally very high.

FIGURE 5.2 – **Success ratio of the project coordinator in Belgium per thematic area and the total success ratio**



Source: e-Corda Common Research Datawarehouse of the European Commission.
Notes: For the discussion on the success rates, the thematic areas 'General Activities', 'Regions of Knowledge', 'Research Potential of Convergence Regions' and 'Support for the Coherent Development of Research policies' are not taken into account due to the limited number of submitted project proposals. In those cases, one less or more main listed project proposal would change the success rate drastically.

When comparing the success rate of the Belgian project partners to the ones of the Belgian project coordinators, the success rate on eleven thematic areas is higher when a project partner of another country is responsible for leading the project. For six thematic areas the success rate is higher when a Belgian project partner acts as coordinator. For the thematic area 'Food, Agriculture and Fisheries, and Biotechnology' the success rate is more or less the same. Moreover the total success rate is over four percentage points higher when a Belgian participant leads the project (24.9% vs 20.9%). The involvement of a Belgian coordinator is not a guarantee for success.

The biggest differences may be observed for the thematic areas 'Research infrastructures' and 'Nanosciences, nanotechnologies, materials and new production technologies', in favour of all the project partners in Belgium; and the thematic area 'Security', in favour of the coordinators in Belgium. In addition the thematic area 'Regions of Knowledge' shows a big difference between the success rate of projects with and without a Belgian project coordinator, but the very limited number of project coordinators (only four) makes a comparison irrelevant.

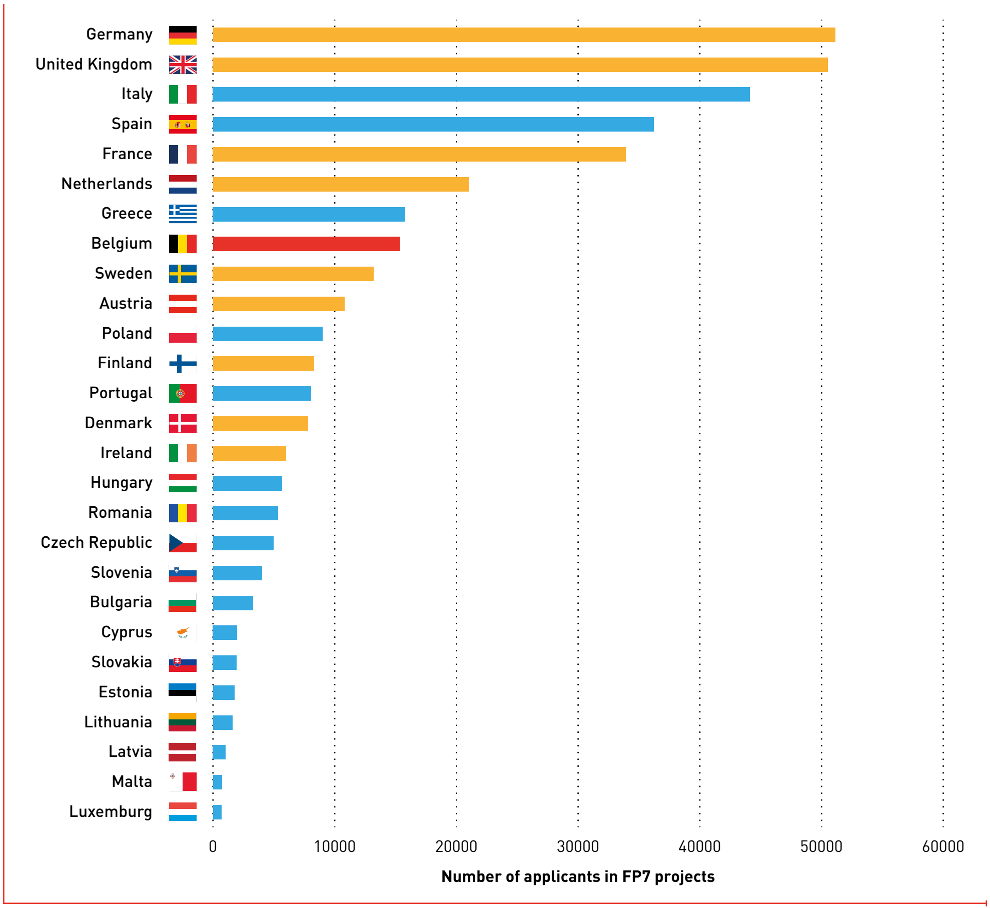
5.6. Belgian performance in the European context

The next step, after the performance of Belgian researchers has been examined, is to compare the results with other countries of the European Union and, more specifically, with the selected member states. The indicators that are taken into account are the total number of applicants and the success ratio based on the number of partners involved in main listed projects.

Total number of applicants in the EU countries

In each project at least one or three project partners are represented, depending on the type of project. All these partners can be allocated to a certain country. As mentioned earlier, the 'Brussels effect' should be taken into account for Belgium. The same partner may be involved in several projects and one partner may, therefore, be accredited more than once (one involvement is one count). The reason an involvement is not taken into account: if a coordinator has the same weight as the smallest contributor to the project.

FIGURE 5.3 - **Total number of applicants in FP7 projects per country of the European Union**



Source: e-Corda Common Research Datawarehouse of the European Commission.

When it comes to total number of applicants in FP7 projects, the frontrunner is Germany, closely followed by the United Kingdom. The top 5 is completed by Italy, Spain and France. These countries are also the biggest Member States when taking the number of inhabitants into account, although the order changes slightly (Germany, France, the United Kingdom, Italy and Spain). In this ranking list, the eighth place is allocated to Belgium, which is slightly better than one would expect based on the number of inhabitants (10th place in the EU).

TABLE 5.4 – **Total number of applicants in FP7 projects corrected for size effects**

Country	Total number of applicants	Number of applicants per million inhabitant	Number of applicants per million R&D expenditures	Number of applicants per thousand researchers
Belgium	15366	1385	1.88	243.1
France	33916	519	0.76	106.3*
Germany	51116	625	0.68	105.5**
Netherlands	21038	1257	1.93*	324.5*
United Kingdom	50529	802	1.88	128.0*
Austria	10801	1279	1.31	182.0**
Denmark	7805	1399	0.14	142.6*
Finland	8299	1536	1.16	144.2
Ireland	5985	1306	2.22	270.4
Sweden	13197	1392	0.11	181.5**
EU-27	364104	723	n.a.	n.a.
Bulgaria	3284	448	n.a.	n.a.
Cyprus	1973	2289	n.a.	n.a.
Czech Republic	4957	472	0.07	108.0
Estonia	1747	1304	4.54	228.5
Greece	15796	1399	n.a.	n.a.
Spain	36201	784	2.55	161.6*
Hungary	5662	569	0.02	153.3
Italy	44118	725	2.23	294.5*
Lithuania	1590	529	n.a.	n.a.
Luxembourg	681	1298	1.12	230.8**
Latvia	1032	506	n.a.	n.a.
Malta	719	1722	n.a.	n.a.
Poland	8983	233	0.77	89.2
Portugal	8039	763	3.14	83.5*
Romania	5323	249	n.a.	n.a.
Slovenia	4011	1951	4.49	320.5
Slovakia	1936	358	4.13	78.3

Sources: e-Corda Common Research Datawarehouse of the European Commission; Eurostat, population at 1 January 2012; OECD (2013), Main Statistics on Science and Technology.
*Notes: Symbols * and ** indicate data from 2010 and 2009 respectively. Not available data are indicated by n.a.*

Compared to the selected countries, Belgium is outperformed by three much larger countries (Germany, the United Kingdom and France), which is expected, and also by the Netherlands, which has 5.8 million more inhabitants. On the other hand, Belgium (15366 applicants) is doing better than Austria (10801 applicants), Denmark (7805 applicants), Finland (8299 applicants), Ireland (5985 applicants) and Sweden (13197 applicants).

A way to compare the participation to FP7 among countries of different sizes is to take the number of inhabitants into account. It is obvious that a large country will have a higher participation in absolute terms, but that does not mean that this is also the case in relative terms. When taking the total number of participants divided by the number of inhabitants of a country, the size of the country is not a factor anymore. The inherent weakness in this way of working is that, for small countries, the relative weight of a project partner involved in a project proposal is many times higher than for a large country: one Maltese applicant more or less changes the number of applicants per million inhabitants by 2.395; one German applicant more or less changes the same fraction by only 0.012.

Two alternative performance indicators are the number of applicants per million R&D expenditures and the number of applicants per thousand researchers. For the first indicator a lower number means more money is spent on R&D or may also be regarded as a less efficient way of using the R&D investments. The second indicator says something about the involvement of the researchers in a country in the Seventh Framework Programme. The lower this number is, the more researchers are involved in the European financing instrument. The problem with the relative weight of a project partner for smaller countries applies also for these two alternative performance indicators.

The best in classification for the participation in comparison with the number of inhabitants is by far Cyprus, at some distance followed by Slovenia and Malta. With 1385 applicants per million inhabitants Belgium occupies the eighth place in the total ranking, more or less at the same level as Greece, Denmark and Sweden. The Belgian ratio almost doubles the European (EU-27) mean. Another fact is the relatively low score of big countries such as Germany, France, the United Kingdom, Italy and Spain. Best in classification of the selected countries is Finland, also in general the fourth best performing country of the EU-27. Finland is sparsely populated but highly R&D intensive. Denmark, Sweden and Belgium follow at a small distance. As mentioned above, the big countries are being outperformed by the others.

The biggest investments compared to the number of applicants are done in Hungary and in the Czech Republic, followed by Sweden and Denmark. Between these four countries and the next group (Germany, France and Poland) lies a big gap. Belgium can be found somewhere in the middle, in the vicinity of the United Kingdom and the Netherlands.

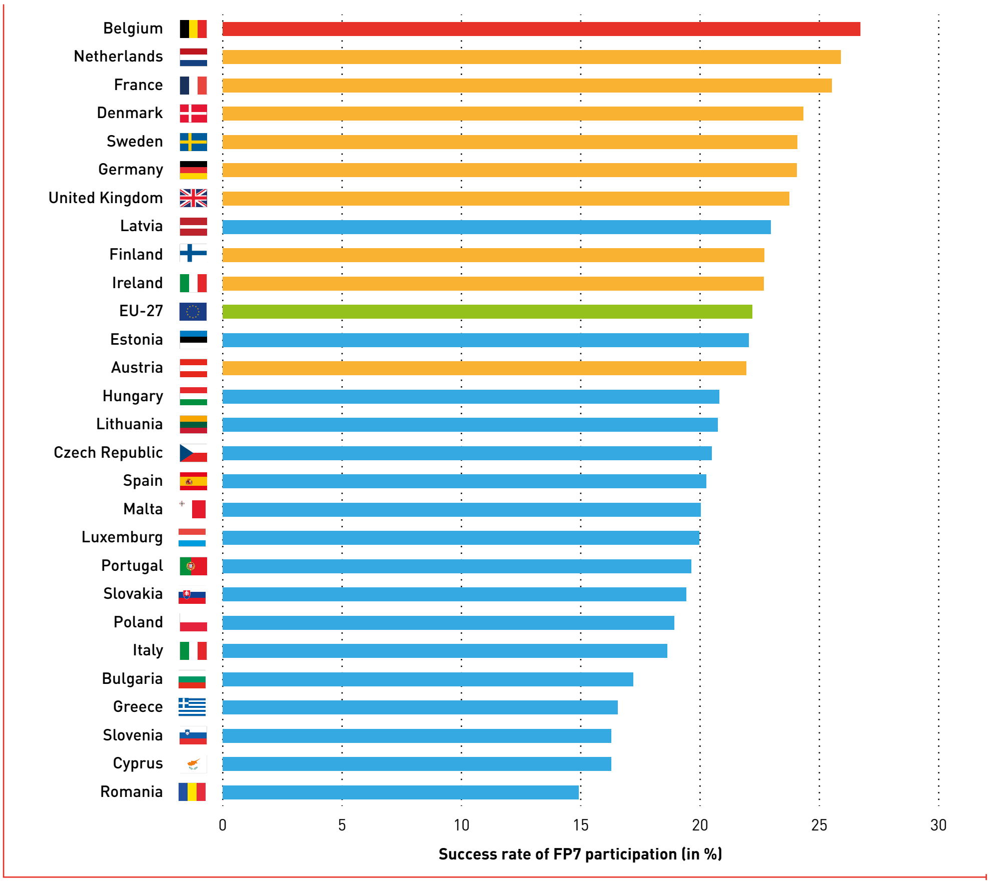
The highest involvement of researchers in the Seventh Framework Programme can be found in the Netherlands and Slovenia, followed by Italy and at some distance Ireland. The fifth position is taken by Belgium just before Luxemburg. The selected countries that are not mentioned yet are having a lower number of applicants per thousand researchers.

Success rate for the total retained project partners

The success rate is the number of project partners involved in main listed projects compared to the total number of projects. As mentioned in the previous section, one partner may be involved in several project proposals and is accredited for as many times as he is involved in a project.

The same project may represent several partners from the same country. One of the consequences is that a main listed project with many partners from the same country affects the success rate in a positive way.

FIGURE 5.4 - **Success rate of FP7 participation per country of the European Union**



Source: e-Corda Common Research Datawarehouse of the European Commission.

In terms of the success rate of FP7 participation, no country is outperforming Belgium. This may be partially explained by the so-called "Brussels-effect" whereby the many international organisations and institutions located in Brussels know their way around the tangle of the European Union. But using this as the main explanation of the good result of Belgium would depreciate the value of Belgian project participants. Two other countries with a success rate over 25% are the Netherlands and France. All other countries fall below this percentage.

Coming back to the total number of project partners compared to the number of inhabitants per country from the previous section, the top three (Cyprus, Slovenia and Malta) is nowhere to be found among the most successful countries. This means that in these countries the participation to FP7 is very high, but this is not a guarantee for success. On the other hand, Finland, which is the fourth best performing country when it comes to participation compared to inhabitants, is also among the better performing countries in terms of success rate.

All selected countries are performing more or less at the same level, ranging from 21.9% (Austria) to 26.7% (Belgium). The success rate of EU-27 is at 22.2% in that same range.

5.7. Conclusion

For Belgium, the most popular FP7 thematic areas are 'Information and Communication Technologies' and 'People', followed by 'Transport (including Aeronautics)', 'Health' and 'Research for the Benefit of the SMEs'. This is also reflected by a high percentage (>12.5%) of Belgian project partners in the role of coordinators for the thematic areas 'Information and Communication Technologies' and 'Health', which is less the case for 'Transport (including Aeronautics)' and 'Research for the Benefit of the SMEs'. Due to the specific nature of the thematic area 'People' (with a limited number of partners, where a single coordinator is no exception), the percentage of Belgian partners leading a project is high by default.

Another issue is the high percentage (almost 15%) of Belgian project coordinators in the thematic area 'Space'. This means that Belgium has a significant amount of very good and experienced space researchers, a statement that is supported by one of the highest success ratios. In contrast, the thematic area 'Nanosciences, Nanotechnologies, Materials and new Production Technologies' also has a very high percentage of Belgian project partners in the role of coordinator, but the success ratio of this group is much lower than that of the thematic area in general (19.2% vs. 34.7%). This means that Belgian project coordinators would benefit from some support. The same conclusion may be drawn for the thematic area 'Research Infrastructures', with a significant difference between the success rates of projects with at least one Belgian partner involved (39%) and the ones led by a Belgian partner (15.79%). On the other hand, the success rate for a project increases considerably when the Belgian project partner is leading the project for the thematic area 'Security' (23.2% vs. 36.8%).

In the European context, Belgium's performance is far from bad. In terms of the total number of applicants, Belgium is positioned in eighth place when comparing EU-27. This is slightly better than one would expect based on the number of inhabitants (tenth place). Because it is difficult to compare a high variety of countries in Europe, it is more equitable to compare the total number of applicants to the number of inhabitants in a country. Moreover, for this indicator, Belgium is holding the eighth position but doing much better than the European mean. Compared to a selection of countries, Belgium is only outperformed by Finland and Denmark, and Sweden is doing slightly better. All the other countries, certainly the large countries, are doing worse.

Belgium is best in classification when it comes to overall success rate. The so-called "Brussels-effect" is only a partial explanation and would depreciate the quality of our researchers. It also indicates that our country possesses talented and successful researchers who are able to compete with European colleagues.

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CHAPTER 6

Impact of the crisis on innovation expenditures

JEOFFREY MALEK-MANSOUR

6.1. Introduction

In chapter 6 we investigate the impact of the economic crisis on the innovation behaviour of firms in Belgium, and in particular on their innovation expenditures. Though the pro-cyclical nature of innovation expenditures is widely documented (see, e.g. European Commission (2011) or OECD (2009)), there is also empirical evidence that some firms actually increase their innovation expenditures during crises. Archibugi et al. (2013) provide additional stylized facts on this and investigate the characteristics of those firms. Specifically, they test two paradigms against each other. First, firms that have increased their innovation expenditures are 'perpetual innovators', whose business model relies heavily on innovation. That is they are large (oligopolistic) firms. There is a phenomenon of cumulative learning going on, which implies a high degree of path-dependency. This is the 'creative accumulation' paradigm. Second, firms that have increased their innovation expenditures are new or smaller firms that take advantage of the shakeout provoked by the crisis to enter new markets or challenge incumbents on existing markets. This is the 'creative destruction' paradigm.

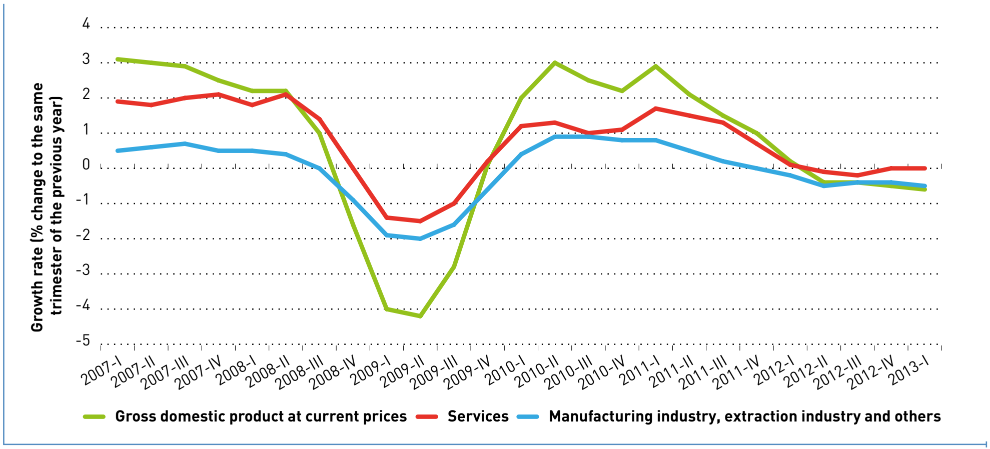
To test these paradigms, Archibugi et al. (2013) use three waves of the Community Innovation Surveys (CIS) and regress increase in innovation expenditures before the crisis (2004-2006) and during it (2006-2008) on a series of characteristics typical of firms. In particular, they examine the impact of (i) whether the firm was a 'fast-growing new firm' or not; (ii) whether the firm was already an R&D performer at the beginning of the period; (iii) whether the firm was a 'radical' innovator, i.e. introduced new-to-market products during the period; and (iv) the strategy of the firm: whether it concentrated on cost-cutting activities (exploitation), on the exploration of new markets or technologies (exploration), or both (ambidexterity).

The present chapter is deeply inspired by the analysis of Archibugi et al. (2013) and tests the impact of their interest variables on innovation expenditures before and during the crisis, using Belgian data. Section 6.2 reviews some stylized facts of the crisis. Then, section 6.3 provides descriptive statistics as well as formal tests on the impact of our interest variables. Next, we estimate an equation for the evolution of innovation expenditures (with Heckman correction for bias selection). Finally, we conclude.

6.2. Stylized facts about the crisis

As was widely argued in the press, the current economic and financial crisis was born in the US in 2007, after the burst of a bubble in the housing market. The shock wave was then quickly transmitted to all developed countries and to all sectors within the economy. Figure 6.1 illustrates what happened in the case of Belgium and shows the evolution of added value in the major sectors of its economy. We use quarterly data to have a more precise spot on the timing of the crisis. Accordingly, the two most critical years were 2008 and 2009, though GDP growth already began slowing down in 2007. The economy then bounced back in 2010 and then engaged in some sort of sluggish contraction.

FIGURE 6.1 – **Quarterly value-added growth rate in the main sectors of the Belgian economy**



Source: National Bank of Belgium - Belgostat (2013).

To scrutinize firm behaviour before and after the crisis, we use four waves of the Community Innovation Survey (henceforth CIS): CIS4 (2002-2004), CIS2006 (2004-2006), CIS2008 (2006-2008) and CIS2010 (2008-2010). Each of these waves contains data on innovation expenditures for the ending year, also known as reference year. The problem is that the crisis expands over two CIS waves: it started during CIS2008 and really unfolded during CIS2010, although 2010 proved to be a relatively good year (given the circumstances). Table 6.1 gives an overview of the dynamics of innovation activities and expenditures during the four periods under review. It displays two important variables: the innovation rate (percentage firms with technological innovation activity during the three year period) and the nominal total innovation expenditures. As can be seen, the effects of the crisis were the most largely felt during the 2006-2008 period, and we can notice a severe drop in innovation expenditures in 2008. The next period, 2008-2010, shows some signs of recovery. All in all, it provides some additional evidence on the pro-cyclicality of innovation behaviour.

TABLE 6.1 – **Innovation expenditures and activities – global overview**

Period	2002-2004	2004-2006	2006-2008	2008-2010
Technological innovators in the population (in %)	51.42	55.76	48.26	51.80
Total innovation expenditures (Mio EUR, ending year)	9815	11151	7726	12760

Source: CFS/STAT (2013).

Now, as argued by Archibugi et al. (2013), not all firms have reduced or stopped their innovation expenditures. The question is then to identify what type of firms has actually increased their expenditures during the crisis. To do this, we use three merged CIS waves: CIS4 with CIS 2006, CIS 2006 with CIS 2008, and CIS 2008 with CIS 2010, in order to be able to capture the growth in innovation expenditures and the factors that might influence it. The next Section presents some stylized facts and correlations between some variables that may affect innovation expenditure growth in crisis time and their actual growth.

6.3. Firms' characteristics and innovation expenditures in times of crisis

Radical innovators

As mentioned above, there is a presumption that firms having an innovation culture, for which innovation is a way of life, would increase their innovation expenditures more than firms which are intermittent innovators ore merely 'adaptors' of someone else's innovations. To test this hypothesis, we restrict our samples to technologically innovative firms and define 'radical innovators' as those firms who have recorded turnover from innovative products that are new to their market. Firms that only innovate with products that are new to the firm are referred to as 'incremental innovators'. The question is then whether firms that were registered as radical innovators at the beginning of the period have increased their innovation expenditures more than incremental innovators. Table 6.2 displays some summary statistics on the increase in innovation expenditures according to the status of the firms. Due to the highly skewed nature of the innovation expenditures distribution, we present statistics on both the means and the medians. We also perform a Wilcoxon test on the difference between radical innovators at the beginning of the period and other firms. Standard parametric t-tests cannot be applied here because of heteroscedasticity and non-normality of the distributions

TABLE 6.2 – **Innovation expenditure growth according to the 'radical innovator' status of the firm**

	Radical innovator (t-1)			Incremental innovator (t-1)			Difference radical vs incremental		
Period	N	Mean (in %)	Median (in %)	N	Mean (in %)	Median (in %)	Mean (in %)	Median (in %)	Wilcoxon (p-value)
2004-2006	134	20.68	7.17	227	-4.80	11.33	-25.49	4.16	0.492
2006-2008	155	15.27	4.45	316	3.99	14.61	-11.27	10.16	0.918
2008-2010	227	5.46	1.80	361	-4.96	-10.01	-10.42	-11.81	0.087

Source: CFS/STAT (2013).
Note: The variable under investigation is the nominal growth rate of total innovation expenditures. (t-1) refers to the status of the firm at the beginning of the period. N refers to the number of observation. Samples are restricted to firms with technological innovation activities. The Wilcoxon test is two-sided.

