



ERAWATCH Country Report 2008

An assessment of research system and policies

Luxembourg

Susan Alexander



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Luxembourg

ERAWATCH Network -
Minerva

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Joint Research Centre

Directorate-General for Research

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Executive Summary

Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are at the heart of the Lisbon Strategy. The strategy reflects this in guideline No. 7 of the Integrated Guidelines for Growth and Jobs which aims to increase and improve investment in research and development, in particular in the private sector. The report aims at supporting the mutual learning process and the monitoring of Member States efforts. The main objective is to characterise and assess the performance of the national research system of Luxembourg and related policies in a structured manner that is comparable across countries. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. This report is based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

In 2006, a review of Luxembourg's national research system (NRS) was conducted by the OECD. Its conclusions were generally positive. The Grand Duchy's NRS functions well and its output was judged as being excellent in its selected niches. Recommended improvements focussed on establishing performance contracts with the major actors in the NRS and harmonising the work of the Public Research Centres (PRCs) and the University. Subsequently, a Foresight Study was undertaken by the National Research Fund to ensure that new programme themes accurately reflected demand and would meet the needs of stakeholders.

Both the OECD review and the Foresight Study were the result of policy decisions and reflect the Luxembourg government's strong support of the Lisbon Strategy. The significant investments made in launching a national university in 2003 and the subsequent development of a "City of Science" as a headquarters for the university and research centres are also evidence of the government's long-term commitment to Lisbon goals.

Luxembourg's research strengths by and large outweigh its weaknesses; the Grand Duchy has a good track record in successfully exploiting opportunities and defusing risks. A robust economy means funding of public sector institutions and providing private sector incentives is limited more by absorptive capacity than by budgetary constraints. New initiatives that encourage more public/private partnerships and promote IP are ways the government has identified to enhance absorptive capacity.

Like the rest of the developed world, Luxembourg could use more researchers in its identified niches. However, this limitation is being resolved by a policy of easing visa requirements for researchers as well by virtue of Luxembourg's geography; the multilingual environment and proximate borders of the Grand Duchy make it feasible to attract researchers from neighbouring France, Belgium and Germany. The new University is also becoming a source of qualified personnel.

Finally, Luxembourg is an active participant in the European Research Area (ERA). All of its CRPs are involved in projects across the EU; FNR programmes support international participation (although funding is only given to Luxembourg entities). Luxinnovation, the national agency for innovation and research, assists private sector

firms in participating in FP6/FP7 programmes as well as in European Space Agency (ESA) projects and EUREKA. Note that Luxembourg became a full member of ESA in 2005.

The tables below summarize the analysis of strengths, weaknesses and policy-related opportunities and risks that is detailed in the report following.

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Luxembourg's GERD is low relative to the EU27; national commitment to Europe and the Lisbon agenda as well as a robust economy make raising that level a policy priority.
	Securing long-term investment in research	Luxembourg's inaugurating a national university and constructing a "City of Science" reflect the government's long-term perspective. Targeting the logistics and medical device sectors as new niches for development indicate long-term goals for the private sector.
	Dealing with barriers to private R&D investment	While access to equity venture capital is limited in Luxembourg, the government has launched several initiatives to promote spin-offs and start-ups including creating business incubators and promoting entrepreneurship. Raising awareness of IP and a favourable fiscal environment for IP revenue increases Luxembourg's attractiveness for both new and established companies.
	Providing qualified human resources	Visa restrictions are being eased to support researcher mobility. A dependence on ex-national researchers can result in a brain drain rather than a brain gain if researchers return home.
Knowledge demand	Identifying the drivers of knowledge demand	The Foresight Study was a major initiative undertaken to identify up-to-date demand drivers involving all NRS stakeholders. Clusters also provide driver input. The focus on industrial to the neglect of service sector needs remains a weakness.
	Co-ordination and channelling knowledge demands	The specificity of FNR programmes are a system strength, while attention to European programmes such as FP7 also channel efforts. However, such a targeted focus can also mean missed opportunities.
	Monitoring of demand fulfilment	Tracking the growth of the ECO R&D funding programme indicates private sector demand fulfilment. Instituting a Performance Contract culture within the public participants of the NRS will help overcome weaknesses in governance and accountability.
Knowledge production	Ensuring quality and excellence of knowledge production	The quality of Luxembourg's knowledge production is a significant strength. Its targeted approach to research is both a strength and a weakness as it prevents dissipation of resources while limiting exploration of unanticipated opportunities.
	Ensuring exploitability of knowledge	Initiatives to actively develop public/private partnerships will enhance knowledge exploitation. Increased attention to IP will also support exploitation.
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	Greater harmonisation between the University and the CRPs is needed and will improve knowledge circulation. The presence of leading international research companies is a strength that will be further leveraged by the initiative to actively promote PPPs.
	Profiting from international knowledge	FNR programmes like INTER and the Accompanying Measures encourage the international participation of Luxembourg researchers, while ATTRACT brings in international expertise.
	Enhancing absorptive capacity of knowledge users	Absorptive capacity could be strengthened by increasing the participation of the dominant services sector and SMEs in public/private partnerships, as industrial sector currently dominates.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	Commitment to, as well as fiscal ability to, meet Lisbon goals.	Small number of native researchers mandates reliance on potentially transient foreign talent.
Knowledge demand	Consideration of European, as well as national, research themes when formulating research agenda.	NRS (benign) neglect of services sector which is dominant in Europe as well as Luxembourg.
Knowledge production	Greater collaboration and knowledge transfer between public and private sector research efforts. Better identification and exploitation of IP	Competition between CRPs and SMEs Encouraging entrepreneurship while lagging in the development of an entrepreneurial culture.
Knowledge circulation	Development of programmes that make PPPs attractive to SMEs	Numerically dominant foreign researchers circulate out of Luxembourg, along with their knowledge.

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1 - Introduction and overview of analytical framework

1.1 Scope and methodology of the report in the context of the renewed Lisbon Strategy and the European Research Area

As highlighted by the Lisbon Strategy, knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are at the heart of the Lisbon Strategy. The strategy reflects this in guideline No. 7 of the Integrated Guidelines for Growth and Jobs. This aims to increase and improve investment in research and development (R&D), with a particular focus on the private sector. One task within ERAWATCH is to produce analytical country reports to support the mutual learning process and the monitoring of Member States' efforts.

The main objective is to analyse the performance of national research systems and related policies in a comparable manner. The desired result is an evidence-based and horizontally comparable assessment of strength and weaknesses and policy-related opportunities and risks. A particular consideration in the analysis is given to elements of Europeanisation in the governance of national research systems in the framework of the European Research Area, relaunched with the ERA Green Paper of the Commission in April 2007.

To ensure comparability across countries, a dual level analytical framework has been developed. On the *first level*, the analysis focuses on key processes relevant to system performance in four policy-relevant domains of the research system:

1. Resource mobilisation: the actors and institutions of the research system have to ensure and justify that adequate public and private financial and human resources are most appropriately mobilised for the operation of the system.
2. Knowledge demand: needs for knowledge have to be identified and governance mechanisms have to determine how these requirements can be met, setting priorities for the use of resources.
3. Knowledge production: the creation and development of scientific and technological knowledge is clearly the fundamental role of a research system.
4. Knowledge circulation: ensuring appropriate flows and distribution of knowledge between actors is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production.

These four domains differ in terms of the scope they offer for governance and policy intervention. Governance issues are therefore treated not as a separate domain but as an integral part of each domain analysis.

