

Chapter 3.

Innovation actors in Luxembourg

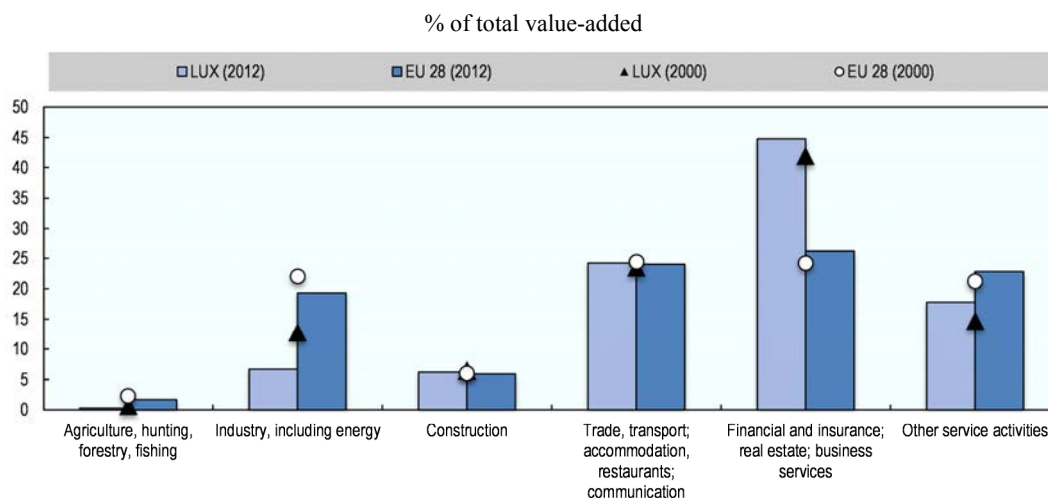
This chapter describes the main actors in the Luxembourg innovation system – business enterprises, the University of Luxembourg and public research centres – highlighting their respective roles in the development of the innovation system in recent years. It reviews scientific, technological and related functions carried out by the main actors within the system and their contributions to innovation.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

3.1 Business sector

Luxembourg's business sector has been strongly shaped by the interplay between the economy's small size, openness to international trade and investment, and its geography at the intersection of four major euro area economies (Belgium, France, Germany and the Netherlands). Having transitioned from agriculture to a steel manufacturing hub over the course of the early 20th century (Zahlen, 2007), Luxembourg entered a second successful transformation in the wake of the decline of the steel industry. Luxembourg's current affluence owes much to the success of its financial sector and development of its service industries, more generally in the latter half of the 20th century. Today, Luxembourg is primarily a service economy, with a strong financial services sector. In 2012, financial and related services, such as insurance and business services, accounted for just under half of value-added in Luxembourg (against one-quarter in the European Union [EU28]), whereas manufacturing and other industrial activity accounted for less than one-tenth (against one-fifth in the EU28) (Figure 3.1). This specific feature of Luxembourg's industrial structure can be understood in light of the importance of banking, financial and ancillary services, and its importance in global value chains – particularly as a transborder regional economic centre and destination for high value-added foreign investment.

Figure 3.1. Value-added by activity, 2000 and 2012



Source: OECD (2014), *OECD Factbook 2014: Economic, Environmental and Social Statistics*, <http://dx.doi.org/10.1787/factbook-2014-en>.

Luxembourg's top employers are mostly multinationals and state-linked companies (Table 3.1). Thanks to its geographic position, good framework conditions and proactive policy towards investment (including through different types of business regulation), Luxembourg is a very attractive location for foreign direct investment. Many multinationals choose to locate critical parts of their global operations in Luxembourg, including their headquarters operations through on-site holding companies (Clancy, 2008). Goodyear, Delphi and DuPont are examples of multinationals with research and development (R&D)-intensive teams operating in Luxembourg (Box 3.1).

Table 3.1. **Main employers, 2012**

Employer	Number of employees
State	25 278
ArcelorMittal Group	5 960
BGL BNP Paribas	4 110
Cactus Group	3 920
CFL Group	3 810
Entreprise des Postes et Télécommunications Group	3 800
City of Luxembourg	3 680
Goodyear Dunlop Tires Operations SA	3 080
Dussmann Luxembourg Group	2 790
Luxair SA	2 400
PricewaterhouseCoopers Group	2 110
Dexia BIL Group	2 100
Centre hospitalier de Luxembourg	2 060
Centre hospitalier Emile Mayrisch	1 870
Banque et caisse d'épargne de l'État, Luxembourg	1 770
RBC Dexia Investor Services Bank SA	1 580

Source: STATEC (2015), *Entreprise* (database), www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=9859&IF_Language=fra&MainTheme=4&FldrName=1.

Small and medium-sized enterprises (SMEs) make up the bulk of Luxembourg's business sector (Table 3.2). They account for almost 68% of value-added and 67% of employment in the country, compared to 58% of value-added and 67% of employment in the European Union. An idiosyncrasy of Luxembourg's business sector is that micro-enterprises (with fewer than ten employees) account for a higher share of value-added (22%) than of employment (18%); EU average figures generally show a reverse trend. The high share of Luxembourg micro-enterprises likely reflects some of the high-value activities in small businesses linked to the financial sector and ancillary activities, including investment companies (wealth managers, dealers, custodians, distributors of shares in undertakings for collective investment, etc.) and related or complementary businesses (brokers, financial advisers, company domiciliation agents, etc.). Examples of ancillary services include computer service suppliers, auditing and consulting firms, investment-fund management companies, compensation and settlement bodies, fiduciaries, corporate lawyers and notaries (OECD, 2008a).

Table 3.2. **Firm demographics, 2013**

	Number of enterprises			Number of employees			Value-added		
	Luxembourg		EU28	Luxembourg		EU28	Luxembourg		EU28
	Number	Share	Share	Number	Share	Share	EUR billion	Share	Share
Micro	25 658	86.9%	92.4%	44 318	17.9%	29.1%	4	21.8%	21.6%
Small	3 129	10.6%	6.4%	61 967	25.0%	20.6%	4	20.5%	18.2%
Medium-sized	605	2.0%	1.0%	58 511	23.6%	17.2%	5	25.5%	18.3%
SMEs	29 392	99.5%	99.8%	164 796	66.6%	66.9%	14	67.9%	58.1%
Large	144	0.5%	0.2%	82 742	33.4%	33.1%	6	32.1%	41.9%
Total	29 536	100.0%	100.0%	247 538	100.0%	100.0%	20	100.0%	100.0%

Source: European Commission (2014), *2014 SBA Fact Sheet Luxembourg*.

Box 3.1. Examples of innovation-intensive companies in Luxembourg

Goodyear Luxembourg

With approximately 3 100 employees, Goodyear is one of the largest private companies in Luxembourg. Located in Colmar-Berg, Goodyear Luxembourg is one of the most diversified sites of the Goodyear Group outside the United States. The main installation of the industrial complex, the Tire Plant, produces tires and civil engineering components. To meet high quality standards, Goodyear established the Goodyear Innovation Center Luxembourg (GIC*L), its largest R&D centre outside the United States, which carries out research and development work, and builds and tests new tires for passenger cars, light and medium trucks and farm vehicles for the European, African and Asian (EMEA) markets. A staff of over 900 engineers, scientists and technicians of 29 different nationalities work on new raw materials, tread designs and rubber quality. The main function of GIC*L is to provide technical support to 25 Goodyear EMEA production facilities, obtain approvals from vehicle manufacturers worldwide, maintain close contact with markets and customers through regularly scheduled product analysis, and guarantee the quality of tires and the good introduction of the products in 185 countries.

Delphi

Delphi is one of the leading suppliers of individual components and complete systems for the automotive industry and beyond. The Delphi Luxembourg site opened in Bascharage in 1971. The Luxembourg technical centre focuses on design, development and testing of components, systems and sub-systems related to energy and engine management; heating, ventilation and air conditioning; power and control electronics; and energy storage for hybrid and electric vehicles. The technical centre is equipped with vehicle wind tunnels, multiple vehicle engine and component test stands, and laboratories for noise and vibration measurements and electromagnetic compatibility. It also develops and manufactures prototypes. Luxembourg also hosts the global headquarters of Delphi Powertrain Systems, a company that develops and applies components and systems for managing passenger-car gasoline and diesel engines. Delphi and the Interdisciplinary Centre for Security, Reliability and Trust (SnT) of the University of Luxembourg co-operate on a joint research programme that involves developing effective and efficient automated verification and validation technologies for electronic control unit software systems.

DuPont de Nemours

DuPont opened its Luxembourg site in 1962. The company aims to create innovative and sustainable solutions in material sciences for use in various fields. DuPont develops and produces polyester films, elastomer polymers and spun-bonded materials for home construction, electronics, chemical protection, medical packaging, transportation, road construction and other key markets. DuPont has 1 150 employees in Luxembourg, 39 of whom specialise in R&D. The R&D section of DuPont de Nemours co-operate regularly with the public research centres (CRPs) Henri Tudor and Gabriel Lippmann, as well as local companies with specialised knowledge.

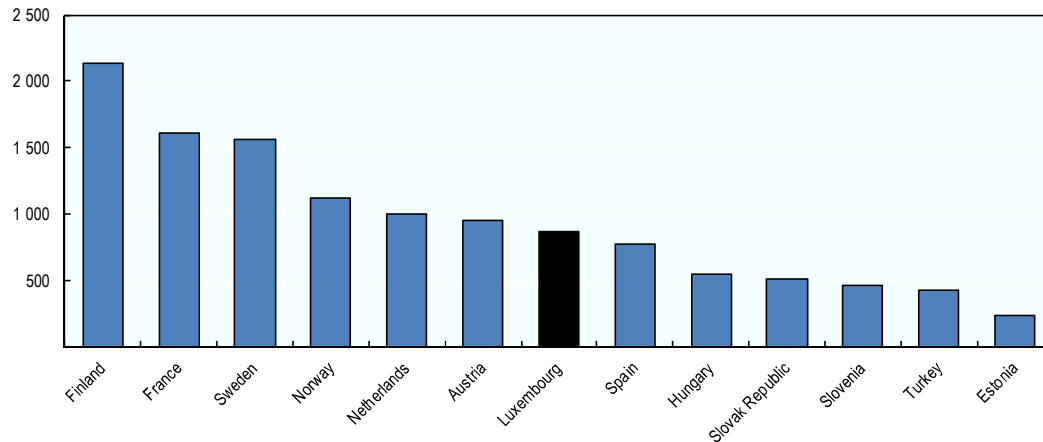
Source: Rieder et al. (2014), *The Luxembourg Innovation System*; Luxembourg Portal for Innovation and Research, www.innovation.public.lu/application/catalogue/entreprises/goodyear-innovation-center-luxembourg/pdf_en_goodyear-innovation-center-luxembourg.pdf.

Innovation and R&D performance

Firms' average innovation expenditure (Figure 3.2) is a broad indicator of the scale of innovative effort, not only for R&D but also for the purchase and integration of the latest

capital goods, new-process implementation, training and additions to the firm’s stock of accessible knowledge (such as licences). As a measure of the scale of expenditure deployed within a firm’s boundaries, average innovation expenditure can be expected to be higher in countries with a high number of larger firms. According to the 2010 Community Innovation Survey (CIS), the average innovating firm in Luxembourg spent about EUR 900 000 on innovation – an expenditure in the same order of magnitude as that of Austria and the Netherlands, two countries where large firms account for a greater share of employment and value-added than in Luxembourg.

Figure 3.2. Average innovation expenditure per innovating company, 2010



Note: Germany and some non-EU member states are missing due to lack of data. At the time of writing, data on innovation expenditure from CIS 2012 were not available.

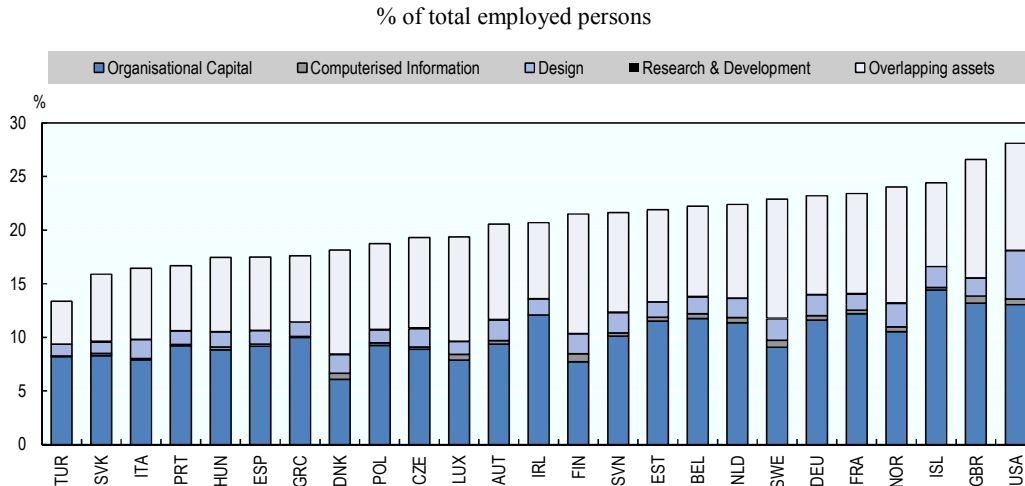
Source: OECD, based on Eurostat (2015).

Though not necessarily related to actual innovation activities, another way to look at firms’ innovation capabilities is from the perspective of knowledge-based employment and related capital investments. In OECD countries, knowledge-intensive activities – such as design and various aspects of engineering – account for a much larger share of employment and investment than R&D. OECD estimates on the basis of tasks performed, skills and knowledge areas suggest that in 2012, about 19% of workers in Luxembourg were employed in occupations contributing to R&D, design, software and database activities, and organisational know-how (Figure 3.3). Luxembourg has a lower share of knowledge-based capital workers than the usual comparator countries (Austria, Ireland, Finland, Slovenia, Netherlands, Germany, France, Norway and Iceland), owing in large part to lower shares in organisational capital (namely, the organisational know-how that increases enterprise efficiency).

In 2013, Luxembourg’s business expenditure on research and development (BERD) amounted to about 0.7% of GDP. BERD intensity is low compared to that of innovation-intensive economies. A break in the time series in 2012 (notably due to the changes in the measurement of software-related activities) makes a direct comparison over time impossible. The same applies to the number of business-sector researchers (Figure 3.4).