Accordingly, in the two first periods, not much can be said: on average, innovation expenditures have grown less fast in the radical innovators group than in the control group, but the median increase is higher in the radical innovators group. The difference is not statistically significant. In the last period, however, the increase in innovation expenditures is significantly lower in the radical innovators group than in the control group. This may be due to the fact that 2010 can be seen as some kind of recovery year, as argued in section 6.2. The analysis would then go as follows: firms that are not accustomed to an innovation culture have taken advantage of the slight boom in 2010 to increase their innovation expenditures; in order to be able to take advantage of a possible recovery. It can also be seen, though this is only a point estimate, that the difference between the medians is highest for the period 2006-2008, which is the 'heart' of the crisis. This supports the hypothesis that persistence in innovation expenditures is higher among radical innovators, although it cannot be taken as formal proof.

To shed additional light on the difference between the two groups, and to eliminate the influence of extreme values and possible outliers, we have created a dummy variable that takes value 1 if firms have increased their expenditures, and 0 otherwise. This enables us to carry out standard chi-square tests to check whether there is a correlation between being a radical innovator and having increased innovation expenditures. Again, there is a presumption that, in crisis time, the proportion of radical innovators that have increased their innovation expenditures is higher than the proportion of incremental innovators with the same behaviour. Table 6.3 displays the results for the three periods as well as standard test statistics.

TABLE 6.3 – **Proportion of firms with increasing innovation expenditures by type of innovator**

Innovator	Expenditures 2004-2006			Expenditures 2006-2008			Expenditures 2008-2010		
	+	Not +	All	+	Not +	All	+	Not +	All
Radical	136	128	264	171	183	354	233	162	395
Incremental	261	70	331	237	80	317	362	118	480
Total	397	198	595	408	263	671	595	280	875
Statistic	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**
$\chi 2$	1	49.4298	0.000	1	49.1240	0.000	1	26.8789	0.000
LR $\chi 2$	1	49.7163	0.000	1	50.1208	0.000	1	26.8642	0.000
φ Coeff.		0.2882			0.2706			0.1753	

Source: CFS/STAT (2013).
Note: The innovator status of the firm refers to the beginning of the period.
The variable under investigation a dummy indicating whether the firms have increased their innovation expenditures (+) or not (not +). Samples are restricted to firms with technological innovation activities.

Table 6.3 clearly indicates that there is a positive association between the fact of having increased one's innovation expenditures and the behaviour as a 'radical innovator'. This is true in every period.

Gazelles

Gazelle is a nickname for young, fast-growing firms. Specifically, in this chapter, we define gazelles as SMEs that were created after 2000 (inclusive) and whose turnover has grown faster than 10% during the three-year period under review. There is a presumption that those firms would take advantage of the crisis to move quickly in new niches or try and challenge incumbents in established industries. As in the previous analysis, we start with wondering if innovation expenditures growth was higher among gazelles than elsewhere. Table 6.4 shows summary statistics on the number of observation, mean and median growth rates for the two groups, as well as a Wilcoxon test statistics. On average, innovation expenditure growth was always faster among gazelles than with other firms, though the effect is never statistically significant at the 10% level. In the last period, median expenditures growth was even lower among gazelles. Maybe this phenomenon is related to what we have already observed about radical innovators: at the beginning of the period (2008), the crisis was hitting very hard, whereas at the end of it some sort of slight recovery was going on. So it might be plausible to say that firms which had reduced their innovation expenditures in the previous period because of the crisis, increased them between 2008 and 2010 to profit from the opportunities offered by a possible recovery.

TABLE 6.4 – **Innovation expenditure growth according to the gazelle status of the firm**

	Gazelle			No gazelle			Difference gazelle vs no gazelle		
Period	**N**	**Mean (in %)**	**Median (in %)**	**N**	**Mean (in %)**	**Median (in %)**	**Mean (in %)**	**Median (in %)**	**Wilcoxon (p-value)**
2004-2006	12	57.12	30.24	349	2.85	7.77	54.26	22.47	0.1291
2006-2008	14	57.54	22.52	457	6.18	11.00	51.36	11.52	0.4375
2008-2010	24	9.28	-4.72	564	-1.37	-0.90	10.65	-3.82	0.9267

Source: CFS/STAT (2013).
Note: The variable under investigation is the nominal growth rate of total innovation expenditures.
N refers to the number of observation. Samples are restricted to firms with technological innovation activities.
The Wilcoxon test is two-sided.

To investigate the issue of gazelles increasing their innovation expenditures in crisis time, versus other firms not increasing or lowering them, we proceed as in the previous section: we use a dummy variable for firms that have increased their innovation expenditures and check whether there is some kind of association between those firms and the gazelles. Results are displayed in Table 6.5. There seems to be no association whatsoever between firms that are classified as gazelles and firms that have increased their innovation expenditures.

TABLE 6.5 – **Proportion of firms with increasing innovation expenditures by type of gazelle**

Gazelle	**Expenditures 2004-2006**			**Expenditures 2006-2008**			**Expenditures 2008-2010**		
	+	**Not +**	**All**	**+**	**Not +**	**All**	**+**	**Not +**	**All**
Gazelle	13	9	22	15	8	23	22	11	33
No gazelle	384	189	573	393	255	648	573	269	842
Total	397	198	595	408	263	671	595	280	875
Statistic	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**
Đ2	1	0.5993	0.4389	1	0.1946	0.6591	1	0.0280	0.8671
LR Đ2	1	0.5806	0.4461	1	0.1974	0.6568	1	0.0278	0.8675
φ Coeff.		0.0317			-0.0170			0.0057	

Source: CFS/STAT (2013).
Note: The innovator status of the firm refers to the beginning of the period.
The variable under investigation a dummy indicating whether the firms have increased their innovation expenditures (+) or not (not +). Samples are restricted to firms with technological innovation activities.

Exploration, exploitation and ambidexterity

In times of crisis, innovative firms can pursue a number of strategic options. A first strategy could be to cut in innovation expenditures for new products and new markets and concentrate on cost-cutting activities in existing lines, thus focusing on their own survival whilst waiting for the clime to improve. This short-term retrenchment strategy is termed 'exploitation'. Alternatively, some enterprises might also focus on their long-term development and engage in the development of new products and the discovery of new markets. That approach is referred to as 'exploration'. Of course, both strategies are not mutually exclusive: '*a probable strategy is a combination of retrenchment and investment, that involves seeking out new products or markets in some areas while engaging in cost-cutting measures and activities aimed at increasing efficiency in other areas*' (Archibugi et al., 2013: 306). That kind of mixed approach is labelled 'ambidexterity'. According to the ambidexterity theory (see e.g. March (1991), Levinthal and March (1993), or O'Really and Tushman (2004)), in crisis time, successful firms engage in a mix of exploitation (i.e. cost-cutting in existing business lines) and exploration (i.e. product or market development) activities. Another way to come to the same prediction '*builds on the argument that the ability of firms to survive crises and technological discontinuities depends on their broader knowledge base and on the fact that "they know more than they do"*' Archibugi et al., 2013: 306)).

To measure exploration, exploitation and ambidexterity, we proceed as Archibugi et al. (2013) and make use of the 'objectives of innovation' question in the CIS questionnaire. We construct three dummy variables. First, exploration refer to firms in the upper two quartiles in the sum of the scores across four-point Likert scales in the question: 'how important were each of the following factors in your decision to innovate': (i) increase range of goods or services; (ii) entering new markets or increased market share', (value 1, others 0). Second, exploitation refer to firms in the upper to quartiles in the sum of the scores across four-point Likert scales in the question: 'how important were each of the following factors in your decision to innovate': (i) improving quality of goods or services; (ii) improving flexibility for producing goods or services; (iii) increasing capacity for producing goods or services; (iv) reducing costs per unit produced. Third, ambidexterity refers to firms which have both exploration and exploitation, and those firms receive the value 1 (while others receive 0).

We measure these strategies at the end of the period under consideration. That is, we do not use the lagged value of the indicator. The reason is that the choice in strategy is necessarily simultaneous with the decision, or lack thereof, to increase investment in innovation. Therefore we are not able to use the period 2004-2006, as the Belgian CIS 2006 questionnaire did not include a question on the objectives of innovation.

Table 6.6 examines whether there is a differentiated impact of the strategic choices at hand on the innovation expenditures growth rate. Surprisingly firms that have pursued an exploration strategy seem to have known a lower increase in their innovation expenditures than the other firms, but the effect is not significant. On the contrary, firms with an exploitation strategy have recorded a higher increase, and the effect is even significant for the 2008-2010 period. As to our main variable of interest, ambidexterity, the point estimates of the differences are always negative but, again, the effect is not statistically significant.

TABLE 6.6 – **Innovation expenditure growth according to firm's strategies**

	Yes			No			Difference Yes vs No		
Strategy	**N**	**Mean (in %)**	**Median (in %)**	**N**	**Mean (in %)**	**Median (in %)**	**Mean (in %)**	**Median (in %)**	**Wilcoxon (p-value)**
Exploration									
2006-2008	263	6.77	11.36	208	8.88	15.49	-2.11	-4.13	0.7759
2008-2010	237	-2.66	-7.36	351	0.23	1.09	-2.89	-8.46	0.2791
Exploitation									
2006-2008	253	9.84	10.54	218	5.23	12.48	4.61	-1.94	0.9656
2008-2010	311	11.33	4.64	277	-14.71	-18.79	26.04	23.43	0.0069
Ambidexterity									
2006-2008	153	7.51	9.53	318	7.80	14.26	-0.28	-4.73	0.8631
2008-2010	136	-7.92	-6.34	452	1.16	0.00	-9.09	-6.34	0.2320

Source: CFS/STAT (2013).
Note: The variable under investigation is the growth rate of total innovation expenditures during the period. N refers to the number of observation. Samples are restricted to firms with technological innovation activities. The Wilcoxon test is two-sided.

Next, faced with these inconclusive and somewhat puzzling results we turn to the question of whether firms adopting an ambidexterity strategy are more likely to increase their expenditures or not, especially in crisis time. As before, we use a dummy variable indicating whether the firm has increased its expenditure on innovation or not, and cross it with the ambidexterity variable. The association is positive and statistically significant in the period 2006-2008, which is when the crisis broke out. However, there is no association to be found in 2008-2010. As we have already argued, this might reflect the fact that the 2010 expenditures were carried out in a relatively optimistic context.

TABLE 6.7 – **Proportion of firms that have increased their innovation expenditures according to whether they pursued an 'ambidexterity' strategy**

Strategy	**Expenditures 2006-2008**			**Expenditures 2008-2010**		
	+	**Not +**	**All**	**+**	**Not +**	**All**
Ambidexterity	103	84	187	120	57	177
No ambidexterity	305	179	484	475	223	698
Total	408	263	671	595	280	875
Statistic	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**
$\chi 2$	1	3.5648	0.0590	1	0.0042	1.000
LR $\chi 2$	1	3.5340	0.0601	1	0.0042	1.000
φ Coeff.		0.0729			0.0022	

Source: CFS/STAT (2013).
Note: The variable under investigation a dummy indicating whether the firms have increased their innovation expenditures (+) or not (not +). Samples are restricted to firms with technological innovation activities.

Initial R&D performers

As reported by Archibugi et al. (2013), persistence in innovation is low but persistence in internal R&D is high. As we have already put it, there is a presumption that firms with an innovation culture, i.e. those that also perform internal R&D, would continue increasing their innovation investments more than other firms. We test this hypothesis the same way as before, that is we first compare innovation expenditures growth rates between firms that were already intramural R&D performers at the beginning of the period and those that were not, and next we test whether firms that were initially R&D performers at the beginning are more likely to have increased their innovation expenditures during the period, and whether this association is larger in crisis time. Table 6.8 displays the results for the differences in growth rates.

Table 6.8 – **Innovation expenditure growth according to initially performing R&D**

	Initial internal R&D			No initial internal R&D			Difference internal vs not		
Period	N	Mean (in %)	Median (in %)	N	Mean (in %)	Median (in %)	Mean (in %)	Median (in %)	Wilcoxon (p-value)
2004-2006	303	0.72	3.56	58	25.22	47.01	-24.49	-43.45	0.0519
2006-2008	403	11.61	15.42	68	-15.43	-25.60	27.04	41.02	0.0905
2008-2010	521	-0.05	-1.16	67	-7.84	-0.43	7.79	-0.74	0.2796

Source: CFS/STAT (2013).
Note: The variable under investigation is the growth rate of total innovation expenditures during the period. N refers to the number of observation. Samples are restricted to firms with technological innovation activities. The Wilcoxon test is two-sided.

Interestingly, in the non-crisis period (2004-2006), innovation expenditures have grown faster among the firms that did not initially perform R&D. However, in the crisis period (2006-2008), the converse occurred and R&D expenditures have grown faster in the group of initial R&D performers. In the post-crisis period (2008-2010), there is no significant difference.

Turning to the question as to whether or not there is a difference in the proportion of firms that increased their innovation expenditures across initial R&D performers and non-performers, Table 6.9 indicates that there is always a significant difference. However, the crisis does not seem to have impacted the association in any noticeable way.

TABLE 6.9 – **Proportion of firms that have increased their innovation expenditures according to whether they were initially R&D performers**

Initial R&D	Expenditures 2004-2006			Expenditures 2006-2008			Expenditures 2008-2010		
	+	Not +	All	+	Not +	All	+	Not +	All
Initial R&D	173	160	333	188	232	420	296	249	545
No initial R&D	224	38	262	220	31	251	299	31	330
Total	397	198	595	408	263	671	595	280	875
Statistic	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob
$\chi 2$	1	141.36	0.000	1	121.25	0.000	1	124.43	0.000
LR $\chi 2$	1	192.67	0.000	1	133.32	0.000	1	139.92	0.000
φ Coeff.		0.4874			0.4251			0.3771	

Source: CFS/STAT (2013).
Note: The variable under investigation a dummy indicating whether the firms have increased their innovation expenditures (+) or not (not +). Samples are restricted to firms with technological innovation activities.

6.4. Putting it all together: a model of innovation expenditures growth during the crisis

In this section, we replicate the analysis done by Archibugi et al. (2013). They estimated an equation for the growth rate in innovation expenditures, using a Heckman correction for selection bias. They estimated their equation on UK CIS data, for the periods 2004-2006 and 2006-2008. We perform approximately the same analysis on Belgian CIS data, for the periods 2006-2008 and 2008-2010. Specifically, we estimate the following models on the full data sets, i.e. with innovative and non-innovative enterprises. The method is ordinary least squares (OLS) with Heckman correction for selection bias; i.e. we first model the decision to invest in innovation, and then we model the growth rate of innovation investments.

The estimated equations are the following:

Period 2006-2008

Selection equation: $IA = \gamma 0 + \gamma 1\ SIZE + \gamma 2\ SECTOR + u$

Expenditures equation: $\Delta \log EXP = \beta 0 + \beta 1 \log rtot\_0 + \beta 2\ great\_0 + \beta 3\ new2000 + \beta 4\ gnewt$
$+ \beta 5\ rdin0 + \beta 6 \log emp\_0 + \beta 7 \log turnemp\_0$
$+ \beta 8\ exploration\_1 + \beta 9\ exploitation\_1 + \beta 10\ ambidex\_1$
$+ \beta 11\ marint\_0 + \beta 12\ SECTOR + \beta 13\ SIZE + \varepsilon$
Knowing that $IA = 1$

Period 2008-2010

Selection equation: $IA = \psi 0 + \psi 1\ SIZE + \psi 2\ SECTOR + \psi 3\ HPRIOR3 + w$

Expenditures equation: $\Delta \log EXP = \phi 0 + \phi 1 \log rtot\_0 + \phi 2\ great\_0 + \phi 3\ new2000 + \phi 4\ gnewt$
$+ \phi 5\ rdin0 + \phi 6 \log emp\_0 + \phi 7 \log turnemp\_0$
$+ \phi 8\ exploration\_1 + \phi 9\ exploitation\_1 + \phi 10\ ambidex\_1$
$+ \phi 11\ marint\_0 + \phi 12\ SECTOR + \phi 13\ SIZE + \phi 14\ HFENT3$
$+ \nu$
Knowing that $IA = 1$

Variable definitions and rationale are as follows. IA is a dummy variable indicating that the enterprise had innovation expenditures both at the beginning and at the end of the period. This is the dependent variable of the selection equation. SIZE is a dummy variable to take into account the size classification of the enterprise. There are three classifications: small (10-49 employees), medium (50-249 employees) and large (250 and more employees). SECTOR is a sector dummy created according to the technology intensity of the sector. We consider the standard classification: high-tech manufacturing, medium high-tech manufacturing, medium low-tech manufacturing, low-tech manufacturing, knowledge-intensive services and less knowledge intensive services and other sectors. HPRIOR3 is a dummy for enterprises indicating no need to innovate due to previous innovation as a highly important factor for not innovating. This variable is alas only available for 2010.The first difference Δ log EXP is the growth rate of innovation expenditures (computed as the difference in natural logarithms). Log RTOT_0 is the natural logarithm of initial innovation expenditures. GREAT_0 denotes radical innovators at the beginning of the period. These are enterprises with strictly positive sales from new-to-market products. NEW2000 is a dummy to take into account young firms, i.e. firms that have started their operations after 2000. GNEWT is the log change in turnover compared to previous period for new firms (NEW2000=1). This variable takes a value of zero for firms established before 2000. RDIN0 is a dummy indicating whether the firm had performed intramural R&D at the beginning of the period. Log RTOT_0 is the natural logarithm of initial employment. Log TURNEMP_0 is the natural logarithm of initial apparent productivity, i.e. the log of the ratio of initial turnover over initial employment. EXPLORATION, EXPLOITATION, AMBIDEX are dummies for the strategy of the firm (exploration, exploitation, or ambidexterity), as defined in the previous section. MARINT_0 is a dummy indicating whether or not the firm was operating on international markets at the beginning of the period. HFENT3 is a dummy indicating whether or not the enterprise felt the lack of availability of internal sources of funds as a highly important hampering factor for its innovation activities. This variable is only available for 2010. Estimates on u, w, ε and ν are error terms.

Our estimation results are displayed in Table 6.10. To save on space, we do not report the results on sector and size dummies or for the selection equations.

TABLE 6.10 – **Estimation of a model for innovation expenditures growth**

	2008-2010			2008-2010		
Parameter	**Estimate**	**t-value**	**Approx. Pr → |t|**	**Estimate**	**t-value**	**Approx. Pr → |t|**
Intercept	-0.4657	-0.60	0.5487	-0.5088	-0.73	0.4681
log RTOT_0	-0.5152	-13.17	0.0000	-0.4956	-14.71	0.0000
GREAT_0	0.0566	0.46	0.6478	0.1372	1.35	0.1779
NEW2000	0.1255	0.53	0.5980	0.1519	0.87	0.3833
GNEWT	0.4747	1.06	0.2910	0.3827	1.06	0.2912
RDIN0	0.5120	3.14	0.0017	0.4693	2.92	0.0035
log EMP_0	0.6142	5.88	0.0000	0.4741	5.00	0.0000
HFENT3				-0.2330	-1.85	0.0648
log TURNEMP_0	0.0365	0.48	0.6294	0.1571	2.49	0.0127
EXPLORATION	0.1705	1.04	0.2980	0.2502	1.68	0.0937
EXPLOITATION	0.1503	0.90	0.3685	0.4081	3.20	0.0014
AMBIDEX	-0.0466	-0.21	0.8369	-0.3790	-1.90	0.0580
MARINT_0	0.3299	1.93	0.0536	0.3202	2.11	0.0352
s	1.2215	28.37	0.0000	1.2180	25.24	0.0000
r	0.0755	0.25	0.8023	0.1766	-0.72	0.4724
Discrete Response Profile of selection equation						
	Value	**Total Frequency**		**Value**	**Total Frequency**	
	1	495		1	629	
	0	822		0	954	
Model fit summary						
Number of observations	1317			1583		
Loglikelihood	-1603			-1929		
Maximum absolute gradient	0.00305			0.00406		
Number of iterations	44			61		
Optimization method	Quasi-Newton			Quasi-Newton		
AIC	3265			3921		
Schwarz criterion	3415			4087		

Source: CFS/STAT (2013).
Note: Dependent variable: Δ log innovation expenditures over the period.

The level of initial innovation expenditures has a significantly negative impact in both periods, indicating low persistence in innovation expenditures, at least in crisis and post-crisis time. In contrast, the fact of having been a R&D performer in the previous period (taken as a proxy for having an 'innovation culture') has a positive impact on the growth of innovation expenditures, in both periods. The lack of internal finance has a significant negative impact on the growth of innovation expenditures, which is conform to the intuition that firms need deep pockets to keep on investing in innovation in crisis time (or to re-boost their investments in the post-crisis period). The strategic variables exploration, exploitation, and ambidexterity do not seem to have a significant impact in the crisis period 2006-2008. However they have an impact which is counterintuitive in the period 2008-2010, as an ambidexterity strategy has a negative impact on innovation expenditures growth whereas an exploitation strategy has a positive impact. This remains puzzling to us. Finally, as widely documented, firms that are active on international markets have a higher increase in their innovation expenditures.

6.5. Conclusion

In this chapter, we uncovered what kind of firms are more likely to increase their investments during the recent crisis period. Building on Archibugi et al. (2013), we considered a series of dimensions. First, we examined whether 'radical innovators', firms who had already introduced new-to-market products in the previous period had an impact on innovation expenditures growth. There was no significant impact, but we uncovered that in each and every period the proportion of firms that increased their expenditures was higher among the radical innovators group. Next, we turned to gazelles, i.e. young and fast-growing SMEs. No significant impact on innovation expenditures growth could be uncovered. Third, we took under consideration the strategic objectives of the firms during the crisis: short-term retrenchment and cost cutting activities (exploitation), forward-looking long-run strategy of developing new products for new markets (exploration), or both (ambidexterity). We obtained somewhat puzzling results, as it seems that at least in the period 2008-2010 firms with exploitation strategies had higher innovation expenditures growth. However, in the period 2006-2008, firms with ambidexterity strategies were significantly more likely to have increased their innovation expenditures. That result does not hold for the period 2008-2010. Finally, the fact of having already been an R&D performer during the previous period clearly has a positive impact on innovation expenditures growth in the next period, which denotes the importance of an innovation culture. Persistence in innovation is higher among (internal) R&D performers. We have then estimated a model with all the variables under consideration, and adding financial constraints issues as a hampering factor in the period 2008-2010 (the variable does not exist for the period 2006-2008). Results show a lack of persistence in innovation investments, except among the firms who had already performed internal R&D during the previous period. We obtain the same puzzling results with our strategic variables that were already mentioned above. And, finally, internal financial resource constraints show up as having a significant negative impact on innovation expenditures growth.

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CHAPTER 7

Scientific literature production

LAURENT GHYS

7.1. Introduction

Scientific literature production or bibliometrics can be defined as the quantitative analysis of the bibliographic data describing scientific publications. It is based on the assumption that researchers publish most of their scientific discoveries and research results in scientific journals. Bibliographic data include information on the source of the publications (journal, author, affiliation, and country), the content of the publications (title, abstract, and keywords), the scientific discipline to which the publication belongs (attributed on the basis of the journal) and the cited publications (bibliographic references).

The bibliographic database used for this study is Scopus produced by Elsevier. Scopus is an abstract and citation database of peer-reviewed literature including the publications from more than 20,000 peer-reviewed journals.

In this study we looked at the number of publications in all fields of sciences (including social sciences and arts & humanities) in Belgium and a selection of reference countries as an indicator of the scientific productivity and the capacity to produce knowledge as well as the number of co-publications of Belgium with other countries as an indicator of international collaborations. When two or more countries appear in a publication, each country is credited for this publication (full counting method). All the indicators were calculated for the years 2003, 2007 and 2011. The data presented for a year are an average on a three-year period, the year presented being the last one of the interval (e.g. 2003 is the average of 2001-2003).