Figure 1: Domains and generic challenges of research systems

Resource mobilisation	Knowledge demand	Knowledge production	Knowledge circulation
<ul style="list-style-type: none"> • Justifying resource provision • Long term research investment • Barriers to private R&D funding • Qualified human resources 	<ul style="list-style-type: none"> • Identification of knowledge demand drivers • Co-ordination of knowledge demands • Monitoring of demand fulfilment 	<ul style="list-style-type: none"> • Quality and excellence of knowledge production • Exploitability of knowledge production 	<ul style="list-style-type: none"> • Knowledge circulation between university, PRO and business sectors • International knowledge access • Absorptive capacity

On the second level, the analysis within each domain is guided by a set of generic "challenges" common to all research systems that reflect conceptions of possible bottlenecks, system failures and market failures (see figure 1). The way in which a specific research system responds to these generic challenges is an important guide for government action. The analytical focus on processes instead of structures is conducive to a dynamic perspective, helps to deal with the considerable institutional diversity observed, and eases the transition from analysis to assessment. Actors, institutions and the interplay between them enter the analysis in terms of how they contribute to system performance in the four domains.

Based on this framework, analysis in each domain proceeds in the following five steps. The first step is to analyse the current situation of the research system with regard to the challenges. The second step in the analysis aims at an evidence-based assessment of the strengths and weaknesses with regard to the challenges. The third step is to analyse recent changes in policy and governance in perspective of the results of the strengths and weaknesses part of the analysis. The fourth step focuses on an evidence-based assessment of policy-related risks and opportunities with respect to the analysis under 3) and in the light of Integrated Guideline 7; and finally the fifth step aims at a brief analysis of the role of the ERA dimension

This report is based on a synthesis of information from the European Commission's ERAWATCH Research Inventory¹ and other important publicly available information sources. In order to enable a proper understanding of the research system, the approach taken is mainly qualitative. Quantitative information and indicators are used, where appropriate, to support the analysis.

After an introductory overview of the structure of the national research system and its governance, chapter 2 analyses resource mobilisation for R&D. Chapter 3 looks at knowledge demand. Chapter 4 focuses on knowledge production and chapter 5 deals with knowledge circulation. Each of these chapters contains four main subsections in correspondence with the four steps of the analysis. The report concludes in chapter 6 with an overall assessment of strengths and weaknesses of the research system and governance and policy dynamics, opportunities and risks across all four domains in the light of the Lisbon Strategy's goals.

¹ ERAWATCH is a cooperative undertaking between DG Research and DG Joint Research Centre and is implemented by the IPTS. The ERAWATCH Research Inventory is accessible at <http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.home>. Other sources are explicitly referenced.

1.2 Overview of the structure of the national research system and its governance

When undertaking an analysis of Luxembourg in any context, there are several salient factors that must first be noted. The first is Luxembourg's small size. Luxembourg has a population of 486,006, in a land of 2,586 km². The second is Luxembourg's relative wealth and resilient economy. With a GDP per capita (PPP) of \$80,500 it is placed only behind Qatar in worldwide rankings.² Even with a currently slowing economic environment in the eurozone, Luxembourg's GDP growth is expected to continue to outpace other eurozone countries.

Table 1: Annual GDP Growth, Luxembourg vs. eurozone (%)

Year	Luxembourg	Eurozone
2006	6.1	2.8
2007	4.5	2.7
2008 (est)	3.6	1.7
2009 (est)	3.5	1.5

Source: Eurostat

The third significant feature of Luxembourg is the high percentage of resident foreigners. At 42.6%, Luxembourg has the highest number of non-national residents of any country in the world. Of this group the largest number are Portuguese, followed by the French. In addition, each working day, more than 135,000 "frontaliers" cross the borders of France (68,600), Germany (31,700) and Belgium (35,000) to jobs that range from shop assistants and waiters to university professors and corporate executives.

Finally, the most important factor specifically concerning Luxembourg's national research system is its youth. Luxembourg's oldest public research centre is just celebrating its twentieth anniversary and its university was established by law only in 2003. Thus Luxembourg's relatively low GERD in the table following reflects the lack of a university for the majority of the years noted as well as its diminutive NRS, as described below. The decrease in GERD in 2004-2005 is mirrored to some extent in EU27 and eurozone declines; while it may reflect the Luxembourg budget deficit in 2004 and 2005, which returned to surplus in 2006, it can also be explained by declines in business R&D, or BERD, which is reported in Section 2.1.3.

Table 2: GERD as % of GDP: Luxembourg compared to EU27 and eurozone

Year	2000	2001	2002	2003	2004	2005	2006
Luxembourg	1.65	n.a.	n.a.	1.65	1.63	1.56	1.66
EU27 (est)	1.86	1.87	1.88	1.87	1.83	1.84	1.84
Eurozone (est)	1.84	1.86	1.87	1.87	1.85	1.85	1.86

Source: Eurostat³

² Source: CIA World Factbook. <https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html>. Note that through most of the 1990s and beyond, Luxembourg ranked first until displaced by Bermuda in 2006.

³ Source:
<http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=0&language=en&pcode=tsiir020>

Luxembourg's national research system is headed by the Ministry of the Economy and Foreign Trade (ECO) for the private sector and the Ministry of Culture, Higher Education and Research (MCESR) for the public sector. ECO's portfolio includes supporting private sector research, attracting innovative companies to establish themselves in the Grand Duchy and championing IP by supporting patent registration and sponsoring legislation to make IP revenues tax advantaged. A diagram of Luxembourg's research system is included on following page.

The MCESR is in charge of the University of Luxembourg, the four public research centres (Gabriel Lippmann, Henri Tudor, Santé⁴ and CEPS/INSTEAD), the National Research Fund (FNR) which provides funding for public sector research and the national funding programmes for undergraduate and graduate studies⁵.

Bridging the private and public sectors is Luxinnovation, the national agency for the promotion of research and innovation, whose work with both new and established companies includes identifying sources of funding and possibilities for public/private partnerships, organising sectoral clusters and assisting in FP6/FP7 and ESA participation.