An examination of BERD trends across broad sectors of economic activity (Figure 3.5) shows that the drop in 2010 was largely due to financial and insurance activities (down EUR 46 million) and manufacturing (down EUR 29 million).

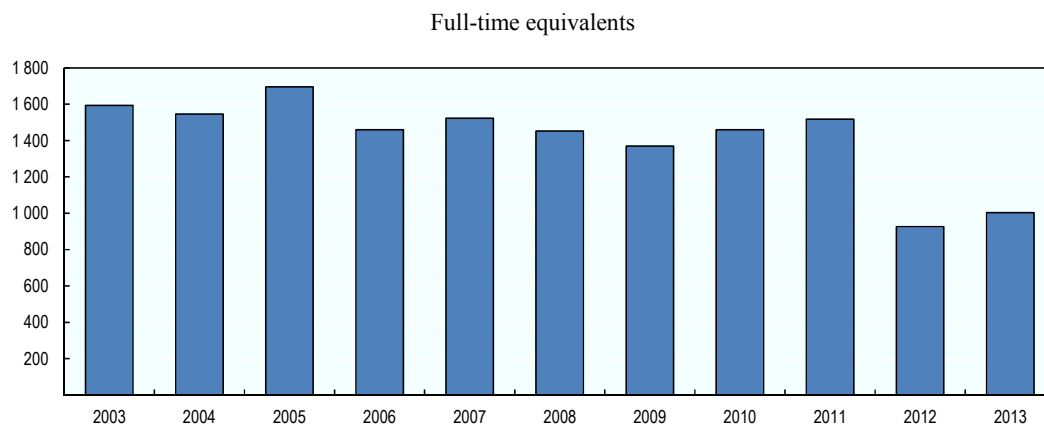
Figure 3.3. Knowledge-based capital workers, 2012



Note: workers contributing to R&D, design, software and database activities and to firms' organisational know-how account for between 13% and 28% of total employment in many OECD countries (total length of the bar). Of these workers, between 30% and 54% contribute to more than one type of knowledge-based capital asset (bar "overlapping assets"). R&D is difficult to discern in this graph as it accounts for less than 1% in all countries.

Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013*, http://dx.doi.org/10.1787/sti_scoreboard-2013-en.

Figure 3.4. Number of researchers in the business sector, 2003-13



Note: Break in time series in 2012.

Source: OECD (2015), *OECD Main Science and Technology Indicators* (database), <http://dotstat.oecd.org>.

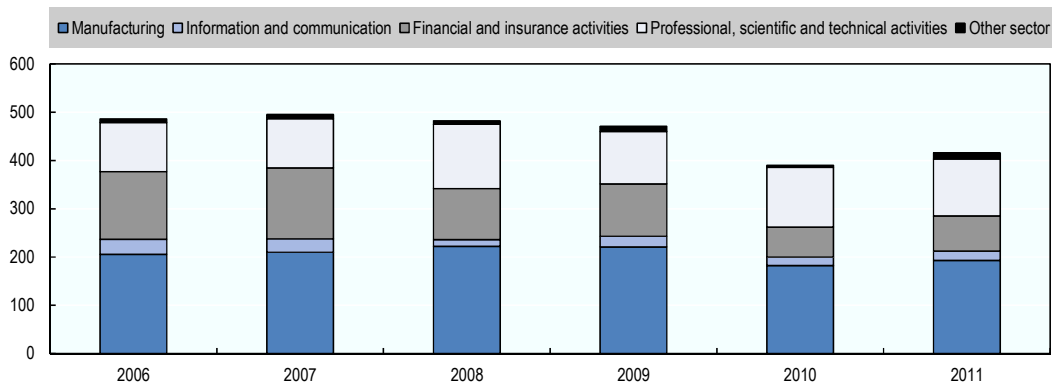
Patterns of innovation output

Evidence from the EU CIS suggests that a strong majority (66.1%) of Luxembourg firms introduced product, process, marketing or organisational innovations over 2010-12,

significantly above the European average of 48.9% (Eurostat, 2013). The rates do not differ much between firms operating in manufacturing (67%) (Figure 3.6) and services (66%) (Figure 3.7). Marketing and organisational innovation is typically more prevalent in services than manufacturing; inversely, product and process innovation is more common in manufacturing than services. International evidence suggests that the productivity impact of different modes of innovation varies across countries and that no single innovation mode is superior (Frenz and Lambert, 2012). Other international studies have shown that different innovation modes can be complementary, implying that firms that engage in multiple modes of innovation are generally likely to benefit the most. It is therefore encouraging that a relatively high share (41% for manufacturing and 35% for services) of Luxembourg firms engages in multiple modes of innovation (in both product/process and marketing/organisational innovation).

Figure 3.5. **BERD, 2006-11**

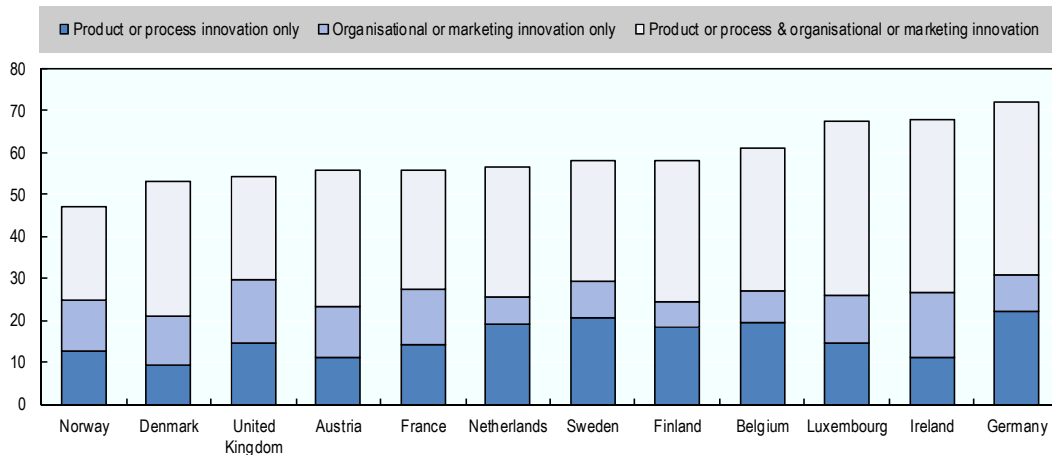
in EUR million



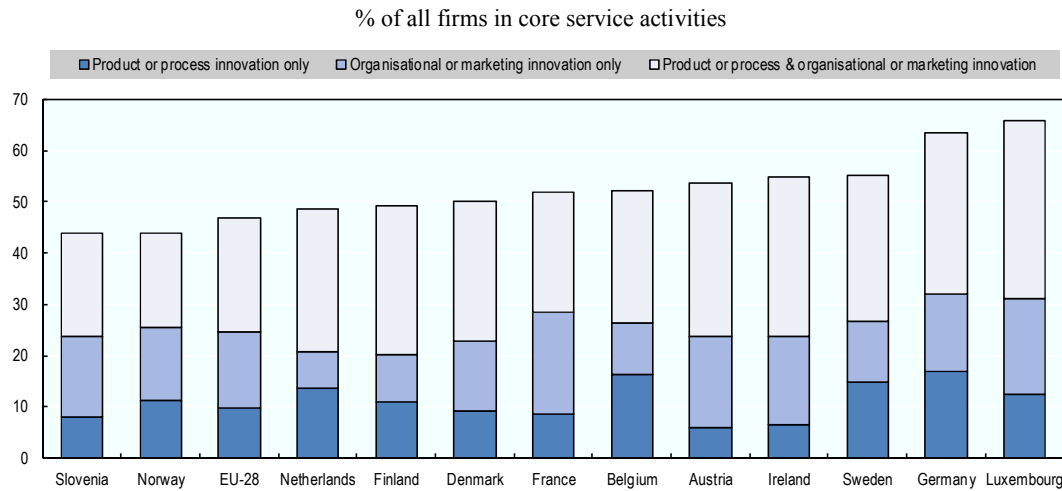
Source: Ministry of the Economy and Foreign Trade (2013), “2013 Competitiveness Report. Ten Years of Competitiveness Scoreboard: A Sawtooth Evolution”.

Figure 3.6. **Innovation in the manufacturing sector, 2010-12**

% of all manufacturing firms



Source: Eurostat (2013), *Seventh Community Innovation Survey*. Highest Proportions of innovative Enterprises in Germany, Luxembourg and Belgium.

Figure 3.7. **Innovation in the services sector, 2010-12**

Note: Core service activities include the following NACE Rev 2 classes 46-H-J-K-71-72-73.

Source: Eurostat (2013), *Seventh Community Innovation Survey. Highest Proportions of innovative Enterprises in Germany, Luxembourg and Belgium.*

According to CIS 2012 data, collaboration on innovation activities between Luxembourg firms and public research organisations (e.g. public research institutes (PRIs) and universities) is generally weaker than in the comparator group of countries, especially with respect to collaboration with universities (Table 3.3). Interpretation of this indicator is complicated by the fact that the denominator is the total number of innovating companies, rather than the population of companies at large. In Luxembourg, about 7% of innovating companies collaborate with universities to carry out their innovation activities – a share that lags behind all other countries in the comparator group – and 8% of innovating companies collaborate with PRIs. As in other countries, the share of collaborating companies increases with firm size. All types of collaboration – except that between large firms and universities – have exhibited a decreasing trend since the previous survey, CIS 2010. Again, low collaboration rates partly owe to the large role of the service sector – which is typically less R&D-intensive and therefore establishes fewer linkages with PRIs and universities – in the economy. In Luxembourg, for example, 6.5% of firms from the service sector collaborate with universities, and 7.2% collaborate with PRIs. According to CIS 2012, shares are higher in the manufacturing sector, where 8.6% of firms co-operate with universities and 9.1% with PRIs.

Factors affecting business innovation

Figure 3.8 presents companies' self-reported barriers to innovation activity featured in CIS 2010 (no data were available at time of writing for this specific question in CIS 2012 for Luxembourg). Whereas companies in the comparator group of countries perceived lack of finance as the leading issue, this is not the case for companies in Luxembourg. Rather, the dominant position of established firms and lack of demand are identified the main inhibitors to innovation activity. Difficulty in finding co-operation partners ranked higher in Luxembourg than in the comparator group countries.

Table 3.3. **Collaboration between companies and higher education institutions (HEIs) and companies and PRIs by firm size, 2010-12**

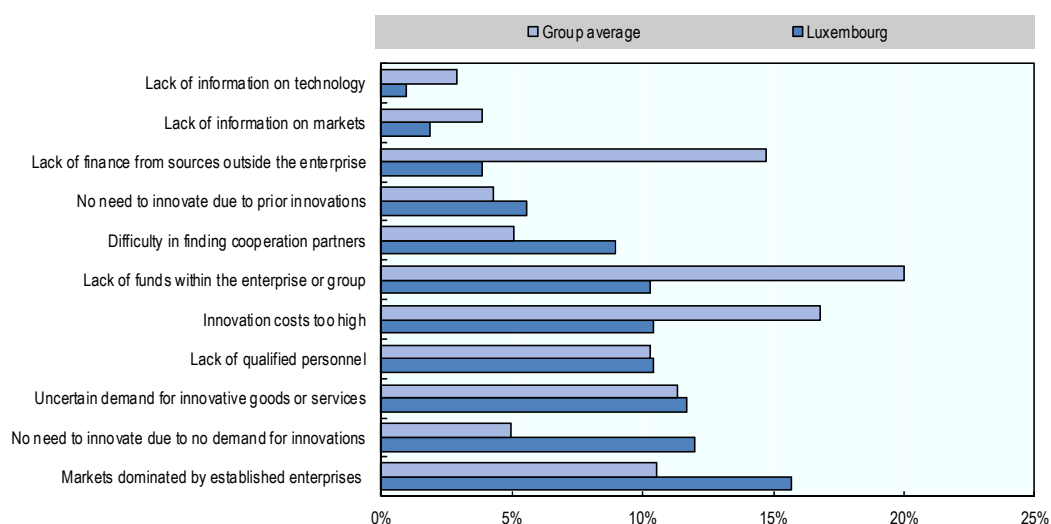
Share of innovative companies, %

	Collaboration with universities or other HEIs				Collaboration with PRIs			
	Firm size bands (numbers of employees)			Total	Firm size bands (numbers of employees)			Total
	10-49	50-249	250 or more		10-49	50-249	250 or more	
Belgium	15%	23%	42%	18%	12%	15%	33%	14%
Denmark	10%	19%	40%	15%	8%	13%	27%	11%
Germany	10%	18%	40%	14%	7%	13%	28%	10%
Ireland	9%	15%	32%	12%	4%	6%	12%	5%
France	8%	15%	32%	12%	6%	10%	23%	8%
Luxembourg	5%	7%	27%	7%	5%	9%	23%	8%
Netherlands	9%	13%	28%	11%	7%	9%	19%	8%
Austria	16%	26%	51%	22%	10%	15%	34%	13%
Slovenia	16%	36%	50%	25%	13%	26%	35%	19%
Finland	19%	33%	68%	26%	16%	30%	64%	23%
Sweden	14%	21%	45%	18%	--%	14%	34%	11%
Norway	9%	16%	37%	13%	10%	17%	40%	14%

Source: based on Eurostat (2015).

Figure 3.8. **Barriers to innovation activity, 2008-10**

Share of innovative enterprises (including enterprises with abandoned/suspended or ongoing innovation activities) considering the barrier as highly important



Note: Comparator group countries include: Belgium, Ireland, France, Slovenia, Finland, Sweden, Iceland and Norway. Data for Luxembourg are not available in the CIS 2012.

Source: based on Eurostat (2015).