The interpretation of the data must be done carefully, as the results may vary with the chosen methodology. In general, the database covers the scientific disciplines with a strong international profile like 'Physical Sciences' and 'Biological Sciences' very well, but to a much lesser extent disciplines with a more pronounced national focus like the 'Arts and Humanities' or 'Social Sciences'. The different culture of publications between disciplines has also to be taken into consideration. In computer sciences or in engineering sciences, for example, researchers communicate their results also via conference proceedings or by taking patents. In the arts and humanities or social sciences researchers are keener to publish books and monographs.

7.2. Evolution of the number of publications

In 2003, 13534 publications were authored by at least one Belgian affiliated author. This number has nearly doubled in 2011 to attain nearly 25000 publications authored by Belgian affiliated researchers.

In 2011, 1.1% of the total amount of publications included in the Scopus database has at least one author with a Belgian affiliation. The Belgian share of world publications stayed stable between 2003 and 2007 and increased by 10% increase between 2007 and 2011. From 2003 to 2011, the highest growth in the world share is demonstrated by Ireland, followed by Belgium, Austria, the Netherlands and Denmark. Sweden, Germany, France and the UK registered a significant decrease of their world share of publication between 2003 and 2011. The share of the EU-28 countries in the world total number of publications increased slightly from 2003 to 2007 and stayed stable in 2011.

TABLE 7.1 – **Number of publications and shares in world and EU-28 (in %)**

	Number of publications			World share			EU-28 share		
	2003	2007	2011	2003	2007	2011	2003	2007	2011
Belgium	13534	19623	24698	1.0	1.0	1.1	3.3	3.4	3.6
France	61642	82687	98493	4.4	4.4	4.3	15.0	14.5	14.2
Germany	86757	116351	134995	6.3	6.2	5.9	21.0	20.4	19.5
Netherlands	24765	35804	44716	1.8	1.9	1.9	6.0	6.3	6.5
United Kingdom	91629	125570	145567	6.6	6.7	6.3	22.2	22.1	21.0
Austria	9881	14135	17908	0.7	0.7	0.8	2.4	2.5	2.6
Denmark	9515	12990	17000	0.7	0.7	0.7	2.3	2.3	2.5
Finland	9160	12591	14719	0.7	0.7	0.6	2.2	2.2	2.1
Ireland	3841	7185	10483	0.3	0.4	0.5	0.9	1.3	1.5
Sweden	18372	24002	27810	1.3	1.3	1.2	4.5	4.2	4.0
EU-28	412311	569034	691965	29.7	30.2	30.1	100.0	100.0	100.0
World	1387014	1886213	2296184	100.0	100.0	100.0			

Source: Scopus, Elsevier (2013).

The total amount of publications of the three largest countries taken together account for nearly 60% of EU-28 total production. As a general tendency, large countries show a slight decrease of their publication share in the EU-28 total. France, Germany and the United Kingdom lost respectively 5%, 7% and 5% of their share between 2003 and 2011. Smaller countries like Belgium (+8.7%), the Netherlands (+7.6%), Austria (+8.0%) and Denmark (+6.5%) increased their share of the total EU-28 publications significantly during the same period. The most dramatic growth is shown by Ireland that increased its share by nearly 63%.

7.3. Publication density: correcting for country size

Comparing the absolute number of publications between countries of different sizes makes little or no sense. To attenuate the size effect in country comparison, a possibility would be to relate the number of publications to a variable reflecting the size of a country. Table 7.2 displays the number of publications per country divided by the number of inhabitants, the number of full-time equivalent researchers, the number of full-time equivalent researchers in the higher education sector or by other inputs in R&D like the gross domestic expenditure in R&D (GERD), the higher education expenditures in R&D (HERD) or the government budget appropriations or outlays for R&D (GBAORD).

TABLE 7.2 – **Number of publications corrected per country size**

	# pub/10000 inhabitants			# pub/total researchers (FTE)			# pub/higher education researchers (FTE)		
	2003	2007	2011	2003	2007	2011	2003	2007	2011
Belgium	13.10	18.60	22.63	0.43	0.56	0.63	1.11	1.34	1.37
France	10.00	13.04	15.19	0.33	0.39	0.42	0.97	1.23	1.42
Germany	10.52	14.13	16.50	0.33	0.41	0.42	1.25	1.70	1.54
Netherlands	15.34	21.90	26.92	0.56	0.71	0.89	1.52	1.99	2.25
United Kingdom	15.44	20.72	23.37	0.46	0.50	0.56		0.86	0.91
Austria	12.23	17.10	21.34	0.41	0.47	0.50	1.42	1.50	1.53
Denmark	17.70	23.88	30.65	0.41	0.45	0.46	1.35	1.46	1.33
Finland	17.61	23.90	27.44	0.23	0.32	0.36	0.75	1.00	1.17
Ireland	9.77	16.87	23.28	0.41	0.59	0.72	1.32	1.54	1.82
Sweden	20.58	26.42	29.66	0.39	0.46	0.57	1.11	1.61	1.66
EU-28	8.42	11.43	13.69	0.39	0.46	0.50	0.89	1.00	1.06
	# pub/GERD (million current PPP $)			**# pub/HERD (million current PPP $)**			**# pub/GBAORD (million current PPP $)**		
	2003	**2007**	**2011**	**2003**	**2007**	**2011**	**2003**	**2007**	**2011**
Belgium	2.26	2.94	2.97	10.75	13.62	12.68	7.41	9.10	9.08
France	1.67	1.98	1.95	8.76	10.33	9.21	3.69	4.96	5.05
Germany	1.53	1.67	1.55	9.10	10.31	8.64	4.85	5.51	4.80
Netherlands	2.55	3.10	3.56	7.59	9.01	8.85	5.98	7.30	7.73
United Kingdom	3.03	3.43	3.69	12.82	13.20	13.52	7.47	9.07	10.38
Austria	1.89	1.92	1.92	6.99	7.93	7.35	6.16	7.25	6.74
Denmark	2.35	2.67	2.47	10.78	10.40	8.53	7.95	9.00	7.74
Finland	1.92	2.06	1.95	10.18	10.98	9.86	6.61	7.15	6.72
Ireland	2.66	3.17	3.34	11.50	11.70	12.66	8.23	8.69	10.65
Sweden	1.77	2.09	2.19	8.57	9.71	8.46	8.09	8.96	8.65
EU-28	2.02	2.26	2.24	9.00	10.02	9.27	4.83	5.92	6.01

Sources: number of publications: Scopus, Elsevier (2013); number of inhabitants: Eurostat; other data: OECD (2013).
Note: The symbol # stands for 'number' of publication; FTE is full time equivalents;
PPP is purchasing power parity. UK data for 2003 is missing.

Belgium and the reference countries have a higher scientific density per inhabitant than the EU-28 average. Belgium is with the Netherlands, Austria, Denmark, Finland, Ireland, Sweden and the UK part of a group of countries producing a high number of publications per inhabitant, far above the EU-28 average. The scientific density per inhabitant of Sweden, the Netherlands and Finland is even 2 times higher than the EU-28 average. France and Germany are countries with a much lower scientific activity per inhabitant, slightly superior to the EU-28 average.

The number of publication per inhabitant increased for all the reference countries between 2003 and 2011 but at different degrees. The scientific density per inhabitant of the EU-28 grew by nearly 60% from 2003 to 2011. Belgium, the Netherlands, Austria and Denmark saw their scientific density increase by approximately 70% while countries like France (+52%), Germany (+57%), Finland (56%), Sweden (44%) and the UK displayed a slower increase than the EU-27 average. The scientific density per inhabitant for Ireland increased by 138%; or nearly twice the growth for countries like Belgium or the Netherlands.

Table 7.2 shows that in 2011 Belgium and the reference countries publish between 0.40 and 0.90 publication per full-time equivalent researcher. With 0.89 publication per researcher, the Netherlands is far above the EU-28 average (0.5 publication/researcher) and the second and third of our reference countries, Ireland and Belgium which produce respectively 0.72 and 0.63 publications per researcher. Three other countries, Sweden, the UK and Austria are still above or equal to the EU-28 average. France, Germany and the other Scandinavian countries produce fewer publications per total researchers than the EU-28 average.

If we look at the number of publications per full-time equivalent higher education researcher in 2011, the Netherlands is again by far leading our list of reference countries, followed by Ireland, Sweden, Germany, Austria, France, Belgium, Denmark and Finland, all above the EU-28 average of 1.06 publication per higher education researchers. The UK is the only reference country under the EU-28 average for this indicator.

A fourth possibility is to relate the number of publications produced to the gross domestic expenditures on R&D (GERD) of a country. The UK, the Netherlands, Ireland, Belgium and Denmark are the first five countries for this indicator, displaying values above the EU-28 average (2.24 publications per million of \$). All the other reference countries display values under the EU-28 average.

Belgium, the UK and Ireland are the only three countries from our comparison publishing more than 10 publications per 10 million of \$ of expenditures on higher education (HERD). Finland and France also display values slightly higher than the EU-28 average of 9.27 publications per million of HERD.

7.4. Belgian share of publication in the EU-27 total by scientific disciplines

The table below shows the evolution of the Belgian share of total EU publication for a series of scientific disciplines. The scientific disciplines are defined on the basis of categories assigned to each scientific journals indexed by SCOPUS.

TABLE 7.3 – **Belgian share of EU-27 publications by scientific disciplines**

Scientific discipline	2003	2007	2011	2011/2003
Agricultural and biological sciences	3.67	4.18	4.35	18.50
Arts and humanities	3.63	3.50	3.99	9.87
Biochemistry, genetics and molecular biology	3.47	3.62	4.15	19.60
Business, management and accounting	2.55	2.76	3.21	25.90
Chemical engineering	2.64	2.97	3.12	18.20
Chemistry	3.18	3.47	3.58	12.60
Computer science	3.57	3.44	3.18	-11.00
Decision sciences *	4.30	4.18	4.07	-5.30
Dentistry *	3.46	3.32	2.80	-19.00
Earth and planetary sciences	2.70	3.11	3.44	27.50
Economics, econometrics and finance	4.24	4.19	3.98	-6.10
Energy	2.85	3.13	3.62	26.90
Engineering	3.38	3.38	3.44	1.81
Environmental science	3.50	3.78	3.68	5.27
Health professions	4.87	5.03	3.89	-20.00
Immunology and microbiology	4.00	4.68	5.14	28.60
Materials science	3.12	3.47	3.65	17.00
Mathematics	3.28	3.47	3.32	1.21
Medicine	3.40	3.61	3.88	14.20
Neuroscience	2.92	3.29	3.90	33.60
Nursing *	2.35	2.32	2.76	17.20
Pharmacology, toxicology and pharmaceutics	3.57	3.97	4.82	34.90
Physics and astronomy	3.46	3.75	3.86	11.70
Psychology	3.68	4.25	4.56	23.90
Social Sciences	2.74	3.11	3.60	31.30
Veterinary	5.77	6.03	6.43	11.40

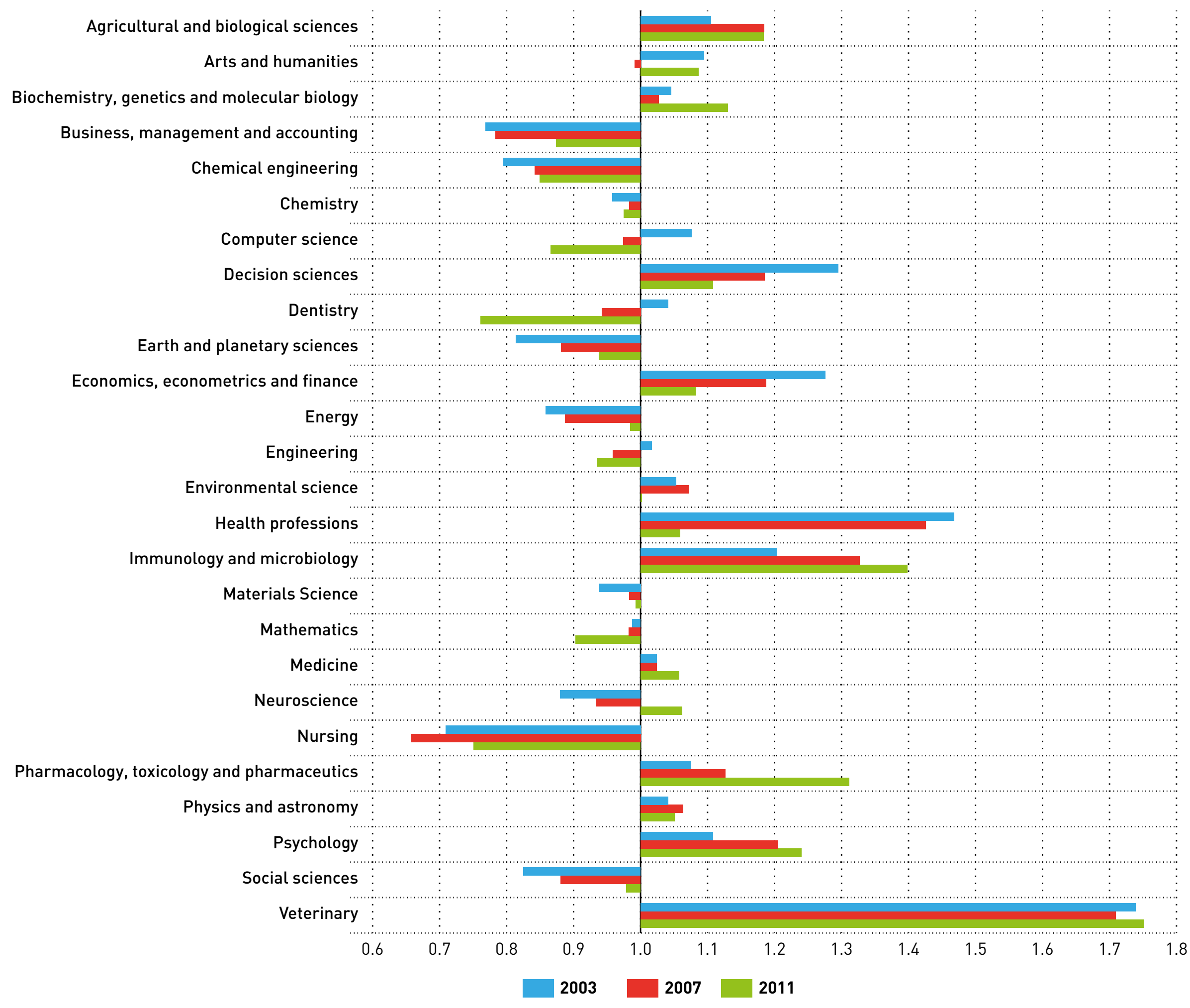
Source: Scopus, Elsevier (2013).
*Note: The symbol * denotes very low number of publications (<100).*

The share of Belgium in the EU-27 publications grew strongly (more than twice than the Belgium average of ~9 %) in 'Agricultural and biological sciences', 'Business, management and accounting', 'Biochemistry, genetics and molecular biology', 'Earth and planetary sciences', 'Energy', 'Immunology and microbiology', 'Neuroscience', 'Pharmacology, toxicology and pharmaceutics', 'Psychology' and 'Social sciences'. The Belgian share in the EU-27 publication decreased strongly for 'Computer sciences', 'Dentistry', 'Health professions'.

7.5. Publication profile

By comparing the share of publication in a scientific discipline for Belgium in the total number of Belgian publications with the share of publication for the same scientific discipline in the total number of EU-27 publications, it is possible to determine the publication profile or the degree of activity of Belgium in a scientific discipline relative to EU-27 average. If the value calculated is significantly superior to 1, Belgium is more active in that discipline than the EU-27 average, if the value is significantly lower than 1, Belgium is less active in that discipline than the EU-27 average.

FIGURE 7.1 – **Publication profile of Belgium compared to EU-27 average**



Source: Scopus, Elsevier (2013).
Note: The value of 1.0 equals the EU-27 average.

From Figure 7.1, we see that in 2011 Belgium is much more active than the EU-27 average in 'Veterinary sciences', 'Psychology', 'Pharmacology and toxicology' and 'Immunology and microbiology'. The Belgian share in the EU-27 publications in these four disciplines (see Table 7.3) also increases significantly more than the Belgian average between 2003 and 2011, with the exception of 'Veterinary science' where the increase is similar to the Belgium average.

7.6. International collaborations measured by co-publications

In 2011, one out of two Belgian publications is a co-publication with at least one foreign affiliated author. With Denmark this is the highest percentage of the reference countries. This indicator does not take into account the size effect, so comparison makes sense only between countries of similar size. We can see that, for all countries, the international collaborations increased by more or less 20% between 2003 and 2011.

Table 7.4 – **Percentage of international publications in total publications of the country**

	2003	2007	2011	2011/2003 (%)
Belgium	42.25	46.88	50.66	19.90
France	33.43	37.39	40.98	22.58
Germany	32.24	35.99	39.18	21.53
Netherlands	37.57	41.92	45.58	21.31
United Kingdom	30.12	34.25	38.01	26.20
Austria	39.36	43.84	48.39	22.94
Denmark	41.68	45.35	49.22	18.08
Finland	35.37	39.26	42.50	20.15
Ireland	38.61	42.86	46.09	19.35
Sweden	39.40	43.19	46.43	17.85

Source: Scopus, Elsevier (2013).
Note: The data on international publications with at least one non-national affiliation.

Belgium publishes mainly with EU member states or associated countries with two exceptions in the top ten, the US and Canada. There is a strong increase of the share of co-publication with Spain between 2003 and 2011 and to a smaller extent with Italy and Switzerland.

TABLE 7.5 – **Number of Belgian co-publications with the ten countries publishing the most with Belgium**

	2003	2007	2011	2011/2003 (%)
United States	9.95	11.74	13.04	31.15
France	9.49	11.65	12.87	35.59
United Kingdom	7.09	9.17	10.32	45.51
Germany	7.06	8.55	10.31	46.09
Netherlands	6.63	8.82	10.48	58.15
Italy	4.04	5.48	6.96	72.32
Spain	2.82	4.17	5.59	98.39
Switzerland	2.59	3.55	4.34	67.43
Canada	2.08	2.95	3.40	63.52
Sweden	2.02	2.42	2.87	42.10

Source: Scopus, Elsevier (2013).
Note: Data are expressed in percentage of the total number of Belgian publications.

7.7. Conclusion

The Belgian share of world and EU-28 publication grew by approximately 10% between 2003 and 2011, second only in the reference countries to Ireland which displays an impressive growth of the share of world and EU-28 publications of around 60%. The growth in the EU-28 share of publications comes mostly from disciplines in the Biomedical Sciences, a domain where Belgium is also more specialised than the EU-27 average. From the analysis of the co-publication habits, it is noted that from amongst the reference countries Belgium is the most international in its publication, one out of two publications being co-authored by a foreign affiliated author. The foreign author is mostly affiliated to the US, Canada or another EU member or associated country.

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CHAPTER 8

Labour market characteristics of doctorate holders

KARL BOOSTEN

8.1. Introduction

Scientific research is not only driven by investments and technological innovations but also by researchers. For this reason there is a growing interest in the development of indicators to measure the human potential in scientific research. An important category of researchers are those who are specifically trained to conduct scientific research. This scientific training is usually formalised by the awarding of a doctoral degree. Because doctorate holders are no longer exclusively predestined to an academic career, it is interesting to examine the career perspectives of this group of scientifically trained personnel. It is obvious that all university-level educational programmes have the objective to teach critical and scientific reasoning and that in research environments not only people with a doctoral degree are involved in research activities; however for this article we narrow our focus to those people that have obtained a doctoral degree.

In our search for a single factor that reflects the career paths of PhD graduates we have chosen to make use of the variable salary. Although this may seem to be a reductive approach, this variable nevertheless allows us to capture underlying career developments. Throughout their careers people make all kind of decisions that could have a potential influence on the wages they earn. Not seldom do job advertisements mention the number of years of working experience required to fill in a vacancy. The higher the responsibility ascribed to a position or, in other words, the higher the job is positioned in the hierarchy within an organisation the higher the financial reward.

We elaborate this topic in seven sections by starting in section two with an overview of the theoretical background. We give a short introduction to the concepts we use to describe our subject and the different approaches to job mobility and salary we have found in existent literature. In the next section we give a presentation of the content and quality of the data set from which we drew our analyses. Section four introduces the reader to the labour market for doctorate holders. The question we try to answer here is the following, 'what are the career opportunities for doctorate holders after they received their doctoral degree?'. In section five we set out the variables which are linked with salary and which may help us to explain why wages differ across a seemingly homogeneous group. In the final sections six and seven we free up some space for the shortcomings of the data set and we try to give a series of recommendations for policy makers.

8.2. Theoretical background and concepts

Several studies have shown a positive correlation between the presence of a large share of workers that completed tertiary education and the inflow of foreign direct investments (European Commission, 2011; Nicoletti et al., 2003). A reasonable explanation for this relation is that when foreign companies develop strategic partnerships with local companies, knowledge sharing is a necessary step in the development of products for the local markets. This entails spill-over effects from the foreign-owned company to its local partner. In order to translate the knowledge stock from the foreign firm, a highly qualified workforce is needed to integrate the new product and process knowledge into the existing production schemes of the local enterprise. To put these words in a more conceptual framework one can state that the absorptive capacity of the local firm have to be sufficiently extensive to guarantee a flawless conversion of the new technological concepts of the foreign firm into the on-going business activities of the local firm. The exchange of new knowledge is conditional on the grounds that the recipient firm possesses a knowledge base that is capable of absorbing the new technological concepts. According to the insights generated by the literature on absorptive capacity (Cohen and Levinthal, 1990) the developmental gap between the host country and the country of the foreign company must stay within certain boundaries, otherwise a fruitful exchange of ideas will fail to occur.

In our research approach we try to reconcile two topics in the general theory on labour economics: on the one hand the theory on human capital and on the other hand the theory on labour mobility. Both visions share many similarities and the line that sets both research domains apart is not easy to draw. In our approach we try to establish a bridge between both fields by means of studying a particular group of workers in the labour market, namely knowledge workers. Knowledge workers are considered to become a very important segment of the labour market. As we have already explained in the first paragraph, an innovative economy cannot survive without the presence of a sufficiently large stock of knowledge workers. Through a short introduction of the theoretical view points on human capital and labour mobility we will delineate the boundaries that will permits us to examine the relationship between both domains by making use of the job movements of knowledge workers.

Throughout their careers workers refine their knowledge and skills from the working experience they acquire while performing their jobs. Put in a linear perspective this stock of knowledge and skills accumulates through time. This intellectual luggage is highly appreciated by employers, especially with regard to knowledge workers. Through the different job positions a person occupies over time said person develops his own portfolio of assets that will help him in his career development. All the imaginable assets encompassed in this portfolio may be described by the abstract term of 'human capital' (see the seminal work on human capital theory as exemplified by Becker, 1975). This rather abstract concept was given an empirical foundation by Mincer's human capital earnings function. In its most simplified version this function examines the interactions between years of schooling, years of experience and the earnings of an individual worker (Mincer, 1974).

Labour mobility and, more particularly, job movements are one of the main constituencies of labour markets to reach an optimal match between the employee who applies for a job and the employer who wants to fill in a vacant position with the best candidate. Workers change jobs for all kinds of reasons. On the one hand, the absence of job satisfaction with the present job or a desire to explore new career opportunities can be positive stimuli to apply for another job. On the other hand, not all job movements are voluntary; due to corporate restructuring and business bankruptcies workers are forced to search for new jobs. Unfavourable economic prospects and information asymmetries can explain why labour markets do not always have enough dynamism to obtain a perfect match between the number of persons looking for a job and the number of jobs available. Mismatches between supply and demand are considered to be an inherent characteristic of labour markets. In our attempt to approach this subject, we focus our attention on the influence of job mobility on salary. In other words we try to examine if workers who frequently change jobs are better paid than those who are less inclined to change jobs (information asymmetries, Stigler, 1962; job satisfaction, Hamermesh, 1977 and Clark and Oswald, 1996; job search theory, Fearn, 1981 and Jones, 1989, Kiefer and Neumann, 1989).

