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RIO COUNTRY REPORT 2015: Luxembourg

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Abstract
The 2015 series of RIO Country Reports analyse and assess the policy and the national research and innovation system developments in relation to national policy priorities and the EU policy agenda with special focus on ERA and Innovation Union. The executive summaries of these reports put forward the main challenges of the research and innovation systems.

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Foreword

The report offers an analysis of the R&I system in Luxembourg for 2015, including relevant policies and funding, with particular focus on topics critical for EU policies. The report identifies the main challenges of the research and innovation system of Luxembourg and assesses the policy response. It was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites etc. The quantitative data is, whenever possible, comparable across all EU Member State reports. Unless specifically referenced, all data used in this report are based on Eurostat statistics available in February 2016.

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Executive summary

The report was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites, etc. The quantitative and qualitative data is, whenever possible, comparable across all EU Member State reports.

The RIO Country Report 2015 is intended to provide an up-to-date overview of Luxembourg's R&I system. It describes and assesses policies and issues central to the European Research Area and the Innovation Union.

Context

Luxembourg is a small open economy of about half a million inhabitants with one of the world's largest GDP per capita of 67 900 (2013) (the EU28 average being 25 700 (2013)). The financial sector has been the main engine of economic growth in the past three decades. Luxembourg's banking sector accounts for roughly one-quarter of GDP and is the largest in the European Union. In recent years Luxembourg has faced the major strategic task of diversifying its economy, that is, reducing, over time, the heavy reliance of the economy on the financial sector and developing new high value-added economic activities in non-financial services and manufacturing industries.

Luxembourg's national research system is small and very young – the oldest public research institutions were established in the late 1980's and the only university was launched as recently as 2003. Consequently, the national research system is still developing absorptive capacity and the preponderance of research has historically been undertaken by the private sector. Also because of its small size—Luxembourg is its own NUTS2 region—the research system is centralised. It is characterised by multi-annual planning and thematic research funding. Luxembourg benefits from large inflows of foreign researchers. In the area of public R&D, 82% of researchers are non-nationals, hailing predominantly from neighbouring countries.

Despite its wealth, Luxembourg's gross domestic expenditure on R&D (GERD) has declined from 1.71% of GDP in 2009 to 1.31% in 2013 and 1.24% in 2014. While the public sector share of GERD represented 0.62% of GDP in 2013 and 0.59% in 2014, the private sector expenditure on R&D (BERD) has dropped from 1.3% in 2009 to 0.65% in 2014. The numbers mean that Luxembourg is unlikely to meet its R&D intensity target for 2020 of 2.3% - 2.6%. The number of researchers employed in the business sector also dropped during this period: from 1 518 in 2011 to 927 in 2012.

Public finances in Luxemburg have been rather sound, the budget is in surplus both nominally and structurally. Moreover, in the last 4-5 years the structural budget surplus has never fallen under the country's medium-term objective. Therefore it is hard to speak about a post-crisis fiscal consolidation per se. In 2010-2014 there was a positive (and almost linear) correlation between the structural balance and the government budget appropriations for R&D (GBAORD): improvements in the structural balance went hand-in-hand with increases in the governmental R&D appropriations. The government financed GERD has never fallen back to its pre-crisis or crisis level neither in euros, nor in relative terms. Therefore it can be concluded that the post-crisis fiscal adjustments have not come at the expense of the public R&D expenditures in Luxembourg.

Key developments in the R&I system in 2015 included:

- merger of PRCs Gabriel Lippmann and Henri Tudor to form the Luxembourg Institute of Science and Technology (LIST);
- re-branding of PRC Santé to the Luxembourg Institute of Health (LIH) and CEPS/Instead to Luxembourg Institute for Socio-Economic Research (LISER);
- new research funding programme KITS (Knowledge and Innovation Transfer Support) as part of emphasis on valorisation of research projects;

- NASA-ARC (earmarked AFR PhD and postdoc grants for research undertaken at NASA-ARC) and PRIDE (Research-Intensive Doctoral Education) Reform of the AFR PhD funding programme under law of 27 August 2014;
- relocation of the NRF, Luxinnovation and LIST to the City of Sciences in Esch Belval.

The identified challenges for Luxembourg's R&I system are:

1) Consolidating the research and innovation system and meeting R&D intensity targets
2) Addressing gender gaps among researchers
3) Promoting culture of entrepreneurship

R&I Challenges

Challenge 1: Consolidating the research and innovation system and meeting R&D intensity targets

Description

The diversification of Luxembourg's economy, which is an overarching objective of its development, is related to fostering the research and innovation system. In view of the economy's heavy reliance on the financial sector, alternative sources of growth with a particular focus on sectors showing a high gross value added potential are needed. Such sectors tend to be technology and knowledge intensive. However, private investment in Research and Development (R&D) remains relatively low in Luxembourg, although progress towards a more diversified, knowledge-intensive economy represents a political priority. Indeed, the fivefold increase of public sector R&D intensity since 2000 (from 0.12% in 2000 to 0.59% in 2014) reflects the authorities' resolve to build up public research capacities, but Luxembourg is not on track to reach its R&D intensity target of 2.3-2.6% of GDP by 2020. R&D intensity was at 1.24% in 2014, a relatively low level compared with the EU average (2.09%). This is due to the sharp drop in business investment from 1.5% of GDP in 2000 to 0.65% in 2014. (European Commission, 2016)

Policy response

Following the 2013 decision of the government to strengthen the country's policy on innovative clusters, two laws reforming some components of the Luxembourg's R&I system were adopted in 2014. The first law aims to consolidate public research organisations, in particular through the merger of the Tudor and Lippmann Public Research Centres. The build-up of public research capacities has not always been based on a sufficiently thorough assessment of the potential for the development of related economic activities in Luxembourg. Nevertheless, the merger of the Tudor and Lippmann Public Research Centres will help to a certain extent to build critical mass in areas with major prospects for cooperation with Luxembourg's industry, such as materials and sustainable development, with some less promising research subjects being discontinued.

The second law aims to reform the National Research Fund, which allocates funds on a competitive basis. The Fund's reform will enable better valorisation of research results, notably through enabling actions to support 'proof-of-concept' and the reform of the Fund's researchers training scheme will foster inter-sectoral (public/private) mobility.

Measures in place to encourage increases in BERD include the Law of 5 June 2009 for private sector research subsidies and the IP Law of 2008. Luxinnovation promotes private sector R&D through the Cluster initiative, Business Meets Research days and identifying other funding opportunities for businesses.

Assessment

Positive signs in the R&I system development include the reinforcement of the country’s policy on clusters and the reforms of the public research organisations and of the National Research Fund, although their scope is limited. While the initiatives undertaken

could provide an opportunity to foster a more coherent development of the research system, it is essential that the initiatives are steered through a governance system that is able fully to integrate the economic dimension and to ensure that research plays the expected role in promoting innovation-led growth.

Challenge 2: Addressing gender gaps among researchers

Description

With a low share of female researchers in its research and innovation system, Luxembourg lags behind other advanced economies with respect to gender parity in science and research. Just 24% of the researchers in Luxembourg are women, one of the lowest levels in the OECD countries. In the business sector, the share of female researchers is the lowest within the comparator group of countries – down from 14.2% in 2003 to 11.4% in 2011 – compared with a share of over 25% in countries such as Singapore, Iceland, Sweden, Slovenia, Denmark and Belgium. The situation is better in the Public Research Organisations (36%) and the University of Luxembourg (39%). Luxembourg's industrial and research specialisation partly explains the low levels of female researchers: many of the industries and research fields that are prominent in Luxembourg tend to have low numbers of female researchers in all countries. The scope for redressing the gender balance might therefore be limited, though Luxembourg could still do better than it currently does. (OECD, 2015)

Policy response

The law dated 27 August 2014 amending the law dated 31 May 1999 creating a National Research Fund for the public sector and the law dated 3 December 2014 to organise public research centres stipulate that proportions of administrative and scientific board members of each gender may not be lower than 40%. (Government of Luxembourg, 2015)

Assessment

Except for the requirement that boards include at least 40% of the under-represented sex by 2017, the government has no measures to redress the gender imbalance. While the NRF "encourages" proposal submitters to take gender into consideration, the results indicate the request is toothless. Note that the AFR PhD programme is gender-balanced. Performance contract targets are one obvious means of addressing this issue, as noted in the OECD review (OECD, 2015)

Challenge 3: Promoting culture of entrepreneurship

Description

Identified also previously as a challenge, the culture of entrepreneurship still needs promoting in Luxembourg.

While the creation of spin-offs using IP from research activities are included in several PRO performance contracts, the number achieved in the period 2011-2013 was four, with a goal set for the same period of six. The target for the period 2014-2017 is ten spin-offs. It should also be noted that although the law of 5 June 2009 has special provisions for SMEs, there are no specific policies, laws or incentives for entrepreneurs or start-ups.

Insolvency regulations in Luxemburg are draconian: an entrepreneur whose company fails cannot start a new business for eight years, effectively neutering any learning from the failure and stifling "serial entrepreneurship." In addition, bankruptcy proceedings can be lengthy. In certain circumstances, the entrepreneur may be personally liable for the company's debts. Insolvency regulations are one of the few areas of the Small Business Act (Commission of the European Communities, 2008) that Luxembourg fails to address.

In 2012, the European Commission carried out a survey on attitudes to entrepreneurship. Respondents from all EU Member States were polled, as well as individuals from 12 countries outside of the EU, including Brazil, Russia, the US and China. The study shows changes from 2009 to 2012, although the work does not explore the impact the financial crisis might have had on attitudes. When asked to indicate the two risks of which they would be most afraid if they started a business, Luxembourg respondents indicated that fear of bankruptcy and loss of property were their biggest fears.

In the same survey a factor explored was preference for working as an employee or self-employed. 61% of Luxembourg respondents preferred employment, while 38% preferred self-employment. When queried as to whether self-employment would be feasible within five years, 62% of Luxembourgers said it would not be feasible, while 36% said it would be feasible. Reasons for why self-employment was not feasible were lack of capital or financial resources (16%), the economic climate (6%), lack of skills (20%), lack of a business idea (17%), family commitments (15%), consequences of failure (5%) and red tape (1%). However, the most common reason given was an unspecified "other" (50%). 65% of Luxembourg respondents said that self-employment would be undesirable in the next five years. In response to the question "Have you ever started a business, taken over a business or are you taking steps to start one?" only 17% of Luxembourgers responded in the positive, with 83% responding "No."[1] This makes Luxembourg the third least entrepreneurial country in the EU except for France (16%) and Belgium (15%) and on a par with Japan, the least entrepreneurial third country polled. (Alexander, 2015)

Policy response

There are a number of structures in place to support entrepreneurship which include a Master in Entrepreneurship and Innovation; Innovation Master Classes, Luxinnovation, business incubators (Technoport, FutureLab, Nyuko), the Chamber of Commerce's Espace Entreprises, the IP Law of 2008, performance contracts that mandate spin-offs and an active business angel network.

In the direction of supporting young innovative Small and Medium Enterprises (SMEs), the '*Société Nationale de Crédit et d'Investissement*' (SNCI) introduced in October 2014 three new types of loan facilities to businesses including two schemes designed to support young innovative SMEs.

Assessment

Despite a range of measures that offer support for entrepreneurs, company start-up costs are high and funding and capital are scarce, especially for non-high tech ventures. There are no indirect funding measures such as tax incentives or credits. According to the promoters of the "111 company" initiative—"One person, one day, one euro" —the rigidity of the existing system hinders those willing to combine creativity, innovation, hard work, risk taking and optimism to create their "own job, their own revenue and their own contribution to society." The project aspires to create a new, simplified, fast to set up and low cost type of companies that can help in fostering the entrepreneurship spirit and in making Luxembourg 'the place to be' for start-ups and entrepreneurs.[2]

[1] Luxembourg's 17% is an improvement over 2009, when only 13% responded positively.

[2] http://www.change.org/en-GB/petitions/etienne-schneider-launch-the-111-company-simplified-s%C3%A0rl-and-make-luxembourg-the-place-to-be-for-start-ups-and-entrepreneurs (accessed 10 November 2015)

1. Overview of the R&I system

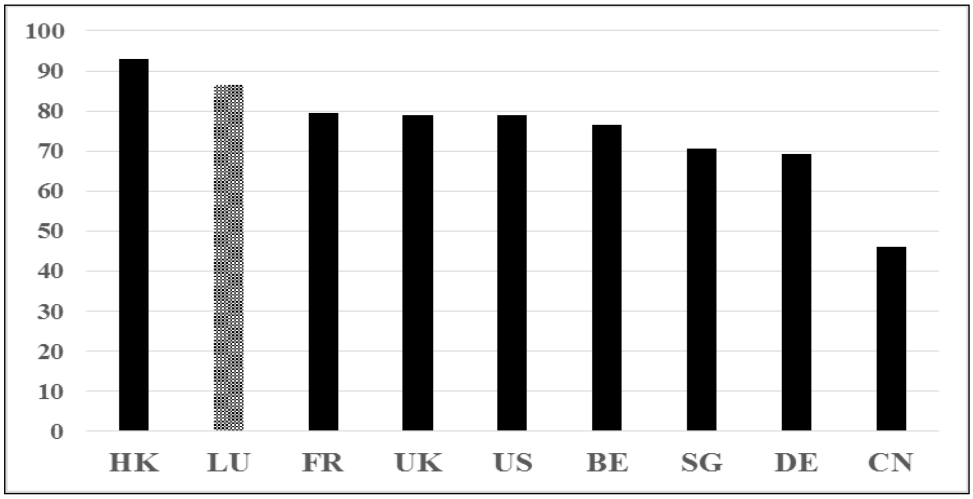
1.1 Introduction

The Grand Duchy of Luxembourg is the second smallest EU Member State with a total area of 2,586 km^2.[3] Of its population of approximately 563,000, 258,700, or 46%, are foreigners.[4] In 4Q2014, Luxembourg had a workforce of 375,264. Of these, 105,816 were Luxembourg nationals, 91,391 were residents from EU Member States and 11,860 were residents from non-EU countries. In addition, every day an additional 166,197 people crossed national borders to work in Luxembourg. This figure represents 44.3% of the workforce. Called "frontaliers," 41,541 were from Belgium 41,090 were from Germany and 83,567, or 50.3%, were from France.[5] These figures are reflected in the composition of Luxembourg's researchers and are discussed further in Section 4.4.

Luxembourg is a wealthy country—by far the wealthiest in the EU in terms of GDP per capita. In 2014, it also experienced a healthy GDP growth rate of +5.5%, compared to +1.3% in Belgium, +0.2% in France, +1.6% in Germany and an EU average of +1.4%.[6] This robust economic performance is reflected in a budget surplus of +0.6% as a percentage of GDP. [7] On the other hand, despite positive GDP performance, unemployment has increased from 4.9% in 2009 to 6.1% in 2014.

Luxembourg's is a services economy, with the services sector contributing more than 86% to GDP. The chart in Figure 1 below compares Luxembourg to other "Service Economy" nations. At 93%, only Hong Kong is higher.

Figure 1: Contributions of the services sector to GDP, 2013 est.



Luxembourg's transition from an industrial to a service economy occurred after the collapse of the steel industry in the 1970's. The figures below show the evolution from 1970 to 2007 (AMCHAM Luxembourg, 2009). Industry has shrunk from 47% to 9.3% of added-value, while agriculture, formerly 4% of the economy, is a negligible 0.4%.

[3] Malta is the smallest.
[4] Figures as of 1 January 2015. Retrieved 10 October 2015 from http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=384&IF_Language=eng&MainTheme=2&FldrName=1&RFPath=71
[5] Retrieved 9 October 2015 from http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=7252&IF_Language=fra&MainTheme=2&FldrName=3&RFPath=92
[6] Retreieved 10 October 2015 from http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tec00115&plugin=1
[7] Retrieved 10 October 2015 from http://appsso.eurostat.ec.europa.eu/nui/show.do

Figure 2: Luxembourg Economy 1970. % gross added-value by sector

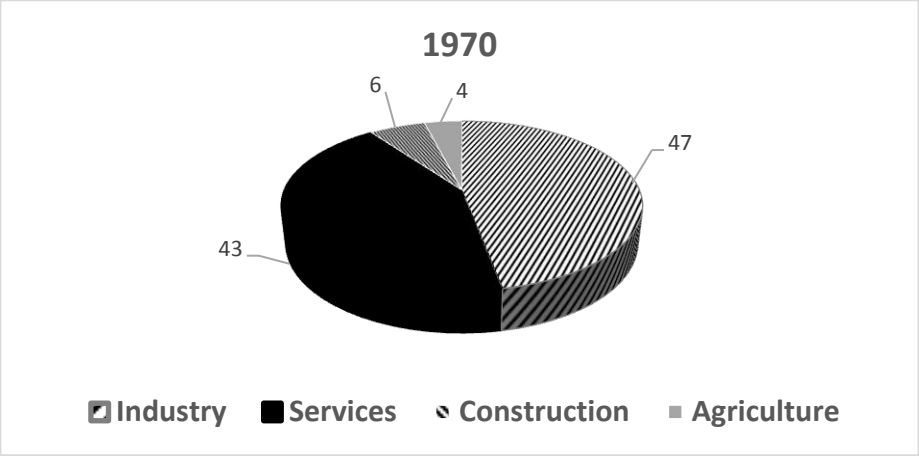
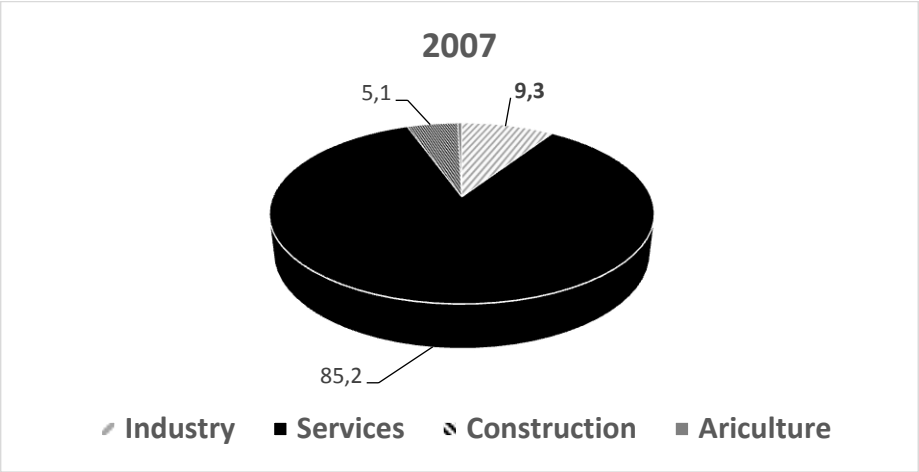


Figure 3: Luxembourg Economy 2007. % gross added-value



Because of the dominance of the services sector, and in particular financial services, diversification is a central concern of both the government of Luxembourg and the European Commission and is the reason "Industry" is indicated as part of Luxembourg's Smart Specialisation Strategy, which is further discussed in Section 2.4.

The government has set a national objective for R&D intensity of between 2.3% and 2.6% of GDP, of which 0.7% to 0.9% comes from the public sector, as of 2020. However, the table below indicates that 2.3% may be difficult to attain, primarily due to decreasing levels of BERD.

Table 1: GERD and BERD

	2009	**2010**	**2011**	**2012**	**2013**	**2014**
GERD	1.71	1.53	1.5	1.29	1.31	1.24
BERD	1.3	1.01	0.99	0.71	0.69	0.65

The event in Luxembourg which might have had a substantial impact on the research and innovation system was an early election was held on 20 October 2013. The election resulted in the formation of a new government based on a coalition comprised of the Liberal Democrats (DP), Socialists (LSAP) and the Greens. The Prime Minister is the DP's Xavier Bettel and the Deputy Prime Minister and Minister of the Economy (ME) remained Socialist Etienne Schneider. The Minister of Higher Education and Research (MESR), who is also the Minister of National Education and Youth, is DP Claude Meisch. Meisch was the third Minister of Higher Education and Research in 2013. He succeeded CSV Minister

Martine Hansen, who had replaced François Biltgen, who was also a member of the CSV. However, despite the new government, policies and programmes have essentially remained in place.

Table 2: Main R&I indicators 2012-2014

Indicator	2012	2013	2014	EU average
GDP per capita	€82,000	€85,300	€87,600	€27,400
GDP growth rate	-0.7	4.4	4.1	1.3
Budget deficit as % of public budget	0.2	0.7	1.4	-3.0
Government debt as % of GDP	22.1	23.4	23.0	86.8
Unemployment rate as percentage of the labour force	5.1	5.9	6.0	10.2
GERD in €m	561.4	605.7	614.2	10107.46 (Total for EU28)
GERD as % of the GDP	1.29	1.31	1.24	2.09
GERD (EUR per capita)	1069.6	1127.9	1117.4	558.4
Employment in high- and medium-high-technology manufacturing sectors as share of total employment	0.9	0.8	1.3	5.7
Employment in knowledge-intensive service sectors as share of total employment	56.6	57.8	58.1	39.8
Turnover from innovation as % of total turnover	7.9	-	-	11.9
Value added of manufacturing as share of total value added[8]	12.5	12.1	-	26.2 (2012)
Value added of high tech manufacturing as share of total value added	-	-	-	-

1.2 Structure of the national research and innovation system and its governance

1.2.1 Main features of the R&I system

Luxembourg's R&I system is centralised and well-defined. It enjoys multi-annual planning and funding. The public research system is also young--the University of Luxembourg was established as recently as 2003. While the private sector has traditionally undertaken the lion's share of research, in recent years BERD has declined

[8] Manufacturing, value added (current US$) retrieved 10 October, 2015 from http://data.worldbank.org/indicator/NV.IND.MANF.CD/countries/EU?display=default and gross value added at factor cost (current US$) retrieved 10 October, 2015 from http://data.worldbank.org/indicator/NY.GDP.FCST.CD/countries/1W?display=default

dramatically for reasons that are not clear. Luxembourg is its own NUT2 region and thus policies are national.

1.2.2 Governance

The governance of Luxembourg's national research system is simple and straightforward. In spite of the change of government it has remained consistent and coherent. In addition to the Parliamentary Commission of Higher Education, Research, Media, Communication and Space (Commission de l'Enseignement supérieur, de la Recherche, des Médias, des Communications et de l'Espace), there is the High Committee for Research and Innovation (Comité Supérieur de la Recherche et de l'Innovation), which has as its objective ensuring consistency and coherence in RDI policy. Established in 2008, its co-chairs are the Ministers of the Economy and of Higher Education and Research.[9]

The Ministry of Higher Education and Research (MESR) is in charge of all public research performers and implements policy. The primary public research funding agency, the National Research Fund (NRF) is also overseen by the MESR. Founded in 1999, the NRF administers funding for public sector research programmes as well as the national funding programme for doctorate and post-doctorate studies, Aid for Research Training (AFR).