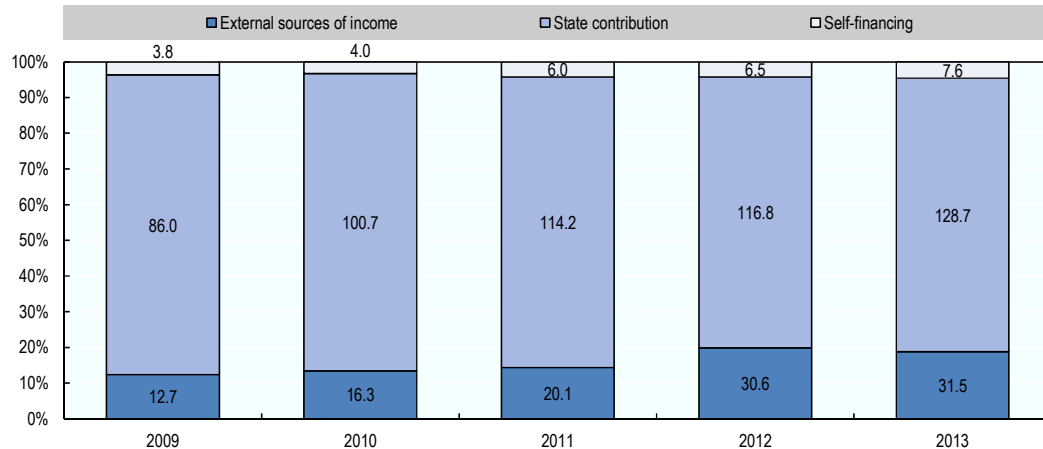
3.2 University of Luxembourg

A key structural development in Luxembourg's innovation system was the creation of the University of Luxembourg in 2003. The University is a small-sized institution numbering around 6 200 students and 1 460 staff aiming at excellence in research and

education in a few selected areas. It had revenues of EUR 168 million in 2013, with 77% coming from a government block grant and 19% from external funding – a mix of contractual and competitive research funding from the Fonds national de la recherche (FNR), European projects, businesses and government ministries (Figure 3.9).

The University is located on four different campuses: Kirchberg, Limpertsberg, Walferdange and Belval. Over the next few years, most of the University will be relocated to the Cité des Sciences in Belval.

Figure 3.9. University of Luxembourg revenues, 2009-13, million EUR (MEUR)



Source: University of Luxembourg (2014), *Report 2013: Key Performance Indicators*.

The University was founded by bringing together four existing institutes involved in higher education (and some research) in Luxembourg: the Centre universitaire, the Institut supérieur de technologie, the Institut supérieur d'études et de recherches pédagogiques and the Institut d'études éducatives et sociales. Meyer (2009) has characterised this collection of institutes as a “loosely-coupled system” marked by a relative lack of co-ordination, differences in methods, aims and missions, little lateral interdependence and a general “invisibility” of activities. Yet many decision-makers continued to openly oppose the creation of a university, arguing that Luxembourg was too small to host its own institution, that even without research and higher education Luxembourg was a prosperous country, and that students’ need to study at foreign universities was an enriching experience for them and for Luxembourg. Importantly, it was the idea of creating a university focused on teaching *and* research, rather than a teaching-only university, that made it more palatable and neutralised some of the arguments against it. This coincided with a significant change in perspective on the very purpose of a university, from knowledge diffusion (primarily through teaching) to knowledge production (primarily through research), positioning the university within the discourse on diversifying the national economy (Meyer, 2009).

The OECD 2007 Review of Luxembourg’s innovation policy (OECD, 2007) applauded the decision to create a research university, but identified obstacles related to the merger of established structures with new ones. In particular, broadening the University’s focus beyond education and training to encompass strong research capabilities would likely create serious tensions for the University. These tensions have

been partially managed by establishing interdisciplinary centres strongly focused on research outside of the faculty structure, as described below.

The University comprises three faculties that engage in both teaching and research – the Faculty of Science, Technology and Communication (FSTC); the Faculty of Law, Economics and Finance (FDEF); and the Faculty of Language and Literature, Humanities, Arts and Education (FLSHASE). Each has historical roots to institutes that predate the University’s establishment. In addition to the faculties, two semi-autonomous interdisciplinary centres – the SnT and the Luxembourg Centre for Systems Biomedicine (LCSB) – were founded in 2009 to further strengthen the University’s research performance.

While the number of staff employed in the faculties has continued to grow steadily (Figure 3.10), the research-intensive interdisciplinary centres have seen the most spectacular growth. Across the University in 2013 16% of staff were faculty members (academic staff) and 57% were other scientific and research staff. A relatively high proportion (52%) of the academic staff were full professors; 26% were women, up from 20% in 2010. Academic staff recruitments account for just a small share of recent growth in staff numbers, compared to the very high contingent of other scientific and research staff (Figure 3.11). The interdisciplinary centres made up the bulk of these new appointments, accounting for 25% of total (excluding central administration) staff in 2013 (Figure 3.12), even though they represented less than 3% of academic staff (Figure 3.13). The University continues to increase its international profile: in 2013, 22% of staff hailed from Luxembourg, 45% from neighbouring countries (France, Belgium and Germany), 19% from other EU28 member states and 14% from other countries.

Figure 3.10. Evolution in numbers of total staff (headcounts) in different parts of the University, 2008-13

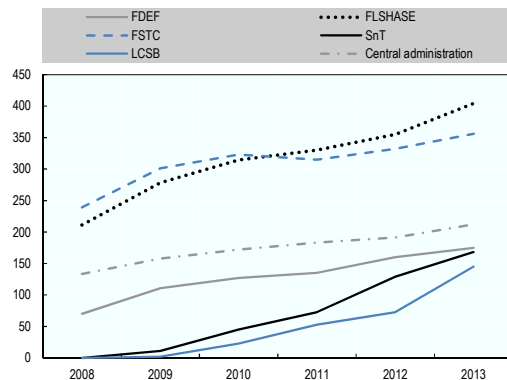
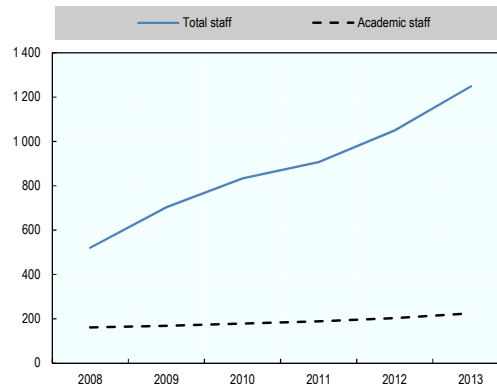


Figure 3.11. Evolution of numbers of total and academic staff (headcounts), 2008-13



Source: Various annual reports of the University of Luxembourg.

Training activities

Nearly 6 200 students enrolled at the University of Luxembourg in 2013/14 – a 20% increase over 2009/10. Bachelor’s programmes account for more than half of students enrolled. While the share of bachelor’s students has remained more or less stable (representing 53.4% in both 2006/07 and 2013/14), their numbers have almost doubled (from 1 784 in 2006/07 to 3 288 in 2013/14). Vocational training courses leading to

diplomas and certificates accounted for 18.5% of enrolled students in 2013/14 – nearly half the high of 34.4% in 2006/07 – even though the number of enrolled students was similar (1 150 in 2006/07 and 1 141 in 2013/14). Postgraduate programmes have grown the most rapidly in recent years: master’s enrolments soared from 259 in 2006/07 to 1 183 in 2013/14 (i.e. 19.2% of all enrolments), while the number of students enrolled in doctoral (PhD) programmes rose from 148 to 545 over the same period (Figure 3.14, Panel a). This growth is in line with the University’s ambition to become more research-oriented. However, the share of postgraduate students – 34.4% of all “Bologna” students (i.e. all students except those registered for vocational courses) – is slightly under the University’s performance contract target of 37%.

Figure 3.12. Percentile distribution of total staff in the faculties and interdisciplinary centres, 2013

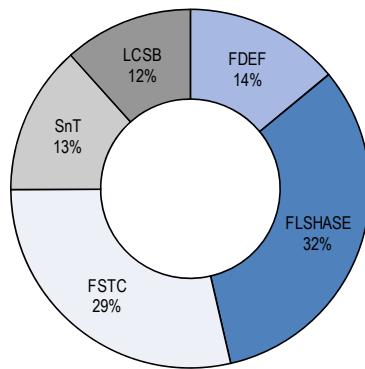
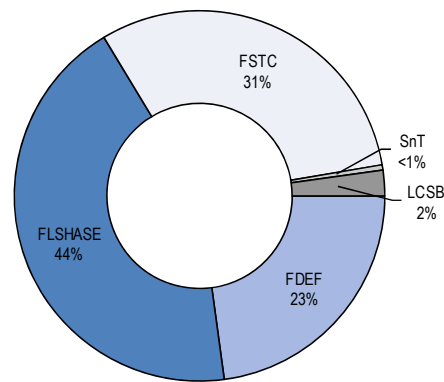


Figure 3.13. Percentile distribution of academic staff in the faculties and interdisciplinary centres, 2013



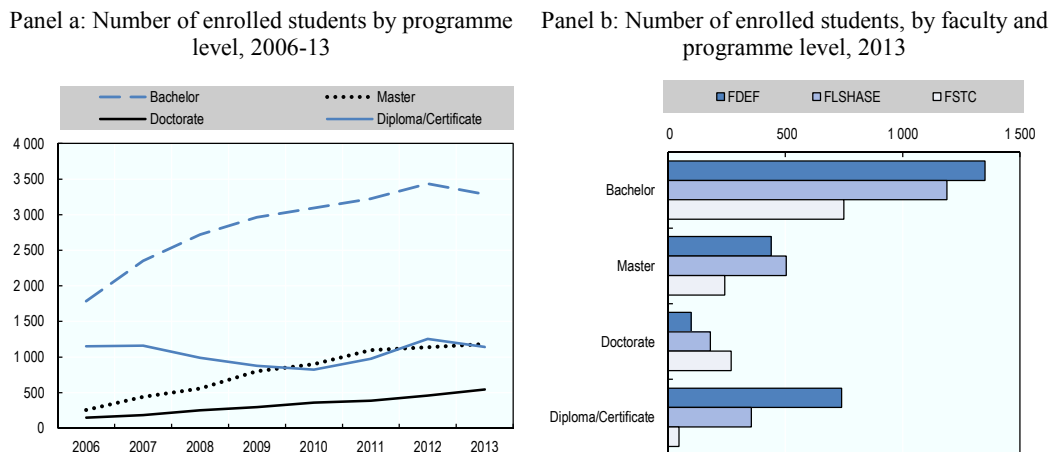
Source: University of Luxembourg (2014), *Report 2013: Key Performance Indicators*.

All three faculties offer bachelor’s, master’s, doctoral and vocational courses (Figure 3.14, Panel b):

- The FDEF offers three bachelor’s and eight master’s courses and has two doctoral schools (in law; and economics and finance). The country’s vibrant international financial sector, the proximity of several European institutions and the presence of innovative industries form natural allies for the Faculty as evidenced by the number of sponsored academic chairs and professionals teaching select courses. The Faculty has the largest number of enrolled students – 2 628 in 2013/14 – in the University. It also accounts for close to two-thirds of the University’s diploma/certificate enrolments.
- The FLSHASE offers 4 bachelor’s and 14 master’s courses and has three doctoral schools (in educational sciences; identities, politics, societies and spaces; and social sciences). It had 2 225 enrolled students in 2013/14.
- The FSTC offers four bachelor’s and ten master’s courses and has two doctoral schools (in systems and molecular biomedicine; and computer science and computer engineering). It had 1 304 enrolled students in 2013/14. Despite being the smallest faculty in terms of total student enrolments, it has the highest number of doctoral students: 268 in 2013, i.e. 21% of the total number of students enrolled in the faculty.

The most popular subject group at the University is business and administration (24% of all students), followed by education (16%); arts and humanities (12%); science, mathematics and computing (12%); law (12%); and social and behavioural sciences (11%); engineering lags far behind, (just 4% of students). Some bachelor's courses are seriously under-subscribed and could be either discontinued or delivered in partnership with other institutes in the Grande Région. Furthermore, graduation rates for bachelor's degrees are below University targets. The ease of entry into bachelor's courses likely contributes to the high dropout rates – where entry requirements are more stringent, dropout rates are lower.

Figure 3.14. **Evolution of student numbers at the University of Luxembourg**



Source: University of Luxembourg (2014), *Report 2013: Key Performance Indicators*.

The 2003 law creating the University states that a bachelor's degree may be conferred only if a student has attended another university or higher education institution (HEI) abroad for a required period (typically one semester). Students are increasingly opting to spend this time in foreign HEIs beyond the neighbouring countries. The University student body is also very international, particularly at the PhD (83% of non-domestic enrolments) and master's (69%) levels.

Research activities

The University conducts research in its three faculties and two interdisciplinary centres (Box 3.2). The faculties feature several research units:

- FDEF: Research Unit in Law; Research in Finance (Luxembourg School of Finance); and the Centre of Research in Economic Analysis.
- FLSHASE: Education, Culture, Cognition and Society; Integrative Research Unit on Social and Individual Development; and Identities, Politics, Societies and Space.
- FSTC: Computer Science and Communications Research Unit; Research Unit in Engineering Science; Mathematics Research Unit; Physics and Materials Science Research Unit; and Life Sciences Research Unit.

Box 3.2. The University of Luxembourg interdisciplinary centres

The SnT

SnT was created to take the lead on implementing the University's focus on information technology security and reliability. This priority is particularly pertinent for Luxembourg, which has for some time sought to position itself as a European centre of excellence for secure, reliable and trustworthy information and communications technology systems and services. Like the LCSB, SnT has experienced fast and steady growth in terms of staff members, doctoral students, industry partners and public grants since its creation in 2009. By the end of 2013, it numbered 222 R&D personnel (including doctoral students and interns), including 17 faculty members. A key defining feature is its Partnership Programme, where key actors contribute know-how and resources to shape and build SnT; 20 such partnerships, involving a mix of public and private organisations, already existed in 2013. That year, SnT spent EUR 11.5 million on R&D; externally funded projects – mostly through various FNR schemes, but also through the Partnership Programme (16%) – accounted for 69% of the total. The Programme is notable for relying upon strategic mid- and long-term research partnerships with strongly committed industry or research players, rather than on short-term service-type projects that are more typical of the industry relationships permeating the more applied research-oriented CRPs. The strategy of SnT is that public funding for high-risk fundamental research should be done in concert with, rather than separately from, more practice-oriented partnership projects. The scientific review panel associated with the 2013 evaluation of the University recommended expanding partnerships further afield – starting with stronger relationships with international institutes – to drive excellence. It also highlighted the unclear division of labour with the FSTC, and its focus on academic research.