A majority of journal articles tackles the topic of mobility of researchers at firm level (Eriksson, 2011; Boschma et al., 2009; Walker and Madsen, 2007). These articles investigate the influence of personnel mobility on the organizational structure of companies. The inflow of workers who have skills that are closely related to the knowledge base of the company has a positive effect on the performance of the company, while the inflow of knowledge that is already present in the company has almost no impact on the company's performance (Erikson, 2011). Two directions of job-hopping define mobility: inbound and outbound mobility. Inbound mobility is the recruitment of (new) employees from other employers or sectors of employment. Outbound mobility covers the movement of employees who decide to work for another employer (in another sector of employment). Both types of mobility have consequences for the knowledge stock of companies, and consequently affect the productivity and organisational structure of companies. Inbound mobility is found to be effective in enabling older inert firms to create innovations and less effective in doing the same for younger and less inert firms (Jain, 2010).

Besides the micro-level which focuses on the internal organisation and performance of a company, the industry level has drawn an equally important share of interest. The stream of personnel between companies contributes to the creation and extension of industry networks. Company reasons to engage in strategic partnerships can be versatile. Common commercial interests or complementary technological knowledge are just a few explanations for interactions between companies. When a certain amount of critical mass has piled up in a region, other companies will follow. Regional clusters become attractive pools for other companies and investors because of the proximity of the available knowledge. This can be a stimulus for lowering opportunity costs. Common research facilities (e.g. research incubators) and the presence of a work force with highly specialized technological skills will provide the necessary conditions for attracting other companies or can create a microclimate favourable for start-ups.

The success of new companies entering the market is determined by their ability to attract workers from incumbent companies. The position of the incumbent in the total network of companies has a pivotal impact on the success of the incoming company. Most especially, workers who come from companies located at the periphery of the network bring along new insights that can help the incoming company to achieve a stable and longstanding position in the network (Walker and Madsen, 2007). Empirical studies highlight the impact of knowledge flows through job mobility to research cluster formation (Saxenian, 1994) and localisation (Jaffe et al., 1993; Almeida and Kogut, 1999). Industry clusters can be a mixture of regional, national and multinational companies. Through the presence of multinational enterprises new knowledge can become locally embedded thanks to spill-over effects. Keeping this in mind, mobility is often studied as a path of knowledge transfer along four dimensions: from multinational companies (MNCs) to MNCs, from domestic organisations to domestic organisations, from MNCs to domestic organisations and the other way round (Angeli et al., 2013). Angeli et al. (2013) state in their article three main findings that are characteristic for the mobility of personnel between multinational and local enterprises situated in the same cluster. First, most of the mobility happens at the local level; the outflow and inflow of valuable employees occurs more often between local firms than between domestic firms and MNCs. Second, if personnel exchanges take place between MNC and local firms, the flow occurs predominantly from the MNC to the local firm. This might be an illustration of the theoretical principle that new knowledge is introduced by high-level international players and that from these centres of gravity the new knowledge permeates the offshoots of the network. Third, inflows of personnel mainly occur from rivals, while outflows distribute equally between rivals and non-rivals.

Mobility is not only a matter of inter-firm flows between locally embedded firms. In recent decades research has become an internationally intertwined system which connects research groups from round the globe. This picture helps us to explain why an increasing number of researchers stay at regular intervals in foreign countries for research-related matters. Several studies have examined the push and pull factors that underlie the mobility motives of researchers. The international mobility decisions and their determinants of a sample of foreign doctorate holders who came to the US to obtain a doctorate in economics indicated that around 50% settle permanently in the US after their PhD; of the other half one third returns to the home country and two thirds take up a job in a third country (Van Bouwel, 2010). These findings reflect the fear of a loss of talented workers from less developed countries to the technologically leading countries. That such a reality is not necessarily a unidirectional path is demonstrated by other researchers, who lay more emphasis on the bilateral benefits for both countries involved in the exchange. Edler et al. (2010) for example investigate how the mobility patterns of university scientists influence the locus of knowledge and technology transfer activities (KTT) to firms. Their results prove that the longer a visit remains abroad, the higher the likelihood that scientists engage in KKT to firms both in the host and the home countries.

Our approach tries to open a new angle from which worker mobility may be examined. In contrast to the models (company performance, industry networks and brain drain – gain dilemma) we have found in existent literature, we focus on job movements of doctorate holders between different sectors as a potential substitute for the study of the career paths of doctorate holders. The earlier described models consider mobility as a macro-phenomenon between aggregated entities like companies and clusters, or even countries in the case of the brain drain – gain dilemma. The strength of our article lies in the fact that we consider career paths as a measure for the implications of job mobility on the careers of individuals. That being said, we note that our analyses were not based on longitudinal data but rather on cross-sectional data.

Before concluding this rather theoretical exposé on the topic of job mobility, we reserve some space for a justification of the division we made between the labour markets in different sectors. Our distinction of the economic sectors is based on the classification system and definitions proposed in the Frascati Manual (OECD, 2002). The Frascati Manual identifies 4 broad sectors: the business sector, government, higher education and the private non-profit sector. Because of the limited number of doctorate holders working in the private non-profit sector and as a consequence of the limited number of job moves between this sector and the other sectors, data for this sector were not sufficiently reliable to put them in our model. The flow of researchers between higher education and the business sector is a field that has attracted a lot of attention (Almeida et al., 2003; Bozeman et al, 2001; Cassia and Colombelli, 2008, Correia and Petiz, 2007; Lundvall, 1992; Pavitt, 1991; Moen, 2005; Salter and Martin, 2001). This strand of literature emphasizes that the access to new knowledge developed within the higher education system is the main stimulus for firms to invest in this type of partnerships. The exchange of researchers between both sectors has a positive effect on the innovation efforts undertaken by the firm and on the production of new products (Ahuja et al., 2008; Cohen et al., 2002; Yli-Renko et al., 2001). Although most research articles recognize the positive effects of this cooperation, it is not a common given that this positive relation will be accepted as being self-evident. Several authors have identified a series of factors which may hamper a smooth integration of academic knowledge into the rather commercial oriented knowledge stock of private firms. The absorptive capacity of the firm may be not sufficient to translate abstract academic knowledge into practical concepts, there may be a resistance of researchers to accept knowledge that was not developed within the firm and the communication between researchers can be distorted because knowledge has a non-negligible tacit part that is difficult to share with others.

8.3. Data and methodology

The research on the doctorate holders focuses on Belgium and draws on a data set constructed in 2010. As the regional communities are responsible for education the data set is constructed from two data sources. Both administrative databases register every person who has obtained a doctoral degree at a Dutch-speaking or a French-speaking university in Belgium respectively, starting from 1990 onwards. Each linguistic community has its proper database. First, a database collected by the Flemish Centre for R&D Monitoring for all Dutch-speaking doctorate holders. Second, a database constructed by the CRef (Conseil des Recteurs francophones) for the French-speaking doctorate holders. In order to approach the respondents and to obtain their most recent addresses, use is made of the resources from the National Register. This National Register is a federal public service authorized to collect and store data with respect to the identity of citizens in Belgium. As a trusted third party, they contacted all potential respondents who, in turn, were able to take part fully anonymously in the online survey.

The survey is composed of five modules that measure aspects with regard to the careers and mobility of doctorate holders. The module on education addresses the experiences of doctorate holders during the preparation of their doctoral dissertation. The module on employment draws a picture of the way doctorate holders develop their careers. The module on mobility assesses to what extent people with a doctoral degree are mobile on the international labour market. The module on career related experience examines whether or not doctorate holders continue to work as researchers after their doctoral attainment, and what the potential reasons could be for a career change. Finally, the module on career related skills explores the knowledge and skills doctoral researchers claim to have acquired and to what extent these are needed for their current professional activities.

Our research on doctorate holders uses the data obtained from a broader project that was originally initiated by the OECD. In 2003, the initiative to conduct research on the careers and mobility patterns of PhDs or doctorate holders was taken during a series of workshops and conferences hosted by the OECD. The main goal was to improve the quality of existing data sets with regard to human resources in science and technology. This effort led to a data collection exercise in 2006 under the aegis of three international institutions, notably Eurostat, OECD and UNESCO. Fifteen countries participated in this initial round. Due to both the interest the subject aroused, and weaknesses and faults related to the first data collection round, the three initiators decided to organize a new data round while attempting to enlarge the group of participating countries.

The Belgian Science Policy Office participated in the project on two occasion, in 2006 and 2010. Although several questions remained the same in both questionnaires, the results have to be interpreted carefully because there were several differences in the sampling methods being used. The first difference affects the composition of the sample. In 2006, all doctorate holders were identified on the basis of the 2001 census data which allowed for addressing the entire group of doctorate holders in which all age groups were represented.

For the 2010 survey we adopted a different approach, using administrative databases from the universities. These databases comprise all individuals who obtained a doctoral degree at a Belgian university, but because these databases were created at the beginning of the 1990s, our age spectrum was more confined. A second difference is related to the fact that in 2006 the sample also contained people who had obtained a doctoral degree at a foreign university. The 2010 databases only registered people who graduated with a doctoral degree from a university located in Belgium. A third difference concerns the fact that the 2006 sample contained people who considered themselves a doctor but who did not classify under the strict definition of a doctorate, for example 'doctors in law' or 'doctors in medicine'. The strict definition of a doctor implies an intensive training in the application of scientific methods to carry out research in a specific scientific discipline. This type of erroneous sampling was avoided in 2010 by making use of administrative databases.

A limitation of the 2010 data set is that we are not able to establish a detailed overview of the representativeness of our data set. Only the questionnaires that were filled in were taken into consideration for our research. It was not possible to make a comparison between the representativeness of the respondent sample and the general population of doctorate holders. Therefore the subjects in the respondent sample might have different career paths than those included in the population. 16912 doctorate holders were invited to participate in the survey. 28% replied positively to this request by filling in the questionnaire with valuable answers.

8.4. Doctorate holders on the labour market

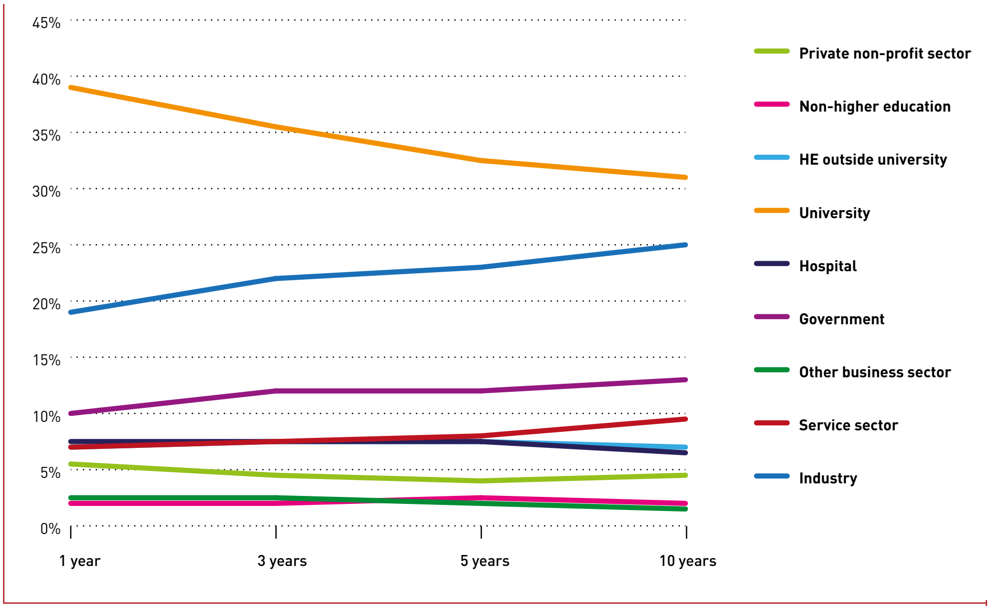
Each year the number of doctoral degrees awarded in Belgium increases and this phenomenon applies to all scientific disciplines. Considering the fact that this increase is not matched with a rising number of vacant academic positions at the professorial level, one might wonder in which employment sectors doctorate holders will find a job. Rather than looking at the 'surplus' of doctorate holders as a 'spill-over effect' on the non-academic labour market, the extra investments in doctoral education were intended as a deliberate attempt to revitalise the economy with more highly-educated staff, innovation-ready and equipped with wide-ranging knowledge.

A similar line of reasoning can be found throughout existing literature. The introduction and assimilation of new technologies are no longer a privilege of the manufacturing sector, as technological advances have found their way into other sectors of the economic landscape. This evolution entails an increased demand for scientists and engineers outside the conventional boundaries of science and engineering occupations (Foray and Lundvall, 1996). In particular the services sector has appropriated an important share of scientists and engineers (Cervantes, 2001; Lavoie and Finnie, 1998; Lavoie et al., 2003).

Because of the increase of the number of people with a doctoral degree several studies express scepticism as to the career opportunities for science and engineering PhDs in higher education, and public research institutes (Dany and Mangematin, 2004; Enders, 2002, 2005; Fox and Stephan, 2001; Giret and Recotillet, 2004; Mangematin, 2000; Martinelli, 1999; Robin and Cahuzac, 2003, Stephan et al., 2004). Lee et al. (2010) summarize their study of the career patterns of the science and engineering graduates of the University of Manchester (1998-2001) with the general conclusion that academic/public research positions have become a secondary career type for science and engineering PhDs in a long run. Most of the PhDs who enter the private sector do not become industrial scientists in manufacturing. Even if they were industrial scientists initially, they transferred to dedicated managers gradually.

According to calculations made by the ECOOM centre of the University of Ghent based on the data of the latest CDH survey (2010) (van Rossem and Derycke, 2013) 68.6% of the 4445 respondents have been employed at least once in another sector outside the university since the time of their graduation, while 31.4% reported they were still employed at the university. More particularly, the number of doctorate holders that is employed at the university declines from almost 40% in the first year after graduation to approximately 30% ten years after the time of graduation. This decrease in employment in the academic sector is substituted by an increase of doctorate holders employed in other economic sectors. Industry, especially, succeeds in attracting a large pole of the outflow of doctorate holders from the university. In a period of ten years 6% (19.2% one year after graduation - 25.0% ten years after graduation) more doctorate holders have made a career turn from academics to industry. The third most important employer of doctorate graduates is government. Government employs on average 10% of all doctorate holders and this percentages is not influenced by important fluctuations. Ten years after the award of the doctoral degree the number of doctorate holders in a governmental job increases at 2%. Other employment sectors, such as hospitals, institutes of higher education outside the university and the private non-profit sector provide fewer career opportunities for professionals with a doctoral degree. These results should be considered as a cross section of the general population of doctorate holders which consists of a diverse mixture of age categories and different graduation time. Consequently is it not opportune to interpret these analyses as representative of individual careers.

FIGURE 8.1 – **Sector of employment of PhD graduates**



Source: Belgian Science Policy Office, CDH Database 2010.
Notes: The frequencies after graduation are: after 1 year N=2690; after 3 years N=2679; after 5 years N=2300; and after 10 years N=1332.

Further analysis of the figures of the last CDH survey by van Rossem and Derycke (2013) shows certain correlations between the field in which the doctoral graduate has been specialized and the likelihood of becoming employed in a particular sector. The knowledge and skills acquired during the preparation of a doctorate differ according to the scientific discipline. Doctorates in engineering and natural sciences possess certain qualifications that are highly regarded in the manufacturing industry. For their analyses the moment of time of employment was set to three years after graduation, allowing for the employment of recently graduated doctorate holders to be measured. Furthermore most doctorate holders settle into a stable job position three years after graduation.

The results show significant differences in sector of employment for the various disciplines (χ^2=886.5, df=40, p<0.001).

TABLE 8.1 – **Sector of employment 3 years after graduation according to scientific discipline of the doctoral degree**

Field of science	University	Industry	Government	Service sector	University colleges	Private non-profit	Hospital	Other business sector	Non-higher education	Total employ-ment
Natural sciences	32.9	27.4	11.6	9.4	6.1	4.1	2.1	3.4	3.0	923
Engineering and technology	26.7	37.6	7.4	8.9	7.8	7.2	0.9	2.8	0.7	460
Medical sciences	36.3	14.1	5.3	3.7	3.5	2.6	32.5	1.5	0.4	455
Agricultural sciences	31.6	27.7	18.8	10.2	5.5	3.1	1.6	1.2	0.4	256
Social sciences	51.5	3.4	14.4	7.2	11.7	6.2	3.1	1.4	1.0	291
Humanities	49.8	0.5	18.1	4.1	15.8	4.5	0.5	1.4	5.4	221
Total employment	933	572	295	201	191	119	185	61	49	2606

Source: Belgian Science Policy Office, CDH Database 2010.

Graduates in the social sciences and the humanities stay longer at the university than their counterparts in other scientific disciplines (51.5 and 49.8% respectively). The group that leaves the university ends up in a government job (14.4% and 18.1%) or a position in the higher education sector outside the universities (11.7% and 15.8%). Medical and health scientists with a doctorate can most often be found in positions at the university or in hospitals, and to a lesser degree in industry. The other three groups (engineering, agricultural sciences and natural sciences) differ in respect to the others by a lower number of jobs at the university and a higher number of positions in industry. This finding could be an indication of the fact that skills and knowledge differ according to disciplines and that employers have certain preferences with regard to these qualifications.

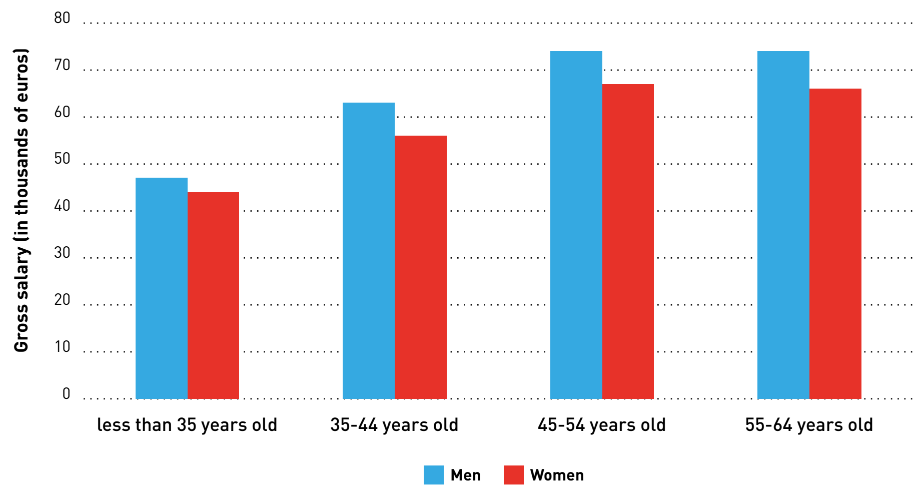
8.5. Empirical analysis

As an indicator for the careers of doctorate holders we have chosen to make use of the variable salary. Although salary is not directly related to the content of the job, it nonetheless permits us to quantify the labour mobility of doctorate holders. A wage increase can, after all, be considered as a compensation for proven achievements or as a rise in the hierarchy of the organisation in which one is employed. In this paper it is our intention to examine the impact of a series of variables on the wages of doctorate holders to sketch a picture of their career paths.

Age and gender

The relationship between seniority, experience and wages has been a topic which has caused a lot of debate in the labour economics literature. Seniority or tenure is defined as the duration of the period an employee works for one employer. Experience is defined as the total time a worker has been active on the labour market. Some authors (Topel, 1991) have found a strong relationship between seniority and wages: 10 years of seniority raises wages by 25%. Other researchers (Altonji and Williams, 2005) obtained results which indicated a less pronounced effect of seniority on salary: seniority raises wages by about 10% over a period of 10 years. But according to these authors labour market experience appears to have a stronger influence on the wage distribution than seniority. Our data set on the careers of Belgian doctorate holders reaffirms this relationship.

FIGURE 8.2 – **Evolution of average annual gross salary according to age and gender**



Source: Belgian Science Policy Office, CDH Database 2010.
Notes: Salary is measured in euros. The frequencies for the age groups are: <35: N=670; 35-44: N=994; 45-54: N=524; 55-64: N=76; men: N=2277; women: N=1071.

By subdividing our sample into four different age categories (younger than 35, 35-44, 45-54 or 55-64 years old), we can observe an increase in salary which keeps pace with each increment in age. Nevertheless, we should add for the sake of completeness that this trend decreases slightly for the oldest age category (55-64), although this difference is not significant. This oldest group of doctorate holders earns a lower or equal salary when compared with their younger colleagues. The difference between the age groups is significant, except for the difference between the last two age groups (Manova: contrast <35 versus 35+: $p<.001$, contrast 35+ versus 45+: $p<.001$, contrast 45+ versus 55+: $p=.43$).

Gender is another well-documented research topic in labour economics. Most studies postulate an income gap between female and male employees (Munasinghe et al., 2008; Brown et al., 2011; Felfe, 2012). This gap is in general attributed to a lower labour force participation rate of women because of childbirth and family care responsibilities. Not only are low-educated women confronted with a lower salary, but in the higher educated segments of the labour market as well men and women do not earn equal pay checks for equal jobs. This finding was confirmed by the analysis of our sample of doctorate holders. When comparing the wages of both sexes, we notice that the traditional wage difference between men and women manifests itself also for people with a doctoral degree. Male doctorate holders earn on average more than female doctorate holders and this difference is persistent throughout their careers (Independent t test: $p<.001$).

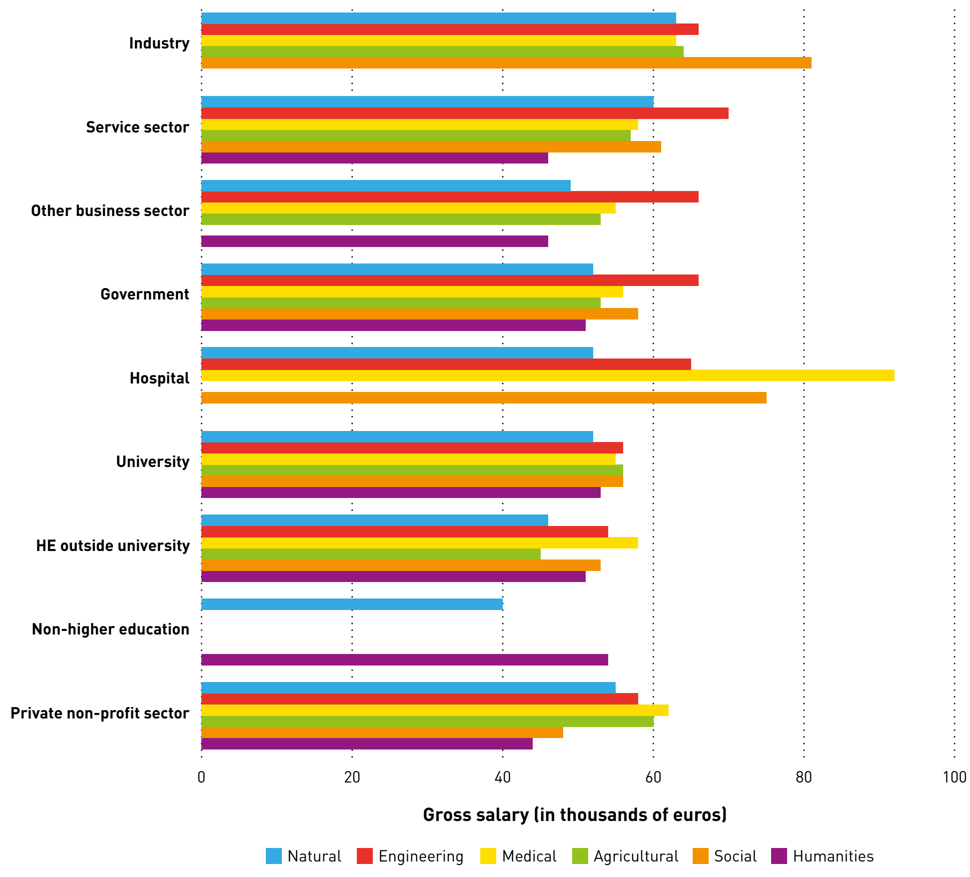
Contract

A majority of doctorate holders work as employees (95%) and have a labour contract that guarantees permanent employment (76%). Apart from this general statement, more particular findings may be revealed by considering other variables such as discipline and age. Part-time employment is most common among doctorate holders in the humanities, social sciences and medical and health sciences: 15.5%, 14.3% and 12.1% respectively work part-time. Doctorate holders in the humanities (30.5%) are most likely to be employed on a temporary basis whereas this is less common among doctorate holders in engineering and technology (16.1%). More women than men have temporary appointment (27.5% vs. 19.6%) (χ^2=34.3, df=1, $p<.001$) and work part-time (19.3% vs. 5.5%) (χ^2=183.2, df=1, $p<.001$). The number of years of working experience will make a difference between a permanent or a temporary position. Young doctorate holders are more often employed in temporary positions than their more experienced colleagues. (van Rossem and Derycke, 2013)

Scientific discipline

The scientific discipline of the doctorate determines the intrinsic value attributed to the doctorate by the labour market. Because of the segmented and specialized nature of the labour market not all segments of the labour market are recruiting the same profiles. For example, engineers are regarded as highly valuable personnel in the manufacturing industry. Doctors and medically trained personnel are more needed in hospitals than in other parts of the labour market. Our analysis confirms these assumptions.