The Ministry of the Economy (Ecomin) manages private sector research programmes under the law of 5 June 2009. Its Directorate of Research, Intellectual Property and New Technology specifically deals with private sector RDI. Bridging the private and public sectors is the national agency Luxinnovation. Established in 1984, Luxinnovation works with companies on identifying sources of funding, managing innovation and intellectual property, promoting possibilities for public-private partnerships (PPPs), organising sectorial clusters and assisting firms with EU and ESA project participation. In 2014, Luxinnovation also began to work with the NRF to identify the potential for the valorisation of the projects it funds.

The NFR has a Scientific Council that advises the Board on all scientific questions and prepares and supervises the scientific evaluation process. The University also has a Scientific Consultation Committee comprised of foreign academics.

The NRF undertook a Foresight Exercise in 2006-2007 to review its CORE funding programme. Proposals are reviewed by international experts. In 2010, the NRF underwent an evaluation that included all funding instruments.

Note that there have been no attempts to macro-economically model R&I impact. Luxembourg's economy derives 86% from the services sector and 38% of GDP comes from financial services. Growth of the contributions of other sectors to GDP that the government supports, such as biomedical and health sciences, would be one indicator of R&I impact. In Luxembourg 2020 (Government of Luxembourg, 2014) the government states that "In general, the performance of non-financial services in the current account balance, which is both largely positive and features significant evolution over recent years, indicates a genuine degree of success of the multi-specialisation strategy." However, specific figures are not available.

1.2.3 Research performers

Public Sector Research Performers

Luxembourg has four chief public sector research performers. They are the University of Luxembourg and three public research organisations (PROs) which are the Luxembourg Institute of Science and Technology (LIST), the Luxembourg Institute of Health (LIH)

[9] The OECD's 2015 evaluation of Luxembourg's innovation system remarks that the committee is not notably active (OECD, 2015).

and the Luxembourg Institute of Socio-Economic Research (LISER). In addition, Statec, the national statistical agency, also undertakes research studies.

The Luxembourg Institute of Science and Technology (LIST) was formed from the merger of Public Research Centres (PRCs) Gabriel Lippmann and Henri Tudor at the beginning of 2015. The new entity has been harmonised and streamlined and has three departments: Materials; Environment; ITC. LIH was formerly PRC Santé while CPS/Instead was rebranded as LISER.

Because of the youth of the University, most public research is still performed by LIST, LIH and LISER. In 2013, research performed by HEIs was 0.18% of GDP, vs 0.27% by GOV and 0.71% by VES.

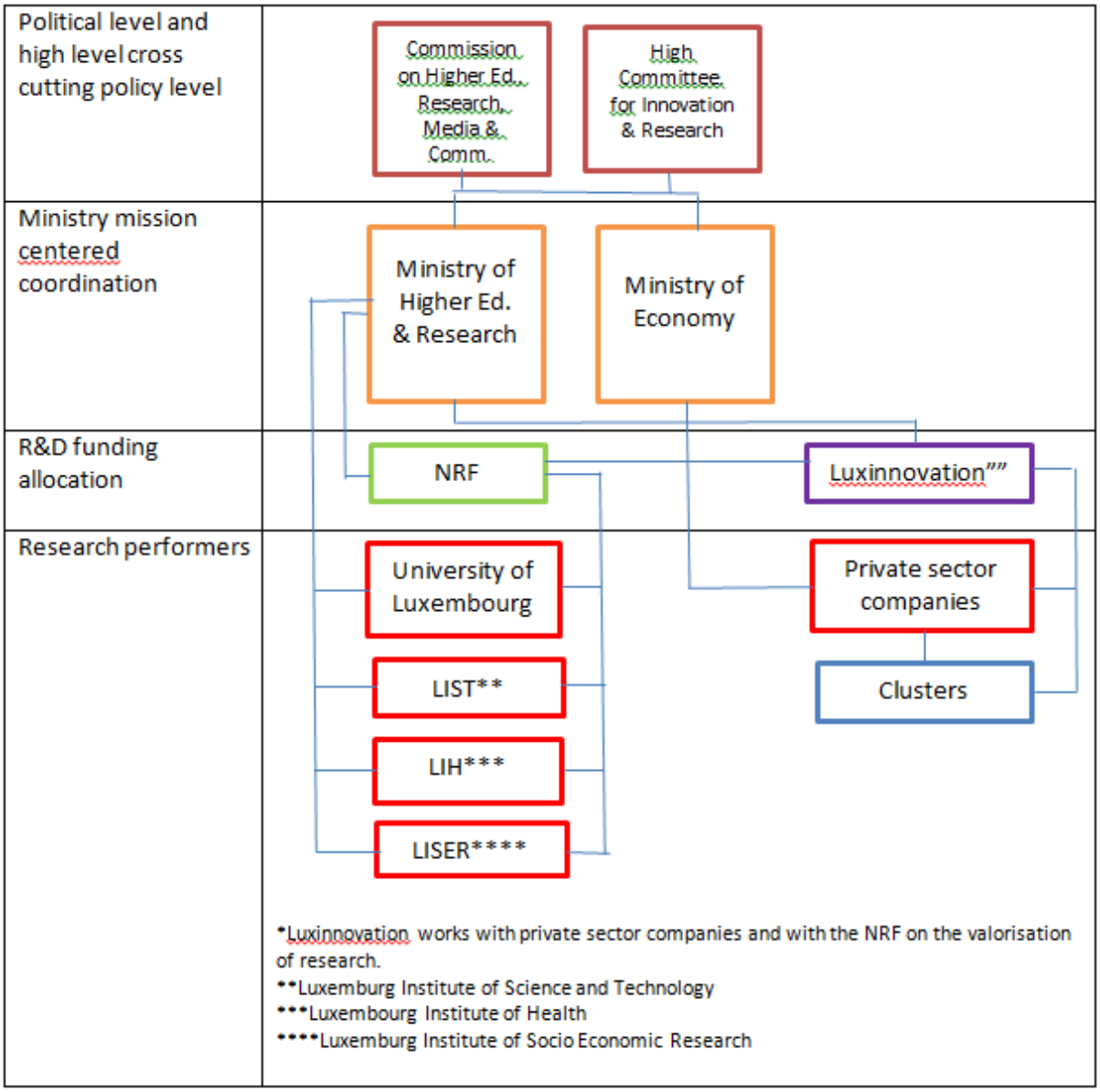
Private Sector Research Performers

There are no national statistics on private sector research performers. The EU Industrial R&D Investment Scoreboard provides a ranking of the EU's top 1,000 research performers. However, it is noted that, except for ArcelorMittal, the companies listed are headquartered in Luxembourg for fiscal purposes and the actual research is performed elsewhere.

Table 3: The EU 2014 Industrial R&D Investment Scoreboard's ranking of the EU's top 1000 research performing companies lists

EU rank	Name	Industrial sector (ICB-3D)	R&D 2013 (€million)	R&D 1-year growth (%)
125	ARCELORMITTAL	Industrial Metals & Mining	195.8	-5.3
265	TENARIS	Oil Equipment, Services & Distribution	76.6	27.2
539	STABILUS	General Industrials	22.6	18.4
583	3W POWER	Alternative Energy	18.3	10.5
613	SAF-HOLLAND	Industrial Engineering	16.4	0.5
617	SAMSONITE	Household Goods & Home Construction	16.2	53.2
652	APERAM	Industrial Metals & Mining	14.5	0.0
688	ORIFLAME COSMETICS	Personal Goods	12.9	1.7
726	SUBSEA 7	Industrial Engineering	11.7	-7.5
787	L'OCCITANE	Personal Goods	9.9	21.3
799	SANITEC	Construction & Materials	9.6	15.7
809	ESPIRITO SANTO FINANCIAL	Banks	9.4	8.9
834	EXCEET GROUP	Financial Services	8.7	2.4
933	UNITED BISCUITS	Food Producers	6.6	1.9
980	TERNIUM	Industrial Metals & Mining	5.5	-13.6

Diagram of Luxembourg's Research and Innovation System



2. Recent Developments in Research and Innovation Policy and systems

2.1 National R&I strategy

Despite the change in government, Luxembourg's R&I structure has remained stable and well-coordinated policies remain in place. Luxembourg employs multi-annual planning supported by accompanying budgets and performance contracts. The current planning period runs from 2014-2017.

Because of Luxembourg's small size, the R&I structure is straightforward and well-defined. It covers the public sector, under the MESR, and the private sector, under the Ecomin.

Also because of Luxembourg's small size and the relative youth of its research system, programmes tend to be thematic, as evidenced by CORE, the main public research funding programme.

Many current R&I strategies and policies derive from a study by the OECD sponsored by the government in 2006 and a Foresight Study of its National Research Fund (NRF) and its programmes in 2006-2007. The former recommended all public research organisations (PROs) establish performance contracts with the MESR, that they stress the exploitation of research results and that they encourage the formation of public-private partnerships (PPPs) and other competitive sources of funding. The Foresight Study identified the research themes which form the basis of the NRF's aptly named CORE programme. Thematic domains generally reflect EU priorities. The INTER programme supports cross-border cooperation, while performance contract requirements for competitive funding encourage participation in EU instruments. Note that Luxembourg does not have a national R&I policy document. However, policies and strategies relating to R&I are well-defined in Luxembourg's annual plan Luxembourg 2020 (Government of Luxembourg, 2015).

In 2013 the government commissioned a new, independent study of the national research and innovation (R&I) system to evaluate the level and degree of quality of the implementation of the OECD report recommendations. The report -- OECD Reviews of Innovation Policy: Luxembourg 2015 - was released late in 2015. One of its main observations was that Luxembourg does not have a specific national strategy for R&I and recommended that one that would cover a period of five to ten years be developed (OECD, 2015).

2.2 R&I policy initiatives

In April 2012, legislation modifying the law of 31 May 1999 relating to the NRF was submitted to Parliament. One of the more important changes proposed was the possibility of opening funding not only to public institutions but also to non-profit organisations and foundations undertaking research activities. In December 2012, new legislation concerning the public research centres was also submitted. Provisions in the law cover the mission and organisational basis of the research centres, propose the integration of the Integrated BioBank of Luxembourg (IBBL) with PRC Santé and the merger of PRCs Gabriel Lippmann and Henri Tudor into LIST (Luxembourg Institute of Science and Technology). The laws were finally ratified in late 2014. The legislation relating to the NRF became the law of 27 August 2014[10] and the legislation merging PRCs Henri Tudor and Gabriel Lippmann became the law of 3 December 2014.[11]

[10] http://www.legilux.public.lu/leg/a/archives/2014/0170/a170.pdf
[11] http://www.legilux.public.lu/leg/a/archives/2014/0260/a260.pdf

The OPEN programme, launched in 2013 to fund the work of senior researchers outside of the themes defined by the CORE programme, had a budget of €1m in 2014 and awarded two grants. However, on the basis of the new NRF performance contract, the programme will be discontinued as of 2015.

In September 2014, the NRF and Luxinnovation, the national agency for innovation and research, signed a collaboration agreement for 2014-2017. The agreement covers the fostering of public-private partnerships, the exploitation of research funded by the NRF, and the support of both private and public sector participation in European programmes including ERA-NETs, Horizon 2020, AAL and Eurostars.[12] A new, related programme is Proof of Concept that is intended to support the commercialisation of selected research projects. The programme is open to the domains Biomedical Sciences, Advanced Materials, Engineering, and ICT, with a particular emphasis on ICT. A new programme launched in 2015 that further supports knowledge transfer is KITS—Knowledge and Innovation Transfer Support--that supports PROs in attracting and integrating professionals in the area of knowledge transfer.

For more than a decade, Luxembourg has been undertaking a massive research infrastructure project called The City of the Sciences. The project, with a budget approaching €1 billion, is designed to provide facilities for the University of Luxembourg and PROs LISER and LIST. It also includes a business incubator, laboratories for public-private partnerships and the Luxembourg Centre for Systems Biology. During 2015, the NRF, Luxinnovation and LIST moved into their new facilities there. The 2015 OECD review recommends that Luxembourg give this infrastructure project greater international visibility (OECD, 2015).

Research programme budget commitments for 2014-2017 are mostly known. The total NRF budget for the period is €232m. This breaks down into €10m for the ATTRACT programme that seeks to bring outstanding young researchers to Luxembourg, €25m for the PEARL programme which also seeks to bring outstanding senior researchers to Luxembourg to undertake a project and develop a project team, and €18m for the INTER programme that funds Luxembourg researcher participation in international projects. The budget for the CORE programme for 2014-2017 is €70m. Note that programme funding is budgeted for the entire period, in this case 2014-2017, and not broken down by year. Consequently, in some years fewer proposals may be funded and, in some, more, depending on the quality of the proposals received. For instance, there were no ATTRACT awards made in 2012, but three were made in 2013.

Changes to research programmes include the discontinuation of the OPEN programme that funded research on subjects not covered by the CORE programme and linking AFR post-doc grants exclusively to projects being undertaken by the University, PROS or in a PPP.

In 2015, reforms of the AFR programme were announced and in October 2015 are still ongoing. A new programme, PRIDE, is designed to award a block of non-nominative PhD grants to a consortium of researchers grouped around one of the five CORE themes. Prospective PhD candidates need to apply directly to the consortium for a PhD position. Funding comprises 4-years of PhD salaries, a lump training and travel allowance for each PhD candidate and a lump sum of 5% of salary costs paid to the consortium to cover training and other direct costs.

Luxembourg enjoys R&I policies that are designed and implemented in a strategic, coherent and integrated framework and tailored to foster innovation and strengthen the knowledge base and fundamental (the University) and applied (LIH, LISER and LIST) research in the public sector. Private sector R&I policies are also strategic and coherent as managed by the Ministry of the Economy. Luxinnovation serves to inform and provide guidance in R&I measures to the private sector and serves as a bridge between the

[12] http://www.fnr.lu/press/press-releases

public and private sectors. Even so, as mentioned above, the OECD review suggests a separate R&I policy document would be beneficial (OECD, 2015).

Evaluations, consultations, foresight exercises

As mentioned in Section 2.2 above, the OECD undertook a study of Luxembourg's national research system in 2006 and a Foresight Study of the National Research Fund and its funding programmes was performed in 2006-2007. The OECD study resulted in the government's instituting performance contracts, the merger of PRCs Henri Tudor and Gabriel Lippmann and a greater emphasis on third party funding, including PPPs (OECD, 2006). The Foresight Study resulted in the identification of the themes of the CORE programme.

In 2013, the government commissioned a new, independent study of the national research and innovation system to evaluate the level and degree of quality of the implementation of the OECD report recommendations. A preliminary version of OECD Reviews of Innovation Policy: Luxembourg 2015 was released late in 2015. A wide range of recommendations included developing a national R&I strategy document, promoting of the City of sciences infrastructure project, taking a carrot as well as stick approach in performance contracts and rewarding outperformance, making joint appointments between the University and PROs, undertaking a formal evaluation of the funding of private sector research, as provided by the law of 5 June 2009, creating initiatives to promote greater gender equality, reviewing the thematic domains of the CORE programme and their alignment with the research foci of the PROs and the University and achieving greater centralisation of the NRS at the City of Sciences in Belval (OECD, 2015).[13]

Regular evaluations of the University are a condition of its founding legislation. An evaluation by independent external experts was performed in 2013 and the results published on the University website. In addition, the University publishes an annual report of "Key Performance Indicators." PROs are also mandated to have annual evaluations by external international experts as a requirement of their performance contracts. The NRF and Luxinnovation have had evaluations as well. Evaluations from 2010, 2011 and 2012 are published on the MESR website. In 2016-2017, broad evaluations will be conducted of all NRS actors.

All proposals submitted to the NRF are evaluated by independent, external experts. In fact, the NRF is exemplary in its use of external evaluators in its funding programmes and, under the fostering of the MESR, Luxembourg's NRS now enjoys a culture of evaluation. Indicators required by performance contracts mandate additional objective assessments of system performance.

As mentioned above, the OECD recommends that government support of private sector research under the law of 5 June 2009 and its outcomes be evaluated (OECD,2015).

2.3 European Semester 2014 and 2015

In May 2015, the Commission published the country-specific recommendations for Luxembourg.

There were no Council Specific Recommendations for the Grand Duchy on R&I (European Commission, 2015b), Recommendations were in three areas: taxation; pensions; wage-setting.

Luxembourg 2020, 2015

In Luxembourg 2020 (Government of Luxembourg, 2015) the following key measures for meeting national R&I objectives were identified.

[13] This listing of recommendations is intended to be indicative rather than exhaustive.

For the public sector

- The law of 27 August 2014 that amended the law of 31 May, 1999 that created the NRF. The main changes were expanding the organisations eligible for NRF funding programmes to include foundations and private research organisations and introducing collective subsidies for PhD training.
- The law of 3 December 2014 concerning the public research centres. The main changes were the merger of PRCs Henri Tudor and Gabriel Lippmann into LIST and the merger of the Integrate Biobank of Luxembourg into LIH.
- Concentrating research on a limited number of domains through the CORE funding programme.
- The selection of Parkinson's Disease as the first project under the National Centre of Excellence in Research (NCER) progamme.
- The signing of the 2014-2017 performance contracts
- The launch of the Proof of Concept (POC) programme to promote the valorisation of research
- The "Assisses de Recherche" held in December 2014 focussed on the joint recruiting for positions of responsibility by the PRCs and the University and formalised coordination between research centres.
- Follow up on the OECD 2006 study of Luxembourg's research system
- Transnational cooperation, supported by the INTER programme
- Opening the labour market for researchers through the AFR, ATTRACT and PEARL funding programme
- Achieving greater gender balance by mandating that the proportions of administrative and scientific board members of each gender may not be lower than 40%
- Supporting Open Access and a digital access initiative,

For the private sector

- Formulating a Smart Specialisation Strategy that focuses on industry, eco-technologies, logistics, health technologies and ICT
- Signing a performance contract with Luxinnovation
- Further revising the amended law of 5 June 2009 that supports private sector research
- Supporting the Cluster Initiative
- Establishing the Luxembourg Institute for Intellectual Property (IPIL)
- Implement the recommendation to establish a Composite Competence Centre
- Launching a LEAN and GREEN label promoting the reduction of CO2 emissions of logistics companies
- Supporting business incubator for start-ups
- Supporting 1 2 3 Go and Seed4 Start
- Supporting Fit4Horizon 2020
- Promoting IP through IP Tuesdays and the BOOST-IP and IPorta projects

All R&I-related measures cited in the NRP are either implemented or are well under way to implementation.

2.4 National and Regional R&I Strategies on Smart Specialisation

Luxembourg is its own NUTS2 region. Therefore, all Smart Specialisation strategies apply to the entire country. In the NRP Luxembourg 2020, areas of Smart Specialisation are identified as industry, eco-technologies, logistics, health technologies and ICT (Government of Luxembourg, 2015). On the Luxembourg page on the EC Smart Specialisation Platform website, 14 the targeted fields duplicate thee five thematic

[14] http://s3platform.jrc.ec.europa.eu/regions/LU

research areas specified in the NRF's CORE research funding programme.15 While the themes include eco-technologies and health technologies, they do not include industry, logistics and ICT. The OECD review of 2015 notes a lack of coherence in the identification of specialisation domains (OECD, 2015).

Measures to stimulate private investment in R&I include the general law of 5 June 2009 that provides support for research and the law of 1 February 2010 that includes support for eco-technologies. [16] At the same time, the government is actively supporting the ongoing development of its logistics sector and ICT-based projects are included in both NRF funding and funding under the law of 5 June 2009. R&I infrastructure projects are not specifically included smart specialisation strategies. It is perhaps more accurate to say that existing policy initiatives have determined Luxembourg's choice of areas of specialisation rather than vice versa.

2.5 Main policy changes in the last five years

Main Changes in 2011
New performance contracts between the MESR and the public research institutions for the period 2011-2013
Main changes in 2012
Establishment of Life Sciences Fund and Luxembourg Future Fund by government. Launch of NRF Open programme Announcement of future merger of PRCs Henri Tudor and Gabriel Lippmann
Main changes in 2013
Early election results in new coalition government of Liberal Democrats, Socialists and Greens. Three Ministers of Higher Education and Research, the first minister retired and the second was replaced as a result of the new government being formed.
Main Changes in 2014
New performance contracts for 2014-2017 between the MESR and public research institutions. Budget cuts or lack of budget increases for public sector research institutions for period 2014-2017. New laws covering expanding NRF funding recipients, merging PRCs Henri Tudor and Gabriel Lippmann and Luxinnovation review of CORE programme proposals for their valorisation potential. Launch of NFR Proof of Concept programme to assist valorisation of research projects.
Main Changes in 2015
Merger of PRCs Gabriel Lippmann and Henri Tudor to form the Luxembourg Institute of Science and Technology (LIST). Re-branding of PRC Santé to the Luxembourg Institute of Health (LIH) and CEPS/Instead to Luxembourg Institute for Socio-Economic Research (LISER) New research funding programme KITS (Knowledge and Innovation Transfer Support) as part of emphasis on valorisation of research projects, NASA-ARC (earmarked AFR PhD and postdoc grants for research undertaken at NASA-ARC) and PRIDE (Research-Intensive Doctoral Education)Reform of the AFR PhD funding programme under law of 27 August 2014. Relocation of the NRF, Luxinnovation and LIST to the City of Sciences in Esch Belval. Preliminary draft, OECD Reviews of Innovation Policy: Luxembourg 2015, following up the 2007 review.

[15] http://www.fnr.lu/funding-instruments/core
[16] http://www.legilux.public.lu/leg/a/archives/2010/0044/2010A0712A.html

3. Public and private funding of R&I and expenditure

3.1 Introduction

Analysing the table below, one fact predominates—the declines in GERD and BERD. The decline is of special concern as it impacts Luxembourg's chances of meeting its 2020 R&D intensity target of 2.3%-2.6% of GDP. At 1.24% of GDP in 2014, wealthy Luxembourg is far below the EU average of 2.09%. It is also below the EU average in every other category of basic R&D indicators.

Government funding detailed in section 3.3.2 indicates that budgets, while flat, have not been reduced. Also, in the previous public sector research funding period of 2011-2013, budget commitments were kept and targets for third party funding were met by the PROs. Declines in BERD therefore are the major cause of the drop in GERD but the reasons behind this have yet to be identified.

Table 4: Basic indicators for R&D investments

Indicator	2011	2012	2013	2014	2015	EU average
GERD (as % of GDP)	1.5	1.29	1.31	1.24	-	2.09 (14)
GERD (Euro per capita)	1233.6	1069.6	1127.9	1117.4		558.4 (14)
GBAORD (€m)	252.832	282.091	308.713	312.333		92828.145 (Total for EU28)
R&D funded by BES (% of GDP)	0.68	0.23	0.22	-	-	1.12 (13)
R&D funded by PNP (% of GDP)	0.02	0.02	0.01			0.03 (13)
R&D funded by GOV (% of GDP)	0.5	0.58	0.63	-		0.66 (13)
R&D funded from abroad (% of GDP)	0.29	0.44	0.42	-		0.2 (13)
R&D performed by HES (% of GDP)	0.16	0.22	0.24	0.23		0.47 (14)
R&D performed by government sector (% of GDP)	0.35	0.36	0.38	0.36		0.25 (14)
R&D performed by business sector (% of GDP)	0.99	0.71	0.69	0.65		1.3 (14)

3.2 Smart fiscal consolidation[17]

3.2.1 Economic growth, fiscal context[18] and public R&D

Luxemburg weathered the 2008-2009 economic crisis with a relatively moderate loss of real GDP of 6.2% in 2008-2009 that has been recovered quickly in 2010. Except for 2012, real GDP growth remained above 2% between 2011 (2.6%) and 2015 (4.7%, estimated). The financial sector is the country's growth engine. The strength of this sector allowed Luxemburg to create and sustain a generous welfare state without endangering public finances. The Commission expects a real GDP growth of 3.8% in 2016 and 4.4% in 2017 driven mainly by public and private consumption.