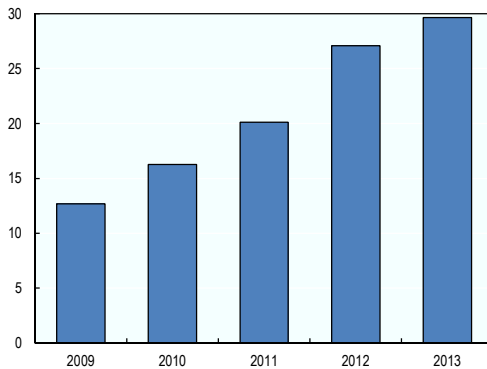
The LCSB

The LCSB originated in the Luxembourg government's Health Sciences and Technologies Action Plan and was built through a partnership with leading United States (US) institutes specialising in systems biology. Its aim is to carry out fundamental research in the field of systems biology and biomedicine, as well as analyse the mechanisms of disease pathogenesis, with a special focus on neurodegenerative diseases and more specifically Parkinson's disease. By the end of 2013, the LCSB employed more than 140 R&D personnel, including only 7 faculty members; the remainder are supported by a mix of University funding, FNR studentships and fellowships, FNR research grants, EU Seventh Framework Programme/Horizon 2020 funding and funding from other national sources. In 2013, the LCSB secured more than EUR 13 million in research grants. According to the scientific review panel associated with the 2013 evaluation of the University of Luxembourg, the LCSB fills a niche that is not yet over-populated. The panel was impressed with its performance, judging it to be "very good" and firmly on track to becoming "excellent". At the same time, the panel raised concerns about inadequate facilities at Belval and the need to improve collaboration with other parts of the University, notably related research units in the FSTC.

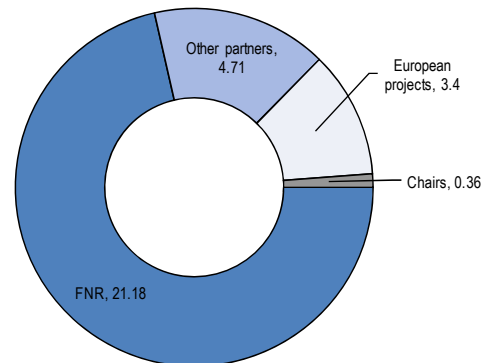
In 2013, the University secured almost EUR 30 million in third-party funding for research, up from EUR 16 million in 2010 (Figure 3.15, Panel a). This is above its performance contract target to secure EUR 23 million of external funding annually by 2013 and reflects in part the University's increasing professionalisation of grant-income support through its Research Service. It also reflects the growing strengths of the interdisciplinary centres, which have been especially successful in securing grant income. More than 70% of external funding for University research was sourced from the FNR in 2013, and 11% from European projects (Figure 3.15, Panel b).

Figure 3.15. External funding for research at the University of Luxembourg

Panel a: Growth of external funding for research, MEUR, 2009-13



Panel b: Breakdown of external funding for research, by funding source, MEUR, 2013



Source: University of Luxembourg (2014).

The University also exceeded its performance indicator target of achieving a publication intensity of two refereed publications per researcher for the duration of the 2010-13 performance contract (Table 3.4). The number of citations of University publications has also increased markedly –from 289 *Web of Science* citations in 2007 to 3 491 in 2013.

Table 3.4. Publications of the University of Luxembourg, 2010-13

Type of publication	2010	2011	2012	2013
Refereed conference proceedings	x	341	391	383
Refereed journals	x	385	468	633
Published books	81	67	64	84
– Authored books	x	34	32	31
– Edited volumes	x	47	32	53
Book chapters	x	208	241	145
Publication Intensity (refereed publication/researcher full-time equivalent)	2.23	2.38	2.24	2.61

Note: x = not applicable.

Source: University of Luxembourg (2014), *Report 2013: Key Performance Indicators*.

Reflecting its ambition to achieve international visibility in a few research areas, the University has identified a number of research (and teaching) priorities. These are intended to provide a reference framework for the University when hiring new staff, with a view to strengthening scientific competences in selected fields. The University revisits its priorities every four years to coincide with the cycle of performance contracts negotiated with the government. The University's current four-year strategic plan (2014-17) identifies the following (central) research priorities:

- Computational sciences: this refers to the interdisciplinary combination of mathematical modelling and computer science/computer engineering with specific applications to various scientific domains, such as physics, engineering and life sciences. The FSTC and the two interdisciplinary centres are highly involved in computational science research. Prioritisation is intended to consolidate and strengthen existing competences with new positions in the relevant fields.

- Law, stressing European law: the presence of the Court of Justice of the European Union makes this an obvious priority. Prioritisation will not so much lead to further increasing the number of academic staff, as to strengthening its European character and buttressing its collaboration with the newly founded Max Planck Institute for International, European and Regulatory Procedural Law (see Section 3.4).
- Luxembourg School of Finance: the importance of international finance for Luxembourg makes this another obvious priority for the University.
- Educational sciences: improving Luxembourg’s education system is a long-term project requiring a research-based understanding of the social and historical dynamics of Luxembourg’s society and the role of its education system. Prioritisation is intended to translate into targeted appointments to enhance the University’s excellence and international status in the field of educational research.

The University’s strategic plan also sets four so-called “other” priorities, covering the following areas: physics and materials science; entrepreneurship and innovation/audit; multilingualism and intercultural studies; and sustainable development. In addition, the two interdisciplinary centres are identified as a separate class of priorities. Taken together, this is a broad set of priorities, covering much of the University’s research and teaching activities. Considerable continuity exists with earlier articulations of priorities – which is hardly surprising given their breadth; there are also some divergences, as different parts of the University – e.g. the interdisciplinary centres – build new capabilities. In most instances, prioritisation appears to translate into some modest top-up funding (a projected EUR 100 000-200 000 per year for each priority area in 2014-17), to be used by the faculties and interdisciplinary centres to make a few additional staff appointments.

The 2013 evaluation of the University highlighted the lack of visibility of faculty research, which hampers recruitment of top talent. By contrast, the two interdisciplinary centres are increasingly visible at the international level and provide a major boost to the University’s research profile. Their independent status lends them considerable agility and has allowed them, for example, to install swift recruitment procedures and to expand very rapidly. At the same time, such autonomy risks disconnecting them from the faculties, and weakening the links between research and teaching activities. Differences in contracts, workload distribution and promotion tracks contribute to tensions between interdisciplinary centre staff and the faculties. Tensions also arise over the University’s allocating the bulk of its block grant to the faculties, despite the interdisciplinary centres’ strong research performance.

The University has previously committed to developing a whole-of-university research strategy that would define present and novel strategic areas. This strategy has yet to be developed. The 2013 evaluation of the University highlighted the need for a University-wide research strategy. It recommended that the University’s central administration develop, together with all parties concerned, a clear and balanced strategy on the relationship between faculties/research units, the interdisciplinary centres and the University’s overall priorities, also taking into account the relationships between research, teaching and valorisation. The evaluation committee viewed such a strategy as an opportunity for the University to promote a common understanding of “research quality” and the means to monitor, improve and reward it, as well as provide clarity on the meaning and utility of research priorities.

Notwithstanding the pressures of the upcoming move to Belval, the University should articulate and implement such an inclusive whole-of-university research strategy as soon as possible. Among other things, the strategy should aim to set University research priorities;

define the meanings, relevance and implications of research excellence; delineate a fair reward system for research excellence and relevance among faculty research units and interdisciplinary centres; clarify the relationships between interdisciplinary centres and faculties; consider the merits of establishing further interdisciplinary centres; and define relationships with external actors, including the CRPs and international research partners. The research strategy process could also include a review of how other young universities have successfully developed on the basis of strong research capabilities – a couple of well-known examples are briefly described in Box 3.3.

Box 3.3. Leading “young” universities in Europe

The École Polytechnique Fédérale de Lausanne (EPFL)

EPFL is a technical university established in 1969 in Lausanne, Switzerland. It covers disciplines in basic sciences, engineering, architecture and life sciences. Almost 10 000 students from 112 countries were enrolled in EPFL courses in 2014 (of which approximately 2 600 are master’s and 2 000 doctoral students). EPFL employed more than 5 500 staff in 2014, including doctoral students. The 2014 EPFL budget amounted to approximately EUR 850 million, 72% of which was funded by the Swiss Government and 28% from competitive and contractual funding – including grants from the Swiss National Science Foundation (10.2%), European programmes (6.4%) and industrial contracts (6.7%). It was the fourth most successful institution in Europe in terms of received European Research Council grants during the Seventh Framework Programme period.

EPFL is part of the Swiss Federal Institutes of Technology Domain (ETH Domain), which groups the two Swiss Federal Institutes of Technology (ETH), namely EPFL and ETH Zurich, as well as four research institutes. The Swiss Federal Council and the Swiss Parliament define the ETH Domain’s overarching objectives. The ETH Board defines the strategy of the organisations within the ETH Domain; operational and managerial responsibilities lie within the organisations themselves. EPFL students can take courses, as well as undertake internships or part of their doctoral research at the four research institutes of the ETH Domain.

EPFL ranks 2nd in Europe and 21st in the world in the Leiden ranking of 750 major universities worldwide; 1st in Europe and 2nd in the world in the Times Higher Education ranking of universities less than 50 years old; and 3rd in Europe and 19th in the world in the Shanghai ranking of engineering/technology/computer science universities.

Universitat Pompeu Fabra (UPF)

UPF is a public university established in 1990 in Barcelona, Spain. UPF focuses on three main areas: social sciences and humanities; health and life sciences; and information and communications technologies. Nearly 10 000 undergraduate students, 1 800 master students, 1 200 doctoral students were enrolled at UPF in 2013/14. In 2013, UPF had almost 600 teaching and research staff, including 339 permanent professors and over 650 administrative staff. The UPF budget in 2014 was EUR 124 million.

UPF pays particular attention to its internationalisation strategy: 22% of its faculty is international and 30% of its graduate students studied abroad before joining UPF. In addition, UPF has signed agreements with 27 of the top 50 universities in the world (Times Higher Education ranking 2013) and has run a summer school programme with the UCLA since 2012. UPF ranks among the top 20 European universities in terms of the number of ERC-funded projects.

UPF is well positioned in 2014 international university rankings: according to the Times Higher Education ranking of universities less than 50 years old, it ranks 13th in the world; according to the Shanghai ranking, it is among the top 400 universities in the world and is the top Spanish university in social sciences.

Sources: www.epfl.ch; www.upf.edu/en.

Valorisation activities

The government's performance contracts with the University include performance indicators for patenting and licensing. In the 2010-13 contract, the University was expected to obtain five patents and two licences a year. Table 3.5 shows that while the University met its patenting target over the period of the performance contract, it missed its licensing target every year except for 2013. The latest performance contract (2014-17) raises these targets further, to 12 patents and 6 licences a year. In addition, the government expects the University to set up three spin-off companies every year.

Table 3.5. **Patents and licences of the University of Luxembourg, 2010-13**

	2010	2011	2012	2013	2010-13
Patents	4	2	5	12	23
Licences	1	1	-	2	4

Source: University of Luxembourg (2014), *Report 2013: Key Performance Indicators*.

The gross revenues generated from the commercial exploitation of a patent owned by the University of Luxembourg are equally shared between the University and the inventors who helped implement the invention. Such arrangements are common in other OECD countries. The University's Legal Affairs Office provides administrative and legal support to researchers seeking to commercialise their research findings. Luxinnovation also offers support. More recently, SnT has piloted arrangements to support the creation of research-based spin-off companies. These could be rolled out across the whole University.

3.3 Public research centres

The R&D law of 1987 established three major public research centres: CRP Gabriel Lippmann, CRP Henri Tudor and CRP Santé. In early 2015, CRP Gabriel Lippmann and CRP Henri Tudor merged to become Luxembourg Institute of Science and Technology (LIST), and CRP Santé has been renamed the Luxembourg Institute of Health (LIH). LIST focuses on research in three main areas – environment, information technology and materials (see Box 3.4) – while LIH focuses on clinically oriented biomedical research and public health (Box 3.5). The Luxembourg Institute of Socio-Economic Research (LISER) (formerly CEPS/INSTEAD) performs both basic and applied research in areas such as population and employment, geography and development, and business and industrial organisation, with the aim of informing social policy making in Luxembourg (see Box 3.6). All these centres are under the direct responsibility of the Ministry of Higher Education and Research.

The recent merger and name changes have been introduced as part of a wider amendment of the law establishing the CRPs. A new CRP law (2014) cements the status of the CRPs as autonomous public legal entities with financial and administrative autonomy, and alters the terms of their relationship with the Ministry of Higher Education and Research. Specifically, the role and composition of the administrative board of each CRP have changed: boards are no longer called upon to take all management decisions related to their CRPs; instead, they are expected to define the general policy and strategy of the CRP in keeping with the objectives defined by law and specified in the multiannual performance contracts with the government. CRP chief executives have greater autonomy to implement the strategy defined by the board and to take all decisions relating to the day-to-day management of the CRP. The law also views legally institutionalised performance contracts as the medium through which the government and CRPs agree on

the general orientation, goals and strategic choices of the CRP, as well as the funds provided by the government. Chapter 4 discusses these arrangements extensively. The law also introduces more transparent and open recruiting procedures for researchers.

Box 3.4. The Luxembourg Institute of Science and Technology (LIST)

LIST describes itself as a research and technology organisation (RTO) active in the fields of materials, environment, and information technology (IT). It was created in 2015 from the merger of CRP Gabriel Lippmann and CRP Henri Tudor, designed to achieve greater critical mass and enhance the international visibility of their research. Through its activities in applied research and technology transfer, LIST aims to support all companies – whether large groups or small to medium-sized enterprises (SMEs) – in their innovation projects. The Institute also contributes to the establishment of new companies in Luxembourg by developing innovative technology and expertise. Finally, it offers scientific support to national policy making.

LIST works across the entire innovation chain, including development of fundamental and applied scientific research, knowledge and competences; experimental development, incubation and transfer of new technologies, competences, products, and services; scientific policy support to the Luxembourg government, businesses and society in general; and doctoral and post-doctoral training, in partnership with universities.

LIST works in partnership with other RTOs, universities, large industrial groups, SMEs and public bodies across a range of sectors, including manufacturing, construction, logistics and mobility, eco-technology, space, IT services, and the public and healthcare sectors. Partnerships can take several forms: collaborative research (with joint financial involvement and risk-taking, and shared results); contract research (aimed at both SMEs that lack the resources required to conduct research and large corporate groups that wish to outsource part of their R&D and innovation activities while retaining ownership of the results); hosting of researchers within the framework of public-private partnerships (P/PPs) (making LIST staff available to companies and vice versa); and provision of services (providing access to LIST technology platforms to carry out research and innovation projects).