FIGURE 8.3 – **Average annual gross salary by sector and scientific discipline**



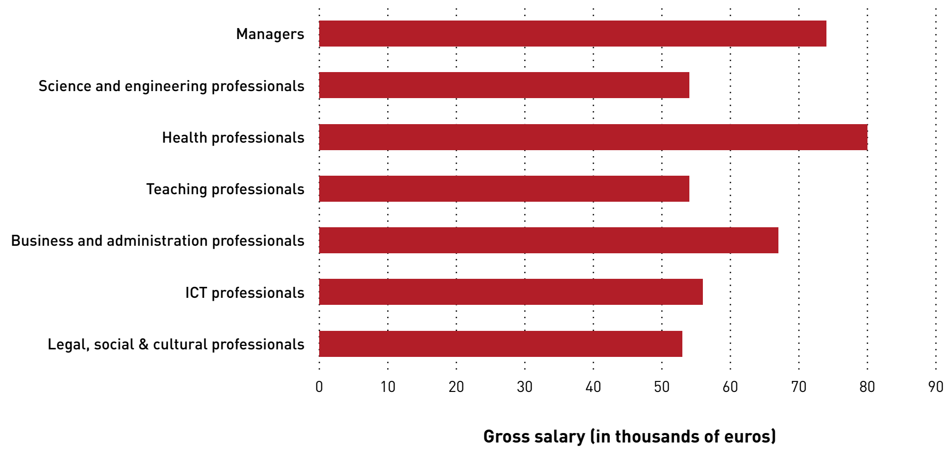
Source: Belgian Science Policy Office, CDH Database 2010.
Notes: Frequencies by sector: industry: N=749; service sector: N=303; government: N=400; hospital: N=205; university: N=1154; higher education outside university: N=232; non-higher education: N=59; private non-profit sector: N=152. Frequencies by scientific discipline: natural sciences: N=1151; engineering and technology; N=610; medical and health sciences: N=532; agricultural sciences: N=310; social sciences: N=361, humanities: N=301).

Figure 8.3 shows which sector is most lucrative according to scientific discipline. In university, there is little difference in salary among all doctorate holders. In the medical and health sciences sectors, it is the medically trained doctorate holders who are obviously the best paid. The wages of doctorate holders in the humanities are generally lower compared to those of doctorate holders in other disciplines, in particular in industry and the service sector. However, it should be noticed that PhD graduates in the humanities are only rarely employed in these latter sectors. The peaks in salary in industry and hospitals earned by social sciences doctorate holders must be interpreted with caution due to the strong influence of a very small group of high earners in high-level positions.

Sector of employment and occupation

Because of the mixed results drawn from studies investigating the relation between seniority, experience and wages, more factors were inserted into the existing model in an attempt to explain a larger fraction of the variations found in wage distributions. One factor in particular that has attracted a lot of interest is the specificity of skills. Some skills are specific for certain occupations and others are industry-specific. On the most general level it is also possible to distinguish skills that are employable in a wide variety of labour settings since these skills are transferable across a wide range of employment sectors. The effect of human capital on wages is not the same across occupations. Wages can be quite divers across industries and occupational categories (Sullivan, 2010).

FIGURE 8.4 – **Average annual gross salary by occupation**

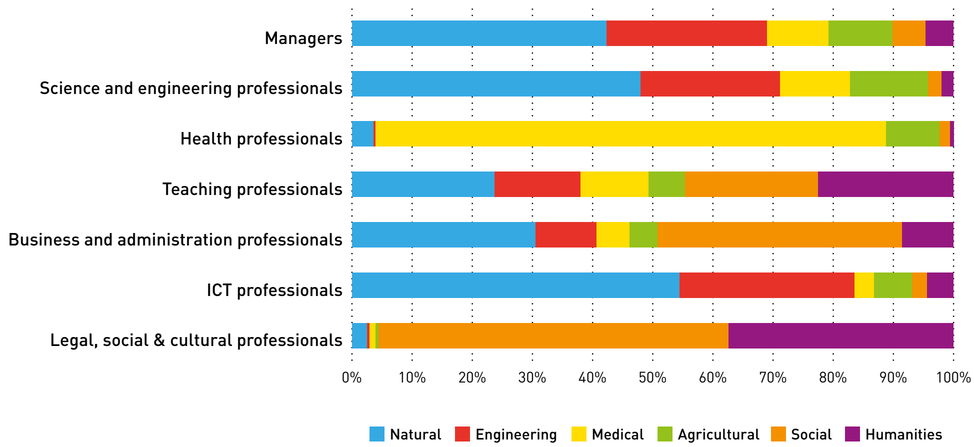


Source: Belgian Science Policy Office, CDH Database 2010.
Notes: Frequencies: managers: N=402; science and engineering professionals: N=1421; health professionals: N=255; teaching professionals: N=681; business and administration professionals: N=105; ICT professionals: N=127; legal, social and cultural professionals: N=169.

The wages of doctorate holders are strongly dependent upon their sector of employment. The medical sector shows to be the best paying sector followed by industry and the service sector. Salaries paid by the government, university, the non-university higher education sector and the private non-profit sector are comparable. The lowest incomes are found in secondary education. Salaries not only differ depending on the sector of employment but also depending on the position one holds inside a company or organisation. We take a closer look at the salary of PhD holders according to their profession: the classification we use to divide doctorate holders in occupational categories is the international standardised ISCO-classification. Health professionals receive the highest salaries. Managers come in second place, followed by business and administration professionals and information and communication (ICT) specialists. The remaining categories fall more or less in the same income group.

In order to put the results of the previous figure in a broader perspective, we compared doctorate holders' occupations according to the discipline of their doctoral degree.

FIGURE 8.5 – **Composition of the different occupational categories according to scientific discipline**



Source: Belgian Science Policy Office, CDH Database 2010.
Note: percentages at horizontal axis depict the proportion of each scientific discipline in the different occupational classes.

Figure 8.5 shows that managers, science/engineering professionals and ICT specialists are occupational categories dominated by PhD graduates in natural sciences and engineering and technology sciences. Doctorate holders in the social and natural sciences are frequently recruited for an occupation as business or administration professional. The legal, social and cultural professions are mainly occupied by social sciences and the humanities doctorate holders.

Mobility / researchers versus non-researchers

Doctorate holders who have stayed abroad during a certain period within the scope of research and/or work-related activities (mobile doctorate holders), in general do not earn more than their non-mobile counterparts. It appears that a stay abroad has no influence on the level of salary (mobile doctorate holders: N=663, non-mobile doctorate holders: N=2583, Satterthwaite independent t-test $p>.28$). Similar findings are obtained for the salaries of researchers versus doctorate holders with a non-research job: The wages of researchers is comparable to those of people who are no longer involved in research activities (researchers: N=2275, non-researchers: N=857, Pooled variance independent t-test $p>.30$).

8.6. Shortcomings of the data set and the methodology

There are some shortcomings on the existent data set. First, it is not possible to make a distinction between those PhDs that changed their job voluntarily in search of better career opportunities and those that were obliged to do so due to a restructuring of the firm or organisation in which they were employed. In the first case, subjects are often well prepared for the decision they will take, as a careful consideration of opportunities and possible setbacks precedes this type of voluntary action. In the latter case, subjects are less prepared for the consequences of such an event.

Additional parameters may complicate the search for another job; for example older people are less mobile in comparison with younger people, and a dismissal at an older age is often an obstruction for re-entering the labour market. There is also the inevitable reality that some companies do not succeed in adjusting to a changing economic environment. This inability to cope with cost effectiveness issues in the competition with emerging companies might cause underinvestment in training of staff members. This is in turn might entail that the skill depository of the people employed in these companies becomes ossified, which broadens the gap between their skills and the new set of skills demanded by the new companies that enter the market. All these reasons are possible explanations why employees confronted with unexpected job loss do not possess the requested set of skills that should help them to find a new job.

The used data set consists of a cross-sectional analysis of the career paths of all people who have obtained a doctoral degree at a Belgian university in a certain time period. The obtained results should be interpreted within this context. The analysis of individual career tracks of doctorate holders with panel data analysis techniques could offer a complementary and/or supplementary source of information that could bring new insights to the surface.

8.7. Conclusion

In recent decades doctoral degrees are no longer the privilege of a small group of graduates who have the ambition to pursue an academic career. Higher education policy deliberately started to stimulate young people to develop and refine their skills in scientific research by doctoral trajectories. This was realised by providing larger budgets via scientific investment funds to faculty research groups in hopes of giving more students the opportunity to acquire a taste for scientific and technological research. The objective of this policy measure was not to raise the number of academic staff, but to create a spill-over effect to other sectors of the economy. This chapter showed a growing awareness in public debate that a knowledge-driven economy is of pivotal importance for the maintenance and creation of wealth.

Analysing the figures we brought together in this chapter with this policy objective in mind, one can conclude that the envisioned spill-over effects did in fact take place. A majority of doctorate holders make a successful transition from an academic environment to a diversity of employment sectors in all types of professions. Apart from this general statement, doctorate holders in certain disciplines face higher barriers in their search for a non-academic job. As Table 8.1 demonstrated, graduates with a doctorate in the social sciences and the humanities stay longer in an academic position than doctorate holders in other disciplines. PhDs in the humanities are also prone to lower salaries, which implies that their career opportunities are more restricted to lower-paid jobs. This might be an indication that the skills they have acquired while working on their doctoral dissertation are undervalued by employers or that employers do not have a clear view of how these specific capabilities could be integrated in a business environment.

Although most doctorate holders - except for some initial difficulties - find their way into other working environments we should be critical of a potential brain drain of gifted engineers and medical professionals from the academic sector. Attracted by better wages and more challenging career opportunities the risk exists that academia will no longer be able to offer its most talented researchers an attractive career perspective. Industry and government focus more on research activities which are usable in practical applications. The formulation and development of theories in which universities excel do not receive the same priority in these sectors. But applied research is often the result of a long and laborious process in which theories are developed, tested and verified before they become manipulable knowledge units that help us to solve everyday problems. To prevent an outflow of highly qualified personnel from certain university faculties, policy makers should make an effort to promote an academic career path as a valuable choice of career.

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Fiscal measure for R&D knowledge workers

ANDRÉ SPITHOVEN

9.1. Introduction

One of the most popular policy instruments to stimulate the research and development (R&D) activities of the key players in the innovation system is the use of tax incentives. The reason for its popularity is its ease of implementation, its low administrative burden and its uptake by all types of firms and organisations. In 2011, 26 countries in the OECD offered tax incentives to stimulate business R&D (Köhler et al., 2012).

The policy instrument of tax incentives has spurred a vehement debate on the side of policy, business, and academics alike. Policy makers show an interest for two reasons. First, R&D expenditures are deemed to contribute to long-run economic growth and welfare (Romer, 1986). Because of this importance tax incentives have often been scrutinized. Overall results posit that one euro spent through tax incentives gives rise to an additional expenditure of one euro (Hall and van Reenen, 2000). Second, knowledge of the effects tax incentives exert on R&D expenditures is a prerequisite in the design – e.g. incremental or volume based incentives – and efficacy of fiscal measures (Lokshin and Mohnen, 2012).

The Federal Authority reported 1.1 billion € of forgone fiscal revenues in the field of R&D in 2010 (Federale Overheidsdienst Financiën, 2012), which is about one third of total public involvement (see chapter 10). Three major measures account for the bulk of these forgone revenues. The most important measure stems from the partial exemption from advance payment on the wages of R&D personnel or R&D knowledge workers and accounts for 528.6 million € in 2010. The second most popular measure is 308.6 million € (in 2010) as tax credit for R&D having an environmental character. As a third measure we find 219.5 million € as deductions on revenue from patents. The remaining 21 million are devoted to other measures such as innovation premiums, deductions for risk capital, fiscal treatment of foreign researchers, deductions for R&D investments covering intangible assets, and tax relief for regional subsidies (Rekenhof, 2013).

Most R&D activities are performed by the human resources within organisations, the so-called R&D knowledge workers. Performing R&D requires highly skilled knowledge workers, and it is precisely those workers who are costly in Belgium because of high labour costs. Because Belgium risks becoming less attractive for R&D active firms, the Federal Authority remedies this drawback by lowering labour costs for certain types of R&D staff.

The aim of this chapter is to take a closer look at the partial exemption from the advance payment for R&D knowledge workers as described in article 275/3 of the Belgian income tax law. This scheme applies to R&D personnel in universities, university colleges, research funds, and registered scientific organisations; and also applies to R&D knowledge workers in the business sector (private enterprises, young innovative companies).

The remainder of this chapter is organised as follows. Section 9.2 offers a quick glance of the fiscal measure for knowledge workers for all target groups. The fiscal measure aims to lower the cost to perform R&D activities. Since the majority of R&D investments are related to personnel costs, these costs weigh heavily in the R&D decision-making in enterprises. The Public Service of Finances reports that the costs of the fiscal measure due to forgone tax income amounts to 560.19 million € in 2011 (Rekenhof, 2013). This section focuses on the distribution of the total sum of forgone tax income over the three target groups and also takes other countries into consideration. The policy mix between indirect (tax incentives) and direct (subsidies) is the subject of section 9.3. Section 9.4 introduces the opinion poll towards enterprises to screen the knowledge and use of the fiscal measure. Section 9.5 further uses the opinion poll to screen the effects of the fiscal measure on employment, R&D projects, motives for additional R&D, and additionality effects. Finally, section 9.6 draws conclusions.

9.2. Target groups benefitting from the R&D measure

The basic principle of the partial exemption runs as follows. The advance payment to be levied on the wages paid to the R&D staff continues to be calculated using the prevailing scales. The R&D knowledge workers eligible for the pre-emption still receives the same salary, but the employers are exempt from paying the Treasury part of the advance payment they deduct monthly from the gross salary of the employee. Hence the wage cost is lower than before. The fiscal measure is targeted to three specific groups of beneficiaries.

The first target group consists of universities, university colleges and research funds. They use the partial exemption from the advance payment for R&D knowledge workers since its announcement by the special law of 24th December 2002. It became operational on 1st October 2003. The original percentage of the exemption was 50%, which corresponded to the time spent on R&D by a university assistant, and was subsequently raised to 65% on 1st January 2005 and, again, to 75% on 1st January 2009. This percentage has further risen to 80% on 1st July 2013. The fiscal measure applies to universities, university colleges and research funds (FWO and FNRS), and focuses on the assistants, postdocs and researchers in research projects (R&D knowledge workers). It does not apply to university professors. The starting point of the fiscal measure is grounded on the typical situation of a university assistant who spends 50% of his/her time on R&D activities. Hence this percentage of 50% is the threshold to apply for the eligibility of the fiscal measure. The fiscal measure cannot be used to lower the wage cost of the R&D staff. In accountancy terms the wage cost is still taxed at 100% as if it were transmitted to the Treasury. The universities, university colleges and research funds must use the revenue, generated by the partial exemption from the advance payment for R&D staff, for additional investments in R&D.

The second target group is made up by scientific organisations. At the federal level a list is drawn up of all scientific organisations from the non-profit sector (public and private) eligible to take part in the pre-emption for the advance payment for R&D staff. This category of organisations has been included since April 2003. The same percentages of exemption apply to universities. The original percentage of 50% was raised from 1st July 2008 to 65%, to 75% from 1st January 2009 and then to 80% from 1st July 2013. As in the academic sector, the fiscal measure is based on the assumption that a typical university assistant devotes 50% of his or her time to the performance of R&D. This percentage of time allocation forms the threshold. Whenever a knowledge worker – with the right degrees – spends more than 50% of time to research activities, the fiscal measure is applicable. Again, the fiscal measure does not change the wage cost, and the partial exemption remains at 100% as if the money had been given to the Treasury. As in the case of higher education institutes, the money saved has to be re-invested in additional R&D investments.

The third target group is formed by the business enterprise sector. The article 275-3 of the fiscal law has four distinct measures; on one of these is the partial exemption from the advance payment for R&D knowledge workers. First, there is starting from 1st October 2005, a 50% pre-emption on the wages for enterprise staff that participate in research projects set up in collaboration with universities or research organisations that are located in the European Research Area. Second, there is a 25% exemption beginning in 2006 for enterprises that employ knowledge workers with a doctorate degree (PhD) in the exact or applied sciences, doctors in the medicine sciences or veterinary sciences, or civil engineers. Third, there is a 25% exemption from 2007, for enterprises employing knowledge workers with a master's degree, with the exception of masters' degrees in the social and human sciences. Fourth, young innovative companies are also eligible – on top of the measures already mentioned – for pre-emption on the wages of other supporting staff like research technicians and project managers in R&D. However, administrative and commercial personnel remain out of the picture. The categories of degrees overlap each other and, moreover, the percentages of the partial exemption from the advance payment were gradually raised and levelled. From 1st July 2008, the percentage was raised to 65%; then to 75% from 1st January 2009; and finally to 80% from 1st July 2013. By these measures the distinction between the categories has become irrelevant. The money that remains in the enterprise due to the pre-emption has to be considered as revenue according to accountancy rules. This revenue can be used for financing additional R&D investment, although there is no legal obligation to do so.

Three target groups employ R&D personnel that are potentially eligible to benefit from the partial exemption from advance payment on the wages: Higher education institutes, scientific organisations and enterprises. Table 9.1 shows the evolution of the forgone pre-emption tax for these three target groups.

TABLE 9.1 – **Partial withholding tax exemption for knowledge workers according to target group – in million euros, % growth rates, % share**

	Amount of tax incentive (in million €)				
Target groups	**2007**	**2008**	**2009**	**2010**	**2011**
Higher education institutes	84.5	97.0	132.8	139.8	155.0
Scientific organisations	24.9	39.0	48.5	61.2	60.9
Enterprises	68.0	191.0	179.0	296.7	340.0
Total cost tax incentive	177.4	327.0	460.3	497.7	555.9
	Annual growth rates				
Target groups	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**% 2011**
Higher education institutes	14.8	36.9	5.3	10.9	27.9
Scientific organisations	56.6	24.4	26.2	-0.5	11.0
Enterprises	180.9	46.1	6.3	14.6	61.1
Total cost tax incentive	84.3	40.8	8.1	11.7	100.0

Source: Public Service of Finances.

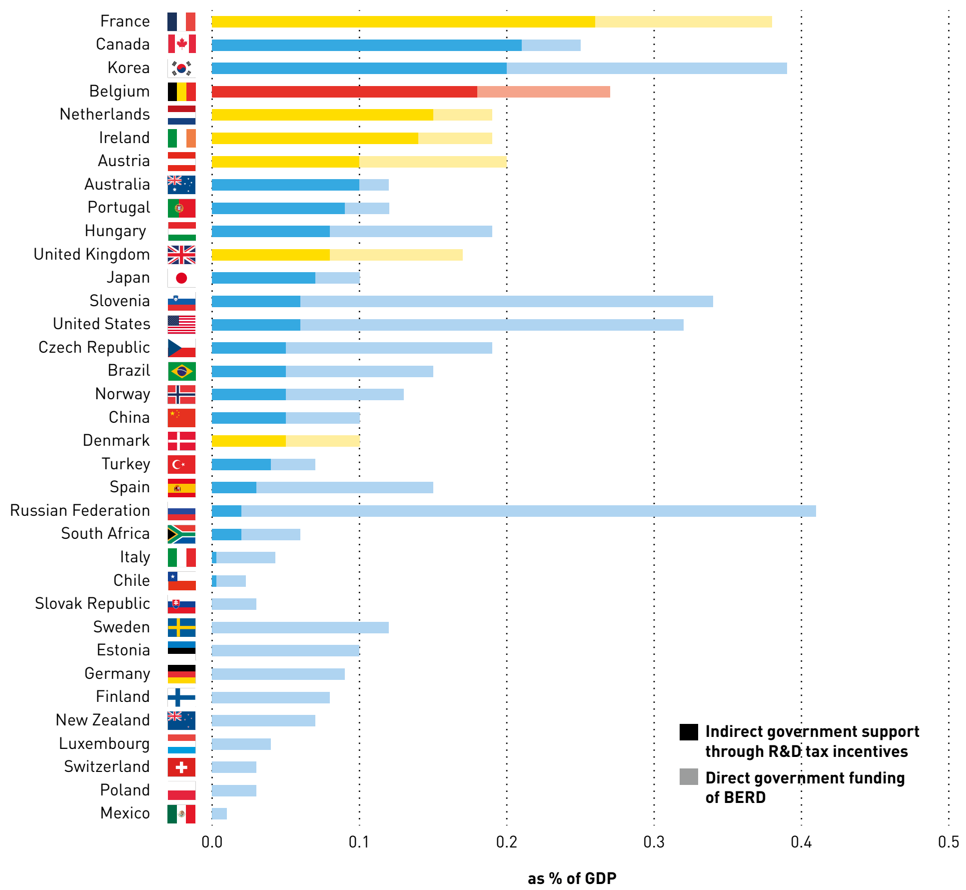
Since 2007 all three target groups have been eligible for the entire set of educational degrees for which the measure has been designed (masters' degrees have been eligible since 2007). Hence, the time series start in 2007, a year in which the higher education institutes still had declared some more eligible knowledge workers to benefit from the partial withholding tax exemption. In 2008 this situation changed and the growth between 2007 and 2008 (+180.9%) was the largest for the enterprises, which were gradually getting aware of the existence of the measure and, therefore, drew the attention of more enterprises. In 2011 the share of enterprises amounts to 61.1%. Due to the fact that the number of higher education institutes (universities, university colleges and research funds) is stable, the growth rates are relatively modest. Finally, the number of scientific organisations also grew over the first years (and with it the amount of tax exemption), but it stagnated in 2010-2011.

The remainder of this chapter focuses on public involvement through the fiscal measure for R&D knowledge workers in the business sector. As seen earlier, this sector covers about 60% of the entire measure.

9.3. Policy mix and international comparison

Government funding of R&D in the business sector runs through two distinct channels: indirect and direct funding. Measures such as subsidies, grants, loans and contracts are direct measures that apply to cover costs incurred in specific R&D projects. Indirect measures for R&D, of which only the one on R&D staff is included for the Belgian figure, have a looser relation to R&D activities. Several countries make use of both modes of government funding. Figure 9.1 gives an international overview of the policy mix.

FIGURE 9.1 – **Modes of government funding of business R&D – in % of GDP in 2007/2008**



Source: OECD (2013).
Notes: Data for Belgium, Ireland, Australia, Brazil and Chile are for 2010; China, South Africa and Luxembourg are for 2009; and Switzerland for 2008. Solid fills of the bars indicate indirect government funding; the upward diagonal fill point to direct government funding. The selected countries are yellow coloured and Belgium in red.

When looking at indirect government support, one notes that Belgium occupies the fourth position compared to other countries in Figure 9.1. Of the selected countries only France outperforms Belgium in the case of direct support, while smaller countries like the Netherlands, Ireland and Austria all fall to some extent behind. Some countries with high R&D intensities – like Sweden, Finland and Germany – do not engage in offering indirect support to firms, and even their direct funding proves to be modest (around 0.1% of GDP).

In the case of total government funding – i.e. direct and indirect funding – Belgium takes sixth position in order to attract additional R&D. This time, Belgium is again preceded only by neighbouring France when it comes to the selected countries. Other top five countries exceeding 0.3% of GDP are the Russian Federation, South Korea, Slovenia and the United States.