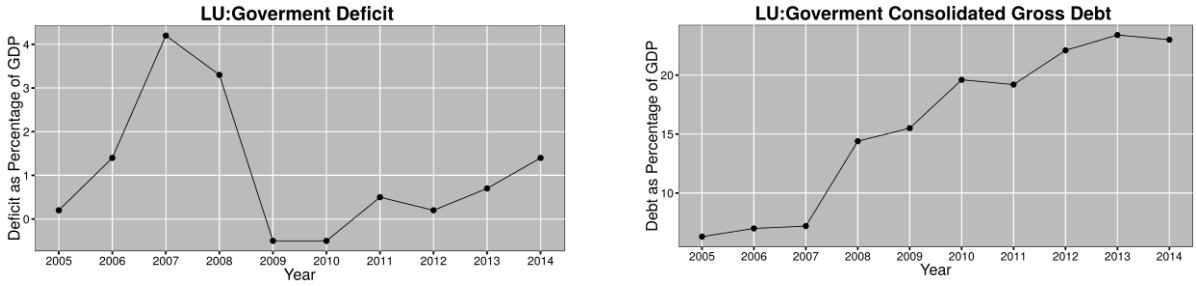
[17] Smart fiscal consolidation is defined as public budget cost-cutting programmes aimed at establishing a foundation for long-term growth. This public policy strategy is based on a trade-off between the need to safeguard growth enhancing elements (including R&D) from budgetary cuts and the need to reduce public spending in a context of economic crisis. For reference see Kolev, G. and Matthes, J.: Smart fiscal consolidation a strategy for achieving sustainable public finances and growth, Centre for European Studies, 2013; Veugelers, R.: Undercutting the future? Bruegel Policy Contribution Issue 2014/06, June 2014).The conclusions in our analysis focus only on the R&I aspect of Smart Fiscal Consolidation.

[18] Sources: Country Report Luxembourg 2015, http://ec.europa.eu/europe2020/pdf/csr2016/cr2016_luxembourg_en.pdf

The country's public finances were sound throughout the last decade. While during 2005-2008 the general government budget recorded high surpluses (e.g. 4% of GDP in 2007), as of 2009 the otherwise rather low (0.5% of GDP) headline deficit turned into a surplus in 2011 that has been maintained ever since (Figure 4, left). In structural terms the budget has always been in surplus since 2011 (0.5-2.6%). Public debt tripled from its 2005-2007 levels of 4-5% of GDP, but it is still one of the lowest in the EU (21.3% of GDP in 2015). In 2015 the budgetary surplus is expected to be "trimmed" down to 0.2% by a change in the European legislation on VAT on e-commerce entered into force on 1 January 2015 that has been only partially offset by consolidation measures on both revenue and expenditure side. The Commission expects 0.5% headline surplus for both 2016 and 2017. Public debt is expected to remain around 21-22% during the same period.

The structural budget balance has been well above its medium-term objective (MTO)[19] in 2011-2015. Although the impact of the VAT legislation change would still not endanger the MTO, the government committed to an ambitious fiscal consolidation plan. [20] Luxembourg continues to face the challenge of ageing in terms of the long-term sustainability of its public finances.

Figure 4: Government deficit and public debt



Data source: Eurostat

Total GERD in Luxemburg was €605.7m in 2013. There are three main sources of R&D funding: the business sector (€100m), the government (€293.1m), and foreign funding (€195.9m).[21]

Table 5: Key Luxemburgish R&D Indicators

	2007	2009	2013
GBAORD, % of gov. exp.	1.02	1.19	1.72
GERD, % of GDP	1.61	1.71	1.31
out of which GERD to public, % of GDP	0.26	0.42	0.62
Funding from GOV to, % of GDP			
Business	0.05	0.04	n.a.
Public (GOV+HES)	0.24	0.37	n.a.
Total	0.29	0.41	0.63
EU funding, % of GDP	n.a.	n.a.	0.02

Source: Eurostat

[19] 0.5% of GDP surplus of the structural budget

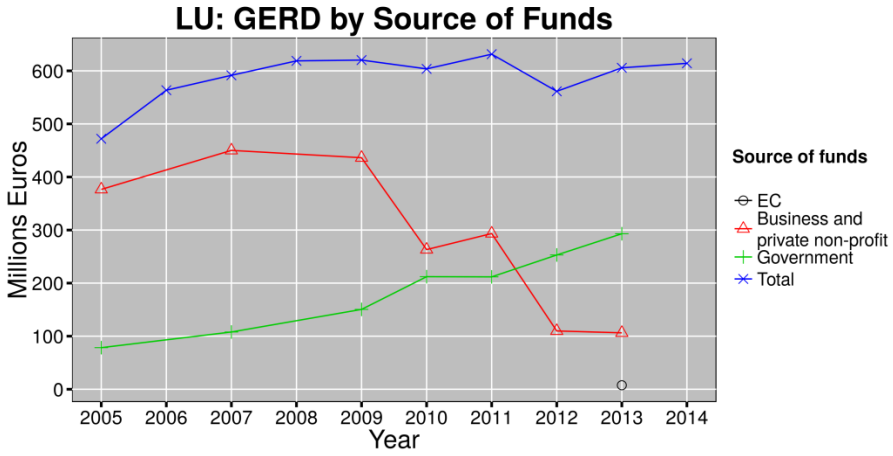
[20] Multiannual framework, VAT rate increases and more rationalised expenditures

[21] According to Eurostat Luxemburg does not provide information concerning the destination of government funding (i.e. disbursement of public resources). The information is claimed to be confidential.

3.2.2 Direct funding of R&D activities

Figure 5 below shows the historical evolution of GERD financing in current prices in Luxembourg.

Figure 5: Development of government funding of the total GERD



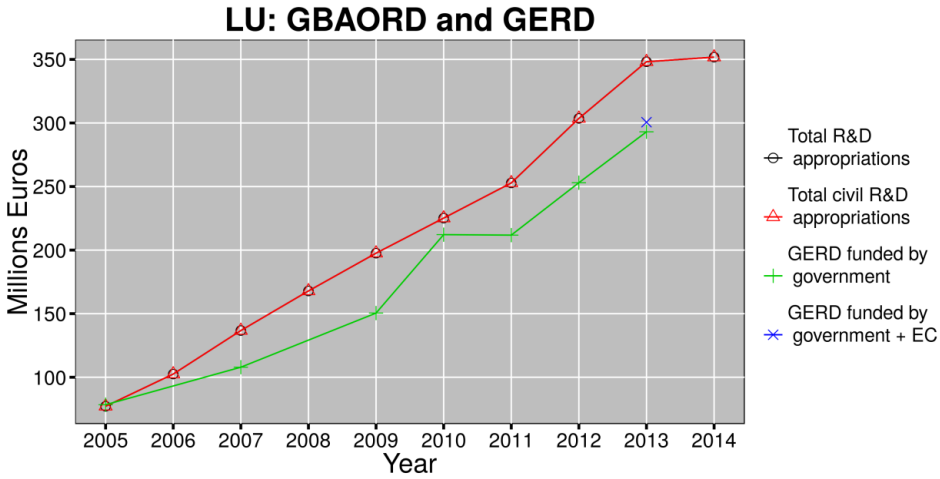
Data source: Eurostat

One observes a declining trend in the total GERD, in nominal values, from 2009 onwards. After 2009 we witness a collapse of the private sector as funder of the Luxembourgish GERD: the levels in 2013 are around one fourth of what they used to be in 2009. Meanwhile, in 2011-2012, the government approximately doubled its contribution to the GERD with respect to 2007, but this proves insufficient to fully compensate for the dramatic decrease in private sector GERD after the crisis.

3.2.2.1 Direct public funding from the government

Figure 6 below shows the time evolution of the total R&D appropriations (GBAORD) and the GERD directly funded by the government in units of millions of national currency.

Figure 6: R&D appropriations and government funded GERD in millions of national currency



Data source: Eurostat

The total (civil) appropriations grow practically linearly in the period 2005-2013 slowing down only in 2014 and are unaffected by the 2008-2009 crisis. Luxembourg does not conduct any military research, as one can see from the perfect overlap of the total and civil R&D appropriations. We do not have data about the EC contribution to the Luxembourgish GERD. In 2011 we observe a widening of the gap between the appropriations and the government GERD, but the lack of subsequent government GERD data does not permit to draw any further conclusion.

3.2.2.2 Direct public funding from abroad

Data on the external funding to R&D in Luxembourg is sparse, as shown in Table 6 below. Due to the lack of a breakdown, nothing can be said about the role of the EC or the public sector from abroad. We only notice a vast expansion of the role played by the funding from abroad in the R&D landscape of Luxembourg in 2010-2011.

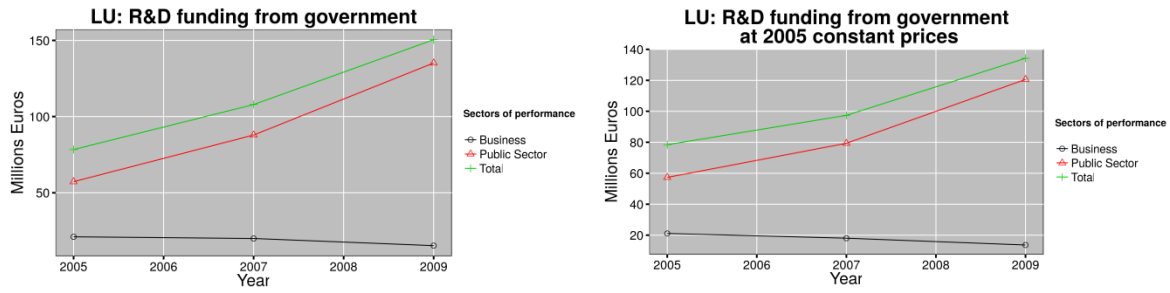
Table 6: Public Funding from abroad to Luxembourgish R&D (millions of national currency)

Source from abroad	2005	2007	2009	2010	2011	2012	2013
Total	16.8	33.5	33.32	124.596	122.905	193.349	195.906
EC							7.564
GOV							0.364
HES							0.266
International Organizations							0.608
Total as % GERD	3.56	5.66	5.37	20.64	19.47	34.44	32.34
EC as % GOVERD							2.58

Distribution of public funding

Figure 7 below shows how the distribution of public funding to sectors of performance evolved over time:

Figure 7: Government intramural expenditure by sectors of performance



Data source: Eurostat

The public sector is the main recipient of the government funded GERD.. Luxembourg does not report systematically data on the amount of government funded R&D[22]. Unfortunately, there are no data provided after 2009.

3.2.3 Indirect funding – tax incentives and foregone tax revenues

Considering the absence of harmonisation of the tax regimes in EU law, data come directly from national sources, using domestic definitions. Attention should be paid when interpreting data from different sources.

Luxembourg's main fiscal instrument for R&D is the law on IP tax incentives. Implemented on 1 January 2009, it gives a preferential tax treatment to revenues from

[22] Imputation of missing data is beyond the purposes of this report.

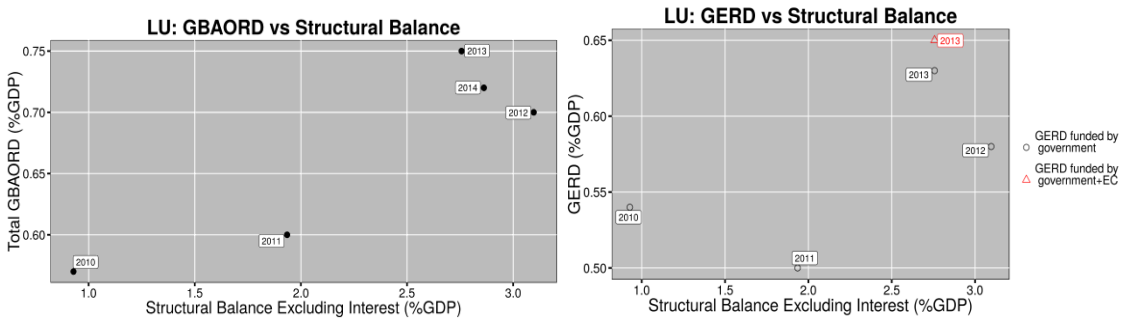
intellectual property (IP) registered in Luxembourg. Under this law, up to 80% of the net income generated by the exploitation of an IP right is exempt from tax, which means the effective average tax rate on IP income is 4.84%. The exemption applies to income paid to Luxembourg tax payers (individuals or companies) for the use of software copyright, patent, domain name (registration or license), trademark, design or model. Luxembourg does not offer expenditure-based R&D tax incentives.

Luxembourg does not provide tax support to business expenditure on R&D, so the total government support for business R&D is just 0.4% of GDP while the business R&D as percent of GDP is 1.3%.

3.2.4 Fiscal consolidation and R&D

As it has already been stated in Section 3.2.1, public finances in Luxemburg are rather sound, the budget is in surplus both nominally (headline) and structurally. Moreover, in the last 4-5 years the structural budget surplus has never fallen under the country's MTO. Therefore it is hard to speak about a post-crisis fiscal consolidation per se. Figure 8 below shows the scatterplot of the structural balance and GBAORD as % GDP, first panel, as well as GERD as % GDP, second panel[23]:

Figure 8: Fiscal consolidation and R&D



Data source: AMECO, Eurostat

Based on Figure 8 left, in 2010-2014 there was a positive correlation between the structural balance and the GBAORD: improvements in the structural balance went almost "hand-in-hand" with increases in the governmental R&D appropriations. Based on Figure 6, government financed GERD has never fallen back to its pre-crisis or crisis level neither in euros, nor in relative terms. The small decrease in 2011 (Figure 8 right) may not even be related to the improvement of the structural balance since it was followed by a much bigger increase and higher surplus. Therefore we can conclude that direct public support to R&D expenditures has not been negatively affected by post-crisis improvements in the structural budget balance.

3.3 Funding flows

3.3.1 Research funders

The main public research funder is the government in the form of the Ministry of Higher Education and Research (MESR), and the National Research Fund (NRF) which administers a range of funding programmes, described in section 3.4.3 below. The main public research funder for the private sector is the Ministry of the Economy, which funds research under the provisions of the law of 5 June 2009.

Budgets for the four public research performers as well as for the NRF and Luxinnovation are based on performance contracts between the MESR and the organisation and are detailed in the table below.

[23] Structural balance data come from the AMECO database. The other indicators were taken from Eurostat.

Private not-for-profit funding of research in Luxembourg is negligible. In 2013, the Luxembourg University Foundation was established for the purposes of funding research projects and research chairs as well as providing support for scientific conferences and scholarships for needy students.[24]

3.3.2 Funding sources and funding flows

Funding commitments and targets set by the performance contracts for 2014-2017 are given in the table below. As noted in section 3.2 above, government funding is flat between 2015-2017, with increasing amounts envisaged to come from third party funding including structural funds and public-private partnerships.

Table 7: Proportions of government vs. third party funding (€ millions)

	2014	2015	2016	2017
University				
Government	124.7	145.4	145.4	145.5
Third Party	32.0	34.0	36.0	38.0
Total	160.7	179.4	181.4	183.5
% third party	18.9	19.0	19.7	20.7
PROs				
PRC H Tudor	22.0	-	-	-
PRC G Lippmann	15.0	-	-	-
LIST*	(37.00)	39.0	39.0	39.0
LIH*	23.0	23.5	23.5	23.5
LISER*	10.4	10.5	10.5	10.5
Total Gov. all PROs	70.4	73.0	73.0	73.0
Total Third Party all PROs	40.1	42.4	43.4	44.1
Total PROs	110.5	115.4	116.4	117.1
% third party	36.3	36.7	37.3	37.7

Source: MESR *Government funding

In 2014, the government funding of the universities and PROs totalled €195.1m, with €72.1m expected to come from third party sources. The FNR's annual commitments in 2014 came to €48.7m, much of which were in the form of multi-annual grants. This meant that to meet performance contract targets, at least €23.4m was required from third party sources, which would include structural fund projects. Luxembourg's participation in structural funds is provided in the table below. While Luxembourg's percent of total EU project participation remained the same in FP6 and FP7 with a slight increase in Horizon 2020 as of October 2015, there is a significant increase in the number of projects (2.4X), participants (2.2X), coordinators (2.3X) and EU contributions (2.6X) between FP6 and FP7.

Table 8: Participation in FP6, FP7 and Horizon 2020

No. of projects	No. of participants	No. of coordinators	EU Contribution	% of total EU
FP6				
98	121	15	€23,253,166	0.1%
FP7				
229	263	35	€60,949,896	0.1%
Horizon 2020				
72	84	14	N.A.	0.3%

[24] http://www.fdlux.lu/en/foundation/luxembourg-university-foundation

3.4 Public funding for public R&I

3.4.1 Project vs. institutional allocation of public funding

The table below shows a significant increase in the proportion project funding to institutional funding in 2014 from previous years. Performance contract targets for third party funding include project funding. As indicated in the table in section 3.3.2 above, third party funding targets are 18.9% for the University and 36.3% for the other PROs.

Table 9: % GBAORD by Funding Mode25

	2009	2010	2011	2012	2013	2014
Institutional	94.39	92.64	92.49	93.46	94.24	82.9
Project	5.61	2.36	7.51	6.54	5.76	17.1

Source: Eurostat

In the period of the previous performance contracts, 2011-2013, the total amount of funding for the PROs was €318.1m of which €201.3m, or 63.3% was from the government and €116.8m, or 36.7% was from third party funding, which included project funding.

Finally, note that third party funding targets are aggregates and do not specify the source, which can be from NRF programmes, i.e., project funding, Horizon 2020, government contracts, public-private partnerships, etc.

3.4.2 Institutional funding

Institutional funding is based on performance contracts between the MESR and the university and PROs. Targets for third party funding, which include project funding, are specified in the contracts as are other indicators such as numbers of patents and publications. For specifics see section 3.5.

3.4.3 Project funding

Project funding for Luxembourg's PROs is provided by the funding instruments administered by the NRF. A list of the programmes is provided in the table below. Note that the AFR programme that funded PhD and post-doc research is being revised. The identification of the CORE programme domains grew out of a Foresight exercise undertaken by the NRF in 2007. The OECD review of Luxembourg's research system also had an impact on how programmes are administered.

[25] Retrieved 10 October 2015 from http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

Table 10: NRF Public Sector Funding Programmes[26]

Funding Programme	Timeline	Budget	Programme Description
AFR	Currently under reform		AFR supports research training at doctoral and postdoctoral level in Luxembourg and abroad. Following the introduction of block grants at PhD level under the new PRIDE scheme, the individual AFR grants will be reformed.
AFR Bilateral Grants	Ongoing		The National Research Fund Luxembourg (FNR) intends to strengthen the cooperation between Luxembourg and specific strong research performers in selected countries. Therefore FNR opens a call for PhD or Postdoc grants dedicated to bilateral research projects with: • Universities and research institutions from Singapore, • RIKEN research centres from Japan, and • NASA's AMES Research Centre (NASA-ARC
ATTRACT	Ongoing	€10 million (2014.2017)	The ATTRACT programme is designed for researchers not yet established in Luxembourg and offers them the opportunity to set up their own research team within one of the country's research institutions.
CORE	Ongoing	€70 million (2014.2017)	CORE is the central programme of the FNR. A multi-annual thematic research programme, CORE aims to strengthen the scientific quality of Luxembourg's public research in the country's priority research domains: Innovation in Services (IS), Sustainable Resource Management in Luxembourg (SR), New Functional and Intelligent Materials and Surfaces and New Sensing Applications (MS), Biomedical and Health Sciences (BM), Societal Challenges (SC)

[26] http://www.fnr.lu/funding-instruments

INTER	Ongoing	€18 million (2014.2017)	The INTER Programme aims to give Luxembourg's public research a higher profile in the international context by providing funding for international collaboration. INTER enables the FNR to initiate bi- or multilateral arrangements for project calls in conjunction with other national or international funding bodies.
INTER Mobility	Ongoing	Funding may cover full costs for the Luxembourg PRO (according to internal organisational rules)	INTER mobility promotes exchanges between Luxembourg PROs and research groups abroad, in order to foster innovative, internationally competitive research and support the exchange of key knowledge and technological know-how. The programme may also foster exchanges between the research communities in the public and private sector.
KITS	Ongoing	Up to €350k per proposal	The Knowledge & Innovation Transfer Support Programme (KITS) provides competitive funding to Luxembourg PROs that allows them to attract and integrate highly skilled professionals in the area of knowledge transfer, with the goal of generating economic and societal value through their research programmes.
PEARL	Ongoing	€25 million (2014-2017)	The PEARL programme attracts established and internationally recognised researchers in strategically important areas from abroad.
Proof of concept (POC)	Ongoing	Up to €500k in biomedical sciences and up to €250k for any other domain	The Proof of Concept programme provides funding to PROs for the translation of high impact research into commercially viable innovations and make their research ideas more attractive to potential investors. It is open to the following domains: • Biomedical Sciences • Advanced Materials • Engineering • ICT
PRIDE	Ongoing		PRIDE is FNR's new programme for funding doctoral research in Luxembourg. The introduction of PRIDE is based on the FNR law of 27 August 2014. The objectives of PRIDE are to support Luxembourg research institutions to: • Build and sustain critical mass in a limited number of fields of excellence • Attract and recruit outstanding PhD candidates to sustain excellent research; • Train PhD candidates to become highly skilled professionals.

Luxembourg's main research funding programme is CORE, which grew out of the NRF's Foresight Study. It focuses on five themes which correspond closely to the Grand Duchy's institutional research landscape. They are Innovation in Services, Sustainable Resource Management in Luxembourg, New Functional and Intelligent Materials and Surfaces and New Sensing Applications, Biomedical and Health Sciences and Societal Challenges.[27] In addition to Sustainable Resource Management, societal challenges are addressed in the eponymous theme with sub-themes of Social and Economic Cohesion, Education and Learning and Identities, Diversity and Interaction.

Proposals for CORE funding are reviewed by independent, international experts who provide feedback at an early stage. In addition, Luxinnovation reviews proposals for their valorisation potential. Other programme proposals are also evaluated independently. Except for the AFR doctoral programme, which is under revision, all funding is linked to an institution rather than an individual. This applies even to ATTRACT and PEARL grant recipients.