LIST conducts its research activities within three departments:

- **Environmental Research and Innovation** develops strategies, technologies and tools to better monitor, assess, use and safeguard natural and renewable resources. Its mission is to implement a smart green vision, creating better understanding of complex environmental and biological systems and their interaction with the technosphere, in order to accelerate innovation towards sustainable management of natural resources and the transition towards a circular economy.
- **IT for Innovative Services** focuses its research around innovation in services with a high level of information intensity. It focuses on “big data” operational issues for decision-making, use of information systems in measuring and controlling the quality of services, and tools for innovation processes in IT services. It co-operates directly with market stakeholders within the framework of an open innovation approach and implementation of a “living lab” associating all stakeholders in service design and roll-out. The department is active in several sectors, including construction, logistics and mobility, healthcare and IT.
- **Materials Research and Technology** aims to translate cutting-edge materials research into applicable technology by engaging in close relationships and joint projects with both academic and industrial partners. Its research and technology activities target two main areas: nanomaterials and nanotechnology, and composite materials. Its experts – who come from academic institutions, RTOs and industry and include chemists, physicists, materials and engineering scientists, and increasingly life scientists – work on an interdisciplinary basis, both within the LIST departments and with actors from the Luxembourg public or private ecosystem.

Source: LIST website (www.list.lu).

Box 3.5. The Luxembourg Institute of Health (LIH)

LIH (formerly CRP Santé) is Luxembourg's leading public organisation for basic, pre-clinical and clinical research in life sciences. It performs research and carries out studies in clinically oriented biomedical research (oncology, infection and immunity, immunology and cardiovascular diseases) and public health. It works with health-sector stakeholders, including hospitals and public and private biomedical organisations, at both the local and international levels. It carries out its research activities within five research departments:

- **Translational Cardiovascular Research** focuses on understanding the mechanisms responsible for the development of heart failure. It works in close collaboration with the Centre hospitalier de Luxembourg (CHL) and the National Institute of Cardiac Surgery and Interventional Cardiology.
- **Immunology** has a broad field of interest, from basic research to contract R&D for the diagnostic and vaccine industry. It is a partnership with the Laboratoire national de santé.
- **Oncology** focuses on experimental cancer research with a strong translational profile and the potential to develop into a clinical outcome. It closely collaborates with CHL.
- **Public Health** provides information on the population's state of health, advises public authorities on healthcare projects and their evaluation, and carries out economic analysis of the healthcare system. It is also home to two Luxembourg National Focal Points: the European Medicines Agency and the European Monitoring Centre for Drugs and Drug Addiction.
- **Infection and Immunity** has two laboratories that perform fundamental and applied research in the fields of chronic viral infections and allergic and immune-mediated diseases.

These thematic research departments are supported by three competence centres: Luxembourg Biomedical Research Resources, the Competence Centre for Methodology and Statistics and the Clinical and Epidemiological Investigation Centre. The competence centres provide services to internal customers, public organisations and private partners. LIH also has a technology transfer office whose mission is to help commercialise research results. It works to identify inventions with commercial potential, assists with securing the necessary property rights and helps to market new technologies by collaborating with industry and creating start-ups.

Since 2015, the Integrated BioBank of Luxembourg (IBBL) has merged with LIH. IBBL retains extensive autonomy and its own multiannual performance contract under this arrangement, while working under the supervision of the LIH board of administration. Its integration into LIH aims to help create synergies in financial, administrative and technical matters, including in terms of sample storage to meet the needs of national research actors. The arrangements also guarantee IBBL the independence necessary to carry out its national and international activities. Chapter 4 discusses IBBL more extensively.

Source: LIH website (www.lih.lu).

While the University has displaced the CRPs as the largest public-sector research performer in Luxembourg, the CRPs have also expanded significantly over the last 15 years, thanks to a significant increase in public investment that has led to a large influx of new researchers. This expansion has gone hand in hand with a broadening of the missions of CRPs: while they were originally established to support service-oriented applied research to meet business-sector needs, CRPs have increasingly focused on more strategic applied (and occasionally oriented basic) research. The new CRP law confirms this positioning: while CRPs should continue to focus on research, development and innovation

to promote knowledge and technology transfer, they may occasionally undertake oriented basic research. Furthermore, they may engage in technological development to support product development, production processes and services. In this context, the law envisages scientific and technological co-operation at the national and international level. It also gives increased weight to valorisation activities, including through creating spin-off firms, to foster new economic activities in Luxembourg. Finally, the law explicitly calls on the CRPs to encourage researcher mobility and contribute to training research personnel, including by supervising doctoral candidates (in collaboration with the University of Luxembourg or other universities) and participating in doctoral schools.

Box 3.6. The Luxembourg Institute of Socio-Economic Research (LISER)

LISER (formerly CEPS/INSTEAD) is a public research centre active in the fields of social and economic policy. It covers topics such as poverty, inequality, education, social inclusion, employment, unemployment, health, housing, mobility and regional convergence. Its mission is to produce relevant insights for social and economic policy based on empirical evidence, in order to improve the understanding of causal relationships and provide sound evidence on the impact of institutional settings and policy options. It organises its research activities around three research departments:

- **Labour Market** primarily addresses the process of labour-income determination, both from a worker's perspective and from the perspective of companies and employers.
- **Living Conditions** focuses on the social aspects of income and wealth distribution.
- **Urban Development and Mobility** focuses on the spatial dimension of social and economic policy.

The institute also includes a transversal co-ordination unit that has two main tasks: providing common services across departments (e.g. survey data collection, and social and economic indicator provision); and creating synergies across departments through co-operation based on common methodology or overarching topics.

Source: LISER website (www.liser.lu).

These sorts of changes are far from unique to Luxembourg. In many OECD countries, the role of mission-oriented, applied research-intensive PRIs has shifted from performing purely applied and industry-oriented research to becoming increasingly involved in basic research activities and projects (see Box 3.7). In addition, PRIs have rebalanced their R&D personnel to include a greater number of researchers. At the same time, universities often perform applied research and increasingly co-operate with the business sector. This leads to significant overlaps between the missions and tasks of PRIs and universities, with the potential of increasing both competition and co-operation between them. The presence of similar dynamics in Luxembourg leads to some questioning about the roles of CRPs. In some respects, the CRPs serve considerably different functions than the University of Luxembourg. For instance, providing support to evidence-based policy features prominently in the mission of both LISER and LIST (which also has the explicit objective of strengthening business-innovation capacities), but these types of activities are notoriously difficult to measure and account for using rigorous performance indicators.

Box 3.7. Public research institutes (PRIs) in OECD countries

PRIs play an important role in national innovation systems. Together with universities, they are the main public research actors and an important tool for governments seeking to promote research and innovation (OECD, 2011). PRIs are key actors, not only within national boundaries but also in international networks. In Europe, PRIs are important nodes in the innovation and research networks created by European programmes (Technopolis, 2010). The mission of PRIs is to provide R&D, technology and innovation services to companies, governments and, more generally, society. In this respect, they distinguish themselves from universities, whose main mission is to educate students.

Different national innovation systems and historical or socio-economic contexts have shaped the process through which PRIs were established. In Europe, many PRIs were created after the Second World War to support industrial and technological development (Leijten, 2007). In some cases, PRIs (e.g. PERA, the former Production Engineering Research Association, in the UK or some parts of SWEREA in Sweden) originated from research associations that were originally established to solve practical problems in some industries and then were institutionalised in the form of institutes. In other cases, PRIs (e.g. SINTEF in Norway or the Fraunhofer Institutes in Germany) were created with the specific goal of promoting industrial development. In some countries, PRIs were established as institutes providing services such as measurement, testing and certification, generally transitioning over time towards more science and research-intensive organisations. For example, VTT in Finland was originally conceived as a service-based organisation, but has morphed into an organisation promoting industrial development in the country (Technopolis, 2010).

Because of the multiple rationales and historical paths that led to their creation, PRIs today have extremely diversified functions (Technopolis, 2010) and funding, as detailed below:

- Some PRIs are scientific research institutes that largely perform the same kind of research as universities. PRIs of this kind generally get a large part of their funds through block grants. Examples are the Max Planck Institutes in Germany or the Centre national de la recherche scientifique in France.
- A second category of PRIs consists of government laboratories that provide services and information to governments. They include institutes performing applied mission-oriented research around different technologies, such as energy technologies, biotechnologies and telecommunications. They generally belong to the ministries responsible for policy initiatives in their domain of research. LISER and, to some extent, LIH fall into this category.
- A third category of PRI comprises applied research institutes focusing on research to solve practical problems or challenges for the benefit of society or some actors in the innovation system, typically private companies (also known as RTOs). These PRIs generally obtain part of their income through government block funding and the remainder through contractual research projects financed by the business sector. For example, the Fraunhofer Institutes in Germany, TNO in the Netherlands or VTT in Finland generally manage to attract more than half of their funding from the market.

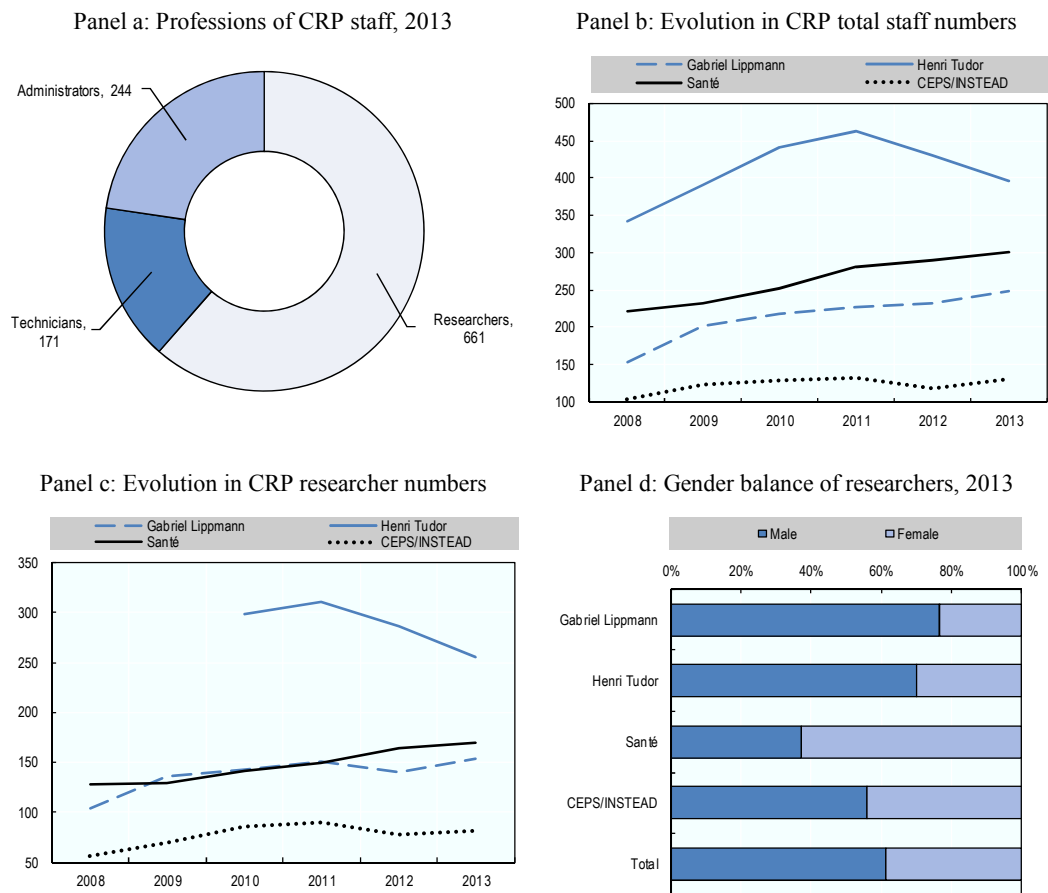
It should be noted that many PRIs perform several functions simultaneously. Other tasks associated with PRIs include preserving, storing and ensuring access to knowledge and scientific data through libraries, datasets and repositories, or providing major scientific infrastructure and facilities (e.g. satellites, telescopes).

Since the Luxembourg CRP name changes and merger are very recent, all available data refers to their pre-2015 status. For this reason, the remainder of this chapter uses the former names of the CRPs.

CRP staff

The CRPs employed 1 076 staff in 2013 – more than three-quarters of whom were researchers or technicians (Figure 3.16, Panel a). This is up from 819 staff in 2008, but down from a peak of 1 101 in 2011. The recent decline is solely due to changes in what used to be the largest CRP, Henri Tudor, where staff numbers decreased from 462 in 2011 to 396 in 2013 (Figure 3.16, Panel b). Most of the decline owes to a fall in the number of researchers, from 311 in 2011 to 256 in 2013 (Figure 3.16, Panel c). Almost 39% of CRP researchers are female, though gender composition varies considerably among CRPs, reflecting the traditional disciplinary gender imbalances seen in most countries (Figure 3.16, Panel d).

Figure 3.16. CRP staff profiles (based on headcounts)

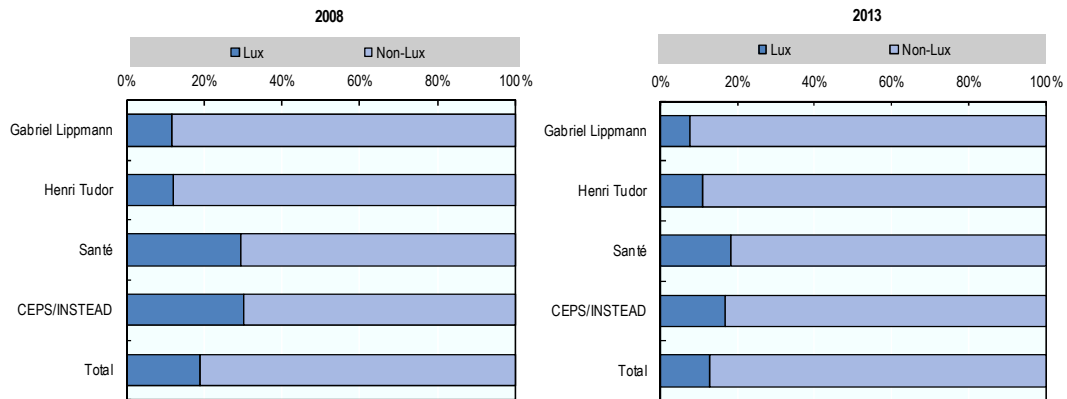


Source: Ministry of Higher Education and Research (2014), *Rapport d'Activité 2013*.