When looking at the policy mix of countries, one notes that tax incentives are quite popular in Canada (5.3 times more indirect than direct measures); and in Australia (5 times more). The Netherlands (3.8 times more indirect than direct); Portugal (3.0), Ireland (2.8) and France (2.2), all favour indirect support over direct support to a larger extent than Belgium (2.0). Hence the policy mix in Belgium is about two third indirect and one third direct funding: the share of direct support coming mainly from regional authorities and the share of indirect support stemming predominantly from the federal level. For the other selected countries – Austria, Denmark and the United Kingdom – the shares of both support mechanisms are more or less equal.

9.4. Opinion poll: knowledge and use of the fiscal measure for R&D knowledge workers

An opinion poll directed to the effects of the tax incentive for enterprises was organised in June 2011 by the Belgian Science Policy Office. The poll was sent to all firms present in the bi-annual R&D survey. This OECD R&D survey lists 2,706 R&D active firms from which 336 firms reacted, yielding a response rate of 12.4%. The opinion poll covers 14.3% of total R&D expenditure and 17.3% of total R&D staff.

Knowledge and use

In order to make use of the fiscal measure it is assumed that this measure is known to the 336 firms in the sample. Following its instalment in 2006 the measure has become known, in 2011, to a large majority of the 83.3% of the respondent firms. But that also implies that one out of six firms (16.7%) is still ignorant of the existence of the fiscal measure. Firms are asked to state if they know the existence of the fiscal measure for R&D staff and if they are using it.

TABLE 9.2 – **Knowledge and use of the fiscal measure for R&D staff – in % (N=336)**

		Use the fiscal measure	
		Yes	No
Know the fiscal measure	Yes	66.1	17.2
	No	0.0	16.7

Most firms have heard of the fiscal measure (83.3%), but about two thirds of the firms (66.1%) actually make use of it. Looking at the size categories of firms shows that the unawareness of the fiscal measure is the largest in small firms (19.9%) with up to 50 employees. This share is lower (13.5%) in the case of medium-sized firms employing 50 to 500 persons and still lower in the case of large firms (9.3%) with more than 500 employees. A minority of one in six firms (16.6%) did not know the fiscal measure and, consequently, have not made use of it. Since the initial list of potential respondents was drawn from the database containing all permanent and occasional R&D active firms, this finding needs closer examination.

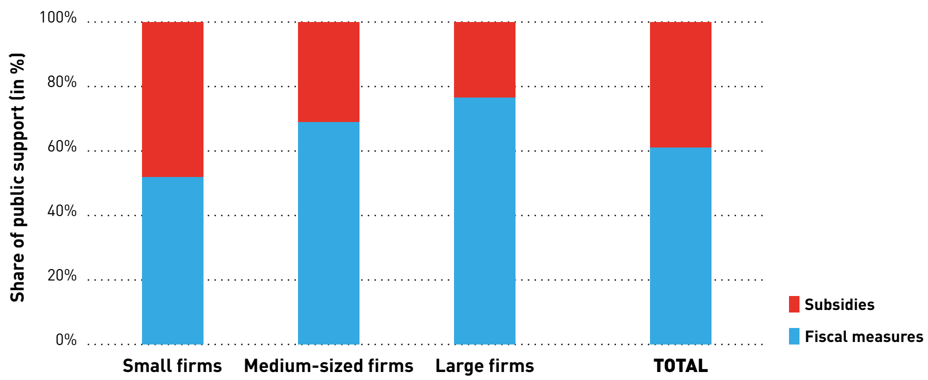
Almost one in five firms (17.2%) acknowledged the existence of the fiscal measure but did not use it. There are several reasons for this: either these firms do not perform R&D (on a regular base), or their R&D staff is not eligible to make use of the measure in terms of diplomas.

Policy instrument mix

Following the example set by the OECD (see above) the opinion poll also looked into the mix between using direct and indirect measures. About one third (32%) exclusively relied on direct fiscal measures; whereas a minority of 3% only used subsidies. Two thirds of the firms (65%) use a mix of both fiscal measure and subsidies. Due to the ease of use, the popularity of the more recent fiscal measure outranks that of the subsidies, resp. 97% versus 68%. The administrative burden to obtain subsidies is frequently cited as an impediment to its use.

If the financial amounts of both measures – tax incentives and subsidies – are taken into account the share of fiscal measures is 61% and the share of subsidies is 39%. However, there are marked differences when firm size is accounted for as depicted in Figure 9.2.

FIGURE 9.2 – **Share of policy mix benefits of firms according to size (N=229)**



Note: Small firms (up to 50 employees); medium sized firms (between 50 and 500 employees); and large firms (500 and more employees).

Figure 9.2 draws attention to the fact that small firms use more R&D subsidies when compared to larger firms. One possible reason for this is that the amounts from subsidies are related to a specific R&D project selected by the regional authority when they cover a large share of total costs. The average benefit of the tax incentive is about 15% of the total wage cost. But small firms have, by definition, little hired personnel. The fiscal measure for R&D staff is related to the number (and the wage level) of R&D staff. For large firms, the share of subsidies is, therefore, expected to be lower. Or, in other words, the more R&D intensive the firm, the higher the potential share of indirect support related to R&D staff.

9.5. Opinion poll: effects of the fiscal measure for R&D knowledge workers

Four effects are examined using the opinion poll. As firms are at liberty to spend, at will, the money freed by the tax incentive, the policy maker is uncertain as to the outcome of the fiscal measure. Since the fiscal measure is directed towards R&D knowledge workers, the first effect tackles employment consequences. The idea behind the measure is to lower the wage cost of R&D knowledge workers the employer has to pay. The tax pre-emption results in additional money for firms. This money could be used to generate employment, to change the content of the R&D job, to raise wages (see Lokshin and Mohnen, 2013 and Dumont, 2013), or other effects. Second, the money that is not spent could be directed toward additional, riskier, research intensive R&D projects. Third, the opinion poll probes the issues that keep firms busy in their decision to perform additional R&D. Fourth, the poll uses the counterfactual case to look into the possible action of firms should the fiscal measure not exist.

Employment effects

The partial exemption from the advance payment for R&D staff was explicitly directed to benefit the firms employing R&D personnel. As the fiscal measure pertains to certain categories of R&D personnel, there is likely to be an effect on firm employment. A lower wage cost is expected, *ceteris paribus*, to stimulate the demand for personnel. Even though the fiscal measure has been installed for a limited time and has been continuously changing ever since, it might take some time before this lower wage cost translates itself into employment effects. Due to the rigidity of the labour market the firing of personnel is not always straightforward. This makes hiring new people a rather laboured venture for businesses operating in economically uncertain times.

Firms are, however, at liberty to use the freed amount of money resulting from the non-payment of taxes. In other words, firms could decide to stimulate the employment of all types of personnel (production workers, administrative tasks, etc.); employ more R&D staff; re-organise the work force to include a higher share of R&D staff; upgrade the educational qualifications of the R&D staff (e.g. opt for PhD degrees); sustain the R&D staff that already works in the firm in view of the current economic downturn; and use the funds to raise the salaries of researchers because of potential scarcity situations. The question on employment effects received 185 useful answers. Respondents had to rate every item using a Likert scale ranging from 1 (disagree completely with the statement formulated) to 5 (agree completely with the statement). Table 9.3 gives an overview of the answers according to six statements.

TABLE 9.3 – **Firm-level effects on employment by beneficiaries of the fiscal measure (N=185)**

Effect on employment	Score given by the users of the fiscal measure	Difference from neutral score '3' (sig.)
More employment	3.30	0.30****
More R&D employment	3.38	0.38****
Larger share R&D jobs	3.18	0.18***
Higher qualified personnel	3.15	0.15**
Sustaining R&D employment	3.52	0.52****
Higher salaries researchers	2.62	-0.38****

	Polychoric correlations					
Effect on employment	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
More employment (1)	1.000					
More R&D employment (2)	0.704****	1.000				
Larger share R&D jobs (3)	0.624****	0.775****	1.000			
Higher qualified personnel (4)	0.493****	0.671****	0.548****	1.000		
Sustaining R&D employment (5)	0.116*	0.126*	0.099	0.098	1.000	
Higher salaries researchers (6)	0.001	-0.053	0.036	0.118	0.029	1.000

*Note: Respondents are asked to rate the question using Likert scales: 5 = agree completely and 1 = disagree completely. The symbols *, **, ***, and **** refer to significance levels of 10%, 5%, 1%, and 0.1%.*

Respondents agreed most (average score of 3.52) with the statement that current R&D employment is sustained by the fiscal measure. This effect can be classified as being a positive one because of the fact that the economic downturn could otherwise result in a lay-off of R&D staff. R&D staff holds a lot of essential tacit knowledge that is part and parcel of the knowledge base of the firm. Hence, firms are very much helped in economically difficult times if the personnel wage cost is lowered. Many respondents even state that they have created more R&D jobs. This may be within the firm and explains why this is correlated with a greater share of R&D jobs in the firm. As certain types of diplomas are targeted, higher qualified R&D personnel may be hired.

Most respondents disagreed with the statement that the fiscal measures resulted in higher wages for the current researchers in the firm. However, this does not imply that higher wages are excluded as a result (see Dumont, 2012). It depends, among other factors, on the elasticity of labour supply and on the fields of science in which the researchers are active that might form a bottleneck on the labour market (e.g. the shortage of chemists in the pharmaceutical industry).

More employment and more R&D employment are obviously strongly related to each other. The idea is that if the score on one statement increases by 1, the score of the other will, on average, increase by 0.704). As such the results in the above Table 9.3 may be somewhat nuanced because the apparent correlation between the high scores on sustaining R&D employment and more R&D employment seem to be correlated at only a 10% level of significance (0.116). Respondents that rate high on one statement are less prone to rate the other statement as high. The offering of high salaries never significantly correlate with the other statements made.

Figure 9.3 shows the response patterns to the statements described above on the effects on employment.

FIGURE 9.3 – **Rating the employment effects of the fiscal measure (N=185)**

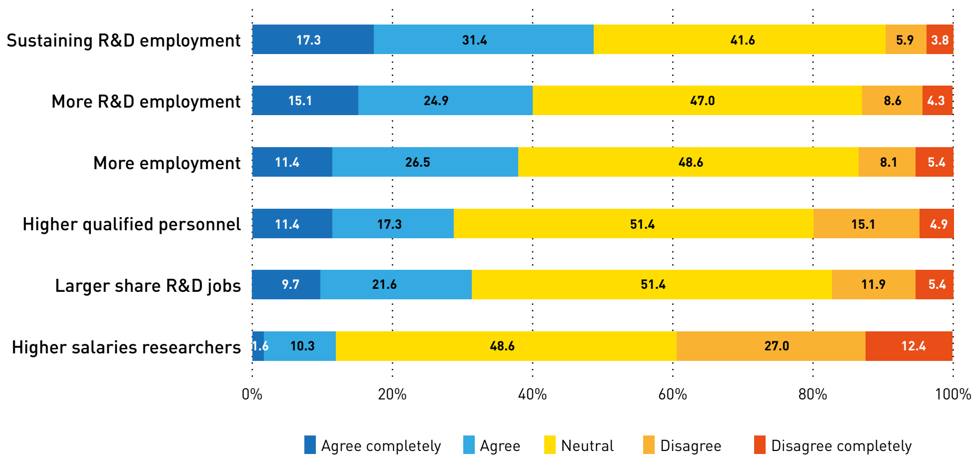


Figure 9.3 shows that most firms are rather neutral on most statements. If they have an opinion, the statement on maintaining R&D employment is the most agreed upon since 48.7% of the respondents agree with this (either completely or partially). Additional employment is said to be the case for 37.9% of respondents (and 40% in the case of R&D employment). The change towards higher qualified personnel or a larger share of R&D jobs is considered a valid statement for about one third of the respondents.

Effects on R&D projects

The fiscal measure cheapens the labour cost of performing R&D. Since labour is an indispensable ingredient in R&D projects, the measure is expected to exert some influence on R&D projects. At this R&D project level the results are somewhat less spectacular, as exemplified by Table 9.4.

TABLE 9.4 – **Effects on R&D projects by users of the fiscal measure (N=184)**

Effects on R&D projects	Score given by the users of the fiscal measure	Difference from neutral score '3' (sig.)		
Financing R&D investments	3.16	0.16**		
More research versus development	3.28	0.28****		
New R&D projects	3.49	0.49****		
Start riskier R&D projects	2.97	-0.03		
	Polychoric correlations			
Effect on R&D projects	**(1)**	**(2)**	**(3)**	**(4)**
Financing R&D investments (1)	1.000			
More research vs development (2)	0.307****	1.000		
New R&D projects (3)	0.424****	0.585****	1.000	
Start riskier R&D projects (4)	0.133**	0.359****	0.376****	1.000

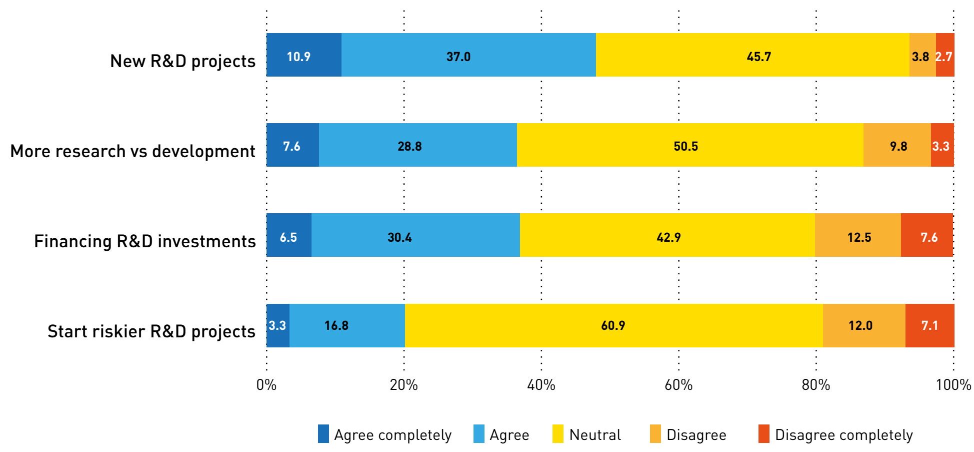
*Note: Respondents are asked to rate the question using Likert scales: 5 = agree completely and 1 = disagree completely. The symbols *, **, ***, and **** refer to significance levels of 10%, 5%, 1%, and 0.1%.*

The largest effect crystallises itself through additional R&D projects (3.49). Funding results in more financial resources in the firm and this 'slack' (or non-destined financial means) is used to undertake R&D projects that had not been considered in the past. Since it is assumed that the most profitable, or the least uncertain, R&D projects are realised first, the financial slack due to the fiscal measure offers possibilities for firms to undertake less profitable or more uncertain R&D projects.

A second effect is that firms devote more time to research when compared to development activities. This also relates to a shift towards more uncertain R&D projects since basic research takes longer to be converted into commercial products or services. As emphasised earlier, firms are not obliged to finance additional R&D expenditures with the money saved on the labour costs. But in the case firms benefit from a pre exemption, the funds might be used to finance R&D expenses other than R&D personnel. This correlates with the shift towards more research activities (compared to development) because this often necessitates investment into R&D infrastructure, equipment, other material costs, etc. The lower panel on Table 9.4 shows the polychoric correlations of the four items. All of them are positively correlated which implies that all effects are more or less combined.

In Figure 9.4 the response pattern is highlighted.

FIGURE 9.4 – **Rating the effects of the fiscal measure on R&D projects (N=184)**



Decision factors relevant to performing additional R&D

The opinion poll presented the respondents with a set of predefined motives playing a role in the decision to perform additional R&D. Table x lists these as they appeared in the questionnaire. Respondents had the opportunity to indicate whether the item applied or did not apply to them by stating their level of agreement with the item according to a 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree).

TABLE 9.5 – **Decision factors by users of the fiscal measure (N=181)**

Decision factors	Score given by the users of the fiscal measure	Difference from neutral score '3' (sig.)
Changing demand	4.09	1.09****
Technical changes	4.15	1.15****
Availability high-skilled personnel	3.22	0.22***
Time horizon of R&D project	3.31	0.31****
Availability private R&D partners	3.13	0.13**
Availability public R&D partners	3.16	0.16**
Cost of R&D staff	3.54	0.54****
Cost R&D material/infrastructure	3.31	0.31****
Existence of R&D subsidies	3.61	0.61****
Existence of fiscal measure	3.66	0.66****

	Polychoric correlations				
Effect on R&D decision factors	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Changing demand (1)	1.000				
Technical changes (2)	0.705****	1.000			
Availability high-skilled personnel (3)	0.056	0.214***	1.000		
Time horizon of R&D project (4)	0.135*	0.176**	0.486****	1.000	
Availability private R&D partners (5)	0.120**	0.073	0.363****	0.415****	1.000
Availability public R&D partners (6)	0.177**	0.140*	0.402****	0.346****	0.677****
Cost of R&D staff (7)	0.314****	0.242***	0.238***	0.346****	0.335****
Cost R&D material/infrastructure (8)	0.237***	0.227**	0.282****	0.342****	0.416****
Existence of R&D subsidies (9)	0.254****	0.269***	0.269****	0.287****	0.363****
Existence of fiscal measure (10)	0.212***	0.258***	0.276****	0.324****	0.267****

	Polychoric correlations				
Effect on R&D decision factors	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Availability public R&D partners (6)	1.000				
Cost of R&D staff (7)	0.321****	1.000			
Cost R&D material/infrastructure (8)	0.297****	0.602****	1.000		
Existence of R&D subsidies (9)	0.370****	0.591****	0.503****	1.000	
Existence of fiscal measure (10)	0.265****	0.669****	0.398****	0.817****	1.000

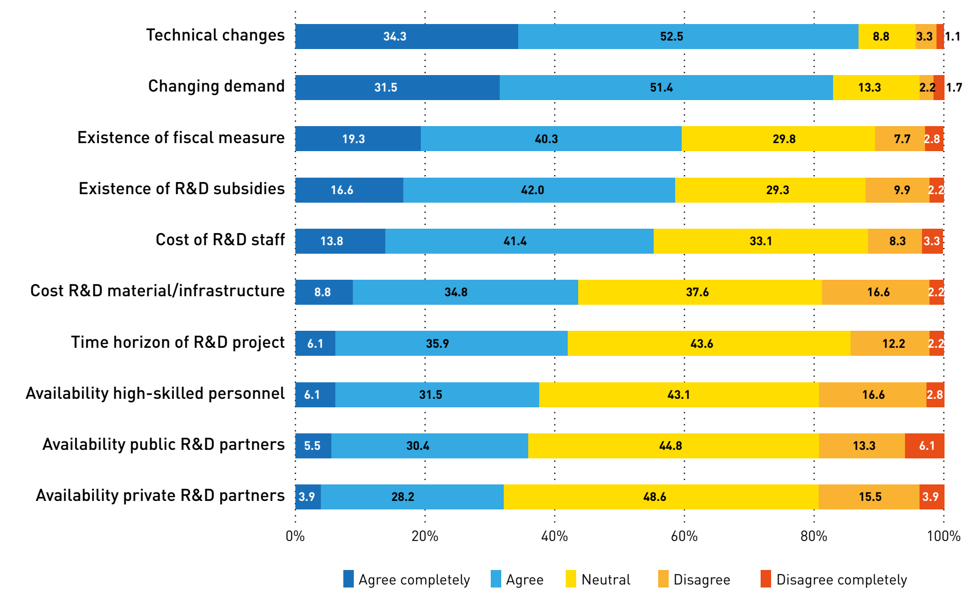
*Note: Respondents are asked to rate the question using Likert scales: 5 = agree completely and 1 = disagree completely. The symbols *, **, ***, and **** refer to significance levels of 10%, 5%, 1%, and 0.1%.*

Table 9.5 shows that the demand and supply conditions of firms are highly relevant in R&D decisions. This means that firms need a market to sell their product or service. This might be a niche market for specialised offerings, or an international export market for 'common' goods and services. The supply conditions are characterised by the technical changes that exist. Firms might be leaders if they are setting the technical standard by breakthrough research, or they might be followers that have to comply with a changing technical environment in order to offer up to date products and services.

The cost of R&D staff, when considered as relatively high, is reduced by the fiscal measure on the partial exemption from the advanced payment for knowledge workers. This measure is an initiative of the Ministry of Finance.

The scores in Table 9.5 generated by the users of the fiscal measure have been ordered by their level of total agreement in Figure 9.5. Figure 9.5 shows that the category of neutral answers (scale 3) is growing.

FIGURE 9.5 – **Rating the effects on decision factors for additional R&D of the fiscal measure (N=181)**



Additional R&D activities are largely dependent on supply and demand conditions. Firms are stimulated, or forced by competitive pressures, to engage in additional R&D because technical changes occur. When firms do not incorporate these changes they lose touch with the market by offering technically obsolete products, or using technically inferior processes. The origin of these changes might be internal or external to the firm. Technology turbulence is, moreover, quite sector- dependent. The key sectors in Belgium are in the most turbulent sectors (pharmaceuticals, microelectronics and biotechnology).

Changing demand affects the need for additional R&D activities. Firms are inclined to step up R&D in the expectation of servicing a need for paying customers. This aspect is crucial, especially in times of economic crisis. Striving for the most recent technically advanced product is a necessary, but insufficient, condition to boost firm performance should that product not have the chance of getting sold in the (international) market.

The positive response on the next three items – the existence of tax incentives and subsidies as well as the issue of high wage costs for R&D staff – shows that public support is welcomed by firms. For one, the cost of R&D staff and fiscal measure are, as expected, highly correlated (0.669, see Table 9.5). But the fact that subsidies are similarly rated implies that other aspects of the costs of R&D projects are of equal importance. As such there is a large complementarity between fiscal and subsidies (as exemplified by a correlation coefficient of 0.817 in Table 9.5 and corroborated by the results that two thirds (65%) used them both (see earlier).

Additionality effects

To look for additionality effects of the fiscal measure, respondents are given a list with possible actions that might be taken should this measure not exist. Table 9.6 looks at these counterfactual effects, again using a Likert scale ranging from 1 (completely disagree) to 5 (completely agree) on the statements made.

TABLE 9.6 – **Additionality effects by users of the fiscal measure (N=179)**

Additionality effect	Score given by the users of the fiscal measure	Difference from neutral score '3' (sig.)
Smaller R&D budget	3.32	0.32****
Slower R&D speed	3.34	0.34****
Smaller R&D scale	3.47	0.45****
R&D outsourced to private partners	2.41	-0.59****
R&D outsourced to public partners	2.53	-0.47****
Delocalising R&D activities	2.68	-0.32****
Abandoning R&D activities	2.87	-0.13

	Polychoric correlations						
Additionality effects	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Smaller R&D budget (1)	1.000						
Slower R&D speed (2)	0.606****	1.000					
Smaller R&D scale (3)	0.690****	0.883****	1.000				
R&D by private partners (4)	0.288****	0.196***	0.180***	1.000			
R&D by public partners (5)	0.277****	0.276****	0.227***	0.789****	1.000		
Delocalising R&D activities (6)	0.143*	0.244***	0.281***	0.405****	0.321****	1.000	
Abandoning R&D activities (7)	0.288****	0.386****	0.498****	0.296****	0.167**	0.465****	1.000

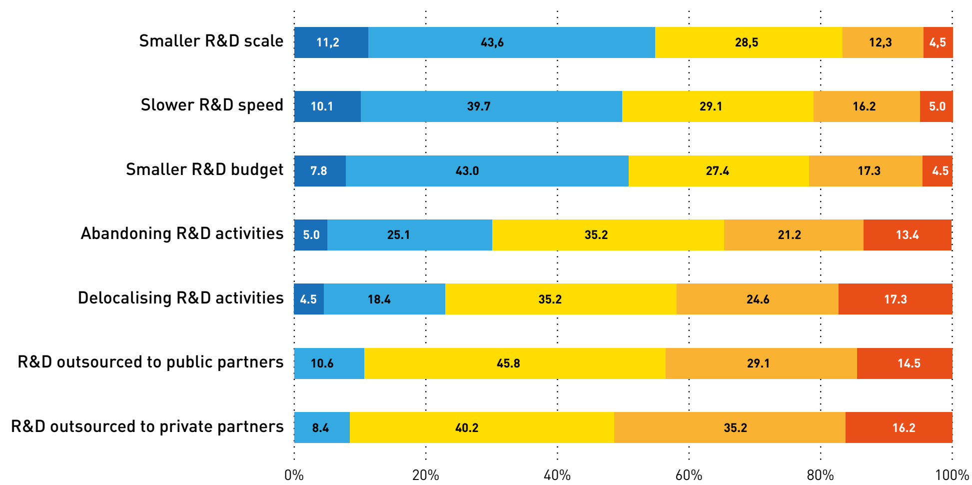
*Note: Respondents are asked to rate the question using Likert scales: 5 = agree completely and 1 = disagree completely. The symbols *, **, ***, and **** refer to significance levels of 10%, 5%, 1%, and 0.1%.*

Table 9.6 shows that, should the fiscal measure not exist, R&D projects will be carried out, be it at a smaller scale, slower pace and with a smaller budget. The main reason for this is the strategic importance of R&D activities in firms, demonstrating that no clear alternatives are available if firms want to maintain their competitive edge. However it does imply that R&D spending will be lower, which might have a negative impact on R&D employment opportunities.