Project funding is competitive as shown by the success rate. For example, in 2014 the aptly named CORE programme received 114 eligible proposals. Of these, 30, or 26%, were ultimately selected and given funding commitments of €17m.[28] Distribution of funding is fairly evenly divided among the five programme themes, as indicated in the table below. This is in contrast to the proportions of domains funded by the Ministry of the Economy through the law of 5 June 2009 as shown by the chart in section 3.5.

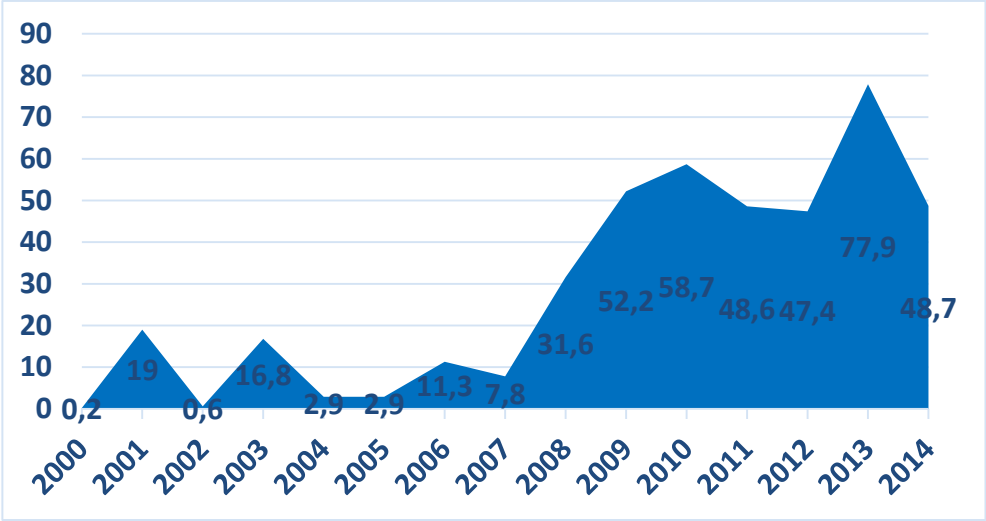
Table 11: CORE projects by domain 2008-2014 (NRF, 2015)

Domain	Projects funded	Amount €m
Biomedicine and health	46	26.7
Materials	49	26.4
Sustainable resource mgt.	41	23.9
Innovation in Services	53	23.7
Societal Challenges	43	21.0

Overall NRF funding trends since 2000 are illustrated in the following chart. The surge in funding between 2007 and 2009 reflects the inception of performance contracts and requirements for third party/competitive funding, which includes project funding.

[27] The OECD 2015 review suggests that these thematic domains should be revisited (OECD; 2015).
[28] As CORE projects are multi-annual funding is distributed over several years.

Figure 9: NRF Project Funding 2000-2014, in €m (NRF, 2015)



In terms of the balance between project funding and individual grants (i.e., the AFR progamme), in 2014, €33.79m were committed to NRF projects, versus €17.85m in AFR grants (NRF, 2015). Note commitments for both projects and AFR grants are multiannual.

3.4.4 Other allocation mechanisms

There is a limited amount of contract funding which mainly applies to work done for the government by organisations such as STATEC, the national statistical agency, and LISER. Figures are not available.

3.5 Public funding for private R&I

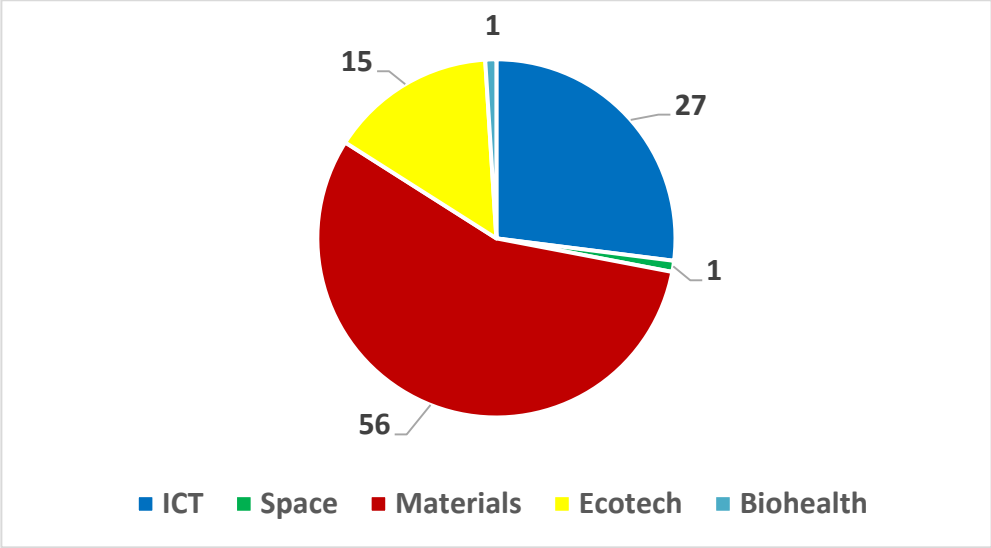
3.5.1 Direct funding for private R&I

The main public funding instrument for private R&I is the law of 5 June 2009 which is administered by the ministry of the Economy. The amended law of 5 June 2009[29] provides national funding for R&D projects with a special focus on SMEs. The scheme covers three types of R&D--experimental development, industrial research and fundamental research.[30] The law also covers the funding of projects concerning "process innovation" and "organizational innovation"[31] as well as "de minimis" measures that enable companies and private research institutions to receive funding if the entity is not eligible for one of the other specific schemes defined by the law.

The chart below shows the sectors of projects funded in 2014. It is interesting to note that Materials R&D represented more than half of the number of grants, while Space and Bio-health were a mere 1% each.

[29] http://www.legilux.public.lu/leg/a/archives/2009/0150/index.html
[30] http://www.innovation.public.lu/en/financer/competitivite/grants/meco-projets-programmes-rd/index.html
[31] Process innovation is the implementation of a new or significantly improved production or distribution method. Organizational innovation the implementation of a new business practice or structure in the workplace or with an external relationship. For expanded definitions, see the Oslo Manual (OECD, 2005).

Figure 10: Projects funded under the law of 5 June 2009 by domain (Ecomin, 2015)



The evolution of funding private sector research by the Ministry of the Economy is shown in the table below. It is interesting to note that both NRF and Ecomin funding peaked in 2013 and then dropped sharply in 2014. The reason for this is not known. It is evident that in some categories for which the law of 5 June 2009 provides, the number of applications for aid declined between 2013 and 2014. For example, the number of projects submitted by "Young innovative enterprises," covered under Article 8 of the law, fell from ten in 2013 to five in 2014. The same is true for "Protection of Technical Industrial [intellectual] Property" (Article 7). In 2013, 13 projects were submitted, while in 2014 there were only eight. Exceptionally, aid provided for the use of consultancy services in innovation and innovation support (Article 9) increased from one application in 2013 to nine in 2014 (Ecomin 2015).

Table 12: Evolution of Private Sector R&I Funding, in €m (Ecomin, 2015)

Year	Costs covered under the scheme (€mn)	Funding Allocated (€mn)
2000	21.36	6.17
2001	20.28	5.43
2002	74.26	20.74
2003	27.26	5.68
2004	55.85	17.46
2005	48.53	12.00
2006	88.93	26.93
2007	90.19	24.94
2008	66.04	22.04
2009	116.12	38.51
2010	104.60	38.28
1011	71.52	27.21
2012	87.44	33.56
2013	199.40	74.90
2014	127.30	36.99

In August 2015, the Ministry of the Economy submitted a proposal to revise the law of 5 June 2009.[32] The reforms include a simplification of the application process for state aid, an emphasis on public-private partnerships and a focus on the establishment of Centres of Excellence, with a target of two by 2018 and four by 2020.[33] It also sets BERD targets of 1.1% of GDP in 2017 and 1.4% of GDP by 2020.

Other resources

Based on Luxembourg's membership in the European Space Agency. LuxLaunch supports the development of preparatory studies to help position organisations in the space market.[34] A special emphasis is accorded to studies investigating applications in the fields of satellite telecommunications, satellite navigation and Earth observation. A typical project is less than six months in duration with costs of not more than €100,000.

Fit4Horizon2020 is a government programme that helps companies with the costs associated with preparing proposals to participate in Horizon2020, Eurostars and Ambient and Assisted Living (AAL).[35] Allocated funds represent 5% of the requested EU co-financing, with €15.000 being the maximum amount for project coordinators and €5.000 for project participants.

Discussion

Luxembourg's aid scheme is structured to promote a variety of R&I for a broad range of actors in the private sector. Luxinnovation assists companies in identifying the type of aid which would best meet their needs and for which they are most suitable. Luxinnovation also shepherds the companies through the application process and key ministry people are also generally available. Much of the R&I process is included in the scheme and what is not is generally covered in other ways (e.g., the business incubator initiative.)

Public-private partnerships form part of PRO targets for third party funding and Luxinnovation works to put private and public sector actors together on an individual basis as well as through "Business Meets Research" days. The use of consultants in the innovation process is covered by the law. The FItHorizon2020 progamme is most explicitly aimed at reducing the administrative burden for small businesses. While young companies are included in the aid programme, starts-ups are not.

The most recent external evaluation known is the OECD review of 2006 that preceded the current aid scheme but which was taken into account when the law was drafted. The process by which aid is granted is opaque. The 2015 OECD review is explicit about the need for an evaluation of the scheme, selection processes and outcomes (OECD, 2015)

3.5.2 Public procurement for innovation

Background

Public procurement represented 15% of GDP of Luxembourg in 2011[36]. The procurement expenditure was 28.4% from the government expenditure in 2013, which is almost equal to the average of the OECD countries (29%)[37].

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[32] The text of the proposed legislation and its progress through Parliament, including stakeholder comments, can be viewed at http://www.chd.lu/wps/portal/public/RoleEtendu?action=doDocpaDetails&backto=/wps/portal/public/accueil/actualite/!ut/p/b1/04_SjzQxNTUwMja2NNSP0I_KSyzLTE8syczPS8wB8aPM4l2MXMKCPE2MDPxdg82AKgOMHYOCjQwMDEyACiKBCgxwAEcDQvr9PPJzU_Vzo3IsAFbtGIs!/dl4/d5/L2dBISEvZ0FBIS9nQSEh/&id=6854#

[33] In 2015, a Composites Centre of Excellence was established.

[34] Retrieved 2 October 2015 from http://www.innovation.public.lu/en/financer/competitivite/esa/luxlaunch/index.html

[35] Retrieved 2 October 2015 from http://www.innovation.public.lu/en/financer/excellence-scientifique/horizon2020/fit4horizon2020/index.html

[36] http://www.luxinnovation.lu/Actualit%C3%A9s/Archives/Promouvoir-les-solutions-innovantes-%C3%A0-travers-les-march%C3%A9s-publics

[37] OECD Government at a Glance 2015, Country Fact Sheet Luxembourg, http://www.oecd.org/gov/Luxembourg.pdf

Legal Public Procurement Framework

The Law of 25 June 2009 on public procurement implemented Directives 2004/18/EC and 2004/17/EC.

Few companies use electronic procurement systems to respond to call for tenders (8% in 2014)[38].

Public Procurement for Innovation (PPI) initiatives in Luxembourg

Luxemburg procurers participate in the buyers group of the EU funded PPI project *HAPPI* on healthy ageing (EHL – Entente des Hopitaux Luxembourgeoises) and in the *P4ITS* networking project that is preparing a PPI to deploy intelligent transport systems.

HAPPI[39] is a project funded in the framework of the previous EU Competitiveness and Innovation Programme (CIP) aiming at linking European health public procurers to work together in order to detect and purchase innovative and sustainable solutions which will improve "ageing well". The project consortium brings together 10 partners from 6 EU Member States.

P4ITS is a thematic network gathering contracting authorities experienced or planning to shortly embark on deploying Cooperative Intelligent Transport Systems and Services (C-ITS), and willing to improve the market roll-out of innovative transport systems and services through Public Procurement of Innovation (PPI).[40]

The National Agency for Innovation and Research (Luxinnovation) acknowledges the importance of public procurement in fostering innovation and has published a guide on promoting innovative solutions via public procurement in 2015[41].

In order to facilitate the dialogue between innovative companies and public procurers, Luxinnovation also presents an overview of innovative solutions "made in Luxembourg"[42], which have been grouped in five fields:

1) Building;
2) Communication with citizens;
3) Health/Care;
4) Information management;
5) Water.

3.5.3 Indirect financial support for private R&I

Government support for private sector R&D is direct. There are no R&I tax incentives with the exception of the law on Intellectual Property (IP). Implemented on 1 January 2009, the legislation gives preferential tax treatment to all IP registered in Luxembourg. It offers an 80% exemption on royalties and capital gains deriving from most types of IP which gives an effective rate of 4.84% to qualifying income. Note that the law not only encourages companies to patent their innovations but also attracts foreign companies to register their existing patent portfolios in Luxembourg. There is no information on the cost of the scheme in lost tax revenues nor a formal evaluation of the law.

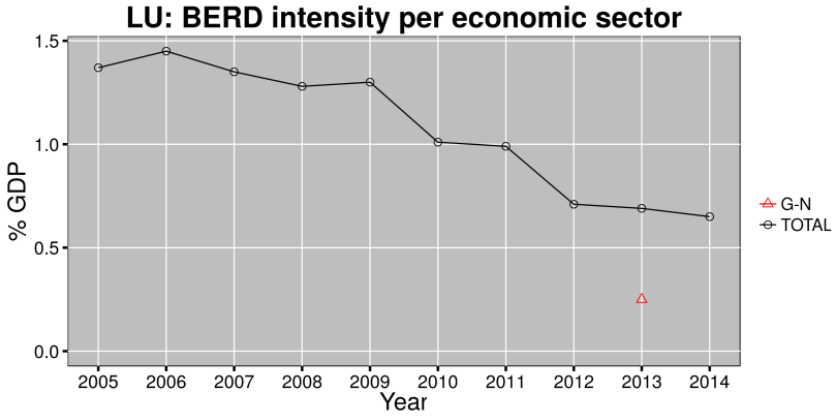
[38] Ibid.
[39] http://www.happi-project.eu/accueil.aspx
[40] http://p4its.eu
[41] http://www.luxinnovation.lu/Actualit%C3%A9s/Archives/Promouvoir-les-solutions-innovantes-%C3%A0-travers-les-march%C3%A9s-publics
[42] http://en.luxinnovation.lu/Innovating-in-Luxembourg/Innovative-solutions-made-in-Luxembourg

3.6 Business R&D

3.6.1 The development in business R&D intensity

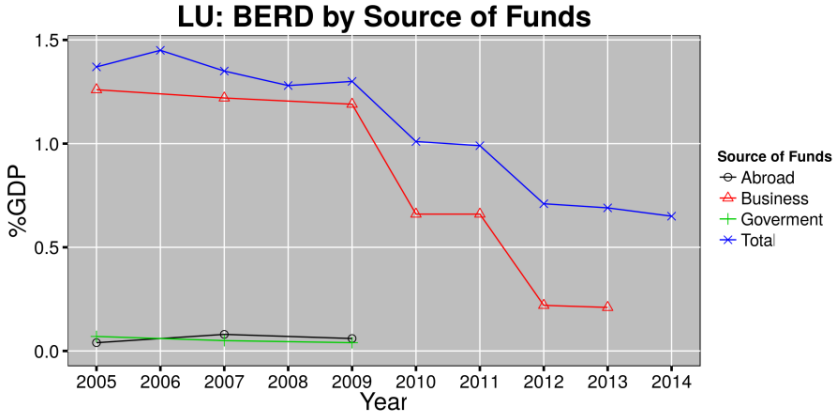
As one can see from Figure 11 and Figure 12, the Luxemburgish BERD intensity has been on a steady decreasing path since 2006 (2006: 1.45% of GDP, 2014: 0.65% of GDP). The reasons behind the decline in BERD are not clear, mainly due to the lack of data. The main part of the total R&D efforts is carried out by a limited number of large enterprises. Moreover, the top 15 business research performers in Luxembourg listed in the EU Industrial R&D Investment Scoreboard, except for one, are headquartered in the country for fiscal purposes and the actual research is performed elsewhere.[43] A possible reason for the decline of BERD in the banking sector is the financial crisis.

Figure 11: BERD intensity broken down by most important macro sectors (G_N=services)



The private sector is the main funder of the Luxembourgish BERD (Figure 12). BERD financing from this source has been on a gradual decreasing path since 2005. Funding from other sources (government, abroad) is practically negligible. The available data are not sufficient for an in-depth sectorial analysis.

Figure 12: BERD by source of funds



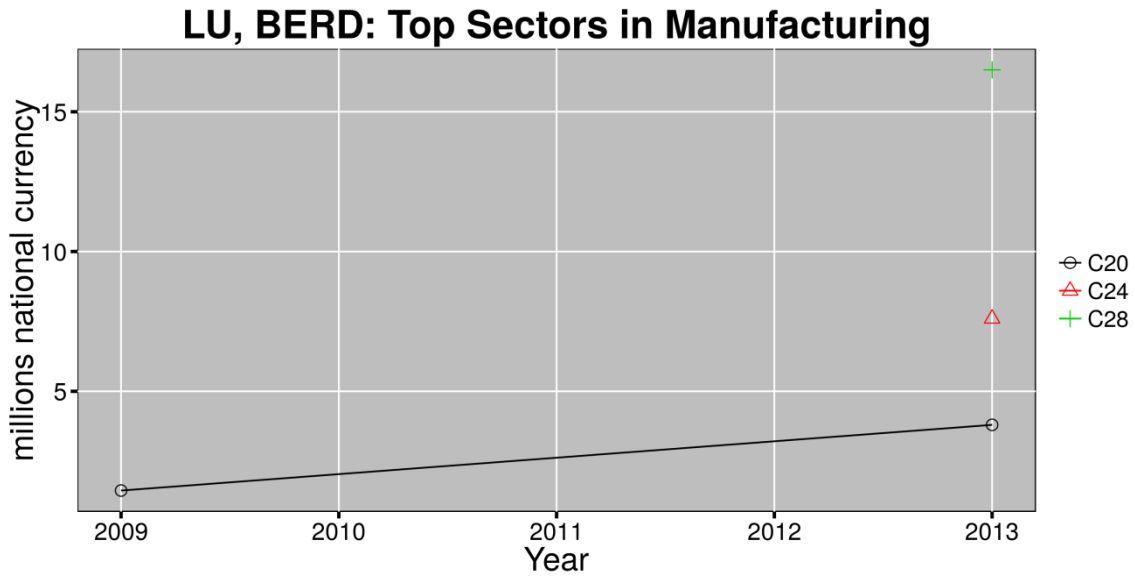
3.6.2 The development in business R&D intensity by sector

In Luxembourg, 45% of the private investment in R&D is made in the manufacturing sector, compared to 23% in financial services and about 30% in other services. Figure 13 shows that manufacturing BERD in Luxemburg is of a rather small amount. In 2013 the top three sectors cumulated BERD of around €28m (0.06% of GDP). Machinery and equipment is the leading manufacturing sector in terms of BERD (€16.5m in 2013),

[43] RIO Country Report 2014: Luxembourg, Draft.

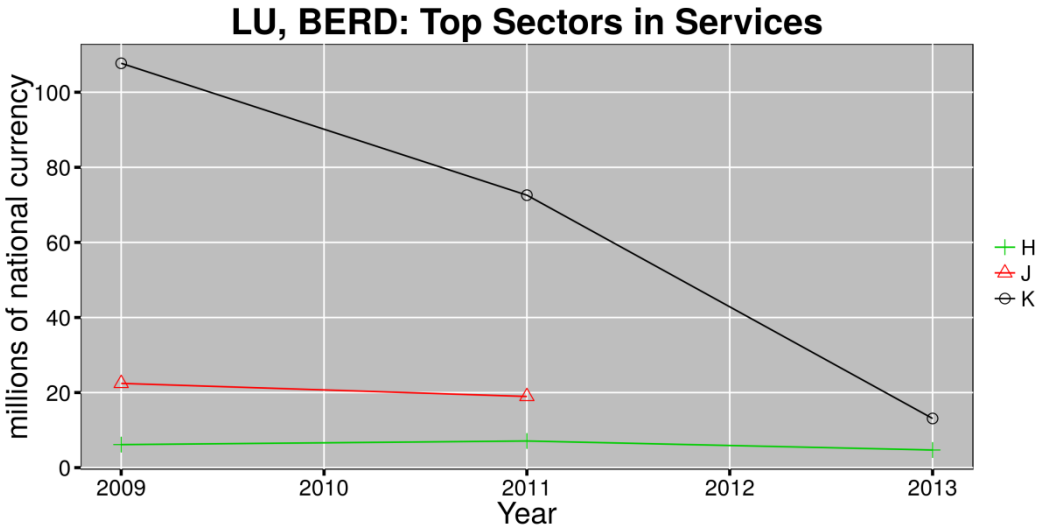
followed by manufacture of basic metals (7.6 MEUR) and of chemicals (€3.8m). Lack of further data hinders us from carrying out a more in depth analysis.

Figure 13: Top sectors in manufacturing (C20=chemicals, C24=basic metals, C28=machinery and equipment)



As can be deduced from Figure 14, BERD in the business services sector is much higher than that in manufacturing (0.25% of GDP in 2013). The top three sectors in terms of BERD intensity are the financial and insurance sector, ICT and transportation. In 2009, the financial services BERD was highly important with its over €100m (0.28% of GDP). However, by the end of 2013 it lost more than 85% of its 2009 value, falling below €15m. This huge drop was probably due mainly to the financial crisis.