Much of the recent expansion in CRP researcher numbers has been fuelled by the hiring of non-Luxembourgers. Reflecting Luxembourg's small size and openness, a remarkable 87% of CRP researchers are foreigners, up from 81% in 2008 (Figure 3.17). The largest changes have taken place at CRP Santé – up from 71% of foreign researchers in 2008 to 82% in 2013 – and CEPS/INSTEAD – up from 70% in 2008 to 83% in 2013. Most of the foreign researchers are from neighbouring countries, particularly France – which accounted for 46% of researchers at CRP Henri Tudor and 36% at CRP Santé

in 2013. However, increasing numbers of foreign researchers are coming in from further afield. In this regard, the CRPs have benefitted from the PEARL and ATTRACT programmes of the FNR to attract – though only to a minor extent – top international talent to Luxembourg. Chapter 4 discusses these programmes.

Figure 3.17. Proportions of foreign and national staff in the CRPs (based on headcounts)

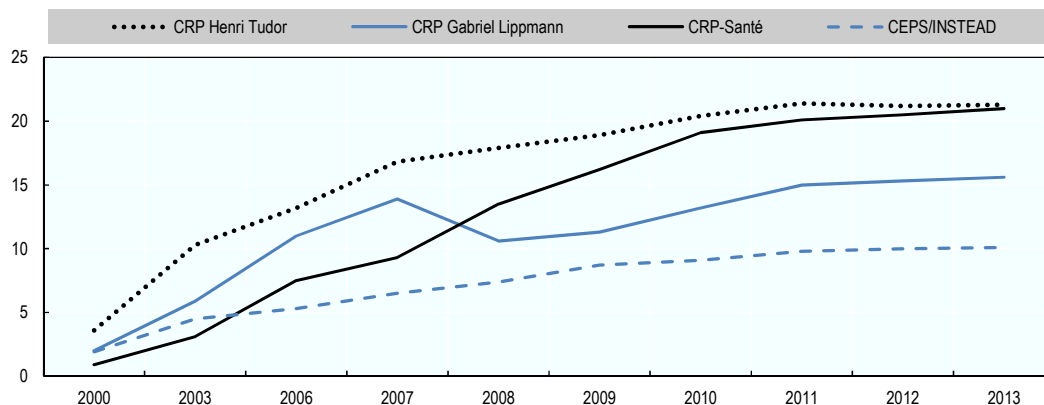


Source: Ministry of Higher Education and Research (2014), *Rapport d'Activité 2013*.

Research funding

The growth of CRPs owes to generous increases in public funding for the CRPs – the value of block grants from the Ministry of Higher Education and Research increased from EUR 8.4 million in 2000 to EUR 68.0 million in 2013 (Figure 3.18). Most of the increases occurred in the 2010s; in fact, since 2011, the value of block grants has remained more or less static. Some CRPs have benefitted more from these increases than others, e.g. CRP Santé saw its block grant grow from EUR 0.9 million in 2000 to EUR 19.1 million in 2010, while CEP/INSTEAD saw its block grant grow from EUR 1.9 million to EUR 9.1 million over the same 10-year period. The proportion of block grants in CRP revenues varies slightly among institutes and has mostly declined slightly in recent years: block grants accounted for 63% of CRP revenues in 2013, down from 65% in 2008 (Figure 3.19).

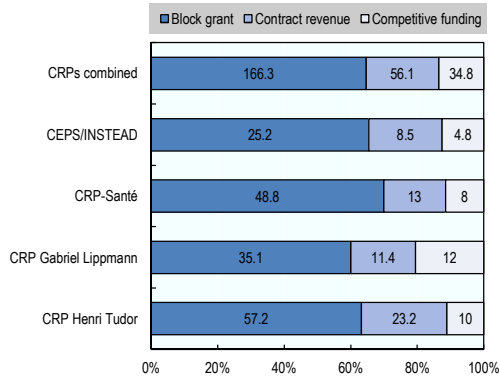
Figure 3.18. Evolution of block grant in the CRPs, 2000-13 (MEUR)



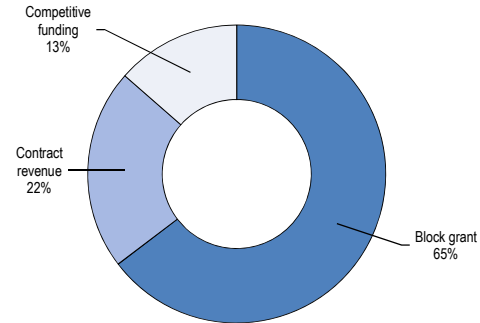
Source: Rieder et al. (2014), *The Luxembourg Innovation System*.

Figure 3.19. CRP revenues

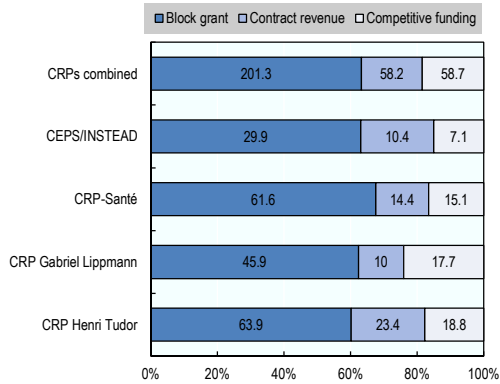
Panel a: Breakdown of revenues by CRP, 2008-10 (MEUR)



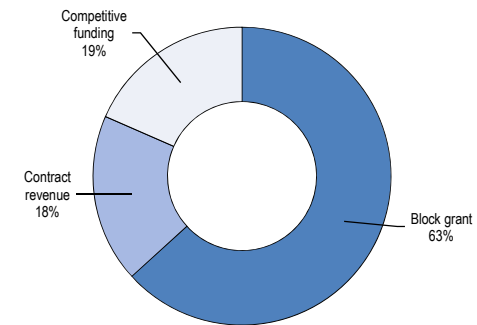
Panel b: Percentage breakdown of revenues of all CRPs combined, 2008-10



Panel c: Breakdown of revenues by CRP, 2011-13 (MEUR)

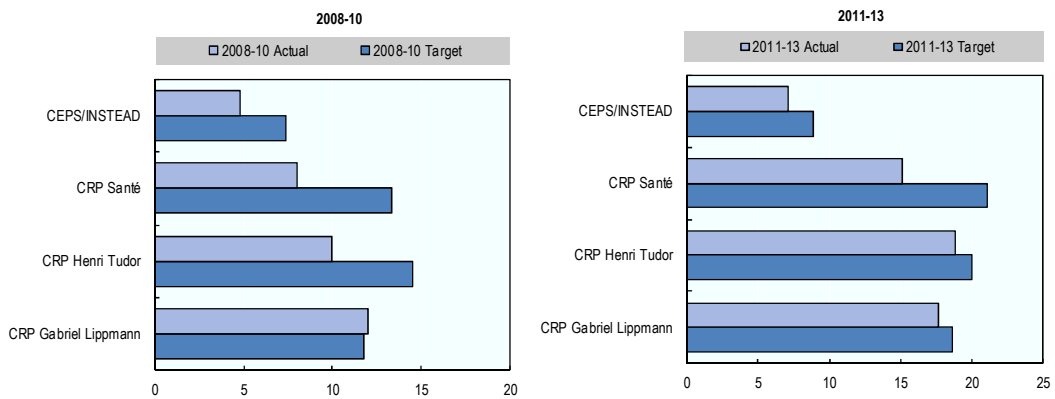


Panel d: Percentage breakdown of revenues of all CRPs combined, 2011-13



Source: Rieder et al. (2014), *The Luxembourg Innovation System*.

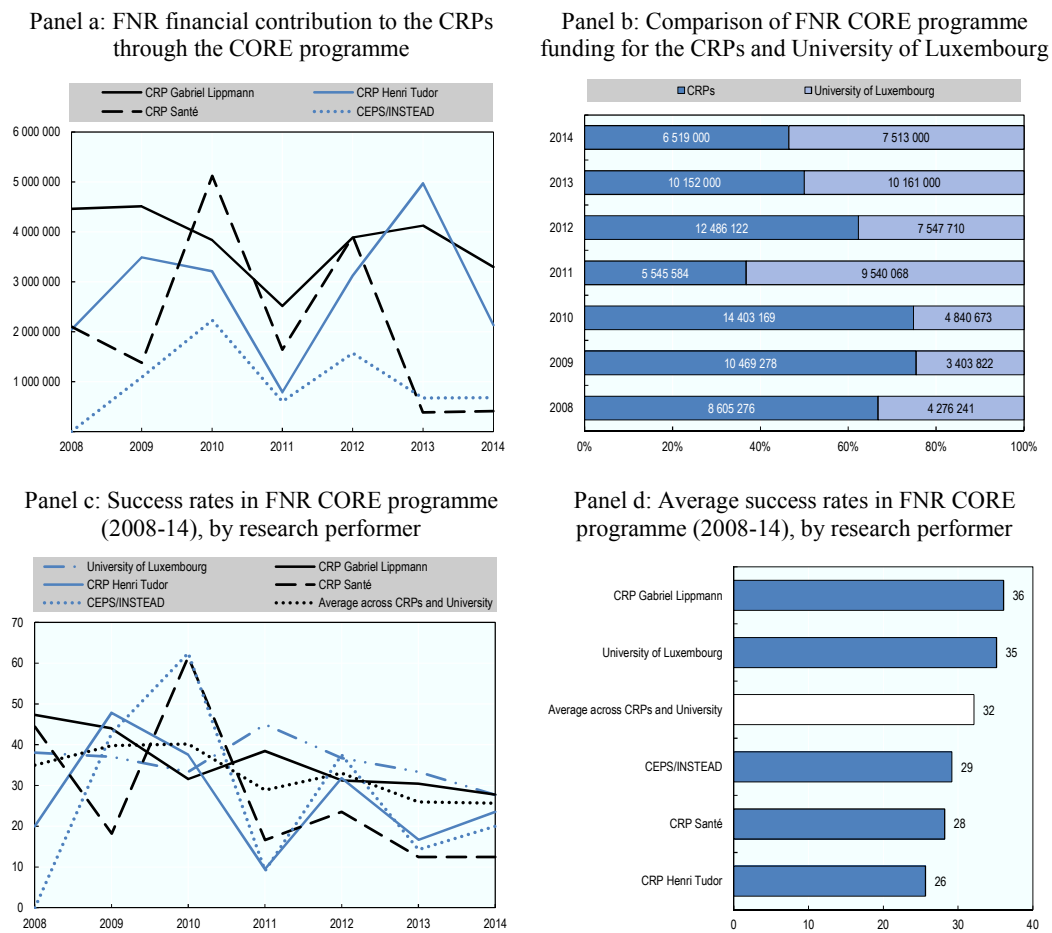
Figure 3.20. Competitive research revenues in the CRPs (MEUR)



Source: Rieder et al. (2014), *The Luxembourg Innovation System*.

Competitive funding – obtained chiefly from the FNR and, to a lesser extent, the European Union – accounts for an increasing share of CRP revenues (Figure 3.19). In the most recent three-year performance contract period 2011-13, the CRPs attracted EUR 58.7 million (19% of their revenues) in competitive funding, compared to EUR 34.8 million (13% of revenues) for the previous performance contract period 2008-10. The share of revenue from competitive funding varies by institute, standing for example at 24% in 2011-13 for CRP Gabriel Lippmann and 15% for CEPS/INSTEAD. While the growth of competitive funding in CRP revenues is a promising development, it still falls short of government expectations: the CRPs have almost always missed their performance targets for competitive funding – although to a lesser degree in 2011-13 (Figure 3.20). In many OECD countries, it is not unusual for CRP-type institutes to obtain around one-third of their revenues through competitive funding.

Figure 3.21. FNR CORE Programme funding



Source: FNR (2015), personal communication.

The CRPs together received about 10% of European 7th Framework Programme funding allotted to Luxembourg up to August 2014 – approximately half of the funding received by the University of Luxembourg over the same period. This disappointing performance contributes to the CRPs missing their competitive-funding performance targets. The FNR, primarily through its CORE programme, accounts for the bulk of competitive funding

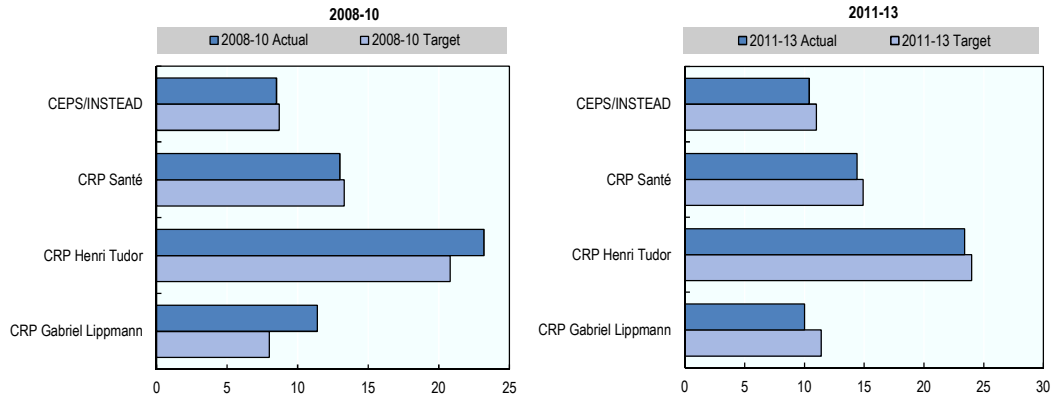
obtained by the CRPs. The amount of funding flowing from the FNR to the CRPs fluctuates considerably from one year to the next, partly on account of small numbers, though CRP Gabriel Lippmann has done consistently well (Figure 3.21, Panel a). The University's growth in recent years – particularly its increasing research intensity through the interdisciplinary centres – has increased competition for FNR funding, which has had an impact on the amounts of funding flowing to the CRPs (Figure 3.21, Panel b). This is reflected in the gradual decline in success rates for grant applications in recent years (Figure 3.21, Panel c), though the situation varies by institute: CRP Gabriel Lippmann had the highest success rate (36%) and CRP Henri Tudor the lowest (26%) among the main research performers in Luxembourg in 2008-14 (Figure 3.21, Panel d); CRP Santé has been particularly unsuccessful in the last couple of years in securing FNR funding. Some CRPs, e.g. Henri Tudor, complain that the sole focus of the FNR on scientific excellence discriminates against other types of excellence; they have repeatedly called on the government to set up new competitive-funding instruments for innovation and technology transfer, as is the case in some other OECD countries. To some extent, provisions in the 2009 law on research, development and innovation, an initiative of the Ministry of the Economy, aim to include funding of collaborative research between business and public research organisations, including the CRPs and University, without the stringent scientific excellence criteria applied by the FNR. However, uptake of this funding until now has been disappointing. Chapter 4 discusses this initiative.