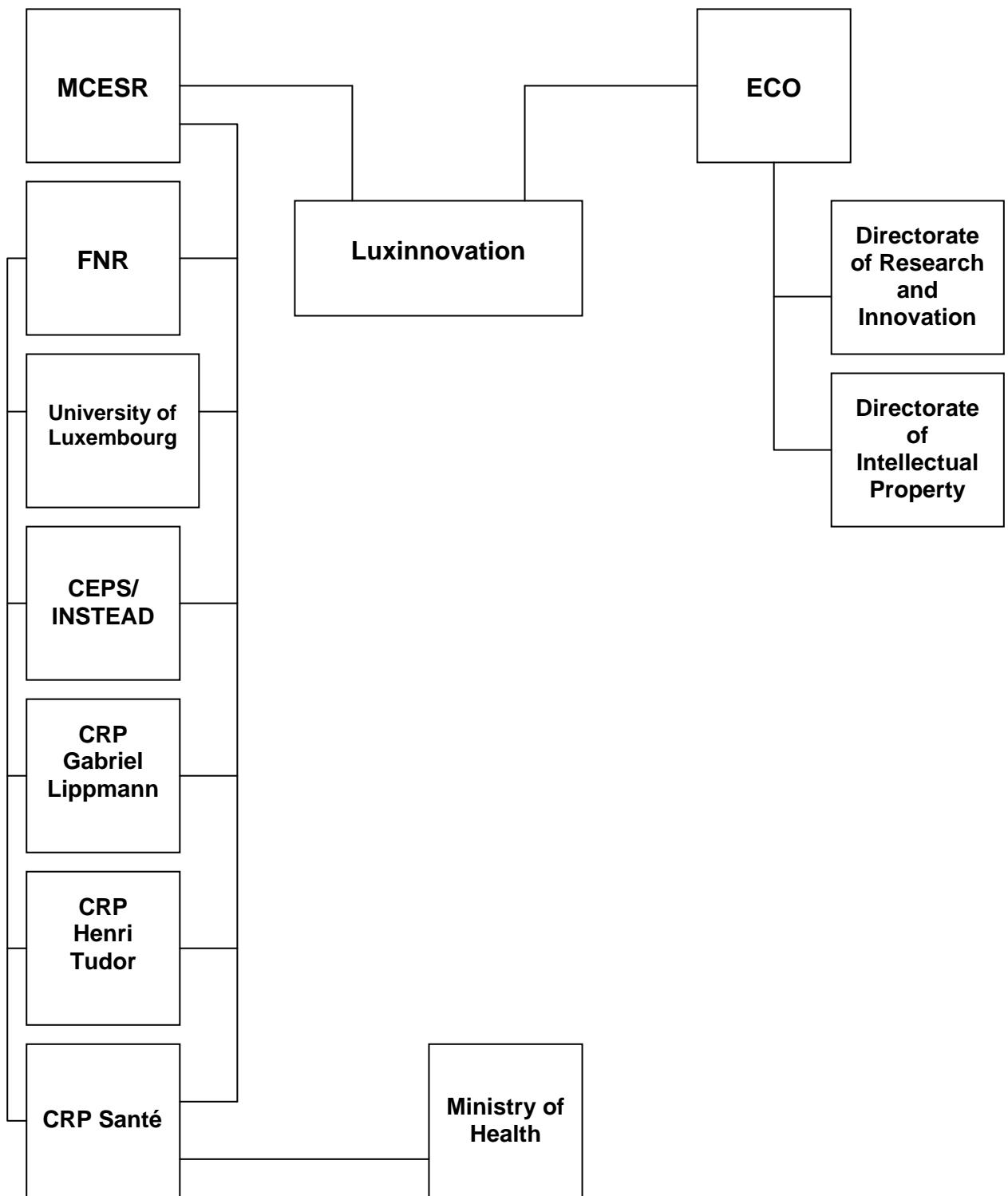
For the private sector there are business incubators supported by ECO and MCESR and funding opportunities for start ups.

Most recently, a Superior Committee for Research and Innovation (Comité Supérieur de la Recherche et de l'Innovation) was created (NRP 2007, ID 3). Its co-chairs are the Ministers of the Economy and Foreign Trade and of Culture, Higher Education and Research, assisted by other members of the government and the business and civil community. Its mandate is to develop a coherent national approach to research and innovation, with supporting policies, strategic objectives, targeted programmes and plans for implementing the preceding over the long-term.

⁴ CRP Santé is also overseen by the Ministry of Health.

⁵ The programme also includes post-doctoral researchers.

Figure 2: Luxembourg's National Research System



Source: Authors

2 - Resource mobilisation

The purpose of this chapter is to analyse and assess how challenges related to the provision of inputs for research activities are addressed by the national research system. Its actors have to ensure and justify that adequate financial and human resources are most appropriately mobilised for the operation of the system. A central issue in this domain is the long time horizon required until the effects of the mobilisation become visible. Increasing system performance in this domain is a focal point of the Lisbon Strategy, with the Barcelona EU overall objective of a R&D investment of 3% of GDP and an appropriate public/private split as orientation, but also highlighting the need for a sufficient supply of qualified researchers.

Four different challenges in the domain of resource mobilisation for research which need to be addressed appropriately by the research system can be distinguished:

- Justifying resource provision for research activities;
- Securing long term investment in research;
- Dealing with uncertain returns and other barriers to private R&D investment; and
- Providing qualified human resources.

2.1 Analysis of system characteristics

2.1.1 Justifying resource provision for research activities

Luxembourg's ability to successfully justify provision for research activities reflects several factors. First, Luxembourg enjoys a particularly stable political environment. Christian Democrat Jean Claude Juncker has been Prime Minister since 1995, serving through two successful coalition governments and currently enjoying an 85% approval rating. Decisions in the social-political arena are made through consensus building and involve all stakeholders. When the collapse of the steel industry left the economy devastated in the 1970's, Luxembourg reinvented itself as a financial centre, which now accounts for 11% of employment.⁶ Both government and citizens are aware of the need for additional diversification and view the NRS as one means of achieving this.

Second, Luxembourg has been a prime mover in the "European project" since its inception and was one of the six founding partners of the European Economic Community, now the EU. This allegiance is reflected in an overall commitment to the aims of the Lisbon agenda and the Barcelona objectives as evidenced in the Implementation Report 2007 for the National Plan for Innovation and Full Employment (NRP 2007) (Government of Luxembourg, 2007) and the National Plan for Innovation and Full Employment 2008. Luxembourg has as a stated goal committing 1% of GDP to R&D, depending on the state of the economy.⁷ The table below shows current progress (Government of Luxembourg, 2008).

⁶ For additional details refer to Section 5.1.3.

⁷ It is expected that the remaining 2% of the Barcelona R&D objectives will come from the private sector.

Table 3: Meeting the Barcelona Objectives: Budget credits allocated to R&D⁸

Year	2004	2005	2006	2007	2008	2009*	2010*
Amount	€72.0m	€94.5m	€113.6m	€142.0m	€175.0m	€215.0m	€250.0m
% GDP	0.27	0.32	0.36	0.42	0.48	0.54	0.58

*Foreseen

To ensure citizen support for its commitment to meeting the Barcelona objectives, the government has established a range of policies for raising public awareness of the Lisbon agenda. They include the organisation of three international conferences “En Route Vers Lisbonne” in 2004, 2006 and 2008, to provide a discussion forum for issues relating to achieving the Lisbon goals. In addition, the Observatoire de la Compétitivité,⁹ itself a response to the original Lisbon agenda and part of ECO, launched a web site to publicise information about the Lisbon strategy on both the national and European level. The government also backed a highly publicised OECD review of Luxembourg’s NRS in 2006 (OECD, 2007) and a Foresight Study of its National Research Fund (FNR) in 2007 (FNR, 2007). Both of these projects raised public consciousness of the importance the government places on the effective use of R&D resources and its commitment to R&D support.

Looking at Luxembourg in terms of GBAORD, Luxembourg ranked at a relatively low 0.31% in 2005, well below the EU27 average of 0.74%.¹⁰ It ranked somewhat higher in terms of GBAORD per inhabitant, at €208, compared to the EU27’s €166. Between 2000-2005, Luxembourg’s total GBAORD was €95m, with an AAGR of 27.5%, vs. an EU27 AAGR of 4.3%. However, it must be noted that the years quantified were before the launch of Luxembourg’s university and therefore only reflect R&D funding for the public research centres.

2.1.2 Securing long term investment in research

Luxembourg’s commitment to long-term investment in research is evidenced particularly in the multi-annual programmes of the FNR, most of which have lifespans from six to twelve years. Most recently, the FNR announced calls for the new CORE programme, which provides €22m of funding that runs through 2011-2012 for projects relating to thematic areas identified in the recent Foresight Study (FNR, 2007).

The longer-term view is also reflected in the government’s policy that commits it to funding the new university to a level of €72m by 2009 (NPR, 2007 ID 2). A related project is the “City of Science” in Belval Ouest. Its goal is to build a campus that combines the three university faculties¹¹ with the three CRPs and create a critical mass of researchers as well as competence centres. This is a massive project that is not expected to be fully completed for more than a decade.

⁸ Figures do not include expenditures like a recently committed €140m for health technologies research focussing on molecular medicine.

⁹ Refer to <http://www.odc.public.lu/>

¹⁰ Refer to http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-08-029/EN/KS-SF-08-029-EN.PDF

¹¹ The University’s faculties currently are based in three different locations.