Figure 14: Top service sectors (H=transportation, J=information and communication, K=financial and insurance services)

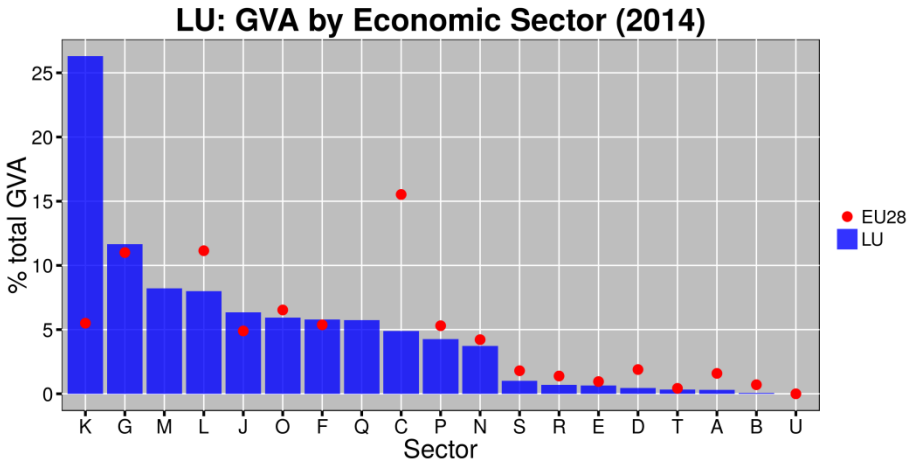


3.6.3 The development in business R&D intensity and value added

When looking at the contribution of the various sectors to the total gross value added (GVA), it can be noticed that financial and insurance services is the absolute leader (1/4 of the total GVA in 2012), which is not surprising in light of the structure of the national economy with a very large financial sector. As we have seen previously, this sector is one of the highest BERD receivers as well. It is followed by wholesale and retail, and professional, scientific and technical activities. Other sectors above 5% share are: real

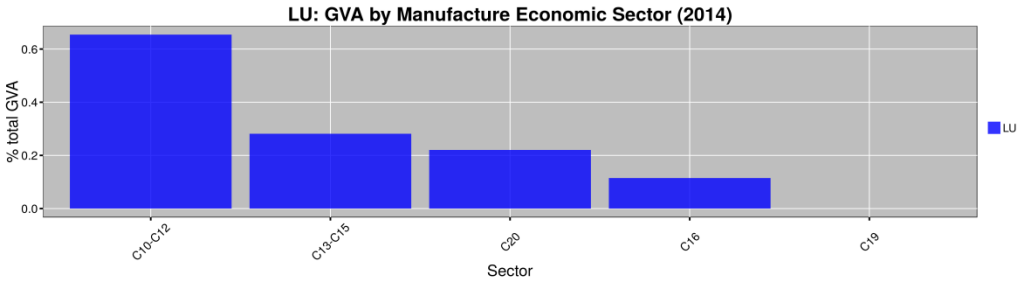
estate sector, information and communication technologies, and public administration and defence.

Figure 15: Economic sectors as percentage of the total GVA. Top 6 sectors in decreasing order. 1) financial and insurance services, 2) wholesale and retail trade, 3) professional, scientific and technical activities, 4) real estate activities, 5) information and communication, 6) public administration and defence



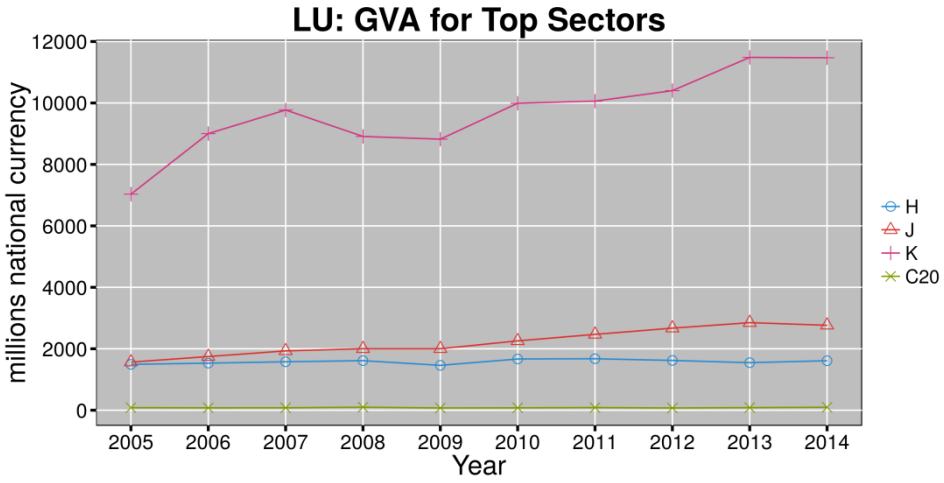
According to Figure 16, GVA in manufacturing is low (the GVA cumulated by the top five sectors is 1.2% of the total GVA of the economy) and comes from the low to medium low-tech industries, which is in line with the economic structure of the country relying heavily on financial services and having a rather small manufacturing sector.

Figure 16: GVA in manufacturing. Top 5 manufacturing sectors: 1) food, beverage and tobacco products, 2) textiles, 3) chemical products, 4) wood products, 5) coke and refined petroleum products



The decisive importance of the financial and insurance sector for the national economy is further emphasized in Figure 17 below. It has been relatively strongly hit by the crisis (cumulated loss of around 14.5%), but it managed to fully recover in 2010. The financial services sector is followed by ICT and transportation. Although of much lower importance, ICT services are increasing dynamically. It should be noted that the government actively supports the ongoing development of the logistics sector and ICT-based projects are included both in the funding from the National Research Fund and in the funding under the law of 5 June 2009 (providing general support to research).

Figure 17: Value added for the leading sectors



The number of researchers employed in the business sector dropped from 1,518 in 2011 to 1,004 in 2013, which is a 14% decrease for the period and is also reflected in the decreasing levels of BERD. It may be attributed to the lingering impact of the financial crisis. An important factor to be considered is the campaign to form public-private partnerships and provisions in the law of 5 June 2009 subsidising the secondment of public sector researchers to the private sector (i.e. the private researchers were in part substituted by the seconded public sector researchers paid by the state and therefore not accounted for in BERD).

3.7 Assessment

Public R&D funding in Luxembourg is well-defined for both public and private sector research performers. Programmes are multi annual and targeted and policies are consistent. The same domains that form the basis of the CORE programme for public sector research are basically the same as the domains of the projects that are funded under the law of 5 June 2009 for the private sector.

Performance contracts for public research performers provide targets for project funding as the basis for receiving institutional block funding. Since before 2008, when the first performance contracts were signed, there were no mandated levels of project funding, good progress has been made and the funding balance is assessed as being appropriate.

Performance contracts also set targets for other types of output. The table below indicates targets and results from previous performance contracts for the period 2011-2013 as well as the new targets for 2014-2017.

Table 13: Performance Contract Indicators and Targets

Indicator	2011-2013 target	2011-2013 achieved	2014-2017 target
Number of scientific publications (having an impact factor over 2)	558	775	1,040
Number of doctoral theses completed	91	90	167
Number of patents applied for	23	34	45
Number of spin-offs created	6	4	10

Source: MESR

The law of 5 June 2009 is fairly comprehensive in providing support for private sector R&D as it encompasses SMEs, feasibility studies, innovation in services as defined by the Oslo Manual (OECD, 2005) and even "de minimus" measures for projects not covered by its other provisions. The possibilities for public-private partnerships are also strongly promoted. Given the assessed adequacy of public sector support for private sector R&I, it is perplexing that levels of BERD have declined from 1.3% in 2009 to 0.71% in 2013. Determining the reasons for the decline in BERD and whether the funding scheme is somehow an issue is needed.[44] As mentioned above, an evaluation of the law of 5 June 2009, its selection processes and outcomes is recommended in the 2015 OECD review (OECD, 2015).

[44] Note that it can be stated unequivocally that corruption is not an issue for the private sector. Luxembourg ranks 11th out of 175 nations on Transparency International's Corruption Index (the higher the ranking the less the corruption.) See http://www.transparency.org/cpi2013/results#myAnchor1

4. Quality of science base and priorities of the European Research Area

4.1 Quality of the science base

For a small country, Luxembourg exceeds the EU average for scientific publications. When the number of scientific publications (having an impact factor over 2) was set as an indicator in the 2011-2013 performance contracts of PROs, the target of 558 publications was surpassed by 217, for a total of 775.

Luxembourg's public research system is highly autonomous in terms of hiring qualified researchers.

In January 2015, the merger of PRCs Henri Tudor and Gabriel Lippmann decreased system fragmentation by harmonizing certain overlaps in research areas. The resulting Luxembourg Institute for Science and Technology (LIST) has been reorganised into three research domains named straightforwardly the Environment, IT and Materials. Another system simplification was the incorporation of the International Biobank of Luxembourg (IBBL, www.biobank.lu) into the Luxembourg institute of Health (LIH).

Table 14: Publication Indicators

Indicator	Year	EU average
Number of publications per thousand of population	2.87 (2013)	1.43
Share of international co-publications	72.7%	30.4%
Number of international publications per thousand of population	1.84	0.52
Percentage of publications in the top 10% most cited publications	13.44 (2000-2013)	11.29 (2000-2013)
Share of public-private co-publications	2.2% (2011-2013)	1.8% (2011-2013)

4.2 Optimal transnational co-operation and competition

4.2.1 Joint programming, research agendas and calls

Because of its small size, Luxembourg has always been committed to transnational co-operation and the NRF has established widespread bilateral and multilateral agreements with other international research performers and consortia that support joint activities. These include participation in seven ERA-Nets as well European Cooperation in Science and Technology (COST), European Research Consortium in Informatics and Mathematics (ERCIM) and ESF Research Networking Programmes.

As an agency, the NRF participates in European Heads of Research Councils (EUROHORCs), the European Science Foundation (ESF) and the International Council for Science (ICSU).The NRF is also a member of Science Europe. As of 2012, proposals under the bilateral agreements with Germany's DFG and Switzerland's SNF with Luxembourg as the Lead Agency are submitted under the NRF's CORE programme. As noted above, all proposals submitted to the NRF are subject to independent, international peer review.

The NRF offers bilateral funding to Luxembourg researchers with the following:

- United Kingdom: Cofunding of bilateral projects with Research Council UK (RCUK)
- Germany: Cofunding of bilateral projects with the Deutsche Forschungsgemeinschaft (DFG)
- Germany: Cofunding of bilateral projects with the Federal Ministry of Education and Research (BMBF)
- EMBL: Co-funding of bilateral projects with the European Molecular Biology Laboratory (EMBL)
- Switzerland: Co-funding of bilateral projects with the Schweizer Nationalfonds (SNF)
- Austria: Co-funding of bilateral projects with the Austrian Science Fund (FWF)
- France: Co-funding of bilateral projects with the Centre National de la Recherche (CNRS)
- France: Co-funding of bilateral projects with the Agence national de la recherche (ANR)

Poland: Co-funding of bilateral projects with Narodowe Centrum Bodon i Rozwoju (NCBR) in Innovation and Services

- Belgium (Flanders): Co-funding of bilateral projects with the Fonds Wetenschappelijk Onderzoek (FWO)
- Belgium: Co-funding of bilateral projects with the F.R.S - FNRS
- Belgium: Co-funding of bilateral projects with the Belgian Federal Science Policy Office (BELSPO)

The NRF offers multilateral funding to Luxembourg researchers with the following:

- Ambient Assisted Living (AAL) Joint Programme
- European & Developing Countries Clinical Trials Partnership (EDCTP)
- European Research Area Networks (ERA-NET)
- EUROSTARS

Luxembourg participation in bi- and multilateral research projects is funded through the INTER programme. In 2014, 18 INTER projects were funded for €6.14m.

Luxembourg's Lead Agency agreements with Germany's DFG and Switzerland's SNF are specific about defining common principles for joint projects. The NRF website provides extensive information about participation in joint projects for each of its bi- and multilateral agreements.

Given its small size, Luxembourg has entered into a significant number of bilateral and multilateral agreements with other nations and provided the means to fund joint projects. Luxembourg correctly sees such cooperation as raising its international R&D profile. The amount it raises the quality of its research system is influenced by the number of foreign researchers alreay working in Luxembourg, as discussed in section 4.4.1.

4.2.2 RI roadmaps and ESFRI

Luxembourg participates in two infrastructures, DARIAH and SHARE, selected by the European Strategy Forum on Research Infrastructures (ESFRI). The government is currently analysing opportunities for strategic participation in other infrastructures on the ESFRI roadmap in conjunction with research institutions and research actors, especially in the bio-medical domain (Government of Luxembourg, 2015).

Luxembourg's major research infrastructure project, the €1 billion City of Sciences in Esch-Belval, is nearing completion. LIST, Luxinnovation the NRF and parts of the University have moved to their new facilities there. The OECD Reviews of Innovation Policy: Luxembourg 2015 recommends that Luxembourg ensure that the City of Sciences

attain international visibility as a research infrastructure and also that more centralisation occur, e.g., that the LIH and all University faculties also be relocated there (OECD, 2015)

As noted in section 4.4.1, many researchers in Luxembourg are foreign and thus may be considered as having access to domestic research infrastructures. The OECD 2015 review considers the City of Sciences to be a major research infrastructure (OECD, 2015).

Note that Luxembourg has no ESFRI roadmap.[45]

4.3 International cooperation with third countries

Luxembourg has several funding schemes with third countries. The most important one is with the United States through the National Science Foundation.

In addition, Luxembourg offers bilateral AFR grants with Singapore, NASA-ARC (Ames Research Center) and the RIKEN research centre in Japan.[46]

The NRF states that it "actively encourages research collaboration between researchers in Luxembourg and abroad. Because Luxembourg does not yet possess a critical mass of researchers that would allow the creation of high-performance research teams in all scientific domains and, in order to achieve international excellence, it is paramount for researchers to cross national borders. In order to optimise the visibility of Luxembourg as an attractive site for research activities within Europe, the FNR plans to reinforce collaborations with selected countries as well as its own international cooperation instruments."[47]

Luxembourg's initiatives promote coherent and sustainable EU-level cooperation with third countries, as evidenced by the bilateral agreements noted above and supported by the INTER funding scheme. AFR grants also provide PhD candidates the opportunity to carry out research with third countries.

4.4 An open labour market for researchers

Luxembourg is a model for researcher mobility, open recruitment, equitable work contracts and fair compensation. All Luxembourg research organisations are signatories to the Charter and Code, two have received HR Awards of Excellence and have also implemented Human Resources Strategy for Researchers (HRS4R). Nevertheless, developing human resources in RDI remains a challenge.

4.4.1 Introduction

Luxembourg research institutions enjoy a high degree of autonomy in their recruitment of researchers. The table below indicates the number of researchers by their sector of performance; in 2013, researchers represented 0.8% of the total workforce.

[45] http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri-national-roadmaps
[46] http://www.fnr.lu/funding-instruments/afr-bilateral-grants
[47] http://www.fnr.lu/international-cooperation

Table 15: Researchers by Sectors of Performance[48]

	2011	2012	2013	2014
Total	3,031	2,491	2,615	-
Business	1,518	927	1,004	-
Government	737	700	721	-
Higher Education	776	864	890	-
Non-profit	-	-	-	-

Note the 14% decrease in private sector researchers between 2011 and 2013 which is also reflected in decreasing levels of BERD and may be attributed to the lingering impact of the financial crisis.

The other predominant characteristic of researchers working in Luxembourg is that the vast majority are foreign, as indicated in the table below. Only the University has more Luxembourgish than foreign researchers.

Table 16: Origin of Researchers in the University and PROs 2011-2014 (MESR, 2015)

Organisation	2011	2012	2013	2014
University				
Luxembourg	-	792	943	977
EU	-	301	314	300
Non-EU	-	147	203	229
Lippmann*				
Luxembourg	25	20	19	18
EU	185	197	213	213
Non-EU	17	15	17	20
Tudor*				
Luxembourg	48	45	43	41
EU	367	344	315	307
Non-EU	47	42	38	30
Santé*				
Luxembourg	65	50	55	54
EU	190	207	216	210
Non-EU	25	33	29	29
CEPS/INSTEAD*				
Luxembourg	25	14	22	25
EU	94	89	90	90
Non-EU	12	15	19	13

*Note in 2015, PRCs Tudor and Lippmann were merged for form LIST, PRC Santé became LIH and CEPS/Instead became LISER.

[48] Retrieved 2 October 2015 from http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsc00004&language=en

Finally, the table below shows the relative numbers of researchers having permanent vs temporary contracts. Temporary contracts are based on the duration of a funded research project and can include PhD candidates and post-docs. This especially applies to the university. Note that not all PhDs have contacts.

Table 17: Researchers: Permanent (CDI) vs Temporary (CDD) (MESR, 2015)

Organisation	**2014**
University	
Permanent (CDI)	681
Temporary (CDD)	825
Lippmann*	
Permanent (CDI)	187
Temporary (CDD)	64
Tudor*	
Permanent (CDI)	286
Temporary (CDD)	92
Santé*	
Permanent (CDI)	188
Temporary (CDD)	105
CEPS/INSTEAD*	
Permanent (CDI)	88
Temporary (CDD)	40

*Note in 2015, PRCs Tudor and Lippmann were merged for form LIST, PRC Santé became LIH and CEPS/Instead became LISER.

The table above indicates that there are high proportions of researchers working in Luxembourg on temporary contracts. At the University there are more temporary than permanent researchers.

4.4.2 Open, transparent and merit-based recruitment of researchers

As indicated by the table above, Luxembourg can be regarded as a poster child for open and merit-based recruitment. Vacancies are announced on a Euraxess site as well as on the site of the recruiting institution and deadlines are reasonable and well-defined. The announcements are specific about the skills, competencies and other information required and the University offers an online application facility. Because many of the institutions work in French, English and German, language is not a barrier as it would be in some Member States.

The candidate selection process varies depending on the vacancy. Applicants for ATTRACT and PEARL fellowships and other high level positions are considered by selection panels made up of both local and independent international experts. Applications for the AFR programme for PhD and post-doc grants are also reviewed by international experts.[49] Junior positions have more limited review processes.

As part of a study done for DG RTD in 2013 titled Impact Assessment Study on Open, Transparent and Merit-Based Recruitment of Researchers, HR departments of several Luxembourg PROs were interviewed and reported that candidates for positions were able to ask for feedback. If they did, it would be provided, but it was unusual. Also the composition of selection panels is not normally published.

As part of PRO performance contracts, HR Departments have been mandated to develop career paths for researchers and annual staff evaluations are standard practice. The law of 28 August 2008, on the free circulation of people and immigration, allows public research institutions to receive a license to enable them to receive researchers from

[49] Note that with the reform of the AFR programme that was underway as of October 2015, it is not known how future candidate evaluations will be undertaken.

outside of the EU without the need to apply for individual work permits. Terms of employment are covered in the law of 3 August 2003 establishing the University. In addition, researcher fixed-term contracts can be extended to five years, rather than the normal duration of two-years.

The University was founded as a "research" university and has targeted strategic research priorities. In 2013, the Luxembourg University Foundation was established for the purposes of funding research projects and research chairs as well as providing support for scientific conferences and scholarships for needy students.

Because many Luxembourgers study abroad and the workforce is comprised of a high percentage of foreign residents and frontaliers, the MESR has a department "Reconnaissance et homologation de titres universitaires" that certifies foreign diplomas. Consequently a foreign diploma is not considered to be a barrier for a researcher.

Young researchers are recruited and the ATTRACT programme was specifically established to "attract" outstanding young researchers to Luxembourg. In addition, AFR post-doc grants are open to foreigners.

Researcher inflows and outflows are detailed in the table below. The University's high levels of inflows indicate that it is young and still in a relative growth phase. PRC Henri Tudor's dwindling numbers reflected the immanence of its merger with PRC Gabriel Lippmann.

Table 18: Researcher Inflows and Outflows 2012-2014 (MESR, 2015)

Organisation	**2012**	**2013**	**2014**
University			
Incoming	243	287	218
Outgoing	37	51	67
Net	+106	+236	+151
Lippmann*			
Incoming	36	37	19
Outgoing	29	24	23
Net	+7	+13	-4
Tudor*			
Incoming	25	23	21
Outgoing	50	52	34
Net	-25	-29	-13
Santé*			
Incoming	30	27	24
Outgoing	26	21	25
Net	+4	+6	-1
CEPS/INSTEAD*			
Incoming	6	12	7
Outgoing	15	11	11
Net	-9	+1	-4

*Note in 2015, PRCs Tudor and Lippmann were merged for form LIST, PRC Santé became LIH and CEPS/Instead became LISER.

Luxembourg is very attractive to foreign researchers. They enjoy full work contracts and social benefits—health care, pension, parental leave, etc.—and a high quality of life. Integration is facilitated by Luxembourg's multi-cultural and multi-lingual environment. The Euraxess portal provides extensive information about living in Luxembourg.

4.4.3 Access to and portability of grants

Access to grants is limited to Luxembourg-based researchers employed at the University or a PRO.[50] Grants are awarded to institutionally-sponsored projects, rather than to individuals. Consequently, grants are not portable. In projects that come under the bi- and multilateral agreements between the NRF and other foreign research institutions, the NRF funds the Luxembourg portion of the project and the foreign institution funds its part. The INTER programme funds Luxembourg researcher participation in external projects.

An exception to the non-portability of grants has been the AFR programme that funds PhDs. Recipients were able to be of any nationality and do their study anywhere; the deciding criterion is that the work be of interest to Luxembourg. AFR post-doc candidates can also be from outside of Luxembourg but recent changes to the programme foresee that the post-doc work is undertaken in the Grand Duchy.

The AFR programme is being revised as of October 2015 and it is unclear whether grants will continue to be portable or if research can continue to be undertaken outside of the Grand Duchy.

4.4.4 Doctoral training

The University of Luxembourg has seven doctoral schools. They are Systems and Molecular Biomedicine, Economics and Finance, Educational Sciences, Computer Science and Computer Engineering, Law, Social Change and Sustainable Social Development and IPSE: Identities, Politics, Societies and Spaces. The PROs also offer opportunities for doctoral students and performance contracts for 2014-2017 have a combined target of 167 doctoral theses to be completed during this period.

The national programme for Innovative Doctoral Training has been the Aid for Research Training (AFR) programme. It provides funding for PhD candidates for up to four years. It is currently being revised and the terms of the new provisions are not yet known.

Previously, the funding scheme has been aligned with the principles advocated in the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers.[51] The AFR had no thematic limitations and was open to all researchers, regardless of their nationality, desirous to engage into research training in Luxembourg or abroad. It embodied the principles of research excellence, an attractive institutional environment, exposure to industry and other relevant sectors, international networking, transferable skills training and quality assurance. Participants were required to be covered by social security, enjoy work contracts and were able to do their research with qualifying companies.

Described as "the new programme for funding doctoral research in Luxembourg," PRIDE is based on the law of 27 August 2014. The programme is designed to support Luxembourg research institutions to attract, recruit and train PhD candidates in the five domains that form the basis of the CORE programme. PRIDE awards a block of non-nominative PhD grants to a group of researchers focussed around one of the designated themes and prospective candidates apply directly to the consortium for a PhD position. The consortium to be funded will be announced by the NRF in April-May 2016. Funding comprises PhD salaries for four years, a travel and training allowance and an additional 5% of salary costs paid to the consortium to cover other related expenses. The PRIDE programme promotes the implementation of the Quality Framework for doctoral Training.

[50] Recent changes in the law also open the possibility of grants to foundations and private research institutes.

[51] As all Luxembourg research organisations including the NRF and the Ministry itself are signatories, any reforms will continue to uphold their standards-

4.4.5 Gender equality and gender mainstreaming in research

Luxembourg's research system has always had issues with gender equality and gender balance has been identified as one of the Grand Duchy's structural challenges.

In 2011, Luxembourg had the second lowest proportion of female researchers in Europe--only 24% of the total. At 22% only Germany was lower. 32.7% of researchers in higher education are female. 34.6% in the government sector, and a mere 11.4% in the business enterprise sector, again ranking Luxembourg in the lowest proportion among European nations.

The table below shows total numbers of R&D personnel, which includes researchers, technicians and other support personnel, and numbers of researchers alone. It shows that women represent an average of 27.9% of total R&D personnel and 22.5% of researchers during the period 2005-2011.