The other major component of revenues for the CRPs is contract research funding, primarily from government departments and businesses. The CRPs attracted EUR 58.2 million (i.e. 18% of their revenues) in contract research funding in the three-year performance contract period 2011-13, compared to EUR 56.1 million (22% of revenues) for the previous performance contract period 2008-10 (Figure 3.19). The share of revenue from contract research funding (e.g. 22% for CRP Henri Tudor and 14% for CRP Gabriel Lippmann in 2011-13) varies by institute. While its relative decline is perhaps more a reflection of growth in other funding streams, all CRPs failed to meet their related performance targets in 2011-13 (Figure 3.22), owing to economic difficulties in the business sector and increasing competition from the University. Still, the proportion of business funding of government intramural expenditure on R&D (GOVERD) in Luxembourg – essentially the R&D performed by the CRP sector as a whole – stood at 6% in 2012, comparing favourably to the 3.5% OECD average (Figure 3.23).

Research outputs

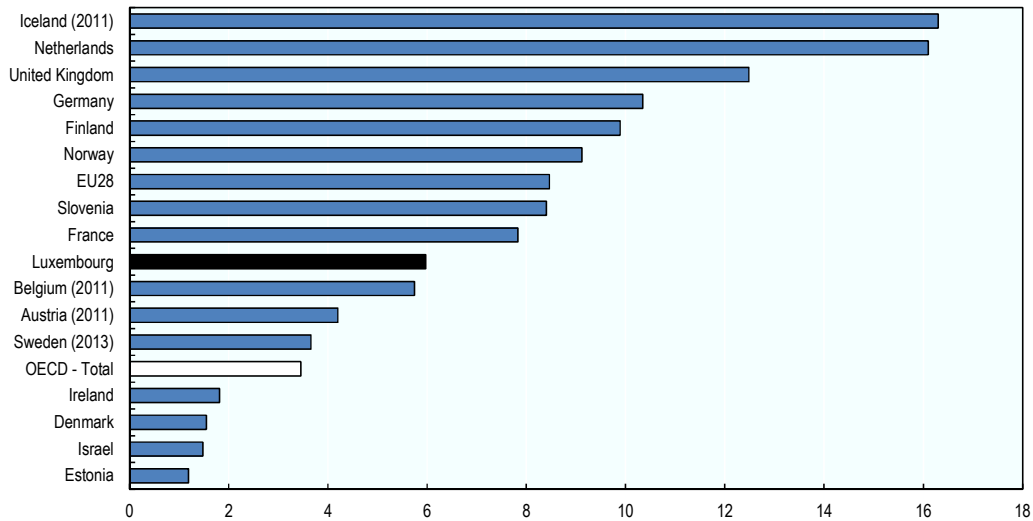
Contract research is perhaps the most visible channel through which the CRPs are believed to contribute to Luxembourg's economy and society, but other channels should not be overlooked. For example, much competitive research funding obtained through the European Union and FNR involves partnering with industry and public policy actors in knowledge co-production. The CRPs are also expected to disseminate their research findings through scientific publications. Bibliometric indicators reveal that all the CRPs (except for CRP Santé) reached, or were very close to reaching, the publication-related targets featured in the performance contracts (Table 3.6). While all CRPs have increased the number of scientific outputs, the impact and number of citations of these publications – especially for CEPS/INSTEAD and CRP Henri Tudor – are not exhibiting similar growth.

Figure 3.22. Contract research revenues in the CRPs (MEUR)



Source: Rieder et al. (2014), *The Luxembourg Innovation System*.

Figure 3.23. Percentage of GOVERD financed by industry (2012)



Note: Data for the private non-profit sector are included in the government sector for Germany and the Netherlands.

Source: OECD (2015), *OECD Main Science and Technology Indicators* (database), <http://dotstat.oecd.org>.

Luxembourg’s CRPs have become increasingly active in patenting, licensing and spin-off creation – related targets are set in their performance contracts – and have recently set up technology transfer offices to support these activities. Table 3.7 shows the CRPs were able to surpass their targets on patenting, but had more difficulties creating spin-off firms.

Table 3.6. **Publications of the CRPs and CEPS/INSTEAD, 2011-13**

	2011		2012		2013		2011-13	
	Target	Actual	Target	Actual	Target	Actual	Target	Actual
CRP Henri Tudor								
Publications with impact factor (IF)>=2	20	51	50	84	50	55	120	190
Publication intensity referenced by Thomson or Scopus	0.3	0.55	0.55	0.52	0.55	0.56		
Publication intensity (publication/researcher)	0.50	0.82	0.80	0.79	0.80	0.86		
CRP Gabriel Lippmann								
Publications IF>=2	x	x	x	x	x	x	100	261
Publication intensity referenced by Thomson or Scopus	0.80	0.95	0.85	0.99	0.85	1.31		
Publication intensity (publication/researcher)	0.90	1.18	1.00	1.12	1.0	1.40		
CRP-Santé								
Publications in journals with IF (Thomson) >5	30	21	30	30	30	32	90	83
Publications in journals with IF (Thomson) >10	7	3	7	2	7	6	21	11
Referenced publication intensity [publication (IF > 2)/researcher]	0.70	0.64	0.70	0.72	0.70	0.65		
CEPS/INSTEAD								
Publications in peer-reviewed journals	--	84	--	115	--	78	124	277
Publication intensity (ISI, SCOPUS, AERES)	0.7	0.43	0.7	0.71	0.7	0.45	--	--
Organised International Conferences (>60 participating experts)	--	2	--	4	--	2	5	8
Scientific conference presentations as keynote speaker, session chairman, etc.	--	27	--	22	--	39	30	88
Co-publications with visiting scientists	--	4	--	11	--	6	>20	21

Note: x = not applicable.

Source: Rieder et al. (2014), *The Luxembourg Innovation System*.

Table 3.7. **Numbers of patents, licences, spin-offs and prototypes in the CRPs, 2011-13**

		Target	Actual
CRP Henri Tudor	Patents	8	9
	Paid licences	50	213
	Spin-offs	4	3
CRP Gabriel Lippmann	Patents	12	22
	Paid licences	12	5
	Free licences	18	8
	Spin-offs	2	1
	Prototypes and processes	15	26
CRP-Santé	Patents	3	3
	Spin-offs	1	0

Source: Rieder et al. (2014), *The Luxembourg Innovation System*.

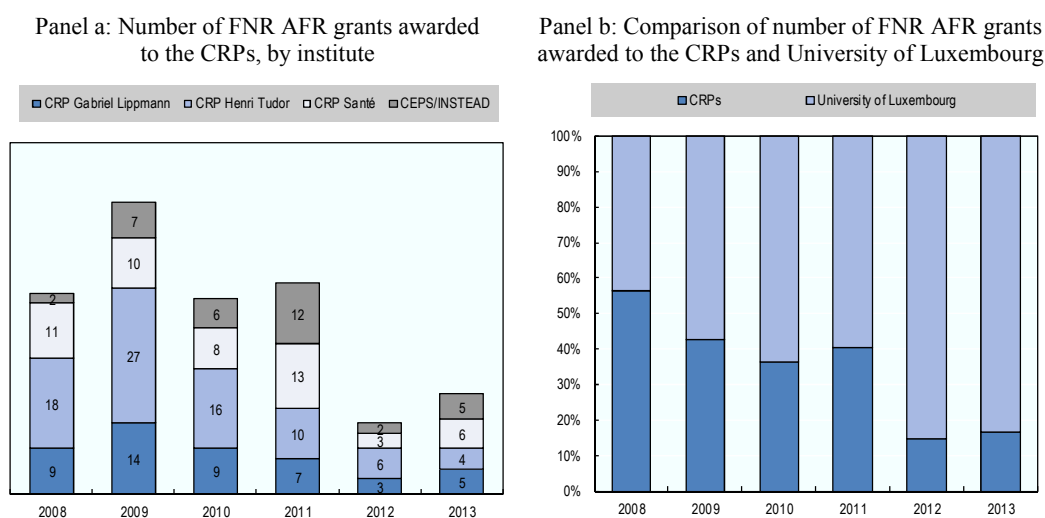
Development of human skills is an often overlooked yet critical contribution of public-sector research to the economy and society; an important component in the CRP context is doctoral training. CRP performance contracts include performance targets on numbers of PhD students and thesis submissions, which the CRPs are more or less able to meet (Table 3.8). The majority of PhD students are registered at universities outside of Luxembourg. The CRPs have secured a sizeable number of the Aides à la formation recherche (AFR) doctoral and post-doctoral grants provided through the FNR, though numbers have sharply declined in recent years as more grants have gone to the University (Figure 3.24).

Table 3.8. Number of doctorates in the CRPs and CEPS/INSTEAD, 2011-13

	2011		2012		2013		2011-13	
	Target	Actual	Target	Actual	Target	Actual	Target	Actual
CRP Henri Tudor								
PhD students	44	56	45	49	45	37		
PhD thesis							30	40
CRP Gabriel Lippmann								
PhD students	35	35	36	39	37	46		
PhD thesis	-	-	-	-	-	-	25	17
CRP-Santé								
PhD students							35	31
PhD thesis							25	25
CEPS/INSTEAD								
PhD students	14	17	16	18	18	21		
PhD thesis		1		2		5	11	8

Source: Rieder et al. (2014), *The Luxembourg Innovation System*.

Figure 3.24. FNR AFR grants, 2008-13



Source: FNR (2015), personal communication.

Evaluation of the CRPs

Between 2010 and 2012, several research units in the CRPs were individually evaluated by peer-review panels:¹

- CRP Henri Tudor: Advanced Materials and Structures; Resource Centre for Environmental Technologies; Service Science and Innovation Department
- CRP Gabriel Lippmann: Science and Analysis of Materials Department; Geohydrosystems and land-use management and Aquatic and terrestrial ecosystems units at the Environment and Agro-Biotechnologies Department; Informatics, Systems and Collaboration Department

- CRP Santé: Department of Oncology; Laboratory of Cardiovascular Research; Public Health Research Department
- CEPS/INSTEAD: Population and Employment (in conjunction with the IRISS and ReEx units); Geography and Development.

It is important to note that evaluations have not been carried out at the level of the whole CRP, but only of individual research units. Furthermore, the 2010-12 round of evaluations did not cover all the CRP research units – the remaining units will be assessed in future rounds of peer-panel evaluation. Evaluation findings vary considerably among research units, even within the same CRP. In fact, more variation sometimes occurs between units in the same CRP than between units in different CRPs. Overall, the evaluations identify many positive features, e.g. a strong focus on industrial collaboration, some good scientific outputs, well-equipped research facilities, good support for PhD students and some strong research links with foreign universities. They also highlight several problems, in particular:

- *A lack of research focus and strategy*: the research priorities set by some research units can be too diverse, and research agendas are insufficiently focused. The evaluations found that the units that performed better in attracting funding and producing scientific publications were more likely to have developed a clear vision of their strategic research priorities.
- *Weak co-operation with other research-performing actors*: there is often underexploited potential to co-operate with other research units in the same CRP, as well as with units in other CRPs and the University of Luxembourg.
- *Mixed results in scientific outputs*: international visibility of CRP research, and the number of publications in highly ranked journal, are often rather low. The evaluations showed that some research units had successfully transitioned towards more research-oriented activities. These units focused their research on specific scientific questions of particular interest to their mission, increased the number of scientific publications and attracted research funding from the FNR and European Union. Other research units were still struggling to reorient their activities towards a more scientific approach.
- *Weak performance in obtaining EU funding*: all the evaluations identified low EU funding performance as a common weakness.

While the evidence presented earlier in this section mostly aligns with these findings, it also suggests some developments in the right direction: CRPs are obtaining an increasing proportion of their research revenue through competitive funding and have improved their scientific-publication record, thanks in part to recent success in attracting good international researchers. Still, CRPs continue to face some important challenges.

First, they need to improve the strategic prioritisation of their research and other activities – which is a challenge, because clients' often short-term industrial and policy needs have traditionally had a strong influence on CRP agendas, limiting their ambition and geographical scope. Further, the legacy of opportunistic (rather than strategic) growth of the CRPs and their research units in earlier periods has sometimes left them with a diverse array of research activities and support services that are difficult to organise strategically. The success of the University's SnT interdisciplinary centre in securing long-term industry funding through its Partnership Programme – which allows it to adopt a more strategic approach to its research – could provide useful lessons for the CRPs.

Some elements of this approach are already in evidence in the CRPs – by way of example, Box 3.8 presents recent strategic developments at CRP Henri Tudor. SnT has also developed approaches for resolving tensions between academic and user-oriented research in the same institute. The CRPs could also apply these approaches, while taking into account their somewhat different missions, histories and legacies.

**Box 3.8. Towards strategic development of markets and partnerships:
The case of CRP Henri Tudor**

In 2011, CRP Henri Tudor introduced a new method for managing its research activities through so-called “innovation programmes”. These programmes aim to provide a multidisciplinary response to the innovation challenges of nine markets: manufacturing, construction, eco-technologies, mobility, transport and logistics, healthcare, public services, regulated IT services for the financial sector and human capital. They are credited with making CRP Henri Tudor’s offerings more understandable and therefore more accessible to its business and policy partners.

In parallel, CRP Henri Tudor also set up a professional management approach for its partners/clients. For some partners, the potential of partnerships was such that it proved useful to develop partnership formulas along the lines of “key accounts”. Partnership framework contracts – with the goal of working in a long-term P/PP on an agreed portfolio of multiannual research activities – have been signed with companies such as Paul Wurth in 2011, PSA Peugeot Citroën in 2012, ArcelorMittal and ILNAS in 2013, and EBRC and POST Luxembourg in 2014.