In the private sector, ECO has launched an initiative to develop Luxembourg as a centre for logistics and a centre of excellence in supply chain management (NPR, 2007, ID 13) as well as a centre for biotechnology/medical devices (NPR, 2007 ID 12). R&D in logistics is already being undertaken by CRPHT. Both are ongoing projects.

In 2005, Luxembourg became a full member of the European Space Agency (ESA). This investment will realise returns only over the long-term as Luxinnovation leads efforts to establish an aerospace cluster and educates companies about opportunities to participate in ESA programmes.

Thus the reason Luxembourg's GERD lags behind other countries in the EU27 and eurozone is not due to a lack of commitment to investing in research or to fulfilling Lisbon goals. It reflects the economic dominance of the services sector and the youth and small size of its NRS.

2.1.3 Dealing with uncertain returns and other barriers to business R&D investment

In contrast to GERD, the contribution of business to R&D investment in Luxembourg exceeds the EU27's and the eurozone's and in fact represents the lion's share of R&D spending in Luxembourg. There are no data to indicate why BERD declined between 2004-2005,¹² there was also a drop in ECO R&D subsidies the same year, see Section 3.1.2. Thus it can only be observed that in 2006, BERD returned to its former, 2004 level.

Table 4: BERD: Luxembourg compared to EU27 and eurozone

Year	2003	2004	2005	2006
Luxembourg	1.47	1.43	1.35	1.43
EU27 (est)	1.19	1.16	1.15	1.18
Eurozone (est)	1.18	1.17	1.16	1.19

Source: Eurostat¹³

ECO oversees a programme of support for business R&D. Funding ranges from up to 75% for fundamental research to up to 50% for applied research, with additional amounts available to SMEs. In 2007, 32 projects were funded for €24.94m, representing a total R&D investment of €90.19m and the creation of 72 new jobs. The programme has no budgetary limits.

Venture capital in Luxembourg is scarce.¹⁴ There are several government financing schemes for SMEs which mainly take the form of loans or guarantees. The SNCI made seven "innovation loans" in 2007 for €1.57m (ECO 2007). The government also sponsors several business incubators which provide infrastructure and guidance to start-ups (NPR 2007 ID 6&7). These incubators include the Ecostart, which offers 4,000 square metres of space for innovative start-ups, and the Technoport. The

¹² GDP grew 4.88% in 2004 and 5.0% in 2005.

¹³ Refer to

http://epp.eurostat.ec.europa.eu/portal/page?pageid=1996_39140985&dad=portal&schema=PORTAL&product=REF_TB_research_development&root=theme0/t_research/tsc00001&zone=detail

¹⁴ Note that Luxembourg's biggest venture capital success story to date has been Mangrove's financing of Skype. See <http://www.mangrove-vc.com/>. However, Mangrove only finances Internet and software companies.

Technoport currently hosts 12 high-tech start ups and another 12 “success story” companies¹⁵ that form part of the Technoport’s Innovation Network. Together they provide employment for 235 and 15 internships for University students.

In addition, in 2007 the government passed legislation creating a more attractive tax environment for IP revenue. The new law provides for an exemption of 80% of the net income deriving from remuneration for the use or the licensing of the use of IP rights on software, patents, marks, trademarks, domain names, drawings or models. As one requirement for the exemption is that the IP right which generates the income must have been created or acquired by the taxpayer after 31 December 2007, the law supports new innovation. This means that in Luxembourg City, for example, IP-related incomes previously taxed at a 29,63% rate, are now taxed at an approximate 6% rate.

It has also adopted policies to promote a more entrepreneurial culture via an MS in Innovation Management and Entrepreneurship, the organisation of visits to start-ups and SMEs on “Open Door” days and the assisting in the creation of new companies by promoting tools such as the Business Plan Toolbox and 123Go (NPR, 2007 ID 46, 47 & 48).

Ironically, and perhaps typically, not one of the five companies listed under Luxembourg in the 2007 EU Industrial R&D Investment Scoreboard’s ranking of the top 1000 companies by member states actually conduct business or undertake R&D in Luxembourg.¹⁶ They are considered Luxembourg companies because they have established holding or investment companies here due to the Grand Duchy’s fiscal advantages. When examining the Scoreboard’s R&D ranking of the top 1000 non-EU companies, however, Delphi and Goodyear are listed, both of which have operations in Luxembourg that undertake substantial research activities and are beneficiaries of ECO’s research subsidies.¹⁷

2.1.4 Providing qualified human resources

Luxembourg has the same issues in terms of researchers as other countries in the developed world: it can use more and seeks to encourage increasing numbers of STI graduates. However, Luxembourg has a geographic advantage in that it can take advantage of human resources from neighbouring France, Belgium and Germany.¹⁸ In addition, Luxembourg has established several programmes to ensure the availability of qualified persons to undertake R&D.

LIASIT is a programme launched in 1999 that since 2006 has been based within the University’s Faculty of Science, Technology and Communication. Currently twelve visiting PhD students work on projects within six local companies under the supervision of university faculty. ATTRACT is an FNR programme that provides up to €1m for five years to young researchers to establish research teams at one of

¹⁵ Companies that have grown and moved out of the incubator into their own offices.

¹⁶ The companies are Basell AF SCS; now relocated to Rotterdam, Nycomed, based in Zurich, Tenaris, based in Houston, Oriflame Cosmetics, based in Sweden and Espirito Santo Financial, focused on Portugal with offices in London and New York. See http://iri.jrc.ec.europa.eu/research/docs/2007/1_2.pdf as well as the companies’ web sites.

¹⁷ Refer to http://iri.jrc.ec.europa.eu/research/docs/2007/1_5.xls. Note that the companies consider their R&D expenditures sensitive information and that ECO also does not specify the recipients of their subsidies aside from their sectors.

¹⁸ Refer to Section 1.2.

Luxembourg's CRPs. The programme BFR (Bourse Formation-Recherche) is being transferred from the MCESR to the FNR as AFR (Aides à la Formation-Recherche) as of October 2008. It provides research funding to PhD candidates and Postdocs in Luxembourg and abroad. There are no thematic limitations or restrictions as to nationality. In 2007, the BFR received 153 applications, made 129 awards and dispensed €6.3m in fellowships.

At the same time, requirements for issuing visas to researchers are being eased and work permits granted freely for citizens from the new EU members states, with the exception of Romania and Bulgaria (NRP 2007, ID 8 & 9). Finally, in 2006, the government launched a programme "Why Not a Researcher?" to interest younger students in careers in research.

2.2 Assessment of strengths and weaknesses

Luxembourg's main strengths and weaknesses in terms of resource mobilisation are summarized below.

Main strengths	Main weaknesses
<ul style="list-style-type: none"> Commitment to Europe and Lisbon agenda on national level Resilient economy with which to support RDI funding 	<ul style="list-style-type: none"> Relatively low level of GERD compared to EU 27 average

Luxembourg's main strength is a consensus concerning its commitment to the EU and the Lisbon agenda, as shown not only in the policies outlined in the National Plan for Innovation and Full Employment (NPR), but concretely in the table below that details the growing amount of the national budget committed to public research activities.

Table 5: Evolution of Luxembourg's Budget for Public Research

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
€millions	28.0	37.6	47.8	60.6	72.0	97.1	113.8	142.6	185.0	215.0

Source: MCESR

An equal strength is a budget recently returned to surplus and the subsequent ability to fund an effective NRS. Luxembourg's size and the youthfulness of its NRS are not considered weaknesses. It is expected that Luxembourg's GERD will increase as its NRS matures.