Table 19: R&D Personnel by Sex and Occupation[52]

	2005		2007		2009		2011	
	Number	%	Number	%	Number	%	Number	%
Total R&D personnel	5,015	100	5,551	100%	5,749	100%	6,189	100%
Women R&D personnel	1,068	21.3	2,019[e]	36.4	1,633	28.7	1,559	25.2
Researchers	2,443	100	2,470	10	2,751	100	3,267	100
Women researchers	445	18.0	575	23.3	626	22.8	784	24.1

When looking at women in academia, the table below shows that Luxembourg has the lowest proportion of female academics in the EU in two categories. Other countries are included for comparison.

Table 20: Proportion of Female academics in %, 2010

	Grade A	Grade B	Grade C	Total
LU	9*	29	31	26*
BE	12	27	34	38
DE	15	21	27	36
FR	19	40	30	34
UK	17	27	37	42
EU-27	20	387	44	40

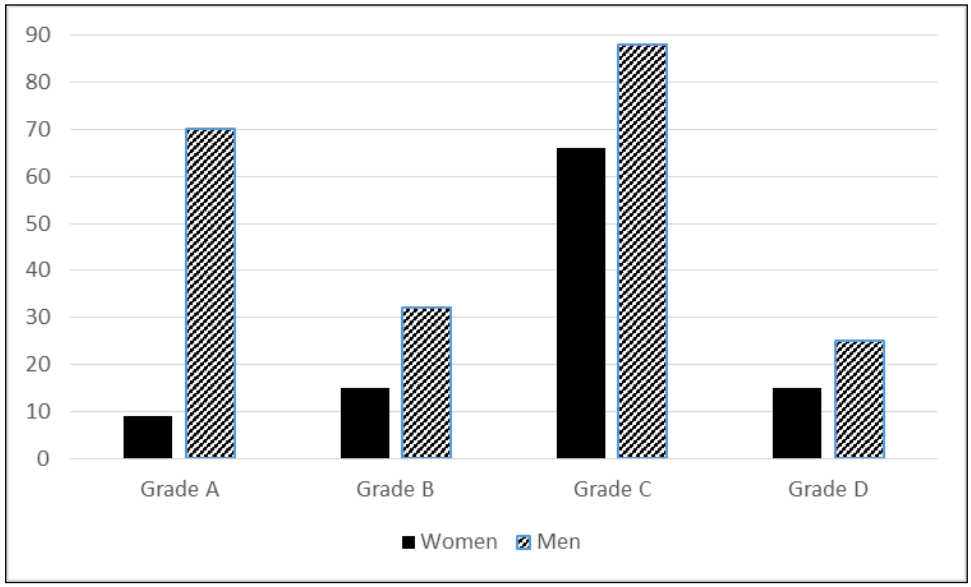
*EU low

The table above is a "snapshot." Looking at the trend over time, between 2002 and 2010, women in the top (Grade A, i.e., full professor) academic positions grew a mere 1.4%, from 10.0% in 2002 to 11.4% in 2010.[53] This is especially significant because the University of Luxembourg was formed in 2003 and many new academic positions were created.

[52] Retrieved March 2, 2015 from http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsc00005&language=en o

[53] The figure places Luxembourg at the next lowest ranking in the EU, second only to Cyprus, 5.6% to 10.7%, which at least showed a significant rate of improvement.

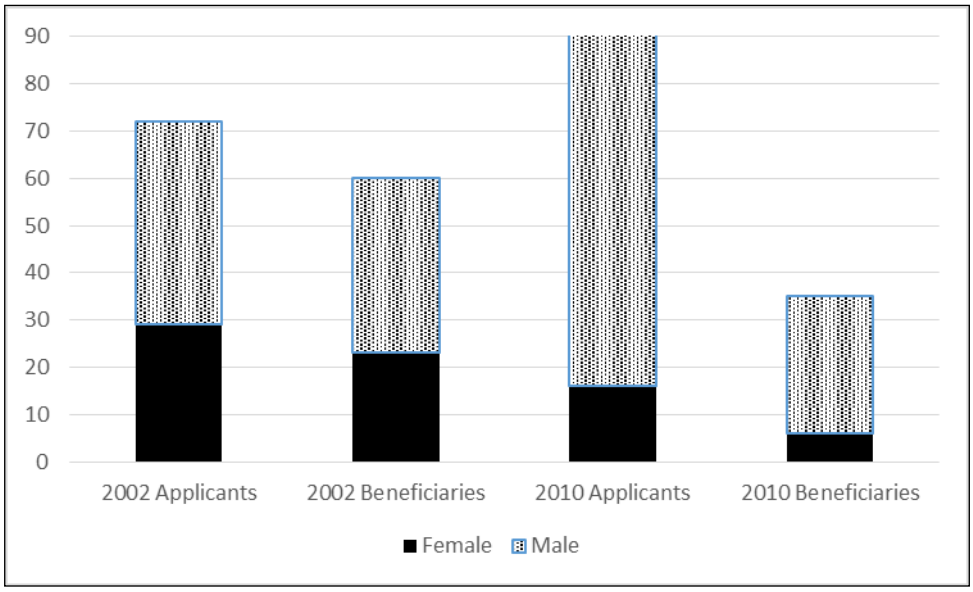
Figure 18: Numbers of Women and Men in Academic Positions by Grade, 2010



She Figures (2012) notes that there are no female heads of higher education institutions in Luxembourg, another EU low. While this figure must be assessed in the context that Luxembourg only has one university, it is also true that there have been three rectors since it was established, all men, and that the rectorate which governs the university is also all male.[54]

As undertaking research also increasingly involves research funding, the following figure compares success rates of male and female researchers. What is significant is not only the far lower success rates of women applying for research funding, but the sharp decrease in women applying for funding between 2002 and 2010, despite an overall increase in applications.

Figure 19: Research funding applicants and beneficiaries by sex, 2002 and 2010 (She Figures, 2012)



[54] Retrieved March 15, 2015 from http://wwwen.uni.lu/university/about_the_university/Governance

While the report European Research Area Facts and Figures 2014 (EC DG RI) assesses Luxembourg as not having implemented any measures to address gender imbalances, since the end of 2014, the MESR has mandated that all boards of PROs be comprised of at least 50% of "the under-represented sex" by 2017 and board composition has already begun to change. This does not apply, however, to the heads of the institutions of Luxembourg's NRS, all of whom are male, as well as their upper management.

The only measure to balance gender representation was only implemented in 2014. This is the requirements that the boards of PROs increase the proportion of the "under-represented" sex to 40%. The 2015 OECD review recommends active initiatives to address gender imbalances be initiated (OECD, 2015).

4.5 Optimal circulation and Open Access to scientific knowledge

4.5.1 e-Infrastructures and researchers electronic identity

In terms of e-infrastructure, Luxembourg's is ranked 21 out of 142 nations in the World Economic Forum's Global Information Technology Report 2012 and gives Luxembourg's infrastructure a rating of 6.3 out of 7 (WEF, 2012). An example of Luxembourg's e-infrastructure that relates to research is the CVCE (Centre Virtuel de la Connaissance sur l'Europe) that is a research and documentation centre for European studies The Centre creates digital publications which are particularly geared towards researchers and lecturers, while remaining open to a wider public. Like the National Library, it is also a major actor in "Digital Humanities."

In addition to the CVCE, Luxembourg has the LIS Cross-National Data Center. The Data Center provides digital information from the Luxembourg Income Study (LIS) and its team was recently joined by Dr Paul Krugman, winner of the 2008 Nobel Prize in economics.

The university library has electronic resources that give online access to e-books and reviews of the university community as well as links to the digital services of the National Library (BnL). This is the central documentary platform of the Grand Duchy that is actively pursuing the national coordination and technological innovation policy in the area of documentary services production and dissemination.

The BnL offers an innovation policy for scientific and research libraries. In 2013, bibnet.lu, the national library's network, took on 17 new member libraries, for a total of 57 members. Six additional libraries are in the process of joining the network. By the end of 2014, a large majority of scientific and research libraries in the country will be included.

In addition, the Luxembourg Consortium, made up of BnL, the University of Luxembourg and the three CRPs, offers 50,000 periodicals, 80,000 books and over 350 specialised databases, plus reference books in English, French and German through the Findit portal. Beginning in 2013, this content also became available through, a unified research portal. Statistics for 2013 again indicate significant increases in the use of the digital library of 50%, a figure that does not include purchased content. If the growing portion of open access content were included, consultation of works would be even higher. The number of users who consulted the digital library grew by 24% in 2013.

Note that although there is no electronic identity for researches, any resident of Luxembourg can obtain electronic access to BnL digital resources. However, there are no measures supporting membership to identity federation communities.

Luxembourg has very strict laws covering data security, with severe penalties for their violation, and for this reason has developed a niche for data centres. Luxembourg strictly observes EU regulations regarding the use of personal data.

4.5.2 Open Access to publications and data

In May 2013, the University of Luxembourg organized an information session on Open Access, based on a cooperation agreement to be signed with the University of Liège (ULg) that includes the establishment of a strategy and a "green" policy on Open Access (OA) at the University of Luxembourg and the creation of an Institutional Repository ORBi based on the model developed successfully at ULg. Under the European Commission's Openair project, the University library will be transformed into a National Free Access Office (NOAD) for Luxembourg.

Additionally, the NRF is also working to develop a policy on Open Access. As a member of ScienceEurope, the NRF endorsed a statement of principles that "advocate that research publications should either be published in an Open Access journal or made available or be deposited as soon as possible in a repository."[55]

In light of the initiatives of the University and the NRF, the report on Open Access Strategies (Caruso et al., 2013) that does not identify any movement in the Grand Duchy on this issue appears to be incorrect. It does state that, "All in all, the number of policies alone is a weak indicator of commitment to OA in a given country." The report also estimates that, "if the precision and recall of the harvesting instrument is taken into account," 50% of journal articles in Luxembourg are being published in OA journals.

PRO LISER publishes a full text selection of its research work on its website that is not published in "commercial" journals. PRC Lippmann provides bibliographic information on its publications but no links to the publications themselves. PRO LIH publishes information on its publications, abstracts and, when possible, provides Open Access versions of the full text. PRO LIST provides a catalogue of its publications, but without access to articles. Finally, like LIST, the University of Luxembourg provides a listing of publications but with limited information or links to the articles themselves.

Archambault et al. (2013) estimated the proportion of OA per country, in a 4-year non-weighted sampling covering 2008-2011. Using a sample of 35 papers, Luxembourg had 11, papers, or 35%, in green or hybrid journals, 2, or 5% in gold journals and 15, or 41% available via Open Access.

The University library has electronic resources that give online access to e-books and links to the digital services of the National Library (BnL).

The Luxembourg Consortium, made up of BnL, the University of Luxembourg and the three CRPs, offers 50,000 periodicals, 93,000 books, 63,000 journals and over 350 specialised databases, plus reference books in English, French and German through the portal findit.lu. In 2013, this content also became available through the www.a-z.lu unified research portal. Statistics for 2014 indicate an increase in the use of the digital library of 29%, a figure that does not include purchased content. Any resident of Luxembourg, in addition to students and researchers, can use the portal. In 2014, applications that permit database access via tablets and smartphones were launched.

Again, the National Library, th BnL, has taken the lead in the long-term preservation of information in an initiative it calls the "Digital Humanities." This project offers public access via the internet to digital copies of previously inaccessible works and is being extended to the national digitisation platforms, such as www.eluxemburgensia.lu, which includes 16 periodicals and 360,977 pages.[56] The National Library also has initiatives in capturing "born again" digital content for researchers. Finally, the BnL is also very active in promoting Creative Commons. It includes Creative Commons in its digital policies and is active in Creative Commons Luxembourg.[57]

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[55] http://www.fnr.lu/en/Press/Press-Releases

[56] eLuxemburgensia is a database of news articles from Luxembourg newspapers going back for more than 100 yearsy. It is integrated into the BnL's website. Searches can be done by date or topic.

[57] www.luxcommons.lu

5. Framework conditions for R&I and science-business cooperation

5.1 General policy environment for business

Luxembourg is a nation of SMEs. Using the criteria defined by the EU in 2005, Luxembourg's business landscape is detailed in the table below. It provides the composition of Luxembourg businesses by size and in comparison with the EU average. It demonstrates that businesses in Luxembourg, like the EU overall, are overwhelmingly SMEs. On the other hand, large companies, which account for only 0.5% of all business, provide 33.4% of employment and 32% of value-added.

Table 21: Luxembourg SMEs 2013 estimate

(European Commission Enterprise and Industry, 2014a)

Type	**Number Enterprises**			**Employees**			**Value Added**		
	Luxembourg		**EU-28**	**Luxembourg**		**EU-28**	**Luxembourg**		**EU-28**
	Number	**%**	**%**	**Number**	**%**	**%**	**€ bn**	**%**	**%**
Micro	20,658	86.9	92.4	44,318	17.9	29.1	4	21.8	21.6
Small	3,129	10.6	6.4	61,967	26.0	20.6	4	20.5	
Medium	605	2.0	1.0	58,511	23.6	17.2	5	25.5	
Total SME	29,392	99.5	99.8	164,796	66.6	66.9	14	67.5	
Large	144	0.5	0.2	82,742	33.4	33.1	6	32.1	

According to the World Bank Doing Business Index, Luxembourg ranks thirtieth out of 31 OECD countries, a surprisingly poor showing. Overall, Luxembourg ranks fifty-ninth.

Table 22: Luxembourg Ranking Among OECD Nations in World Bank Doing Business Index[58]

Criteria	**Rank**	**Criteria**	**Rank**
Ease of Doing Business Rank All	59	Getting Credit	31
Rank among OECD nations	30	Protecting Minority Investors	31
Starting a Business	26	Paying Taxes	7
Dealing with Construction Permits	11	Trading Across Borders	22
Getting Electricity	12	Enforcing Contracts	1
Registering Property	30	Resolving Insolvency	30

The European Commission SBA Fact Sheet for Luxembourg (2014a) rates the Grand Duchy on ten criteria and finds it "status quo" in comparison with other EU Member States in terms of Internationalization, Environment, Responsible administration and State aid and public procurement. It excels in the categories of Access to finance, Skills and innovation and Single market. but lags behind Europe on Entrepreneurship and Second chance. This last rating relates to bankruptcy and confirms the World Bank's low ranking for the Grand Duchy.

Insolvency regulations in Luxemburg are draconian: an entrepreneur whose company fails cannot start a new business for eight years, effectively neutering any learning from the failure and stifling "serial entrepreneurship." In addition, bankruptcy proceedings can be lengthy. In certain circumstances, the entrepreneur may be personally liable for the company's debts. Insolvency regulations are one of the few areas of the Small Business Act (Commission of the European Communities, 2008) that Luxembourg fails to address.

In 2012, the European Commission carried out a survey on attitudes to entrepreneurship. Respondents from all EU Member States were polled, as well as individuals from 12 countries outside of the EU, including Brazil, Russia, the US and China. (European Commission, 2012). The study shows changes from 2009 to 2012,

[58]Retrieved 7 October 2015 from http://www.doingbusiness.org/rankings

although the work does not explore the impact the financial crisis might have had on attitudes. When asked to indicate the two risks of which they would be most afraid if they started a business, Luxembourg respondents indicated that Fear of bankruptcy and loss of property were their biggest fears.

Table 23: If you were to start up a business today, what are the two risks you would be most afraid of?

Risk	**%**
Possibility of going bankrupt	50
Risk of losing property/home	39
Irregular/not guaranteed income	30
Lack of job security	23
Possibility of suffering a personal failure	18
Need to devote too much time/energy to it	15

5.2 Young innovative companies and start-ups

A provision of the law of 5 June 2009 specifically deals with the funding needs of young, innovative companies. Luxinnovation focuses on identifying the most appropriate sources of support for young companies and start-ups, identifying potential partners and match-making to promote public-private partnerships. An annual "Business Meets Research" event showcases public sector research expertise to companies.

As noted above, a specific number of spin-offs is part of public sector performance contract targets.[59] One of the University Vice Rectors is charged with the valorisation of research and the NRF has adopted a policy that all proposals submitted for CORE project funding are evaluated from their inception for their commercial potential by Luxinnovation. Two additional funding instruments—Proof of Concept (POC) and Knowledge and Innovation Transfer Support (KITS)—provide funding for PROs to help make their research ideas more attractive to potential investors. The programme POC covers projects that are at a Technology Readiness Level TLR 3 up to TLR6. It is open to the CORE domains Biomedical Sciences and Advanced Materials Engineering as well as ICT. KITS provides competitive funding to Luxembourg PROs to attract highly skilled professionals in the area of knowledge transfer. The aim is to reinforce research units to engage in the strategic integration and operational implementation of knowledge transfer activities, with the ultimate goal of generating economic and societal value through their research programmes.

Lux innovation runs the Grand Duchy's cluster programme. There are clusters in Materials, ICT, Space, BioHealth, EcoInnovation and Automotive Components and members represent a broad range of knowledge trian7le actors. Maritime and Logistics Clusters operate separately.

Luxinnovation also oversees Luxembourg's 1-2-3 GO business plan competition and there are other entrepreneurial awards given by local business organisations.

In late 2015, the Ministry of the Economy, in conjunction with Luxinnovation, launched a new programme to support start-ups. Fit4Start targets ICT companies formed within the past twelve months and with at least two employees. Fit4Start offers early-stage enterprises public funding of €50,000 (to be matched by €10,000 from the company), rent-free facilities at the Technoport business incubator at the City of the Sciences in Esch-Belval, and weekly coaching by experts in "Lean Start Up" methodology. At the end of the four-month programme, during which a product prototype is developed, an event is organized for the company to pitch its project to potential investors. Twice a year proposals will be considered by a jury and up to five companies will be selected.

[59] The goal for the 2014-2017 performance contract period is 10.

5.3 Entrepreneurship skills and STEM policy

The University of Luxembourg offers a Masters in Entrepreneurship and Innovation[60] and Luxinnovation and the Chambre of Commerce also offer trainings in innovation management and start-up skills. The University also offers PhD candidates Transferable Skills Training that includes developing presentation skills, time management and writing research papers.[61]

Luxembourg has the EU's highest level of human resources in science and technologies (HRST): 56.5% as a percentage of total employment versus an EU 27 average of 42.7% in 2011 and 58.3% in 2012.

The University of Luxembourg has five designated research areas, three of which are in the sciences with a fourth focussed on "Educational Sciences." In addition, two of the three PROs--LIST and LIH—are centred on the sciences. The NRF promotes a national television show—Mr Science—as well as a website, Science.lu and undertakes other activities to promote scientific research through the Promoting Science to the Public (PSP) funding scheme.

A provision of the law of 5 June 2009 provides funding for SMEs to work with external consultants on R&I projects.

5.4 Access to finance

A dearth of venture capital has long been an issue in Luxembourg and cited as one of the main innovation challenges in previous country reports. The grass-roots resurrection of the Luxembourg Business Angels Network (LBAN), headed by two veteran entrepreneurs, has been a positive development.[62] LBAN is partnered with the Chamber of Commerce, Luxinnovation, Seed4Start, the Technoport business incubator and Silicon Luxembourg to work with start-ups and provide seed capital. It offers coaching and organises "pitching days." It is also focussed on social innovation and is part of the European Trade Association for Business Angels, Seeds Funds and Early Stage Players (EBAN.) In 2012, LBAN members invested €2.3m in nineteen companies. According to EBAN (EBAN, 2014), LBAN is Luxembourg's sole business angel network with 80 business angels. In 2013, 17 investments were made totalling €1.7m which created 59 jobs. Average investments were €94,118.

The EU Innovation Union Scoreboard 2015 gives Luxembourg a rating of 305 for Venture Capital Investments (relative to the EU performance = 100). A 13% decline was experienced in this indicator in the period covered.

Another development which should have been positive, the formation of a €150m Future Fund, co-managed by the European Investment Fund (EIF) and the National Society for Credit and Investment (SNCI) has been less happy.[63] With a stated purpose of making investments in innovative SMEs, it has taken more than twenty-eight months since the announcement of the fund in January 2012 to its actual launch, reportedly between July and September 2014,[64] although at year end 2014 there is still no evidence of any activity.

The European Private Equity and Venture Capital Association (EVCA) points out that "Luxembourg provides sophisticated investment fund structures for private equity and venture capital investment" and that "while corporate tax rates… are not particularly low, Luxembourg investment fund vehicles benefit from extensive tax exemptions, which ensure an almost tax-neutral environment in Luxembourg at the level of both the fund vehicle and its investors." (EVCA, 2013). The two vehicles are SICARs (Société

[60] http://wwwen.uni.lu/formations/fdef/master_in_entrepreneurship_and_innovation_professionnel
[61] http://wwwen.uni.lu/formations/etudes_doctorales/ecoles_doctorales/transferable_skills_training
[62] http://www.lban.lu/
[63] http://www.snci.lu/
[64] Retrieved December 29, 2014 from http://paperjam.lu/news/le-luxembourg-future-fund-enfin-sur-les-rails

d'Investissement en Capital à Risque) and SIFs (Fonds d'Investissement Spécialisé). Both instruments are meant to encourage investment but are not limited to venture capital investments—portfolios can contain exchange-traded equities, for instance.

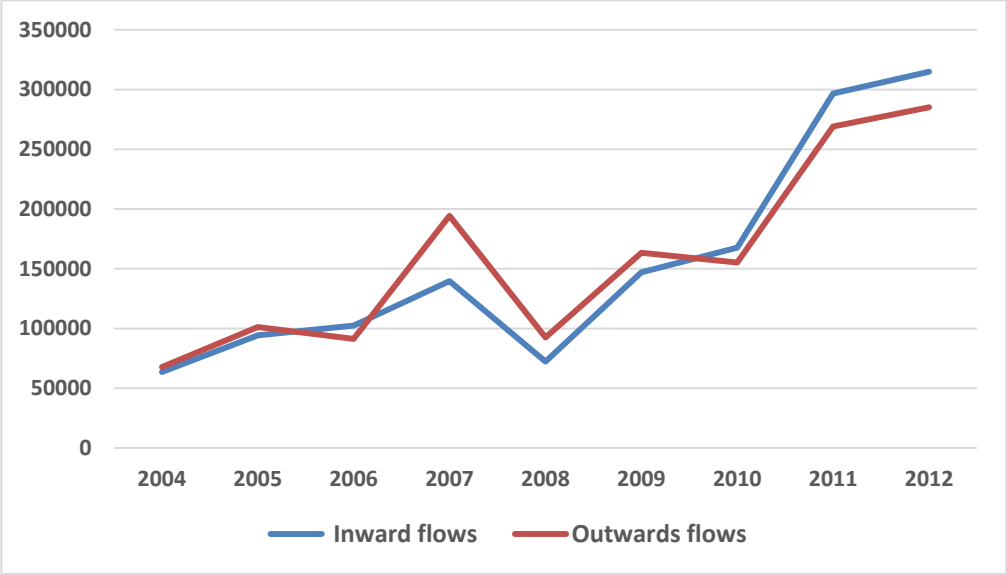
The SNCI also offers a direct loan for Research, development and Innovation. Loans can be granted to innovative SMEs that possess a business permit issued pursuant to the law of 2 September 2011 (right of establishment) for at least 4 years and have a substantial impact on national economic development. An RD&I loan cannot be greater than €250.000 without exceeding 40% of eligible costs and taking into account the extent of the project and the size of the company. At least 35% of investments and expenses shall be co-financed by own resources. Amount of the SNCI loan (or SNCI loans) cannot exceed the total amount of equity of the loan beneficiary. Note that some SCI loans must be guaranteed by the personal assets of the recipient.