The previous paragraph already hints at the fact that a non-execution of R&D projects is no option. Again, the strategic nature of R&D is responsible for this as it guarantees or ensures the existence or creation of a competitive advantage. Delocalising R&D activities are not contemplated, even if the fiscal measure does not exist. This is not to say that this measure might not be attracting R&D intensive or active firms to Belgium. What is does mean is that there are other factors that render Belgium an attractive place for R&D activities; e.g. a highly skilled workforce; good industry-science relations; open minded and multilingual workers, etc. Anchoring R&D proves – at least for SMEs – not to be problematic.

Finally, outsourcing R&D to other partners is not an alternative; this might be explained by the requirement to keep an amount of R&D internal to the firm to maintain or generate some critical level of absorptive capacity to be able to screen, recognise, and implement external research results and unify these with the internal activities. Figure 9.6 confirms the findings made above.

FIGURE 9.6 – **Rating the additionality effects of the fiscal measure (N=179)**



When statements are about the internal functioning of R&D, respondents have strong opinions and less than one third of them is neutral. Fiscal measures have a positive impact on the scale, speed and budget of R&D. In the case of the budget this is self-explicative, since the fiscal measure leads to more financial slack in the firm. But there are some behavioural aspects to the measure as well, since the scale of R&D will be enlarged which might reduce the risk of failure for the R&D project due to diversification. The fiscal measure is also seen to boost the speed of the R&D execution. R&D personnel are less disturbed by other tasks which make their focus better and speed up the attainment of potential results.

As the share of respondents that disagree becomes larger than those that agree, the share of respondents that have a neutral opinion also becomes larger. Therefore the negative effects, which are frequently cited by sector federations, are far less supported by the respondents once they perform R&D activities. This is because the R&D process in firms is a planned one and cannot be abandoned or transferred to other locations without incurring large costs.

The fact that the outsourcing of R&D is hardly considered to be an option for about 90% of the respondents might be related to the previously given argument that internal R&D is important in generating absorptive capacity in the firm.

9.6. Conclusion

The chapter presented a concise overview of the tax incentive measure directed at the cost of R&D knowledge workers taken by the Federal Authority. Three distinct players of the innovation system stand to benefit from the tax incentive: higher education, scientific organisations and the business sector. The business sector represents the majority (61%) of the total cost of the measure.

The findings in the chapter reveal a large complementarity between the regional financed subsidies and the federal forgone tax revenues. Both measures are actively used by enterprises. Belgium is no exception in this respect since the international comparison learns that other, but not all, countries have a similar mix. The comparison learnt that Belgium is a generous country when it comes to public support. Belgium ranks as fourth country for tax incentives (i.e. indirect measures) and holds the sixth position for total public support (i.e. direct and indirect measures).

Due to the weight of enterprises in the tax incentive measure, an opinion poll was organized to screen the effects of the policy measure. A first impact touches upon employment. Maintaining R&D knowledge workers employed is, in itself and in times of economic crisis and high wages, quite an achievement. It shows that R&D activities are upheld by firms to cope with the aftermath of the crisis and to prepare for take-off in the next upswing. The second impact of the tax incentive relates to performing additional R&D which is important in the light of attaining the 3% target (3% of GDP ought to be spent on R&D by 2020). Additional R&D is, however, highly dependent on technical progress and changes in demand conditions. But the motivation for additional R&D is clearly supported by the existence of R&D subsidies and the tax incentive measure. Finally, the opinion poll showed that R&D is considered to be of key importance to firms. The fiscal measure stimulates the start, size, speed and scale of internal R&D activities.

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CHAPTER 10

Science policies in 2012-2013: an overview

WARD ZIARKO

10.1. Introduction

This chapter reviews some of the main science policies that occupied policy makers during the years 2012 and 2013. This complements the more quantitative picture of science policy in this report, where public support for research through all kind of subsidies, the R&D budgets (chapter 2), and tax credits (chapter 9) are discussed. We learnt that budgetary credits for research and development increased slightly (in current euro) between 2009 and 2012, after a drop in 2008. When measured in constant euro, the peak of 2008 was never reached again. On the other hand, we observed a substantial growth in tax credits. Total public funding of R&D in Belgium amounted to 3.5 billion €. Due to the various fiscal measures to stimulate R&D activities, forgone revenues have steadily increased to reach almost one third of total public funding (1.1 billion €) in 2010. Two thirds of public aid (2.4 billion €) is funded through R&D budgets covering all forms of subsidies -– be it through competitive funding or through institutional block funding. This demonstrates a shift in science policies in Belgium in favour of tax measures. It further underlines the growing importance of the federal level in research funding.

In addition to this fundamental shift in policies, less striking events took place on an everyday basis. At regional, community or federal levels, new initiatives were sometimes launched, new programmes were developed, or strategies evaluated, etc. But more often existing initiatives/programmes that had proven to be successful were prolonged and continued to play their role. As a matter of fact, science policies follow an incremental path of improvement. Radical changes are rare in those countries with a well-established science policy system. Belgium is a good example of such a country.

In this chapter we look at some decisions regarding science policies that have been taken during the last year and a half at two different levels of authority: the European and the national (federal) levels in Belgium. Both levels increased in importance for the research community, as well as for the science policy community (the policy makers). Indeed, researchers are funded to a large extent by all levels of authority, while policy makers cannot develop their policies in isolation. European strategies and legislation are often translated in national legislation and strategies.

A multilevel approach renders some of the understanding of these policies difficult. As a matter of fact, for a good understanding one needs the whole picture, meaning an overview of all the strategies and the context in which these policies are being developed. Due to a lack of space in developing these, we direct the reader to other documents that are very helpful in that they complement the picture. In particular, the Belgian Report on Science and Technology and Innovation - BRISTI (Belgian Science Policy Office, 2010) offers a complete overview of the national and regional research and innovation landscape. This describes the role of the main actors and the governance of research and innovation in general.

This chapter does not deal with regional science policies. The Flemish region recently published its 2013 report on indicators with an elaborated overview of the Flemish landscape (ECOOM, 2013). As for the Walloon region, several reports are available from different institutions like the 'Conseil Économique et Social de Wallonie' (CESW, 2012); the Federal Planning Bureau (Biatour et al., 2012), etc. On top of these reports, there are international reviews; e.g. the Walloon research and innovation system has been reviewed by the OECD (OECD, 2012), while the Flemish landscape was reviewed by Luc Soete, rector of Maastricht University (Expertengroep Soete, 2012).

Section two focuses on policy making and strategies at the European level. Policy making goes most often through the Competitiveness Council where ministers in charge of research and innovation meet. Quite often the European Council also takes important decisions like the launching, for instance, of the Innovation Union Flagship and the 3% target. Section three summarises some initiatives of the federal government, like the recovery plan (the so-called 'relanceplan'); the main initiatives of the federal administration of science policy (Belgian Science Policy Office or 'Belspo'); and the revitalisation of the Inter-ministerial Commission for Science Policy which covers the coordination between regions and the federal level.

10.2. The European agenda

Four EU-presidencies followed up on each other during 2012 and 2013: Denmark, Cyprus, Ireland and Lithuania. Presidencies can influence the agenda, but a big part of the agenda builds on initiatives launched earlier. The decisions are mostly being taken by the Competitiveness Council and some have been taken at a higher level in the European Council. But one should never underestimate the role of the European Commission in setting the agenda. By launching 'communications', policy debates are initiated that most often are the first step to a decision by the Competiveness Council.

A big number of topics have been discussed during the past presidencies. Of these, the EU-2020 Strategy (and the Annual Growth Survey), Horizon 2020 and the European Research Area (ERA) were most visible, although other issues such as the European Institute of Technology (EIT), Joint Technology initiatives (JTI's), the European Patent, European Innovation Partnerships, etc. are equally important though not always that visible.

In the following paragraphs we come back to the three most visible topics: Horizon 2020, the EU-2020 Strategy (and the Innovation Flagship)' and the European Research Area.

Horizon 2020

It goes without saying that of all the European research initiatives, the impact of the European Framework Programme is probably the biggest. The amount of money that is being channelled through this programme in the European research system is enormous. As a percentage of total R&D budgets it might still be modest (below 10 %), but as a proportion of competitive funding it reaches in many Member States levels up to 30%. The next framework programme, 'Horizon 2020', is planned to have a budget close to 80 billion € (see chapter 5). This budget is only matched by those of the top American science foundations (NSF, NIH and Energy), but taken together, these foundations go well above the European Framework Programme. One should, however, not forget that Europe also counts important national research budgets. From another point of view, the European Framework Programmes have also always been of high importance: they quite often influence national research programmes in content and in design. National research programmes might find inspiration in the issues being addressed in the framework programme, while copying review systems, cooperation schemes, and foreseeing room for international cooperation, etc.

The Seventh Framework Programme comes to an end in 2013, the last research activities are being launched right now. The preparations for the next framework programme, Horizon 2020, started some time ago. The Competitiveness Council holds a first debate on the new broad lines of the new programme at the end of 2011, and during the Danish presidency in the first half of 2012, a first agreement was reached about the broad lines of the programme. The new programme is supposed to run from 2014 until 2020. At the time of writing we are close to an approval of the new programme by the European parliament. Indeed, the decision procedures are quite complicated since they imply an agreement from the Council, the Commission and the Parliament.

The three main parts of the new framework programme are: the specific programme implementing Horizon 2020, the rules of participation in research projects and the Euratom Programme on nuclear research activities. A main feature of the new framework programme is of course the 'simplification' issue. There was a demand by the research community to simplify the complex finance and reporting systems. The issue was initiated during the Belgian presidency, long before the first debates started on the new framework programme.

Other innovative features in the new programme are the idea that it should cover the whole chain from the idea to the market. In this respect Horizon 2020 integrates a lot of the old innovation focused programme 'Competitiveness and Innovation Programme' (CIP) and the European Institute for Innovation and Technology (EIT). SMEs participation is meant to increase. Public/private partnerships should also increase and the coherence with other EU and national policy and financial instruments should improve.

Each of the three main parts of the specific programme addresses a specific target group of researchers, or a particular type of research challenge. 'Excellent Science' is, according to the Commission, supposed to '*raise the level of excellence in Europe's science base and ensure a steady stream of world-class research to secure Europe's long-term competitiveness. It will support the best ideas, develop talent within Europe, provide researchers with access to priority research infrastructure, and make Europe an attractive location for the world's best researchers*' (European Commission, 2013a). This part mainly addresses the individual researchers or public research institutes. There is room for fundamental research, training of researchers, mobility, research infrastructure, etc. 'Industrial Leadership' is in the first place addressing the business community. This part is supposed to contribute to '*making Europe a more attractive location to invest in research and innovation, by promoting activities where businesses set the agenda. It will provide major investment in key industrial technologies, maximize the growth potential of European companies by providing them with adequate levels of finance and help innovative SMEs to grow into world-leading companies*'. (European Commission, 2013a). Second, targed technologies are enabling and industrial technologies, like ICT, nanotechnologies, advanced materials, biotechnology, advanced manufacturing and processing, and space. Third, the part on 'Societal Challenges' will develop a challenge-based approach, with activities from research to market from all technologies and disciplines, including social sciences and the humanities. We refer to the Commission website for a summary of the main parts of Horizon 2020 and the indicative budgets at http://ec.europa.eu/research/horizon2020/index_en.cfm.

The involvement of the Member States in the preparatory process basically took place through the research working party of the committee of permanent representatives. Meetings were very frequent, demanding a major investment in time from policymakers all around Europe. Following the example of many other countries, the authorities in Belgium decided to produce two policy documents as an input to the preparation. This work was coordinated by the CIS-CFS-commission (see further), which is the body were all authorities in Belgium meet to discuss international science policy issues. The first document was published before the outline of the new framework programme was known, and general principles were formulated on the preferred features of the new programme according to the authorities in Belgium. The second document was published after the Commission issued its first ideas about Horizon 2020, where it was discussed. These documents served as guides in the workshops and conferences that were being organised on the main issues and features of the next framework programme by the presidencies.

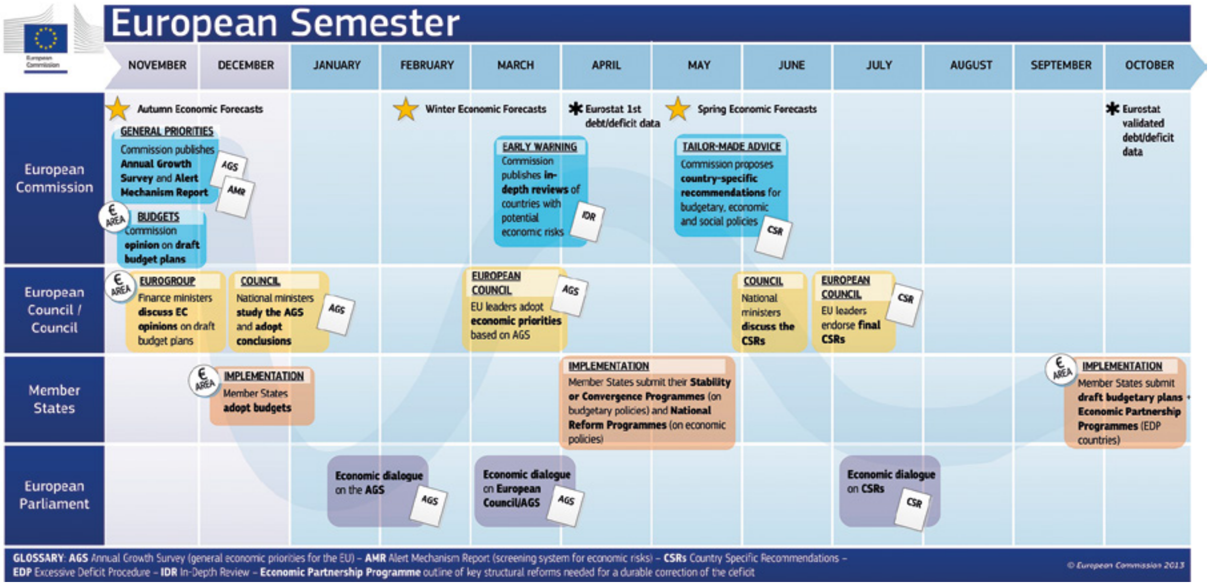
The Innovation Union Flagship

The Innovation Union Flagship was approved by the Competitiveness Council in November 2010 on the basis of a European Commission communication and, since then, it has covered a big part of the research and innovation agenda for all of the Competitiveness Councils that took place afterwards (Council of the European Union, 2010). It is a part of the European 2020 strategy, which covers an action programme in many societal fields: smart growth (digital agenda and innovation flagship), sustainable growth (about resources and industrial policies) and inclusive growth (unemployment and poverty). Head-line indicators were being formulated; on matters of research Member States were being asked to reconfirm the 3%-target (or choose a relevant national target). Belgium did reconfirm the 3%-target, though asking that the tax credits would be taken into account when considering the government effort.

The Innovation Union Flagship identifies a series of weaknesses or bottle-necks in the research and innovation landscapes that should be addressed either by the European Commission or the Member States. However, for some actions both Commission and Member States are responsible for delivering results. These points have been translated later on in a kind of action list for which a detailed roadmap with deadlines was elaborated. In this action list we find the demand for a new innovation headline indicator and a request to consolidate the European single market for research (called ERA, European Research Area); moreover to organise a public consultation regarding this ERA, there is an invitation to assess the performance of the national systems, etc. There are many ideas elaborated in this Flagship, while it also describes the context and identifies the limits of innovation (Council of the European Union, 2010). It underlines the need to use a broad concept of innovation (including technological and non-technological innovation, demand and user-driven innovation, open innovation, eco-innovation, etc.). European innovation partnerships are being proposed for the first time. The need for a European patent is being repeated and so on.

The monitoring of the innovation flagship takes place during what is now called 'the European Semester', which is an annual monitoring cycle involving all European 'Flagships' and not just research and innovation.

FIGURE 10.1 – **Timing of reporting in the European Semester**



Source: European Commission (2013b): http://ec.europa.eu/europe2020/making-it-happen/index_en.htm.

The calendar above describes the general outline for the cycle of all the Europe 2020-strategies and all of the different Flagships. So some of the reporting takes place through general documenting in which research and innovation is one of the issues dealt with. This is the case with the Annual Growth Survey and the National Reform Programmes. The Annual Growth Survey is a policy document from the European Commission, while the National Reform Programme is a country document.

The **Annual Growth Survey** (AGS) is an annual overall assessment of progress at the EU and national levels. It takes stock of the overall macroeconomic situation and progress towards the five EU-wide headline targets as well as the flagship initiatives. The Competitiveness Council usually holds a policy debate on the research and innovation-related issues in the AGS. Most often the European Research and innovation Area Committee (ERAC) – an advisory body to the Commission and Member States on science policy issues – writes down its opinion as an input to this discussion. It deals with the hot research issues and describes some relevant European initiatives. It does not come as a surprise that in the last few years the preservation of the research and innovation budgets was the main item in the AGS and the ERAC opinions. Many Member States witness huge budget deficits and take steps to reduce them. Both the Commission and policy analysts encourage the Member States to safeguard 'future-oriented' investments like research, education, etc. The difficulty in this is exemplified by the data copied from the Eurostat website. In 2011 the European budgets for research and development (R&D) went down. For the European Union of 28 countries the data for the R&D budgets range from 90.0 billion € in 2008 to over 92.4 billion € in 2009; from 92.7 € in 2010 to 91.5 billion in 2011 (Eurostat, 2013). In the case of the Euro area (17 countries) these data are respectively, 70.0 billion € in 2008, 73.3 billion € in 2009, 73.2 billion € in 2010, and 72.1 billion € in 2011 (Eurostat, 2013). The trends offered by the as-of-yet scarce data available for 2012 are not very promising in this respect.

In Belgium, the editing on the writing of the **National Reform Programmes** (NRP) is being coordinated by the Prime Minister's cabinet office. The drafting is subcontracted to the National Bank of Belgium, whereas the Federal Planning Bureau edits the parts on research and innovation. The input comes from the different regions and communities which write their own 'national' reform programmes. The two cited bodies (National Bank and Planning Bureau) are responsible for producing thematic chapters on each issue, thereby aiming at a homogenous treatment of the policy initiatives of each authority. For science policy issues, there is a final reading and debate in the CIS-CFS bodies. But as the Commission guidelines regarding the content of the NRP did not allow for many pages in the core of the text, thus relegating a lot to annexes, the science and innovation policy- related pages in the NRP for Belgium are of a general nature. The main aim of the NRP is to report on the progress of the Europe 2020-Strategy (i.e. the reforms undertaken) and the achievement of the 3%-target. When Country Specific Recommendations (CSR's) are being issued, Member States are also supposed to address them in the NRP's. In 2013 Member States were also asked to document all reforms undertaken to achieve ERA.

The NRP for Belgium dealt with the Belgian position regarding the 3%-target (see chapter 1), the fiscal efforts, and the federal 'recovery plan', and it gave a description of the most recent initiatives of the regional governments. As there are no 'Country Specific Recommendations' (CSRs) in the field of research and innovation, this element is absent in the Belgian report. Twelve Member States did face 'CSRs'. ERAC usually deals with them in specific conferences. These conferences are built around the two or three main themes that are the most frequently addressed in the different CSRs.

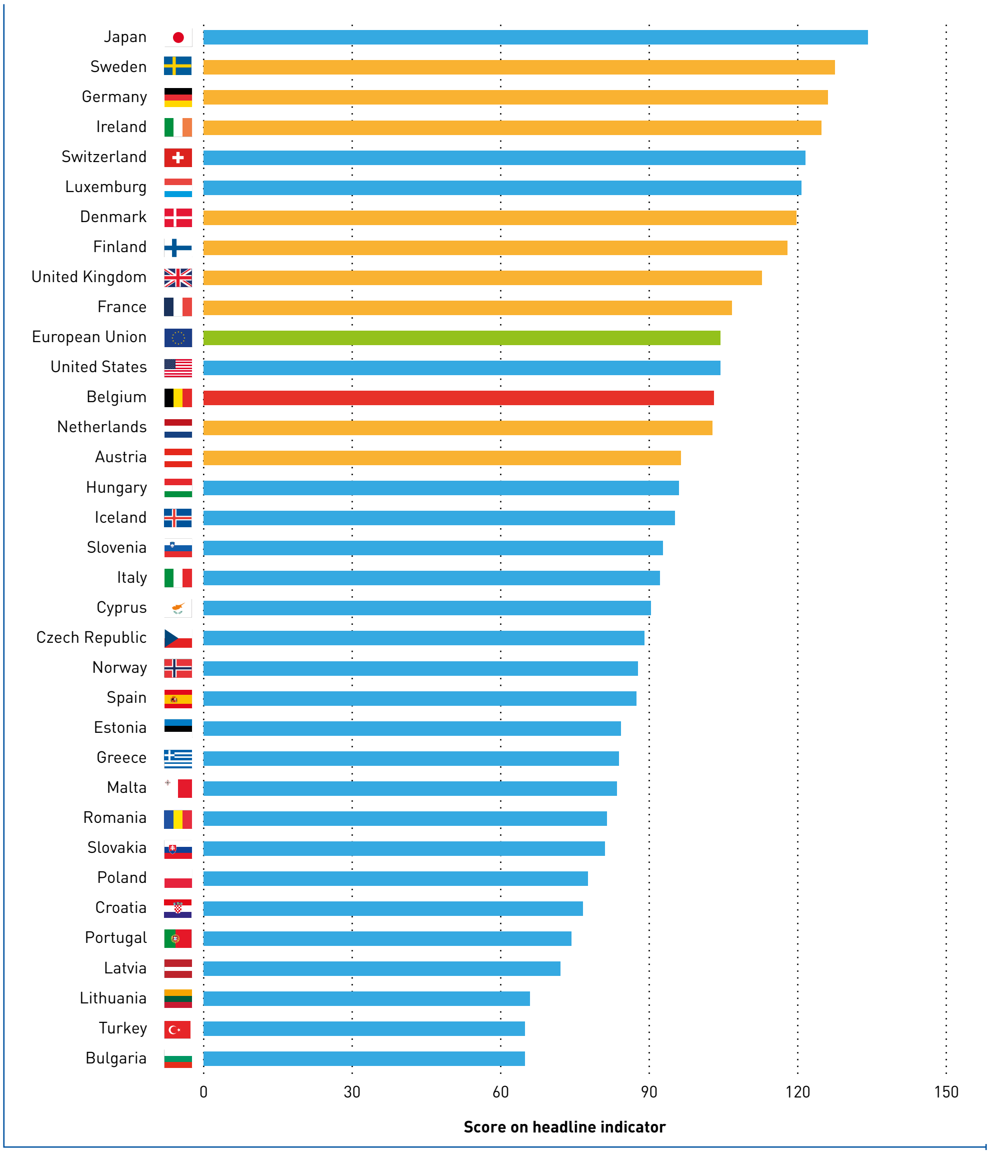
The development of a new **headline indicator** is also one of the proposed actions inside the European Union Flagship. A first proposal has been discussed in a workshop in October 2012, followed by two other workshops in 2013. At the moment, as these pages are written, there seems to be a consensus within the Commission to submit a proposal to the European Council of October 2013. The final reaction of the countries is uncertain, and it is not known whether this new head-line indicator will satisfy the council.