2.3 Analysis of recent policy changes

Challenges	Main policy changes
Justifying resource provision for research activities	<ul style="list-style-type: none"> Increased public RDI funding
Securing long term investments in research	<ul style="list-style-type: none"> Increased university funding Development of logistics/supply chain management and biotechnology/medical devices sectors
Dealing with uncertain returns and other barriers to business R&D investments	<ul style="list-style-type: none"> Establishment of business incubators Change in IP taxation Promotion of an entrepreneurial culture

Providing qualified human resources	<ul style="list-style-type: none"> Launch of ATTRACT programme Opening visas to researchers from new member states and easing requirements for other researchers Shifting oversight of PhD/Postdoc research funding from MCESR to FNR
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Many of the most significant policy changes affecting resource mobilisation, such as the decision to establish a university, occurred before the time period under consideration. Of the policies highlighted in NRP 2007, the decision to develop logistics/supply chain management and biotech/medical device sectors are perhaps the most significant. It supports Luxembourg's approach of niche business development and the recognition of the economy's overdependence on the financial services sector. The new legislation concerning IP taxation makes Luxembourg more attractive to innovative businesses as do policies supporting the mobility of researchers.

2.4 Assessment of policy opportunities and risks

Main policy opportunities	Main policy-related risks
<ul style="list-style-type: none"> "Late adopter" advantage of youthful NRS can speed learning curve Resources and political will to properly fund NRS and meet Lisbon goals. 	<ul style="list-style-type: none"> Narrow sector focus may result in missing other opportunities Promoting researcher mobility can mean brain drain as well as brain gain.

Luxembourg can take advantage of lessons learned by other nations in developing its NRS and speed its "learning curve". It also has the luxury of being able to properly fund an NRS in development. While Luxembourg may be wise in specifically targeting its research and new business development efforts, there is also the risk that unanticipated opportunities could be missed.

2.5 Summary of the role of the ERA dimension

Luxembourg has addressed the ERA dimension in resource mobilisation by policies such as the ATTRACT programme, LIASIT, and its ESA membership. It is easing visa requirements to facilitate the mobility of researchers. In 2007, Luxembourg was participating in ten EUREKA projects and its CRPs active in many European projects. For example, in 2007, CRPHT was active in 53 European projects, representing 36% of its work. They included participations in FP6, ESA, Eureka, ITEA, Leonardo, ERDF Interreg and Objective 2, ESF Objective 3. CRPGL is a member of the Nanobeams Network of Excellence, established under FP6 and run out of the University of Luxembourg, which involves 80 researchers as well as 40 PhD students. It has a budget of €5m for integration and €25m for research covering a period of 4 years. Luxembourg also currently has underway seven FP7 projects, mostly in ICT, totalling €4.7m with EU contributions totalling nearly €3m.

3 - Knowledge demand

The purpose of this chapter is to analyse and assess how research related knowledge demand contributes to the performance of the national research system. It is concerned with the mechanisms to determine the most appropriate use of and targets for resource inputs.

The setting and implementation of priorities can lead to co-ordination problems. Monitoring processes identifying the extent to which demand requirements are met are necessary but difficult to effectively implement due to the characteristics of knowledge outputs. Main challenges in this domain are therefore:

- Identifying the drivers of knowledge demand;
- Co-ordinating and channelling knowledge demands; and
- Monitoring demand fulfilment

Responses to these challenges are of key importance for the more effective and efficient public expenditure on R&D targeted in IG7 of the Lisbon Strategy.

3.1 Analysis of system characteristics

3.1.1 Identifying the drivers of knowledge demand

Due to its small size, Luxembourg has a policy of concentrating on specific knowledge sectors rather than trying to be “all things to all men”. The University has defined seven areas of concentration that include IT security, life sciences and materials science. The CRPs also specialise in specific areas although there are also duplications of pursuits.

Reviewing the relative contributions of BERD, HERD and GOVERD provide another indication of the relative sources of knowledge demand.

Table 6: Relative Contributions to Knowledge Demand (%)

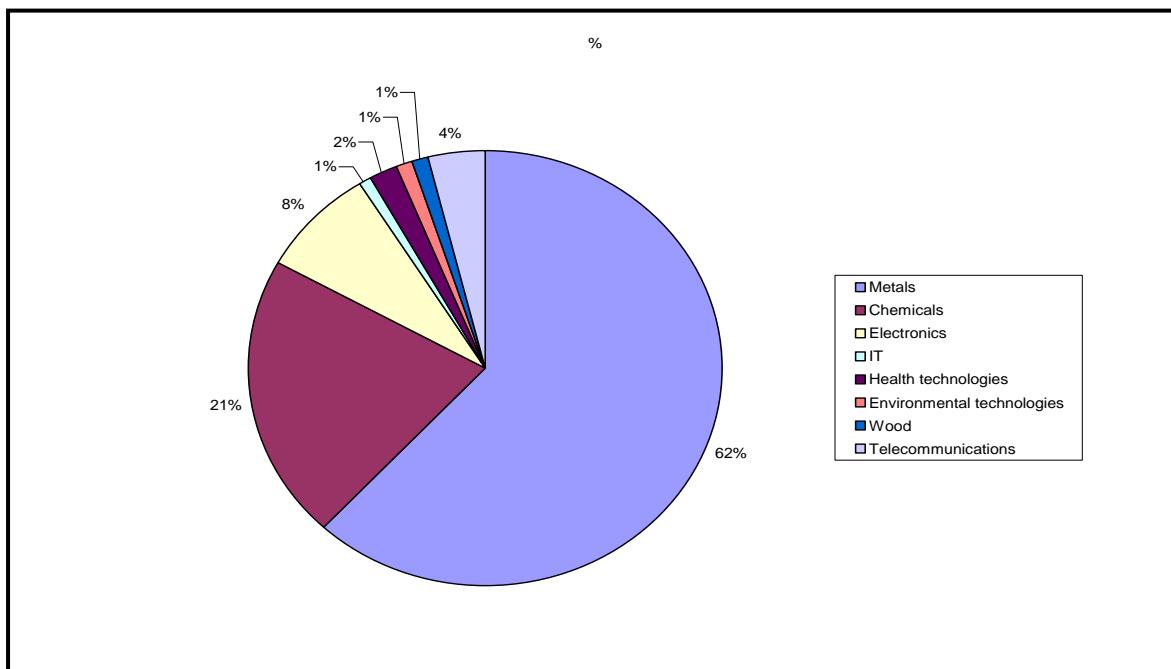
Year	BERD			GOVERD			HERD		
	2004	2005	2006	2004	2005	2006	2004	2005	2006
EU27	63.67	63.38	62.71	13.35	13.62	13.40	22.11	22.04	21.77
Lux.	87.78	86.24	84.90	10.99	12.23	12.60	1.23	1.53	2.40

Source: Eurostat

It is apparent from the table above that business is the primary knowledge driver in Luxembourg and that not having a university conducting fundamental research until recently is the reason for the low HERD contribution.

Another way to consider knowledge demand is to examine the sectoral representation of the companies that have benefited from the ECO's programme of R&D support. The chart below indicates the sectors that generated the most demand.

Figure 3: Sectoral allocation of companies participating in the ECO programme



Source: ECO

In 2007, the FNR undertook a Foresight Study¹⁹ to determine future national research priorities for the public sector. Participants included private sector representatives and international experts as well as NRS personnel. The research themes identified included IT security, high performance telecommunications networks, water resource management, intelligent materials and surfaces, regenerative medicine in age-related diseases and translational biomedical research.

Another identification mechanism lies in Luxinnovation's organisation of cluster groupings. Clusters currently include AeroSpace, InfoCom (ITC), SurfMat (surface treatments and new materials) and, most recently, BioHealth.