There are no crowdfunding sites dedicated specifically to Luxembourg ventures.

5.5 R&D related FDI

Luxembourg's Foreign Direct Investment (FDI) dwarfs all other EU Member States' and even the United States'. In 2012, the most recent year for which figures are available, Luxembourg's FDI inflows were €314,934m and outflows were €285,099m, compared to the USA whose inflows were €124,976m and outflows, €285,607m. Luxembourg's top outflow destinations were Bermuda, Switzerland and the United States (Eurostat, 2013). The reason for the size of the in- and outflows are Luxembourg's financial services sector and its investment funds. Special purpose entities account for 90% of Luxembourg's FDI. The chart below details FDI from all countries and does not indicate how much is associated with R&D.

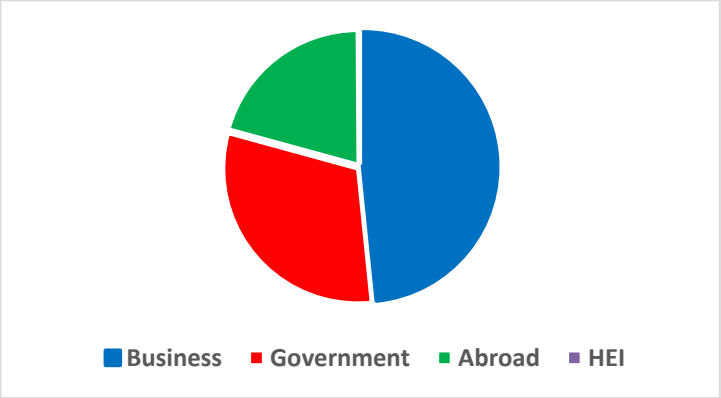
Figure 20: Foreign Direct Investment Inflows and Outflows, All Countries, €m[65]



Otherwise GERD source of funds from abroad (as a percent of GERD) was 5.4% in 2009, 20.7% in 2010 and 20.4% in 2011, the most recent year for which figures are available. Other sources of GERD in 2011 are shown in the chart below. The reason for the large increase of GERD from abroad between 2009 and 2011 is not known, nor the reason for the lack of more recent statistics.

[65] Inflows http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00049&language=en
Ouflows http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00053&language=en

Figure 21: GERD by Source of Funds as % of GERD, 2011[66]



The Ministry of the Economy, which is responsible for attracting foreign investment, promotes the funding available through the law of 5 June 2009, IP tax incentives and a competitive corporate tax rates, as indicted in the table below.

Table 24: Comparative Corporate Tax Rates[67]

Country	Tax rate %	Notes
Belgium	33	
France	33.3	
Germany	30-33	15% Federal, 5.5% Solidarity Surcharge, plus 14-16% municipal tax
Luxembourg	28	20% for companies with less than €15,000 profits, Includes 7% unemployment fund surcharge. Municipal rates may apply.
Netherlands	20-25	20% on first €200,000, afterwards 25%
United Kingdom	28	

5.6 Knowledge markets

Luxembourg's Ministry of the Economy has a DG for Research, Intellectual Property and New Technologies with an Office for Intellectual Property. In 2014, the IP Office organised an information series, "IP Tuesdays," and the seventh Luxembourg IP Day, a joint event with the Benelux Intellectual Property Office and the World Organisation for Intellectual Property. The office also organised trainings on IP.

The joint Ecomin and FEDER (European Funds for Regional Development) project, BOOST-IP, promoted awareness of IP in eco-technology companies and the craft trades. The IPorta project, which was co-financed by the Commission, was intended to maintain the national intellectual property network and provide IP support services to SMEs. Luxembourg, through the intermediary of the Technological Monitoring Centre (CVT), worked to coordinate the project involving a network of thirty national intellectual properties offices. The IPorta project expired at the end of 2014 and a new project, Iporta2, has been proposed.

[66] Retrieved 5 October 2015 from http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsc00031&language=en

[67] http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Tax/dttl-tax-corporate-tax-rates-2015.pdf

Luxembourg has a law giving preferential tax treatment to revenues from IP (circular L.I.R. n°50bis of 5 March 2009). Under this scheme, up to 80% of the net income generated by the exploitation of an intellectual property right is exempt from tax, subject to certain conditions. In other words, the effective average tax rate on IP income is 5.7%. The scheme covers patents, trademarks, designs, domain names and software copyrights and applies to companies located in Luxembourg. In addition, the law of 5 June 2009 relating to the promotion of research, development and innovation provides the framework for a financial aid scheme that contributes to the costs linked to the protection of technical industrial property.

In September 2014 the formation of a Luxembourg Institute of Intellectual Property (IPIL) was announced, as a joint effort of the Office of Intellectual Property and a unit of PRC Henri Tudor (now LIST). IPIL became active in early 2015 and has a mission to coordinate the implementation of public policy, to provide support and assistance to companies, research entities, public institutions and all other interested parties regarding IP and to provide IP training programmes and promotional and awareness activities. IPIL provides companies with information and advice on the identification of valorisation of IP. It provides access to databases so trademark availability can be researched, for instance. It serves as a clearinghouse for IP news, such as the most recent EPO statistics, and promotes and publicises IP-related events, such as a "Webinar on New EU trademark Regulation" (www.ipil.lu).

Luxembourg participates in all the major IP treaties and conventions, including the Bern Convention, the Patent Cooperation Treaty (PCT), the Paris Convention and the Patent Law Treaty (PLT), as well as the Madrid Agreement and Protocol. The country is a signatory of the European Patent Convention, which was set up by the European Patent Office (EPO).

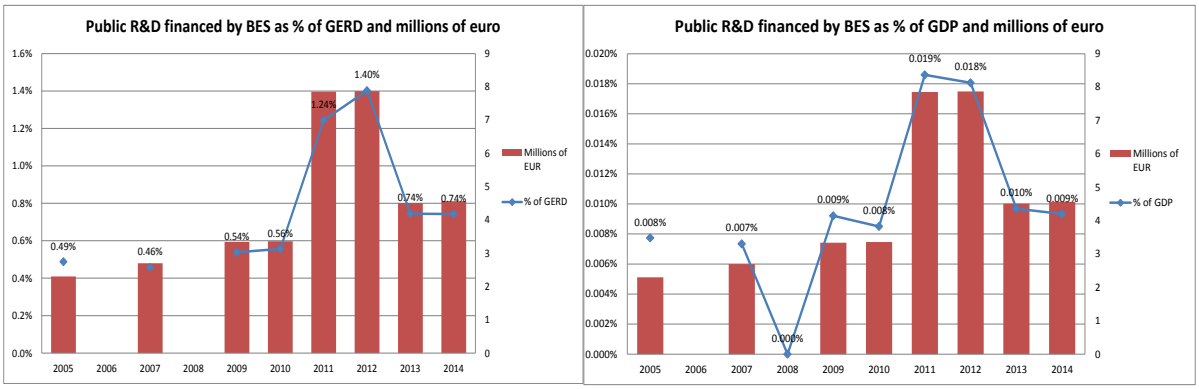
Note that there are no marketplaces for patents in Luxembourg.

5.7 Public-private cooperation and knowledge transfer

5.7.1 Indicators

Funding: BES-funded publicly performed R&D

Figure 22: BES-funded public R&D in LUXEMBOURG as % of GERD (in €MLN) and % of GDP

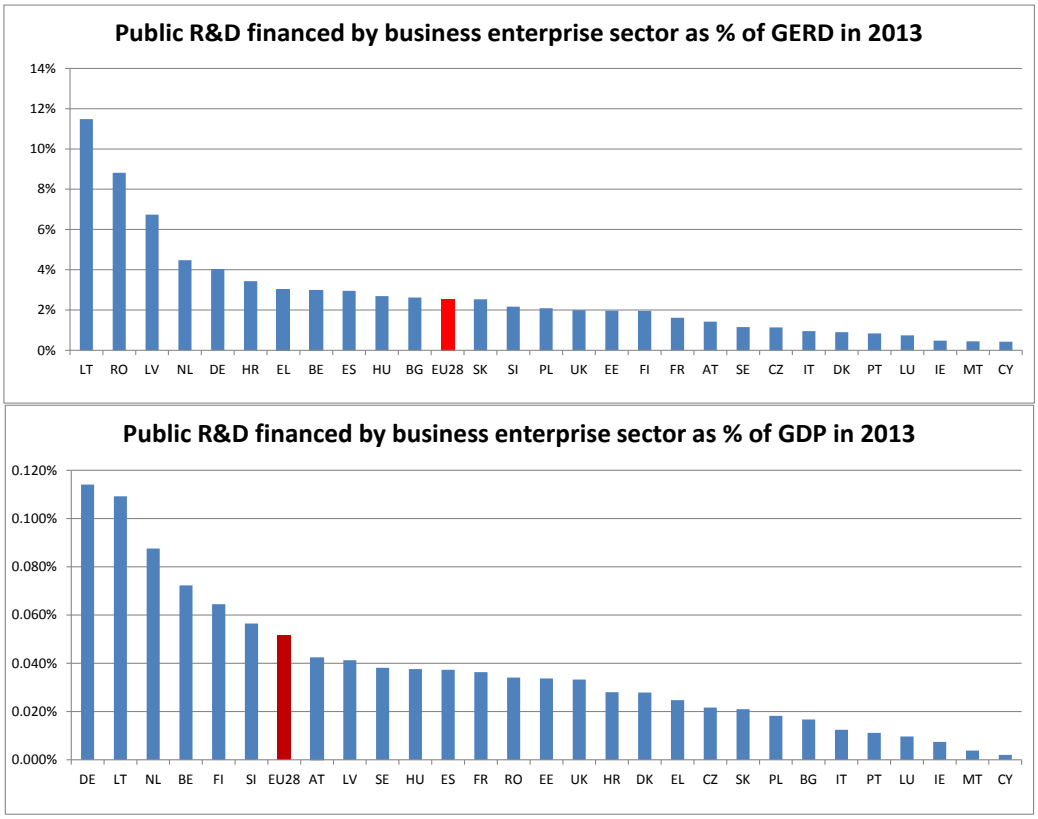


In Luxembourg, the business enterprise (BES)-funded public R&D expenditure as a percentage of GERD increased sharp in 2011 to 1.24% from a level of 0.56% in 2010 and continued to rise in 2012 reaching 1.40%. Then it decreased considerably to 0.74% in 2013 and stayed at the same level in 2014.

The indicator expressed as a percentage of GDP shows a similar trend: after an increase to 0.019% in 2011 from 0.008% in 2010, it stayed at almost the same level of 0.08% in 2012, then decreased to 0.01% in 2013 and 0.009% in 2014.

With nominal values below €8m, Luxembourg's levels of BES-funded public R&D expenditure are extremely low. In such a case the trends are highly sensitive even to minor changes in the positive direction.

Figure 23: BES-funded public R&D as % of GERD and as % of GDP in 2013 in Member States[68]



The two charts in Figure 23 show the values of BES-funded public R&D in all EU-28 as percentages of GERD and GDP respectively.

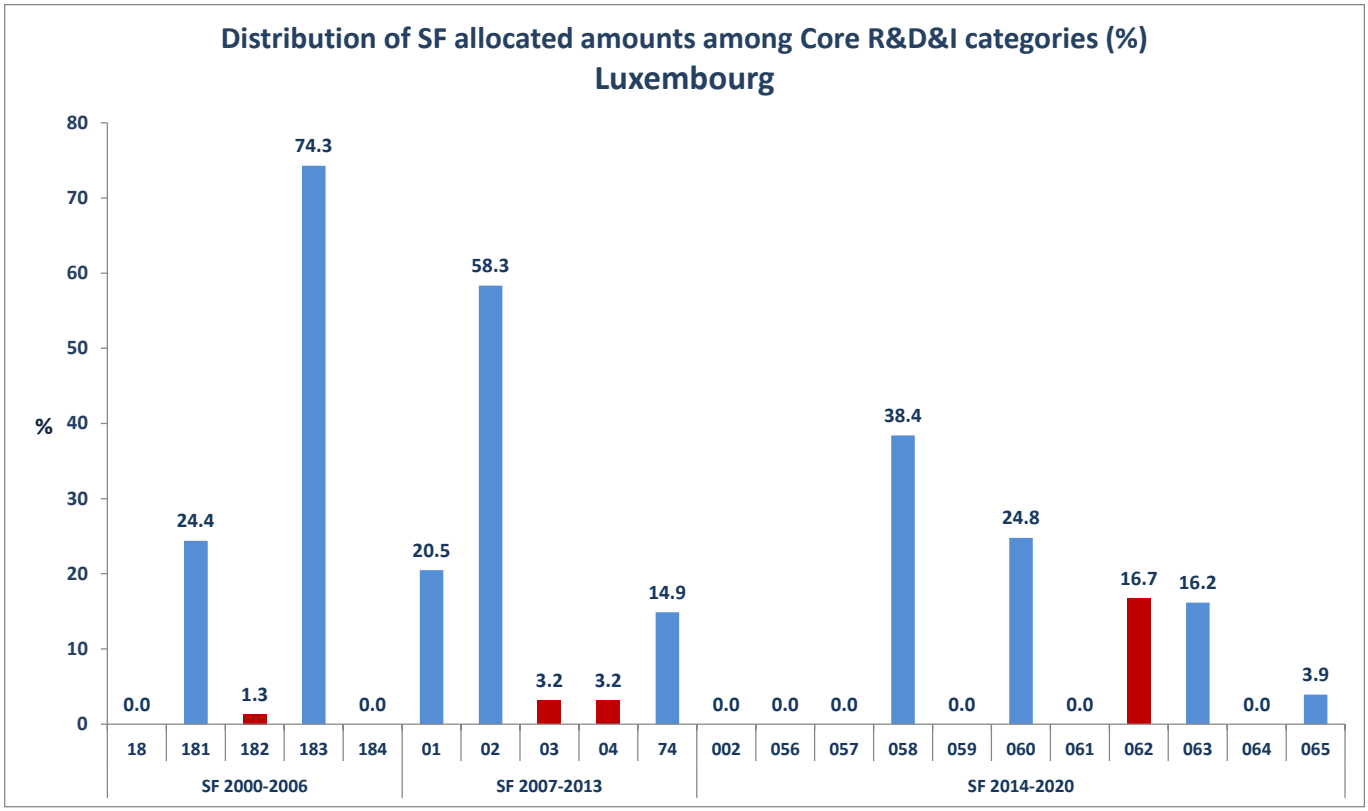
As percentage of GERD, as well as percentage of GDP, Luxembourg's levels of BES-funded public R&D are far below those of the best performers and the EU average.

The lack of science-based entrepreneurship is a main challenge related to the trends exhibited in Figures 22 and 23. In 2013, of the 22 students in the University's Masters in Entrepreneurship and Innovation, only one was a Luxembourg citizen[69] which illustrates the difficulty for the country to build a sustainable human capital base of researchers and scientists that stay in Luxembourg long enough to become agents for successful knowledge transfer.

[68] 2011 was chosen as the latest data series providing a full comparison within EU-28.
[69] RIO Country Report 2014: Luxembourg

Funding: structural funds devoted to knowledge transfer

Figure 24: Structural Funds for core R&D activities 2000-2006, 2007-2013 and 2014-2020[70]. The categories 182 (2000-2006), 03 and 04 (2007-2013), and 062 (2014-2020) are used as proxies for KT activities.

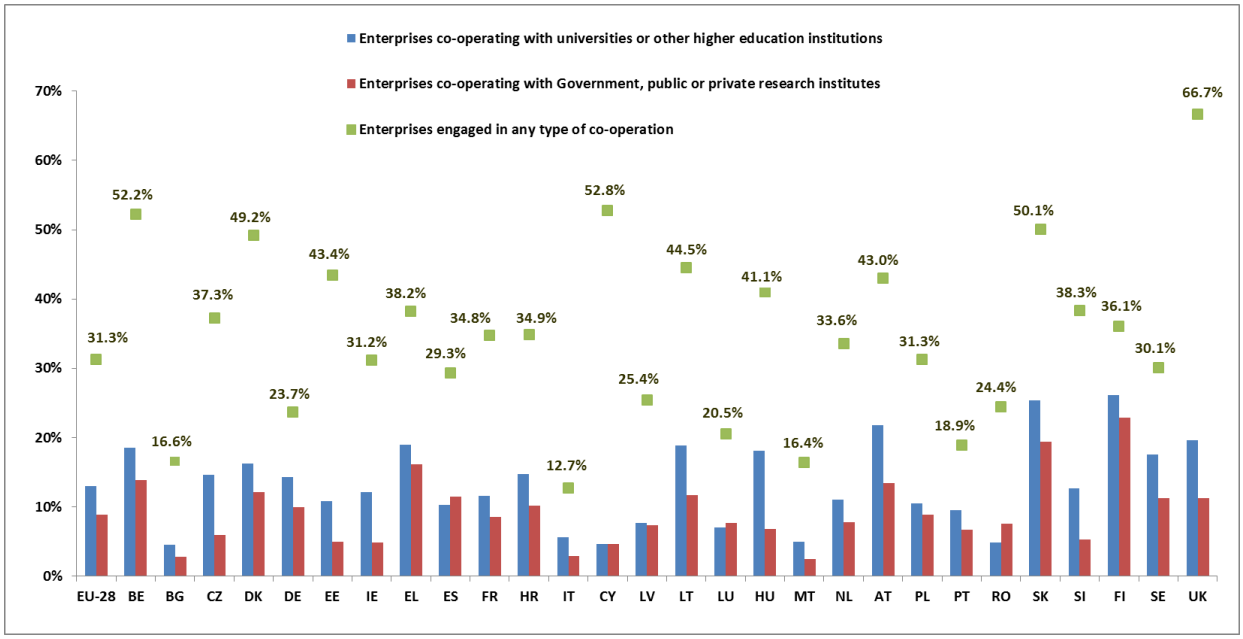


For the current programming period Luxembourg has allocated 16.7% of its structural funds for core R&D activities to "Technology transfer and university-enterprise cooperation primarily benefiting SMEs", which is 1% higher than the EU average of 15.7%, and considerably exceeds the allocations of 1.3% for the 2000-2006 and 6.4% for the 2007-2013 programming periods (the EU average was 26.1% for 2000-2006 and 30.1% for 2007-2013).

[70] Figure 24 provides the Structural Funds allocated to Luxembourg for each of the above R&D categories. The red bars show the categories used as proxies for KT. Please note that the figures refer to EU funds and they do not include the part co-funded by the Member State. The categories for 2000-2006 include: 18. Research, technological development and innovation (RTDI); 181. Research projects based in universities and research institutes; 182. Innovation and technology transfers, establishment of networks and partnerships between business and/or research institutes; 183. RTDI infrastructures; 184. Training for researchers.
The categories for 2007-2013 include: 01. R&TD activities in research centres; 02. R&TD infrastructure and centres of competence in specific technology; 03. Technology transfer and improvement of cooperation networks; 04. Assistance to R&TD particular in SMEs; 74. Developing human potential in the field of research and innovation.
The categories for 2014-2020 include: 002. Research and Innovation processes in large enterprises; 056. Investment in infrastructure, capacities and equipment in SMEs directly linked to Research and Innovation activities; 057. Investment in infrastructure, capacities and equipment in large companies directly linked to Research and Innovation activities; 058. Research and Innovation infrastructure (public); 059. Research and Innovation infrastructure (private, including science parks); 060. Research and Innovation activities in public research centres and centres of competence including networking; 061. Research and Innovation activities in private research centres including networking; 062. Technology transfer and university-enterprise cooperation primarily benefiting SMEs; 063. Cluster support and business networks primarily benefiting SMEs; 064. Research and Innovation processes in SMEs (including voucher schemes, process, design, service and social innovation); 065. Research and Innovation infrastructure, processes, technology transfer and cooperation of enterprises focusing on the low carbon economy and on resilience to climate change

Cooperation: share of innovative companies cooperating with academia

Figure 25: CIS survey 2012 – share of enterprises cooperating with academia



In Luxembourg, 20.5% of innovative companies engaged in some type of cooperation (31.3% for EU-28). Yet, only one third of them (i.e., 7% of total sample of innovative companies) cooperate with universities and higher education institutions. A bit more – 7.7% cooperate with government or public or private research institutes. This is far below from the impressive rate of cooperation in Finland - one of the innovation leaders, where 26% of innovative companies work with higher education institutions and 23% with government or public or private research institutes.

Cooperation: Technology Transfer Offices (TTOs), incubators and technological parks

Luxembourg has a range of business incubators: from a co-working space where an aspiring entrepreneur can network and work on a business plan, to a facility that offers the resources for product prototyping. Nyuko [71] (formerly The Impactory) and Lux FutureLab[72]are grassroots initiatives. In addition, there is the Technoport[73] that enjoys a purpose-built facility in the new university complex in Esch-Belval and includes co-working space and a "FabLab" as well as a start-up incubator. [74] There is also a Technoport 2 business incubator in Foetz under the auspices of the Ministry of the Economy.

Luxinnovation runs the Grand Duchy's cluster programme. There are clusters in Materials, ICT, Space, BioHealth, EcoInnovation and Automotive Components and members represent a broad range of knowledge triangle actors. Maritime and Logistics Clusters operate separately.

For more than a decade, Luxembourg has been undertaking a massive research infrastructure project called "The City of Sciences". The project, with a budget of more than half a billion euros, is designed to provide facilities for the University of Luxembourg and two Public Research Organisations: Luxembourg Institute of Socio-Economic Reseach (LISER) and Luxembourg Institute of Science and Technology (LIST). It also includes a business incubator, laboratories for public-private partnerships and the

[71] www.nyuko.lu
[72] www.luxfuturelab.lu
[73] www.technoport.lu
[74] FabLab—Fabrications Laboratory—is an open prototyping facility.

Luxembourg Centre for Systems Biology. In 2015, the National Research Fund (NRF), Luxinnovation and LIST moved into the new premises.