The most recent proposal at the time of writing suggests a composite indicator consisting of four main components, three of them being extracted from the Innovation Union Scoreboard. The Innovation Union Scoreboard is itself a composite indicator with input indicators, process indicators and output indicators. In order to elaborate this index, three of the existing output indicators were selected from the output indicators. The selection was based on analytical reasons and on the availability of data.

The four components of the headline indicator each count for 25% of the total score. These are: (i) PCT: the number of patent applications filed under the PCT (based on the inventor's country of residence) per billion GDP (Euro-based purchasing power parities); (ii) KIA: the number of employed persons in knowledge-intensive activities (KIA) in business industries as a percentage of total employment. KIA are those sectors where at least 33% of employment has a higher education degree; (iii) COMP: is built out of two indicators that each count for 50 %: GOODS = contribution of medium and high-tech products exports to the trade balance; and SERV = knowledge-intensive services exports as % of total service exports; (iv) DYN: shows the innovation dynamism in fast-growing firms in business industries, with the exception of financial services. The formula used is the following: $DYN_C=\Sigma_S^1(CIS^{Score}*KIA^{Score})_s\frac{E_{sC}^{HG}}{E_C^{HG}}$. The term $(CIS^{Score}*KIA^{Score})$ is the innovation coefficient of a sector, calculated at the EU-level. Implicitly, each sector is supposed to have a unique degree of innovativeness all over the EU. The policy level in Belgium questions this because there is no reason to assume that all sectors in Europe have a similar degree of innovativeness. For example, the textile sector in Belgium is most likely more innovative than this sector in less capital and knowledge-intensive European countries. In the second part, *the nominator* represents the sector share of employment in fast-growing enterprises; the denominator represents the total employment in fast-growing enterprises. Both are multiplied by a sector coefficient and added up to yield a number that reflects the innovation dynamism in fast-growing firms.

The ranking of countries according to the new headline indicator is reproduced in Figure 10.2.

FIGURE 10.2 – **Country ranking according to the headline indicator**

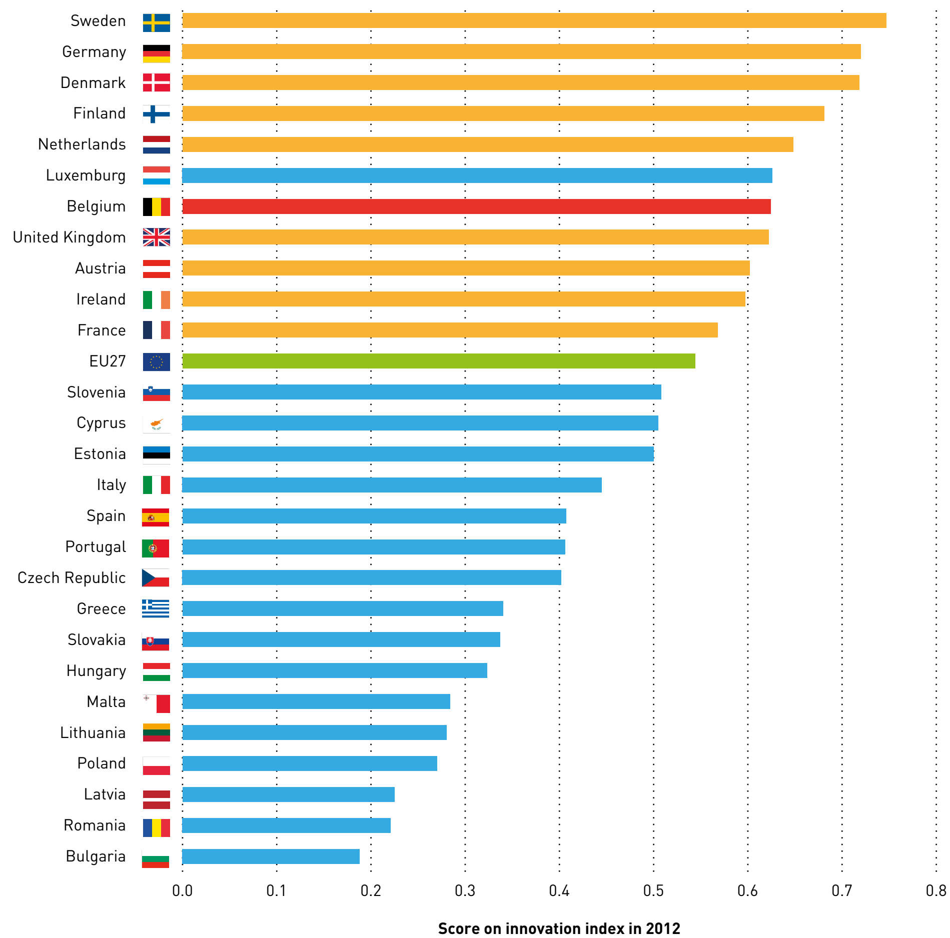


Source: Forthcoming communication by the European Commission (2013c).

Striking and counterintuitive is the place held by the US and Japan in this ranking. One would rather expect their positions to be the other way round with the US leading and Japan in the middle. Japan scores particularly strong on the patent indicator as well as on the GOODS-indicator. Belgium's position is in the middle of this ranking, just below the EU-average. One could cautiously conclude that this lower ranking, compared to the ranking in the Innovation Union Scoreboard (see Figure 10.3), points to a relatively weaker performance of Belgium in the output indicators compared to the other indicators in the Innovation Union Scoreboard (IUS). However, Belgium's position is not bad, as it is surrounded by more or less the same countries as in the IUS. This only demonstrates the fact that these rankings are highly influenced by the choice of indicators and, as we will see below, also on the update of statistics.

The most recent results of the Innovation Union Scoreboard are reproduced in Figure 10.3. In it Belgium is ranked at the seventh position, which raised questions at policy level as to the efficacy of recent measures. The reason for this is that, when comparing the ranking for 2013 with the one for 2012, Belgium falls behind Luxemburg and the Netherlands.

FIGURE 10.3 – **Country ranking according to the Innovation Union Scoreboard**



Source: European Commission (2013d).

Still, the absolute value for Belgium of the composite indicator, on which the ranking is based, did increase. Generally speaking, Belgium has improved its position, but two countries have done so at higher speed. Nevertheless the absolute values for Belgium, Luxemburg, the Netherlands and the UK are so close to each other that the smallest change in an indicator (an update, for example) can set the position of these countries upside down. The general message remains the same. Belgium is not an innovation leader (see chapter 1), but is in the group of innovation followers, still well above the EU-average. This situation differs when based on the new headline indicator we touched upon before.

Progress on the European Research Area

When adopting the Innovation Union Flagship, Member States of the European Union agreed on accomplishing the European Research Area (ERA) by 2014. The following definition of ERA is given in the Communication by the European Commission: '*a unified research area open to the world, based on the Internal Market, in which researchers, scientific knowledge and technology circulate freely and through which the Union and its Member States strengthen their scientific and technological bases, their competitiveness and their capacity to collectively address grand challenges*'. (European Commission, 2012).

The ERA consists of the 27 national research systems of the Member States. The basic idea is that these systems should open up to each other and be more interconnected. This will generate more competition as well as more cooperation, thus increasing the quality of European research through ensuring that the funding goes to the best researchers, compelling the bright minds of Europe to work together.

This is explained in the communication called "A Reinforced European Research Area Partnership for Excellence and Growth" which was published in July 2012. This document suggested developing a strategy around five priorities: (i) more effective national research systems (this refers to increased national competition and greater investments in research); (ii) optimal transnational co-operation and competition (common research agendas and key research infrastructures on a European basis are being promoted); (iii) an open labour market for researchers (researcher mobility, training and attractive careers are the main issues); (iv) gender equality and gender mainstreaming in research; and (v) optimal circulation, access to and transfer of scientific knowledge, including via digital era.

The title of the communication refers to a partnership between Member States, the commission and research stakeholder organisations. The fact that research stakeholders are being mentioned is rather new. For each of the priorities the document proposes a series of reforms and actions to be executed by the three different actors: Member States, Commission, and Stakeholders. Actions to be performed by Member States correspond to a large degree to important features that are already in place in well-functioning science systems. Though it must be noted that some actions demand the stepping up of efforts, or reconfirm engagement and the commitment for the necessary financial and other resources. This is certainly the case for Belgium, where most of the proposed actions are daily practice. However, some actions like the portability of national grants do not fall within the Belgian tradition. Initiatives regarding greater gender equality are not superfluous; the same goes for open access and other suggested actions in the field of circulation of knowledge where efforts might be increased.

Since the ERA is meant to be realised by 2014, the development of a robust 'ERA Monitoring Mechanism' (EMM) is being announced by the Commission. The first step of this monitoring system consists of the calculation of the baseline situation for each of the five priorities mentioned above. A next step consists in measuring 'progress'. As can be imagined, the monitoring will be based on a big set of qualitative and quantitative data which go well beyond traditional statistics. Indeed there are hardly any 'traditional statistics' corresponding to each of the five priorities. The staff working document makes reference to 92 indicators that could be used to allow the monitoring of the process of ERA making. But there is neither agreement on these indicators nor any certainty that these are the optimal ones to measure progress. As a consequence, a big survey was launched by the Commission in 2012 towards research performing and research funding organisations. The aim of the study is to make an inventory of where Europe stands regarding policies and implementation of these policies in the five priority ERA fields.

At the moment this chapter is being written, the first ERA progress report is being published and the debate on the report is just starting. The report lists a number of policy fields where 'progress' regarding ERA making may be achieved, while the staff document paper that accompanies the report describes in some detail the evidence underlying these policy recommendations. It can be expected that the debate in the coming months will focus as much on the policy recommendations as much as on the robustness of the data used. Relevant questions in this context are numerous. Are the data representative? Are the data describing the phenomena that need to be monitored dependable?

Since the ERA is supposed to be 'achieved' in the year 2014, the ERA progress report, the ERA monitoring mechanism, and the policy recommendations in the report will continue to get a lot of attention.

10.3. Policies at federal level in Belgium

Belgium is a federal country, with most of the competencies regarding research and innovation residing at the regional level. Nevertheless there are still fields of competence which are of high relevance that make sure the Belgian innovation system (and their regional sub-systems) does function optimally. Financial regulation (taxes) is the most obvious example, but there are other examples as well: the economics department is responsible for issues such as standardisation, consumer policies, nuclear research etc.; social security is under federal competence, regulation in labour policies as well, etc.

When considering budgets of the different authorities, one will notice that federal budgets have been roughly stable throughout the last years at a high level (around 30 %, see elsewhere for the chapter on GBAORD). However the federal authority launched a very ambitious system of tax credits, lowering the cost of labour and of research investments, as well as lowering taxes on patent incomes. In this chapter we will not mention these tax credits, since they are being discussed elsewhere.

In this section, we will concentrate on three issues of a different nature. The federal government launched a 'recovery programme' meant to support the economic recovery of the country. This plan did entail some (maybe modest) actions in the field of research and innovation. We will also summarize most recent initiatives from the federal science policy department and we will say a few words on the Inter-ministerial Commission for science policy issues (IMCWB-CIMPS) which did receive a new impetus.

The recovery plan

Against the background of a highly difficult budgetary situation, the federal government decided to launch in July 2012 a package of actions supposed to give a new impetus to the economy. The plan was baptised 'recovery programme' (see http://premier.fgov.be/nl/relanceplan for French and Dutch versions). The report recognized that, since budgets were rather scarce, the emphasis should lie on structural reforms, like improving regulations and on the effective functioning of the government rather than on costly measures, of which there are only a limited number. So there are only a limited number of such costly measures. The plan focuses on five topics: the purchasing power of the citizens, employment, competitiveness (especially the SMEs), energy and the markets, and finally research and innovation.

The chapter on research and innovation stresses the importance of these investments for economic growth and welfare for the citizens. The government also reconfirms its ambition to reach the 3%-target launched in Barcelona and recently integrated in the EU 2020-Strategy.

The following actions are part of the 'recovery programme': (i) the tax credits reducing the wage cost for researchers were made more generous. Companies can keep 80 % of the advance tax payments (of the researchers) that they normally have to transfer to the treasury. This is a new increase of 5 %, starting from the summer of 2013. (ii) Revenues from patents are being exempted from taxes at 80 %. And the system has become accessible to all companies since the obligation to have a research centre in the company has been removed. The government hopes that this will help to start companies and SME's in general. (iii) A 'horizontal technology platform' will be created. The name might be slightly ambiguous, but the idea is to create a platform that will unite all expertise available in the country (that is why it is called 'horizontal') regarding strengths and weaknesses of the different sectors and thus contribute to decision making. (iv) Scientific cooperation with BRICS-countries – Brazil, Russia, India, China, and South-Africa – will be intensified. The idea is that enhanced scientific cooperation might also lead to improved trade relations. (v) Creation of a '(bio)pharmaceutical research platform' as well as a 'high level group regarding the chemical sector'.

Besides these, as a general conclusion the federal government speaks in favour of improving the information available regarding the 'scientific visa', and of improved integration of national science actors in the European Strategy Forum on Research Infrastructures (ESFRI). It expresses support for starting a post-master in aeronautics and space in the universities, in cooperation with the federal scientific institutions that are 'space-related'. A double system of monitoring has been developed. On the one hand the Federal Planning Bureau has been assigned with the task of producing reports regarding progress at regular intervals, and integrating official statistics as much as possible. On the other hand the political authority demands regular reporting as well on the progress of each of the above described initiatives.

In the context of this report, the 'horizontal technology platform' should be highlighted. This platform is being set up by Belspo and has four layers, each of them being developed in cooperation with other actors at either the federal level or in cooperation with regional authorities. The first layer consists of a web-based online database. The most important indicators in the field of research and innovation, complemented by a selection of economic indicators will be reproduced. Comparisons with the most important trade partners enable Belgium to be positioned. It is the explicit ambition to integrate the concept of smart specialisation (if possible, since this is still experimental and not always available at all levels of authority). A second layer would consist of a database, an annex publication on all federal instruments, that could be useful in supporting innovation policies in Belgium, at either the federal or regional level. A third layer might consist of building on a micro-linking project started a few years ago with the Central Council for Economy (which is the forum where employers organisations and trade unions meet). The Central Council succeeded in linking tax data at the enterprise level with data on research and innovation, in an anonymized database of course. No confidential data are disclosed. The strength of such a database is that it allows for all kinds of econometric studies on the effects of tax credits versus subsidies. The question is whether or not it is feasible to go forward with such an endeavour, and link other economic micro-data as well. But this is still to be seen. The last layer is the creation of a forum itself, a place where people may meet. By 'people' we mean analysts, civil servants, and representatives of employers and trade union organisations who meet to discuss these different projects and the manner in which they may be pushed forward. The Central Council for Economy might be a good place to start such a dialogue.

Belgian Science Policy Office

The Belgian Science Policy Office (Belspo) deploys too many initiatives to be discussed at this stage. By way of example two case studies are selected to highlight the involvement of the federal administration in the execution of science policy. The first initiative is in the field of space research (ESA); the second is in the field of research programming.

Belspo manages the Belgian participation in the European Space agency (ESA). The European Space Agency is best known for the Ariane missiles that regularly launch commercial or scientific satellites into orbit. But ESA is much more involved in various issues of scientific research, such as earth observation.

Belgium is usually considered as one of the most generous of the small countries when it comes to its financial contribution to those activities. In November of 2012 ESA organised a big ministerial council in Naples that settled a multi-annual work programme and debated a number of crucial strategic issues that will define the course of the next few years. The council updated the ESA-strategy and defined the priorities for the next years. Member States were asked to subscribe to space programmes in the field of earth observation, telecommunication, manned flights, launchers and scientific and technological development. They were asked to determine the level of resources for the period 2013-2017 for the ESA mandatory programmes as well as for the scientific programme; and to cover the funding for the Space Centre in Guyana. There was a debate regarding the future of Ariane 5, which is at the moment considered a very costly launcher. Improved performance and cost effectiveness are of highest importance. Measures had to be taken to improve the effectiveness of ESA, given the difficult economic context. A special issue consisted of clarifying the responsibilities, role and action of the actors of the European space policy, notably the European Union on the one hand and ESA on the other. The European Union has become indeed an important actor, be it through Horizon 2020 or through other instruments. It has developed a presence in fields like the development and operation of Galileo and GMES. It might be an important future actor as well regarding space monitoring or the development of future space infrastructure and the applications for the next generation. Other important issues involved partnerships with the USA (operating the ISS and space exploration in general) or Russia (the 'ExoMars' programme). Of course, Belgium participated in this conference and decided to step up its investment to a budget of around 200 million € per year.

Another initiative of the Belgian Science Policy Office is the launching of the new programme called BRAIN. On 5th October 2012, the Council of Ministers approved the launch on the first phase (2012-2017) of the recurrent Framework Programme for research, BRAIN.be (Belgian Research Action through Interdisciplinary Networks). It is a multi-disciplinary Framework Programme based on open calls, and aiming at the financing of research projects of scientific excellence. It serves to meet the needs for scientific knowledge in the federal administrations and it intends to support the Federal Scientific Institutions. Other objectives are to meet societal needs. In this respect it follows the European example of research in societal challenges. As such it should also contribute in providing support for formulating a Belgian position within various international policy circles. Naturally it also aims at stimulating cooperation within the Belgian scientific community, and provides them with some support that should help them enter international research programmes like Horizon 2020. The Framework Programme is structured around 6 thematic areas: (i) ecosystems, biodiversity, evolution; (ii) geosystems, universe and climate; (iii) cultural, historical and scientific heritage; (iv) federal public strategies; (v) major societal challenges; and (vi) management of collections. BRAIN-be is open to the whole Belgian scientific community: universities, public scientific institutions and non-profit research centres. As mentioned above, open calls will be the main instrument. Two types of research projects will be funded: four-year network projects with the possibility of two-year projects and pioneering projects lasting a maximum of two years. It is expected that a call may take place every year.

The revitalisation of the Inter-Ministerial Commission for Science Policy

The Belgian Science Policy Office (Belspo) runs the secretariat of two commissions where all the different authorities in Belgium (i.e. federal and regional) regularly meet. The Commission on International Collaboration (CIS) makes decisions on international issues, for example deciding on the Belgian position in international meetings. The Commission on Federal Collaboration (CFS) tackles federal issues: for example deciding on how to collect Belgian statistics on the innovation system in a homogenous way. Both commissions have been very active since Belgian science policies have been regionalized, or relegated to the language- based communities in the 1990's. The commissions meet at the administrative level, which means they involve high ranking civil servants from all authorities or they meet at the level of field experts. Factually, these commissions are the executive bodies of the Inter-Ministerial Commission for Science Policy (IMCWB/CIMPS in either Dutch or French). All ministers for science policy of the different authorities in Belgium are members of this Commission. Similar bodies exist for all the other fields of competence (e.g. environment and so on) and there are more or less ten of them. For years the issues discussed in the CIS-CFS commissions were rather of a routine nature, so the IMCWB/CIMPS met at a somewhat irregular frequency and decisions were simply taken whenever called for.

Some years ago, ministers asked the administrative level to organise meetings at a more frequent pace. The different peer reviews of Belgian science policies that have been organised by the CIS-CFS (but made possible by the peer review programme of the European Commission) have already pointed, amongst other issues, to a need for more negotiations and discussions between authorities to improve the presence of Belgium at the European level (see peer review reference: http://www.stis.belspo.be/nl/publications.asp). Other flaws in the Belgian governance system have also been pointed at as well, but the need to ensure that its presence at the European level was not hampered was the trigger to revive the IMCWB/CIMPS.

Since then, the IMCWB has met more often, with an agenda that focuses on three types of issues. In fact a first set of issues deal with the European agenda. The Belgian participation in ESFRI and joint programming have most often been on the agenda: how to deal with these participations when the interest between the different Belgian authorities is not equal, is the basic question. One might be confronted with a situation whereby one Belgian authority is interested in participating (and since the European Commission only accepts 'national' participations, it was decided that this would mean that Belgium as a whole would participate), while researchers from a non-participating authority win an open call for research projects. Who pays for that participation in the open call? This is just one of a set of issues that one can imagine when Belgian governments participate in geometry variable within European activities. Since the deployment of ERA might lead to a multiplication of international governmental cooperation (not always with the Commission involved), the elaboration of some kind of procedures was necessary. And one might say that some solution has been found.

A second set of issues deal with the Belgian agenda. Most innovative in this set is the idea of exploring 'joint programming in Belgium'. If the Belgian authorities start exploring joint programming at a European level, why not then explore the feasibility of such a collaborative scheme within the Belgian context? Some possible avenues have been described in the documents to the IMCWB/CIMPS, but there is at the moment no pilot project for an interregional cooperation. The challenge will be to develop one (or more) pilot project in order to test its feasibility and, more significantly, its added value in the Belgian innovation system. There is certainly an openness towards more interregional cooperation but since there is no tradition, the basic procedures, concepts, and recipes still have to be elaborated. This was also the conclusion of a meeting at the ministerial level between the Walloon and Flemish ministers for science policy that was held in December 2012. The IMCWB/CIMPS was asked to integrate its conclusion in the work programme of CIS-CFS. In addition, 'joint programming in the Belgian context', there were also proposals on the table regarding more and better instruments to monitor the research and innovation system, including STI-policies. The horizontal technology platform was discussed above, but there are also ideas on the table regarding the elaboration of a homogenous classification system, globing all Belgian governments and the projects they finance. The basic question is to simplify data gathering on issues like, for instance, how much do all authorities in Belgium invest in energy research; in health research; in nanotechnologies? These questions are regularly asked by the Commission, the OECD and other international institutions, but most countries (including Belgium) often have difficulties answering them. The third component in this category deals with research programmes/projects that demand, as such, a collaboration agreement. Usually they are taken care of on an ad-hoc basis. Since ministers will meet more often in a revamped IMCWB/CIMPS, this body might well be used.

The third set of issues deal with the improvement of the functioning of the IMCWB/CIMPS and the administrative bodies CIS-CFS. The collaboration agreement was revised and refreshed. After twenty years of being in practice, it needed a revision.

One may only conclude that there is a whole set of new issues on the agenda. Now the challenge will be to live up to these new expectations and deliver. Some of the projects on the table are quite ambitious and probably not all of them will be as successful as others. In general, the governance of the innovation system in Belgium has reached a level of maturity that allows tackling the imperfections of a highly decentralised system. This is especially relevant in a European context that basically remains designed to work with national levels, even though the European Commission starts to recognize the existence of regional policy levels.

10.4. Conclusion

The aim of this chapter was to demonstrate that in Belgium three different levels of policy operate, all shaping the landscape. When analysing the data on the innovation system in Belgium, presented in this document, the analyst will have a tough job attributing the successes or failures of the (local, regional or national) innovation system to a predefined set of policies, be they regional (which most are), federal (like the tax credits) or European (like Horizon 2020, the ERA making and the Innovation Union Flagship).

In this chapter we illustrated that the main policy players who determine the landscape are becoming increasingly active. And one has to acknowledge that the private sector might follow other logics, mind frames and modes of operation (the global value chains, the multinational context, etc.) which go beyond what governments can influence.

If one is to draw just one conclusion regarding science policy in the Belgian context, than the following is the most important: science policy is firmly on the agenda. They suffer less from budget cuts than other competency fields. And in the Belgian context they even succeed in attracting additional resources through tax credits. This mirrors the case in Europe, where Horizon 2020 is bigger than previous Framework Programmes, and is surrounded by lots of other initiatives that multiply the resources.

The main question will be whether or not these policies with increased budgets will succeed in delivering in terms of innovativeness in the Belgian economy, in the short run, and in terms of economic growth and welfare, in the long run.

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