3.1.2 Co-ordinating and channelling knowledge demands

In the public domain, the specificity of the FNR programmes and their award review process effectively co-ordinate and channel knowledge demands. As mentioned above, the FNR Foresight Study involved private as well as public sector stakeholders in identifying demand vectors and resulted in the thematic areas of the new CORE programme.²⁰ FP7 themes are also a factor. In the private sector, ECO has targeted sectors it deems desirable to develop, (e.g. logistics and medical devices). Its R&D support programme is available for developing new opportunities; in fact the applicant is required to identify elements of risk to qualify for funding.

¹⁹ <http://www.fnrforesight.lu/>

²⁰ The new CORE programme's thematic areas are: Business service design; Development and performance of the financial systems; Information security and trust management; High performance telecommunication networks; Sustainable management of water resources; Sustainable uses and sources of energy; New functional and intelligent materials and surfaces; Regenerative medicine in age-related diseases; Translational biomedical research; Challenges for the educational system, labour market, social protection including territorial aspects; Identities, diversity and integration.

Finally, the new Superior Committee for Research and Innovation (Comité Supérieur de la Recherche et de l'Innovation), co-chaired by the Ministers of the Economy and Foreign Trade and of Culture, Higher Education and Research and assisted by other members of the government, was established to provide an additional co-ordinating function. Composed of representatives from the business and research communities as well as government, the committee is intended to define national research priorities and identify the means needed to meet research goals.

Table 7: Total GBAORD (€per inhabitant)²¹

Year	2005	2006	2007
EU27	2.8 (est)	2.8 (est)	n.a.
Luxembourg	0.9	1.1	1.5 (provisional)

Source: Eurostat

In the table above, Luxembourg typically lags the EU27 average although it should be noted that the figure is growing. Analyzing Luxembourg's GBOARD in terms of NABS socio-economic objectives, leading GBOARD expenditures are in the areas of industrial production and technology, social structures and relationships, research financed from GUF and non-oriented research. It should be noted that Luxembourg does not undertake defence research.

3.1.3 Monitoring demand fulfilment

One indicator of demand fulfilment is the steady growth of ECO's R&D funding programme, as shown in the table below.

Table 8: Evolution of ECO R&D Funding Programme

Year	No. Projects	R&D Investment in €m	Financing Awarded in €m
2000	13	21.36	6.17
2001	12	20.28	5.5
2002	15	74.26	20.74
2003	17	27.26	5.68
2004	17	55.85	17.46
2005	18	48.53	12.00
2006	23	88.93	26.93
2007	32	90.19	24.94

Source: ECO, 2007

In addition, as a result of the OECD review of Luxembourg's NRS (OECD, 2007), the CRPs and FNR have signed Performance Contracts for the next three years committing them to certain standards and reporting requirements.

There are few formal mechanisms for private sector input on public sector research foci, the recent FNR Foresight Study and the new Superior Committee for Research and Innovation notwithstanding. However, the success or lack thereof of the policy for promoting PPPs, which was also a recommendation of the OECD review (OECD, 2007), will indicate whether the CRPs and the University are an interesting resource

²¹ Note that when data were expressed as % of GDP results were too small to be meaningful, i.e., <0.1%.

for the private sector. Certainly the work done by the researchers in the LIASIT programme is private-sector driven (see Section 2.1.4).

3.2 Assessment of strengths and weaknesses

Luxembourg's main strengths and weaknesses in knowledge demand are summarised below.

Main strengths	Main weaknesses
<ul style="list-style-type: none"> Business main knowledge demand driver, ensuring commercial foundation of R&D. Thematic focus of R&D programmes prevents dissipation of resources 	<ul style="list-style-type: none"> ECO's R&D funding is more than 90% industrial, although the services sector accounts for 83% of GDP.

The fact that the major portion of Luxembourg's research expenditures come from business means that the eventual commercialisation of R&D efforts is an important factor. The FNR's research themes also take account of private sector specialisations. Given Luxembourg's small size, the decision to concentrate resources on specific research targets is a good one. However, it should be noted that while the new FNR programmes purposefully include some issues relating to the dominant services sector, ECO research support is overwhelmingly distributed to industrial actors, as shown in the chart in Section 3.1.1 above. This imbalance is identified as a weakness.

3.3 Analysis of recent policy changes

Challenges	Main policy changes
Identifying the drivers of knowledge demand	<ul style="list-style-type: none"> Determining new FNR programme themes as result of Foresight Study results
Co-ordinating and channelling knowledge demands	<ul style="list-style-type: none"> Formation of the Superior Committee for Research and Innovation
Monitoring demand fulfilment	<ul style="list-style-type: none"> Signing of Performance Contracts with CRPs and FNR

The Foresight Study brought together main NRS stakeholders to discuss the direction of new FNR programme themes. While several of the themes build on research from previous programmes, some of the new themes, such as sustainability, reflect emerging concerns, while others acknowledge the importance of the services sector in Luxembourg's economy.

Initiating performance contracts with the CRPs and FNR was a main recommendation of the OECD review of Luxembourg's NRS. The contracts have now been signed and will provide a mechanism for judging how well the NRS is meeting research demand.

3.4 Assessment of policy opportunities and risks

Main policy opportunities	Main policy-related risks
<ul style="list-style-type: none"> Improving governance and accountability with Performance Contracts Launching new research programmes 	<ul style="list-style-type: none"> Maintaining status quo with Performance Contracts that set the bar too low. FNR focus on defined themes means

based on Foresight Study results.	business still main source of R&D funding of leading edge innovation
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The signing of Performance Contracts represents a significant step in establishing a culture of good governance and accountability in Luxembourg's NRS. A possible limitation is that the contracts are somewhat general and support "business-as-usual," while requiring increased resources devoted to administration.

The new FNR research programme themes represent both an opportunity and a risk. The opportunity is to develop/continue to develop centres of excellence which have social and economic significance for Luxembourg. The risk is that the focus of the programme themes is inward rather than outward. It limits flexibility in reacting to unforeseen new developments, which is left to the private sector.

3.5 Summary of the role of the ERA dimension

Although not specifically reflected in policy evolution, knowledge demand as presented in FP7 thematic priorities and ESA programmes is used in identifying R&D areas of concentration and suggesting projects. Cross border participation in all FNR programmes is also encouraged although funding is limited to Luxembourg entities.

4 - Knowledge production

The purpose of this chapter is to analyse and assess how the research system fulfils its fundamental role to create and develop excellent and useful scientific and technological knowledge. A response to knowledge demand has to balance two main generic challenges:

- On the one hand, ensuring knowledge quality and excellence is the basis for scientific and technological advance. It requires considerable prior knowledge accumulation and specialisation as well as openness to new scientific opportunities which often emerge at the frontiers of scientific disciplines. Quality assurance processes are here mainly the task of scientific actors due to the expertise required, but subject to corresponding institutional rigidities.
- On the other hand there is a high interest in producing new knowledge which is useful for economic and other problem solving purposes. Spillovers which are non-appropriable for economic knowledge producers as well as the lack of possibilities and incentives for scientific actors to link to societal demands lead to a corresponding exploitability challenge.

Both challenges are addressed in the research-related Integrated Guideline and in the ERA green paper.

4.1 Analysis of system characteristics

4.1.1 Improving quality and excellence of knowledge production

Luxembourg's public sector knowledge producers are the University and the three CRPs, plus CEPS/INSTEAD.²² In 2006, Luxembourg arranged an OECD review of its national research system (OECD; 2007). The results were largely favourable but identified as issues the need for greater harmonisation among knowledge producers and the need for better governance and accountability. The first issue refers to overlaps in research areas between the actors²³ and significant efficiencies that could be achieved by sharing administrative functions. The second issue is being addressed by instituting performance contracts for each institution, as well as the FNR and Luxinnovation. Lack of governance and accountability was also previously identified in a TrendChart study by Luxinnovation on "Overall appraisal of tools for policy making and evaluation" in which Luxembourg rated poorly or very poorly on most criteria.²⁴ Especially targeted was a lack of transparency.