Cooperation: share of public-private co-publications

Figure 26: Co-publications by field 2003-2013 in Luxembourg. Scopus database

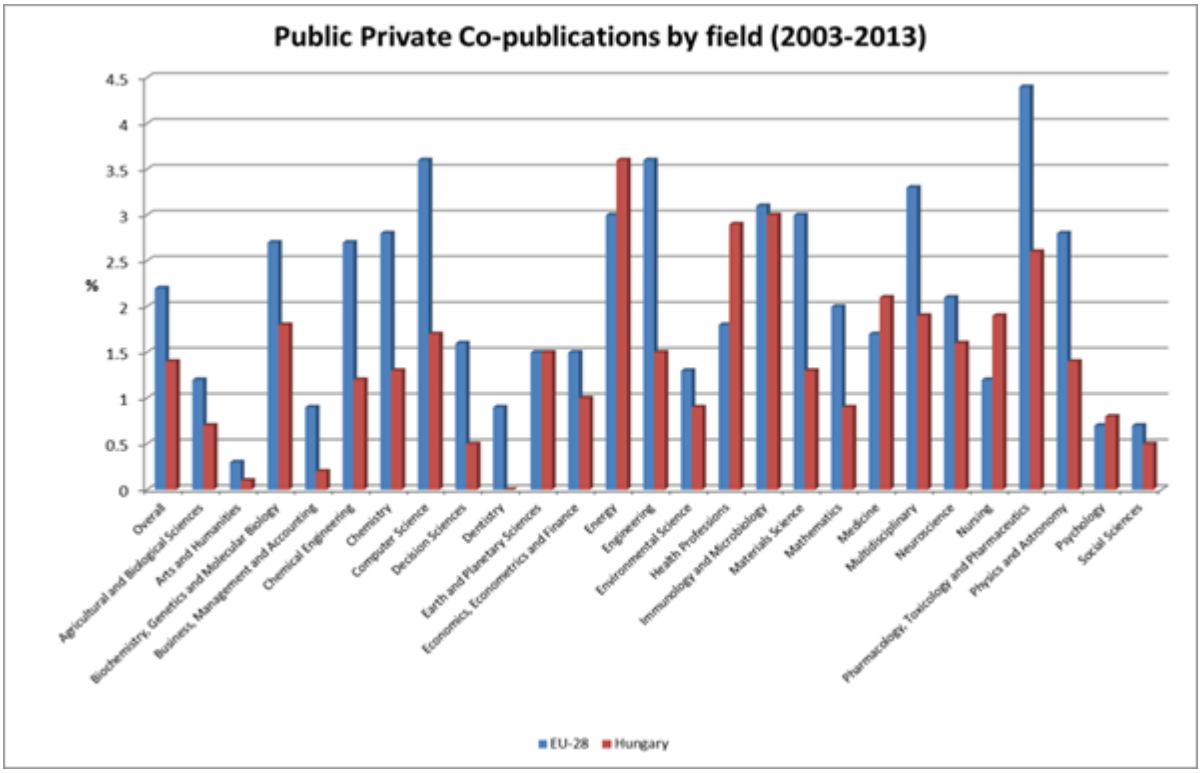


Figure 26 shows the 2003-2013 average percentage of academia-industry co-publications by field in Luxembourg compared to the European average. Scopus data indicate also that the percentage of co-publications reaches 2.6% of academia-business publications in 2013. In 2013 Luxembourg had 65.2 public-private co-publications per million of population compared to 29 for the EU-28[75]. The domains with highest percentage of co-publications (excluding multidisciplinary publications) are nursing, mathematics and computer science.

5.7.2 Policy measures

Luxembourg's R&I strategy is strongly oriented towards public-private partnerships (PPPs). Performance contracts between the government and the University and PROs require third party income[76] that includes PPPs, while the law of 5 June 2009[77] provides government support for private sector research and includes provisions for augmented funding for projects covering experimental development, industrial research and fundamental research undertaken in collaboration with a public research organisation or an SME.

[75] RIO elaboration based on Scopus data. It is a normalised figure, it should be noted that the real value is 35 co-publications for the population of 537,039.
[76] Note third party income includes NRF project funding, EU and ESA funding, etc. as well as revenue from PPPs.
[77] For the full version, see http://www.legilux.public.lu/leg/a/archives/2009/0150/index.html
For an overview of the law's provisions, in English, see
http://www.innovation.public.lu/en/financer-projets/rd-entreprise/projets-programmes-rd/index.html

A repositioning of the AFR programme that funds PhD and postdoc research also stresses public-private partnerships. In 2015, the AFR Postdoc will be limited to the AFR-PPP in collaboration with accredited companies based in Luxembourg. Luxembourg companies are also encouraged to take advantage of undertaking a project with a PhD candidate funded by the AFR scheme.[78]

Opportunities for public-private collaboration and matchmaking are showcased in "Business Meets Research" days organised by Luxinnovation.[79] The most recent event took place on 21-22 May 2015, included participants from throughout the "Grand Region" of neighbouring France, Germany and Belgium.

Performance contracts also set indicators in numbers of patents and spin-offs. In 2011-2013, 34 patents were applied for and four spin-offs were launched, with 23 patents and six spin-offs targeted. For the 2014-2017 period, 45 patent applications and ten spin-offs have been established as goals for the University and PROs. In the period 2011-2013, 36.7% of the funding of the PROs came from third party financing. Note however that the 36.7% included all "competitive funding" from the NRF, FP7, ESA, etc. as well as PPPs.

5.8 Regulation and innovation

Luxemburg does not have specific policy actions or initiatives addressing the impact of regulation on innovation. That being said, Luxembourg's regulatory environment is known for being "business friendly." Luxembourg uses its power as a nation state to enact or amend regulations that develop innovative niches to its economic advantage. Examples include establishing a ship registry and developing a maritime sector. In 2013 the *blue economy" employed more than 300 people locally and over 3,000 on the seas. The 275 ships registered in land-locked Luxembourg contributed €5 million to the state and around €74 million to banks, insurers, lawyers, accountants, etc.[80]

Another example is the establishment of the Luxembourg Freeport. A freeport is a warehouse in a tax-free zone. Items stored in a freeport are exempt from customs duties and can be sold without the application of VAT. A demand for freeports has developed as investors in art and other valuables have needed secure, tax- and duty-free storage for indefinite periods of time. The Financial Times lists the location of world's three leading freeports as being in Singapore, Geneva and Luxembourg (ft.com/lexicon, 2015). Le Freeport (www.lefreeport.lu) opened at Findel Airport in Luxemburg in October 2014. Its establishment was dependent on Luxembourg's creating Structural Capital in the form of legislation exempting goods entering the facility from customs duties and goods sold within the facility from VAT.[81] Goods handled by Le Freeport include not only fine art but also precious metals, wine, classic cars, precious gems and jewelry and even digital art (videos, photos, archives, etc.). In addition to storage fees, adjunct services such as appraisal and verification of provenance, restoration, packing, framing and insurance offered on the premises also provide revenue. Note that while items stored in the facility have tax exemptions, the facility's income and employee salaries are subject to tax.

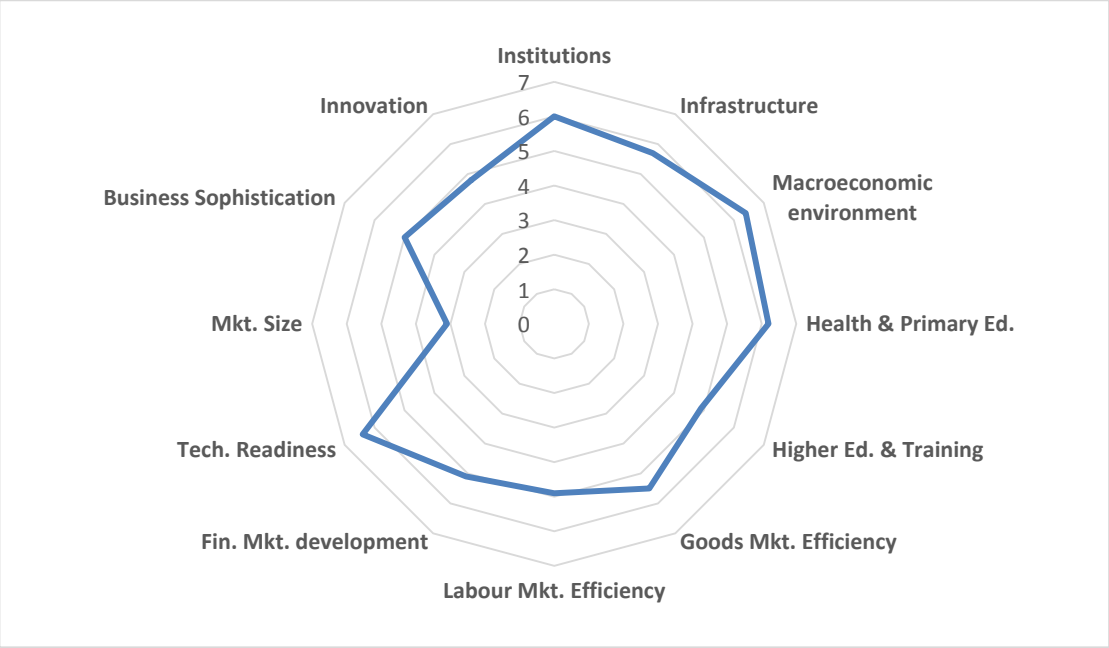
Consequently, while Luxembourg has no formal initiatives to analyse the impact of regulation on innovation, it does have a track record of introducing or amending regulations to facilitate innovative business niches. It also responds to grass roots initiatives to introduce legislation such as the law providing preferential tax treatment to IP.

[78] See http://www.fnr.lu/afr-phd-postdoc-grants/public-private-partnerships-under-afr
[79] See http://www.business-meets-research.lu/
[80] Cluster Maritime Luxembourgeios Activity Report 2014-2015.
[81] Note that exemptions do not extend to the seller's profits in his home country or to the buyer if the item purchased is removed from the freeport.

5.9 Assessment of the framework conditions for business R&I

Luxembourg has put in place framework conditions very conducive to business investment in R&D. In fact in the World Economic Forum Global Competitiveness Index, Luxembourg ranks 19th out of 148 nations (in 2014 it was 22nd) (WEF, 2015). The chart below shows its performance. Polls of business leaders were included in determining the ratings.

Figure 27: Luxembourg. Competitiveness Rankings 2014-2015 (Schwab, 2015)



Therefore, it is bemusing, given the measures and resources described in the sections above, that levels of BERD have been declining significantly without discernible reasons.

6. Conclusions

This chapter provides an assessment of the performance of the national research and innovation system and identifies the main structural challenges faced by the national innovation system.

6.1 Structural challenges of the national R&I system

Currently the main structural challenge of the national R&I system must surely be addressing the declining levels of GERD and especially BERD if the research intensity target of 2.3-2.6% is to be reached.

Three additional key structural challenges are:

- Human resources. Developing a domestic researcher base and addressing issues of gender balance
- Promoting a culture of entrepreneurship
- Achieving greater transparency

Meeting Research Intensity Targets

Council Specific Recommendations express concerns about Luxembourg's ability to meet its research intensity target, especially given declines in R&D investments by the Business Enterprise Sector.

Human Resources

Luxembourg is a model for researcher mobility, open recruitment, equitable work contracts and fair compensation. All Luxembourg research organisations are signatories to the Charter and Code, two have received HR Awards of Excellence and have also implemented HRS4R. Nevertheless, developing human resources in RDI remains a challenge as numbers of Luxembourg researchers continue to decline at PROs. Private sector companies also have difficulty finding researchers with PhDs in physics, math and other sciences.

Improving gender equality as a component of developing RDI human resources is a greater challenge. In the EU study SheFigures 2012,[82] Luxembourg continues to rank at the bottom of the EU in such measures of gender equality as the proportion of female researchers, the proportion of women in Grade A academic positions (9%) and the proportion of Women on Boards. Only 21% of researchers are female, compared to an EU-27 average of 30.

Entrepreneurship

Also identified as a challenge in the Self-Assessment done for DG RTD in April 2011, as well as previous ERAWATCH and TrendChart reports, a culture of entrepreneurship still needs additional development in Luxembourg.

While the creation of spin-offs using IP from research activities are included in several PRO performance contracts, the number achieved in the period 2011-013 was four, with a goal for 2011-2013 of six. The target for the period 2014-2017 is ten spin-offs. It can also be noted that although the law of 5 June 2009 has special provisions for SMEs, there are no specific policies, laws or incentives for entrepreneurs or start-ups, while in 2013, of the 22 students in the University's Masters in Entrepreneurship and Innovation, only one was a Luxembourg citizen.[83]

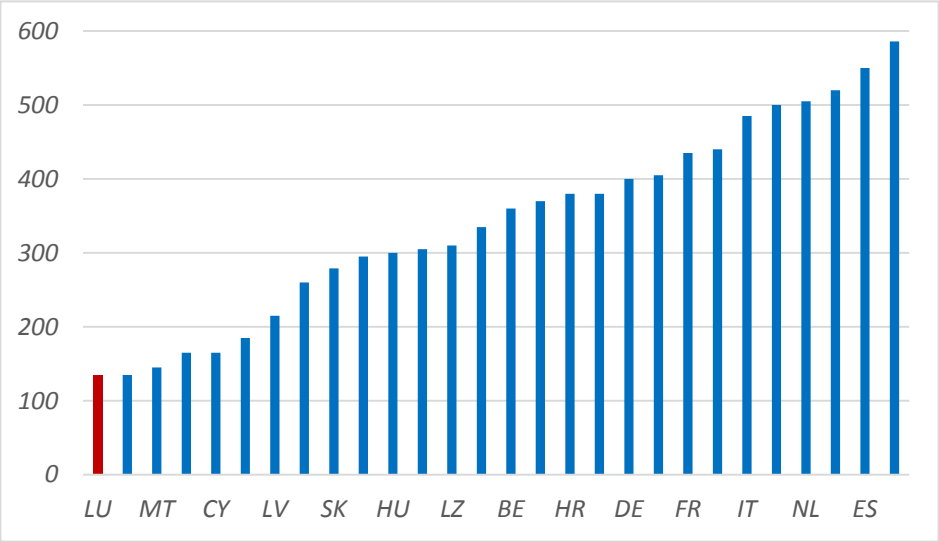
[82] Retrieved on December 28, 2014 from http://ec.europa.eu/research/science-society/document_library/pdf_06/she_figures_2012_en.pdf

[83] Personal communication of the Programme Director.

Transparency

Assessing Luxembourg in terms of R&I is hampered by deficiencies in the information available. Gaps exist on inputs (e.g., budgets for business incubators or the Cluster programme) and significant deficiencies exist on outputs (e.g., results of projects funded under the law of 5 June 2009 or even the identities of the recipients of that aid). While the University and the NRF are models for providing information, the MESR website is years out of date and other PRO websites and reports lack basic information. The ePSI initiative scores Luxembourg as the lowest in the EU in terms of the availability and use of public sector information (ePSI, 2015).

Figure 28: The PSI Scoreboard (ePSI Platform, 2015)



The OECD has an "open Government project.[84] Although an OECD member, Luxembourg is not assessed on its index, probably due to a lack of data. This can be understood as ironic, i.e., evidence of the lack of transparency, or a small country's limitations in data collection.

8484 http://www.oecd.org/gov/public-innovation/open-government-data.htm

Table 25: Structural Challenges Summary

Challenge	Policy measures/actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness
Meeting research intensity target (GERD) of 2.3-2.6%, especially in the private sector (BERD).	The Law of 5 June 2009. Business Meets Research Days. Performance contracts mandating third party income, Luxinnovation.	Ongoing declines in GERD and BERD indicate additional measures are necessary to meet 2020 targets, as well as. Identifying the cause of BERD decline.
Developing a domestic researcher base and addressing issues of gender balance-	PRIDE/AFR programme funding PhDs and post-docs. Initiative "Why Not a Researcher." Ongoing development of University of Luxembourg. Provision in law to improve gender balance on PRO boards.	PRIDE PhD programme too new to be assessed and AFR revisions not yet finalised. Rebalance gender on boards effective but the more action needs to be taken to improve gender balance
Promoting a culture of entrepreneurship	Business incubators. 123 Go. Luxinnovation. Masters in Innovation and Entrepreneurship. Innovation Master Classes, Chamber of Commerce Espace entreprise.	Measures are appropriate; more are needed such as the 1,1,1 initiative, less punitive measures relating to bankruptcy, more sources of funding, lower cost of incorporation.
Achieving greater transparency	No specific measures.	EU public information directives and OECD Open Government Data project offer best practice.

6.2 Meeting structural challenges

Luxembourg has policies in place intended to address some but not all of the challenges identified. Many policies are showing a measure of success in addressing the challenges, although one challenge—research intensity-- has become even more of an issue despite a range of measures. Policies that are in place have been implemented efficiently.

Meeting Research Intensity Targets

Measures in place to encourage increases in BERD include the Law of 5 June 2009 for private sector research subsidies and the IP Law of 2008. Luxinnovation promotes private sector R&D through the Cluster initiative, Business Meets Research days and identifying other funding opportunities for businesses. The continuing decline in BERD, as evidenced by a -33.5% decrease in private sector researchers between 2011 and 2013, suggests additional measures are needed.

Developing a domestic researcher base and addressing issues of gender balance

The AFR programme, which funds PhD and post-doc work and is administered by the NRF, is currently supporting more than 600 researchers. The ATTRACT and PEARL programmes "import" outstanding researchers and the NRF's "Promotion of Scientific Culture" and related activities aim to make a career as a researcher interesting to

students. The decline of the number of researchers who are Luxembourg nationals indicates more measures may be needed.

A new policy requiring boards of PROs to have at least 40% members of the underrepresented sex (in all cases this would be women) was initiated in the Fall of 2014 and is showing results. However, this is the only measure to address the gender gap and more action is needed.

Promoting a culture of entrepreneurship

As noted above, there are many structures in place to support entrepreneurship which include a Master in Entrepreneurship and Innovation; Innovation Master Classes, Luxinnovation, business incubators (Technoport, FutureLab, Nyuko), the Chamber of Commerce's Espace Entreprises, the IP Law of 2008, performance contracts that mandate spin-offs and an active business angel network.

A study by DG Enterprise and Industry on a Member State's meeting three criteria for ease of starting a company—"one stop shop," days to incorporate and cost—gave Luxembourg two green lights, but the assessment is questionable. The Guichet for Business (www.guichet.lu) has some information but is not complete, the three days cited to start a business is a gross underestimation if a business license is required and the cost given of €1,100 is also considerably too low. It overlooks the capital requirements of €12,500 for an S.àr.l. and €32,000 for an S.A. as well as average notary and accountant charges. Also as noted above, insolvency laws are draconian.

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Abbreviations

AFR	Aid for Research Training (PhD and post-doc funding)
BERD	Business Expenditures for Research and Development
BES	Business Enterprise Sector
BnL	Luxembourg National Library
COST	European Cooperation in Science and Technology
CVCE	Centre for the Virtual Knowledge of Europe
EBAN	European Business Angels Network
ERA	European Research Area
Ecomin	Ministry of the Economy
ERA-NET	European Research Area Network
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EU-27	European Union including 27 Member States
EU-28	European Union including 28 Member States
FDI	Foreign Direct Investments
FEDER	European Funds for Regional Development
FP6	6th Framework Programme
FP7	7th Framework Programme
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Intramural Expenditure on R&D
GUF	General University Funds
HEI	Higher education institutions
HERD	Higher Education Expenditure on R&D
IBBL	Integrated Biobank of Luxembourg
IP	Intellectual Property

LBAN	Luxembourg Business Angel Network
LIH	Luxembourg Institute of Health
LISER	Luxembourg Institute of Socio-Economic Research
LIST	Luxembourg institute of science and Technology
MESR	Ministry of Higher Education and Research
NRF	National Research Fund
NRP	National Reform Plan
NRS	National research system
OECD	Organisation for Economic Co-operation and Development
PPP	Public-private partnership
PRC	Public Research Centre
PRO	Public Research Organisation
R&I	Research and innovation
RDI	Research, development and innovation
RI	Research Infrastructures
RIS3	Research and Innovation Strategies for Smart Specialisation
RTDI	Research Technological Development and Innovation
SME	Small and Medium Sized Enterprise
S&T	Science and technology
STEM	Science, Technology, Engineering, Mathematics
ULg	University of Liège
VC	Venture Capital

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Annex 1 – List of the main research performers

Government Research Performers

University of Luxenbourg

Luxembourg Institute of Science and Technology (LIST)

Luxembourg Institute of Health (LIH)

Luxembourg Institute of Socio Economic Research (LISER)

Private Sector Research Performers

Arcelor Mittal

Tenaris

Stabilius

3W Power

SAF Holland

Samsonite

Aperam

Oriflame Cosmetics

Subsea 7

L'Occitane

Note listing as per R&D ranking of EU top 1000 companies (http://iri.jrc.ec.europa.eu/scoreboard14.html)

Annex 2 – List of the main funding programmes

Name of the funding programme	Timeline	Budget	Target group
Law of 5 June 2009	Ongoing	N.A.	SMEs and Service Sector Innovators
AFR	This programme is currently undergoing a reform	N.A.	PhD candidates and Postdocs in Luxembourg and abroad
AFR Bilateral Grants	Ongoing	N.A.	PhD or Postdoc researchers and selected research institutions in Singapore, Japan, and NASA's AMES Research Centre
ATTRACT	Ongoing	€10 million (2014.2017)	Young researchers external to Luxembourg
CORE	Ongoing	€70 million (2014.2018)	University and PROs
INTER	Ongoing	€18 million (2014.2017)	Luxembourg–based researchers in collaboration with foreign colleagues
INTER Mobility	Ongoing	funding may cover full costs for the Luxembourg public research organisation (according to internal rules of this organisation)	Senior researchers in Luxembourg and abroad
KITS	Ongoing	Funding up to 350k€/proposal	Technology Transfer Officers
PEARL	Ongoing	€25 million (2014-2017)	Established researchers external to Luxembourg
POC	Ongoing	Up to€ 500k in biomedical sciences and up to €250k for any other domain	Early-career researchers and established researchers in Luxembourg
PRIDE	Ongoing	N.A.	Doctoral Training Units in Luxembourg
PSP	Ongoing	€1,000 to €50,000 per application	Public institutions or bodies with a research assignment in Luxembourg, as well as teachers, researchers, scientists, students, private individuals and non-profit organisations engaged in activities of a scientific nature
RESCOM	Ongoing	Maximum of €50,000 for International Scientific Conferences; maximum of €2,000 for Lecture Series; maximum of €15,000 for publication of scientific monographs	Researchers in Luxembourg

Annex 3 – Evaluations, consultations, foresight exercises

Evaluations

University of Luxembourg

2010 Evaluations[85]

National Research Fund

PRC Henri Tudor

PRC Santé

PRC Gabriel Lippmann

CEPS/Instead

2011 Evaluations[86]

PRC Henri Tudor

PRC Santé

PRC Gabriel Lippmann

CEPS/Instead

2012 Evaluations[87]

PRC Henri Tudor

PRC Santé

PRC Gabriel Lippmann

Consultations

OECD, 2007 Study of National Research System

OECD Reviews of Innovation Policy: Luxembourg 2015

Foresight Exercises

NRF Foresight Exercise, 2006-2007

[85] http://www.mesr.public.lu/recherche/rapports_evaluation/rapports_evaluation/index.html
[86] http://www.mesr.public.lu/recherche/rapports_evaluation/rapports_evaluation_2011/index.html
[87] http://www.mesr.public.lu/recherche/rapports_evaluation/rapports_evaluation_2012/index.html

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