Source: CRP Henri Tudor (2014), *Annual Report 2013*, www.innovation.public.lu/fr/brochures-rapports/r-ra-crph-t-2013/ra-tudor-en-2013.pdf.

Second, promoting the international focus of the CRPs, e.g. by encouraging greater participation in EU funding programmes and greater co-operation with firms outside of Luxembourg, could also contribute greatly to improving international scientific excellence in a framework of socio-economic relevance. The main area of CRP activities remains the Grande Région. Extending co-operation beyond the region – with firms and other research actors in other parts of Europe and the rest of the world – will require raising the level of ambition of research and increasing its international visibility.

A third challenge is to overcome the continued weak co-operation among Luxembourg’s public research actors. The merger of CRP Gabriel Lippmann and CRP Henri Tudor into LIST seems appropriate in this regard, particularly given their strongly overlapping research areas. Further mergers – e.g. of LIH and LISER with either the University or LIST – would require considerable time to prepare and should be carefully evaluated, taking into account the relative merits of grouping researchers, creating critical mass and reducing administrative costs. Nevertheless, the CRPs and the University could significantly enhance their interaction. For example, very few of the PhD students at the CRPs are registered at the University, and joint staff appointments are extremely rare. Various institutional arrangements at the University that appear to hinder greater co-operation are currently under review or revision; co-location at Belval is likely to offer new opportunities for closer collaboration (see Chapter 4). Luxembourg could learn from experiences in many advanced European countries, where deep and extensive ties exist between universities and CRP-like public research institutes (see Box 3.9). In particular, joint senior staff appointments, PhD supervision and research projects between the University of Luxembourg and CRPs would help build and cement co-operation between the two.

Box 3.9. Linkages between PRIs and universities in selected OECD countries

In many OECD countries, PRIs are increasingly conducting joint research and innovation activities with universities (Technopolis, 2010). Co-operation between the two types of organisations benefits their research activities: universities bring to the table their expertise in fundamental research and education, while PRIs provide knowledge on applied research, technical know-how and infrastructure. Co-operation between PRIs and universities takes place in different ways depending on the different contexts and institutional settings. Personal relationships among researchers with different affiliations also play a role. Examples of linkages include the following:

- *Linkages driven by participation in joint research projects.* Joint research projects between universities and PRIs are the most common and widespread means of co-operation. PRIs increasingly participate in national and international research projects involving one or more universities, which generally lead to joint scientific publications. For example, by the early 2000s more than half of the scientific publications produced by Norwegian PRIs were co-authored with universities; in 2008, Swedish PRIs spent approximately 21% of their core funding on joint projects with universities (Technopolis, 2010); VTT (the Technical Research Centre of Finland) regularly conducts joint research projects with Finnish universities; and the Fraunhofer Institute for Reliability and Microintegration (Fraunhofer IZM) has a long list of university research partners in many German cities, as well as in Italy, Spain, the Netherlands, Finland, Japan, Sweden and the United Kingdom (Fraunhofer IZM, 2014).
- *Linkages driven by joint appointments of research staff.* Another factor fostering the establishment of knowledge linkages is the joint recruitment of human resources for science and research. For example, the directors of the Fraunhofer institutes also work as professors at a nearby university; not only does this foster joint project development, it also facilitates organising internships between Fraunhofer institutes and universities, and recruiting PhDs. The largest Norwegian research institute – the Foundation for Scientific and Industrial Research (SINTEF) – and the Norwegian University of Science and Technology share more than 500 R&D personnel (approximately 25% of SINTEF staff) (OECD, 2008b). Joint affiliation of researchers at both universities and PRIs is also common practice in Italy and France.
- *Linkages driven by joint supervision of PhD students or post-doctoral researchers.* In those areas where clear synergies and research overlaps exist, joint supervision of PhD students or young post-doctoral researchers is a way to strengthen joint co-operation and research linkages. For instance, students enrolled in PhD programmes at the Swiss Federal Institute of Technology Zurich (ETH Zurich) can carry out their doctoral thesis research either at ETH Zurich or at one of the research institutes in the ETH Domain. Joint PRI/university supervision of PhDs and post-doctoral researchers is also common practice in other OECD countries, such as Norway and Germany.
- *Linkages driven by joint provision of education courses,* including higher education courses and lifelong learning. Germany offers interesting examples of these practices: Fraunhofer IZM supports teaching at the Technical University of Berlin by offering students additional seminars and the opportunity to participate in national and international research projects. The Fraunhofer Academy is the Fraunhofer Institutes' provider of lifelong learning and part-time training for specialists and managers. It offers classes and seminars in co-operation with universities. Fraunhofer Institutes contribute by providing practical experience and knowledge around applied research, while universities provide interdisciplinary knowledge.

Box 3.9. Linkages between PRIs and universities in selected OECD countries (continued)

- *Linkages driven by **joint use of research facilities** or the creation of joint research labs.* Some institutions have created joint research campuses and laboratories where researchers affiliated with universities or PRIs can use research equipment, run experiments and generally work together on joint research activities. These are located within the university campus or PRI; alternatively, they are part of larger science and technology parks or innovation clusters. In Norway, the SINTEF headquarters are located on the campus of the Norwegian University of Science and Technology (NTNU) in Trondheim, with the two organisations sharing many research facilities. SINTEF has also strengthened its linkages with the University of Oslo by setting up three joint research centres, on applied mathematics, materials technologies and nanotechnologies. In Finland, VTT and the University of Oulu, together with partners in the business sector, are currently building a 5G Test Network to advance research in the field of wireless communications. In other cases, VTT researchers are hosted by Finnish universities. For instance, the VTT research group on Separation Technology will be located within the Department of Chemistry of the Lappeenranta University of Technology. In Switzerland, competence centres to promote cross-disciplinary research between the ETH Federal Institutes of Technology (ETH Zurich and EPFL Lausanne) and the ETH Domain research institutes have been established.
- *Linkages driven by **shared governing mechanisms**.* Shared institutional mechanisms that formally govern co-ordination between PRIs and universities are less common. In Switzerland, ETH Zurich and EPFL Lausanne and four associated research institutes are part of the so-called ETH Domain (ETH Domain, 2014). The ETH Board, which brings together individuals from politics, industry and society, steers and provides strategic management of the ETH Domain as a whole. This translates into common strategic objectives across ETH Domain organisations, including providing education to students and permanent lifelong learning to citizens; conducting joint research; providing scientific and technical services; and promoting international co-operation. Other examples of governing mechanisms to steer strategic co-operation between PRIs and universities can be found at the institutional level. In 2005, the boards of NTNU and SINTEF defined a long-term common strategy around several areas, including internationalisation; research and industrial policy; research equipment and infrastructure; and academic priorities.

3.4 Other public research-performing organisations

Besides the University and CRPs, Luxembourg is home to several other smaller public research organisations, including the following:

Virtual Resource Centre for Knowledge about Europe (CVCE)

CVCE is a public research centre created in 2002 and financed by the Ministry of Higher Education and Research. It focuses on European integration history and politics and employs approximately 40 people. The Centre's budget has grown considerably since 2002 and amounted to nearly EUR 4 million in 2014, much of it in the form of a block grant governed by multiannual performance contracts signed with the Ministry of Higher Education and Research. Like the CRPs, CVCE secures additional funding from national and European research programmes and contract research.

Max Planck Institute (MPI) Luxembourg for International, European and Regulatory Procedural Law

MPI was founded in 2013. It is one of very few Max Planck Institutes located outside of Germany. Luxembourg finances the Institute entirely – at a cost of around EUR 12 million a year – as part of its broader strategy to develop centres for academic excellence and higher education. The MPI focuses on European law – one of the priorities of the University of Luxembourg. Both institutions expect to co-operate in the area. The MPI also plans to co-operate with international legal institutions, such as the Luxembourg-based European Court of Justice.

The Institute hosts three departments: the Department of Public International Law, the Department of European and Comparative Procedural Law, and the Department of Regulatory Procedural Law. It currently has 65 employees; an increase to 150 employees is under discussion.

Central Service for Statistics and Economic Studies (STATEC)

STATEC is an independent body under the supervision of the Ministry of the Economy. Its main mission is to collect and provide statistics to the general public. The new STATEC law of 2011 allows it to conduct independent research around the following areas: economics, demographics, and societal and environmental modelling.

Centre Hospitalier du Luxembourg (CHL)

CHL is a public organisation under the authority of the Ministry of Health. It was established in 1976 and is currently equipped with 579 beds. Much of the medical research at CHL is done in collaboration with LIH. CHL publishes an average of 100 research papers a year.

National Health Laboratory (LNS)

LNS was established in 1980. The laboratory – which was until 2012 part of the Ministry of Health – became a public-law institution in 2013. It undertakes multidisciplinary research focusing on human medicine, epidemiology and hygiene; it is also responsible for drug and food control, and toxicological analysis. LNS employs approximately 200 people.

Luxembourg Natural History Museum (MNHN)

MNHN hosts the national scientific research centre on natural heritage, created in 1982. The research centre collects data and performs analysis.

European Centre for Geodynamics and Seismology (ECGS)

ECGS was created in 1988 through the European Commission's Open Partial Agreement on prevention, protection and assistance against technological and major natural risks. ECGS undertakes research around tectonic distortions, earthquakes and space techniques. It runs an underground geodynamics laboratory in Walferdange with the necessary scientific and technical equipment for the study of deformation in tectonically active zones.

Robert Schuman Centre for European Studies and Research (CERE)

CERE was established in 1990. It currently employs six people and undertakes research on the history of European integration, as well as Luxembourg's positioning within this process.

Note

1. All reports are online at the Ministry of Higher Education and Research website, www.mesr.public.lu/recherche/rapports_evaluation/index.html (accessed 11 April 2014).

References

- Clancy, B. (2008), “Luxembourg’s Financial Services Sector as a Product of Nimble Tax and Regulatory Policy”, *Perspectives on Business and Economics, Benelux: Integration and Individuality*, Vol. 26, pp. 111-121.
- CRP Henri Tudor (2014), *Annual Report 2013*, www.innovation.public.lu/fr/brochures-rapports/r/ra-crph-2013/ra-tudor-en-2013.pdf.
- ETH Domain (2014), *The ETH Domain in Brief*, www.ethrat.ch/sites/default/files/ETHBiK_2014_EN_web.pdf.
- European Commission (2014), *2014 SBA Fact Sheet Luxembourg*, Directorate-General Enterprise and Industry, http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/files/countries-sheets/2014/luxembourg_en.pdf.
- Eurostat (2015), *Science, Technology and Innovation* (database), <http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database>.
- Eurostat (2013), *Seventh Community Innovation Survey. Highest Proportions of innovative Enterprises in Germany, Luxembourg and Belgium*, http://europa.eu/rapid/press-release_STAT-13-5_en.pdf.
- FNR (2015), personal communication.
- Fraunhofer IZM (2014), *Fraunhofer Institute for Reliability and Microintegration: Annual report 2014*, www.izm.fraunhofer.de/content/dam/izm/en/documents/Publikationen/Jahresberichte/AR_2013_14/AR_2013_14_EN.pdf.
- Frenz, M. and R. Lambert (2012), “Mixed Modes of Innovation: an Empiric Approach to Capturing Firms’ Innovation Behaviour”, *OECD Science, Technology and Industry Working Papers*, No. 2012/6, www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/DOC%282012%296&docLanguage=En.
- Leijten, J. (2007), “The future of RTOs: a few likely scenarios”, in European Commission (2007), *The Future of Key Research Actors in the European Research Area, Expert Group Report*.
- Ministry of the Economy and Foreign Trade (2013), “2013 Competitiveness Report. Ten Years of Competitiveness Scoreboard: A Sawtooth Evolution”, *Perspectives de Politique Economique*, No. 27, www.innovation.public.lu/en/publications/rdi-luxembourg/competitivite-statistiques/bilan-competitivite-2013/index.html.

- Ministry of Higher Education and Research (2014), *Rapport d'Activité 2013*, MESR, Luxembourg.
- OECD (2015), *OECD Main Science and Technology Indicators* (database), <http://dotstat.oecd.org>.
- OECD (2014), *OECD Factbook 2014: Economic, Environmental and Social Statistics*, OECD Publishing, Paris, <http://dx.doi.org/10.1787/factbook-2014-en>.
- OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_scoreboard-2013-en.
- OECD (2008a), *OECD Economic Surveys: Luxembourg 2008*, OECD Publishing, Paris, http://dx.doi.org/10.1787/eco_surveys-lux-2008-en.
- OECD (2008b), *OECD Reviews of Innovation Policy: Norway 2008*, OECD Publishing, Paris, <http://dx.doi.org/10.1787/9789264043749-en>.
- OECD (2007), *OECD Reviews of Innovation Policy: Luxembourg 2007*, OECD Publishing, Paris, <http://dx.doi.org/10.1787/9789264010284-en>.
- Rieder, S. et al. (2014), *The Luxembourg Innovation System*, background report for the *OECD Reviews of Innovation Policy*.
- Technopolis (2010), *Impacts of European RTOs, A Study of Social and Economic Impacts of Research and Technology Organisations*, a report to EARTO, www.earto.eu/fileadmin/.../TechnopolisReportFinalANDCorrected.pdf.
- University of Luxembourg (2014), *Report 2013: Key Performance Indicators*, University of Luxembourg.
- Zahlen, P. (2007), *The Luxembourg Economy: An Eventful History*, www.luxembourg.public.lu/catalogue/economie/letz-economie-histoire/letz-economie-histoire-2007-EN.pdf.



From:
**OECD Reviews of Innovation Policy: Luxembourg
2016**

Access the complete publication at:
<https://doi.org/10.1787/9789264232297-en>

Please cite this chapter as:

OECD (2016), "Innovation actors in Luxembourg", in *OECD Reviews of Innovation Policy: Luxembourg 2016*, OECD Publishing, Paris.

DOI: <https://doi.org/10.1787/9789264232297-6-en>

This work is published under the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of OECD member countries.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of OECD as source and copyright owner is given. All requests for public or commercial use and translation rights should be submitted to rights@oecd.org. Requests for permission to photocopy portions of this material for public or commercial use shall be addressed directly to the Copyright Clearance Center (CCC) at info@copyright.com or the Centre français d'exploitation du droit de copie (CFC) at contact@cfcopies.com.