Many projects undertaken result in publication or conference presentations, as evidenced by the FNR's Accompanying Measures that support researcher participation in conferences, the organisation of conferences in Luxembourg and the publication of research, including PhD theses.²⁵

Luxembourg's public research sector is suboptimal for exploring new scientific opportunities for several reasons. Luxembourg is typically an economic niche player. It has achieved significant success in identifying specific opportunities to exploit such as medical devices in the area of biotechnology and fund administration in the area of financial services. Its funding programmes are highly thematic and tend to leverage existing expertise. The work of researchers in the CRPs is closely tied to specific project funding which allows limited room for exploration. Even the ATTRACT programme²⁶ requires the applicant research team partner with one of the CRPs or University and submit a joint project proposal that results in mid-term integration into the institution. While certainly expanding the Grand Duchy's research resources, this approach supports building on existing capabilities rather than developing brand new competencies. The University also has identified specific areas of focus which by definition means others are excluded.

A recent initiative to avoid missing opportunities is the newly formed Superior Committee for Research and Innovation described in Section 3.1.2 above. With a mission to guide R&D in Luxembourg, it has only been in existence since July 2008 and therefore its effectiveness cannot at this time be evaluated.

²² CEPS/INSTEAD, Centre d'Etudes de Populations, de Pauvreté et de Politiques Socio-Economiques/International Network for Studies in Technology, Environment, Alternatives, Development, provides resources for international researchers in economics and social sciences.

²³ For example, CRPHT and CRPGL both do work in IT and materials science.

²⁴ See http://www.proinno-europe.eu/docs/reports/documents/Country_Report_Luxembourg_2007.pdf

²⁵ For example, an FNR project selected at random, "Modelecotox - Development Of A Predictive Model Of Fauna And Flora To Evaluate The Ecological Status Of Luxembourg's Rivers: Impact Of Pollutants And Toxic Compounds On Aquatic Communities" which was funded between 2002-2005 for €750,000 resulted in the publication of nine papers, see http://www.fnr.lu/multi-Annual_Programmes/Eau_Programme/

²⁶ Refer to Section 2.1.4.

This having been noted, however, the private sector is well supported in exploring new scientific horizons by programmes that include ECO's R&D funding and the business incubator network. In addition, Luxinnovation provides expert support in applying for FP7-, EUREKA- and ESA-related project funding. An example of a current pioneering ESA project is the Solar Sails Materials (SSM) initiative, awarded to a consortium led by LuxSpace Space Systems.

In addition, ILEA, an association of Luxembourgish automotive suppliers, was recently established. It brings together twenty-two Luxembourg companies which specialise in the design and production of automotive components. Delphi alone, whose Global Powertrain and Thermal Divisions are located in the Grand Duchy, has 750 employees, two thirds of whom have engineering skills and 60 of whom are high level researchers. Goodyear, another research-intensive ILEA member, has 900 employees involved in R&D projects. ELTH, which develops automotive temperature control devices, uses 40 researchers, while smaller companies such as EmTroniX and Raval Europe are also research oriented.

4.1.2 Improving exploitability of knowledge production

To improve exploitability of knowledge production, the FNR undertook a Foresight Study in 2006-2007. Participants included not only representatives from the NRS but also social and economic stakeholders and international experts (FNR, 2007). The conclusions of their deliberations resulted in the new CORE programme. The current call for proposals offers €22m of funding for projects of 2-3 years duration.

In addition, in response to one of the recommendations of the OECD review, greater stress has been placed on developing public/private partnerships, or PPP (OECD, 2007). To promote PPP, Luxinnovation organised a "Business Meets Research" Forum in 2007 to allow the public institutions to showcase their capabilities to the private sector and to provide "matchmaking" services for specific projects. A second "Business Meets Research" day took place in October.²⁷

Also in 2007, attractive tax treatment for IP was legislated which, as previously noted, provides an 80% exemption on IP-related income. Efforts have been made to promote awareness of IP including a national IP Day in April. Courses in Innovation Management are also offered through a Masters of Science programme in Entrepreneurship and Innovation Management (NPR ID 10) and in Sacred Heart University Luxembourg's MBA programme.

4.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of Luxembourg's knowledge production are summarized in the table below.

Main strengths	Main weaknesses
<ul style="list-style-type: none"> • Quality of knowledge production • NRS focus on defined themes 	<ul style="list-style-type: none"> • Governance and accountability • Limited public/private collaboration • NRS focus on defined themes

While the OECD review of Luxembourg's NRS made several recommendations about areas that needed improvement, it gave high ratings to the quality of

²⁷ Refer to <http://www.luxinnovation.lu/site/content/EN/400/C5294/>

knowledge production in the niches served by Luxembourg's research institutions. This quality is reflected in the number of publications and conference presentations that are cited on the web sites of the FNR, the CRPs and the University.

In terms of governance and accountability, however, both the OECD and a previous TrendChart report gave the NRS low marks. Signing performance contracts are a first step in remedying this weak point.

Finally, as identified in Section 3, the focus on defined themes is assessed as being both a strength and a weakness. It is a strength because resources can be focused on developing a few specific, internationally recognized centres of excellence. It can also be a limitation because it restricts the NRS' ability to react quickly to new developments in RDI.

4.3 Analysis of recent policy changes

Challenges	Main policy changes
Improving quality and excellence of knowledge production	Launch of ATTRACT programme
Ensuring exploitability of knowledge production	<ul style="list-style-type: none"> • Foresight Study • Public/Private partnership initiatives • IP initiatives • MS in Entrepreneurship and Innovation

The purpose of the ATTRACT programme is to draw outstanding young researchers and their teams to pursue research in Luxembourg institutions. It foresees a five year period for a project carried out in conjunction with the University or one of the CRPs.

A range of new policies have been put in place to ensure the exploitability of the knowledge produced by Luxembourg's NRS. The Foresight Study gathered input from Luxembourg socio-economic actors as well as the research community in determining research priorities while promoting the public/private partnership model also encourages exploitability.

The government has also undertaken several initiatives to raise awareness of IP and entrepreneurship as a means of exploiting IP. Luxembourg's culture is not inclined to entrepreneurship—a high proportion of Luxembourgers are civil servants—so training courses, promotional events, and support systems have been organised to encourage more start-ups.

4.4 Assessment of policy opportunities and risks

Policies implemented to promote increased quality and exploitation of demand offer both opportunities and risks as summarised below.

Main policy opportunities	Main policy-related risks
<ul style="list-style-type: none"> • Greater collaboration and knowledge transfer between public and private sector research efforts • Better identification and exploitation of IP 	<ul style="list-style-type: none"> • Competition between CRPs and SMEs • Encouraging entrepreneurship while lagging in the development of an entrepreneurial culture.

While public/private partnerships greatly increase the possibility that knowledge produced will be commercially exploited, at the same time PPPs can put CRPs in

competition with private companies which could undertake similar development work. This is particularly true in ICT.

Many start-ups and SMEs neither properly identify nor take steps to protect their intellectual property. Raising awareness of IP and related issues is an important aspect of exploiting knowledge as well as supporting entrepreneurship. On the other hand, the risk exists that policies that encourage entrepreneurship can fail to address greater cultural biases. A high proportion of start-ups fail. While bankruptcy is considered a rite of passage in a culture of "serial entrepreneurship" such as prevails in the US, in Luxembourg bankruptcy carries legal penalties as well as a social stigma.

4.5 Summary of the role of the ERA dimension

Like the workforce overall, Luxembourg's research community is diversely European. While this may not be surprising given the new University's need to build up faculty, the CRPs are also multinational. Francophone CRPHT, for instance, draws a majority of its personnel from France and Belgium. The FNR ATTRACT programme is specifically aimed at bringing outside researchers and their teams to Luxembourg.

CEPS/INSTEAD produces knowledge in the form of social and economic micro data that is made available through the IRISS visitors' programme. Expenses of visiting EU researchers from 2006-2009 are covered under FP6. The research centre also sponsors the Impalla programme for advanced training in both quantitative and qualitative research methodologies using its extensive data resources. A Masters degree is awarded to participants jointly with the University of Leuven (K.U.Leuven, Belgium). Luxembourg had five proposals selected by ERA-NET, representing 0.6% of participants, all of which were public entities.

5 - Knowledge circulation

The purpose of this chapter is to analyse and assess how the research system ensures appropriate flows and sharing of the knowledge produced. This is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production. Knowledge circulation is expected to happen naturally to some extent, due to the mobility of knowledge holders, e.g. university graduates who continue working in industry, and the comparatively low cost of the reproduction of knowledge once it is codified. However, there remain three challenges related to specific barriers to this circulation which need to be addressed by the research system in this domain:

- Facilitating knowledge circulation between university, PRO and business sectors to overcome institutional barriers;
- Profiting from access to international knowledge by reducing barriers and increasing openness; and
- Enhancing absorptive capacity of knowledge users to mediate limited firm expertise and learning capabilities.

Effective knowledge sharing is one of the main axes of the ERA green paper and significant elements of IGL 7 relate to knowledge circulation. To be effectively

addressed, these require a good knowledge of the system responses to these challenges.

5.1 Analysis of system characteristics

5.1.1 Facilitating knowledge circulation between university, PRO and business sectors

Realising the OECD's recommendation to increase harmonisation between the three CRPs and the University will facilitate knowledge circulation among public sector actors, as will their sharing facilities at the City of Science; further promotion of public/private partnerships will also enhance knowledge circulation between the public and private sectors. In terms of public-private knowledge sharing, in 2007, CRPHT organised 145 trainings for 1,450 participants for a total of 196 training days. In addition, more than 3,000 people attended conferences and other events organised by the CRP. LIASIT is another initiative that puts PhD candidates at the disposal of the business community. Finally the business incubator Technoport is operated under the auspices of CRPHT and has hosted spin offs from its parent CRP. A spin-off from the University is AxoGlia, which has discovered a molecule which can potentially treat central nervous system diseases such as Alzheimer's and multiple sclerosis.

5.1.2 Profiting from access to international knowledge

The CRPs and University all engage in activities that increase access to international knowledge. For example, CRPHT is a member of the European Business Innovation Centre Network, the European Space Incubator Network, the European Association of Research and Technology Organisations (EARTO) the European Research Consortium in Informatics and Mathematics (ERCIM) and participates in the European Cooperation in the field of Scientific and Technical Research (COST).

The FNR's INTER programme, which runs until 2014 and has a budget of €17.7 million, funds Luxembourg participation in international projects. One grant, in partnership with the US National Science Foundation, fostered a transatlantic alliance between CRPGL and the University of Texas at Austin to form The Materials World Network, which works on the thin films used in nanotechnology applications. In addition, FNR "Accompanying Measures" fund researchers' attending conferences and training abroad.

Luxembourg also participates in ERA-NET projects, as well as collaborations with Belgian, Slovenian, Finnish, Icelandic, Polish and French research institutions. Luxinnovation promotes private sector international knowledge transfer through its Portal for Innovation and Research.²⁸

The role of FDI in Luxembourg is difficult to ascertain because of the role of holding companies.²⁹ In 2003 Luxembourg was the world's largest recipient of FDI, equivalent to 349.96% of GDP. According to the World Bank, Luxembourg's FDI in 2006 was \$126.459b, again more than 3 times GDP. However, even though these figures need to be interpreted with caution, some of the leading private sector

²⁸ See <http://www.luxinnovation.lu/servlet/front>

²⁹ See comments on the accuracy of the EU Industrial R&D Investment Scoreboard in Section 2.1.3.

research companies in Luxembourg, such as Delphi and Goodyear, are subsidiaries of foreign companies and take advantage of ECO's R&D research funding programme. An example of a new company resulting from FDI is Raval Europe, a subsidiary of an Israeli company specialising in plastic parts for the automotive industry.

5.1.3 Absorptive capacity of knowledge users

Although Arcelor-Mittal, the world's largest steel producer, accounts for 11% of Luxembourg's economy, the remaining portion is dominated by the services sector, which comprises 83.3% of GDP and employs 78% of the workforce. The financial services sector provides 11% of employment, which makes it equal to the industrial workforce, and which does not take into account companies providing services such as ICT to that sector.³⁰ However, while the financial services sector may be innovative as per the Oslo Manual (OECD; 2005), it generally does not require STI postdocs. A new FNR programme theme, development and performance of the financial systems, does target the financial sector. In addition, the University's Faculty of Law, Economics and Finance established a Centre of Research in Finance in 2006 which now has nine Post-doc and PhD students undertaking research on topics ranging from quantitative and behavioural finance to financial risk management.

That having been noted, more SME engagement in R&D is being encouraged through PPPs and participation in the ECO's R&D funding programme. Of the 32 projects provided with funding in 2007, nine involved SMEs and four of those were start-ups. The Luxinnovation cluster network also has as one of its purposes promoting R&D among SMEs.

In terms of ensuring a qualified labour force, policies supporting the mobility of researchers, especially from the new member states, have already been noted (NRP 2007 ID 8 & 9), as well as the FBR/AFR programme of support for PhD and Post-doc researchers.³¹

5.2 Assessment of strengths and weaknesses

The strengths and weaknesses of Luxembourg's knowledge circulation system are reviewed in the table below.

Main strengths	Main weaknesses
<ul style="list-style-type: none"> • Presence of leading international research companies • Programmes promoting international knowledge circulation such as INTER, ATTACT and LIASIT • Participation of NRS actors in international knowledge sharing 	<ul style="list-style-type: none"> • Serious promotion of private/public partnerships only recently undertaken • Dominance of services sector in economy vs. dominance of industrial sector in research programmes

A good general indication of the strength of knowledge circulation between Luxembourg's public and private sectors is the amount of training provided by

³⁰ It should also be noted that minus the financial services sector, 73% of GDP comes from other services companies including transportation and logistics, HORECA, communications and retail trade.

³¹ See section 2.1.4.

CRPHT's SITEC division. In the private sector, Luxembourg is home to the subsidiaries of two leading international research companies, Delphi and Goodyear, which operate research facilities in the Grand Duchy, while Luxembourg companies Arcelor-Mittal and IEE conduct research with its own international reach.

The main weakness of Luxembourg's research knowledge circulation, as mentioned previously, is the focus on industrial research to the neglect of the dominant services sector. This focus presents natural limits to absorptive capacity, even though the new CORE programme begins to redress this imbalance.

5.3 Analysis of recent policy changes

Challenges	Main policy changes
Facilitating knowledge circulation between university, PRO and business sectors	<ul style="list-style-type: none"> • Promotion of public/private partnerships • Sponsorship of business incubators
Profiting from access to international knowledge	<ul style="list-style-type: none"> • Launch of ATTRACT programme • Year-abroad requirements for University students
Absorptive capacity of knowledge users	<ul style="list-style-type: none"> • Attracting researchers through easing visa requirements • Active promotion of PPP

Luxembourg's main initiative in supporting knowledge circulation is encouraging public-private partnerships. While such partnerships have been ongoing between business and the CRPs for many years, the current promotion of PPP represents a much more active strategy. It is too recent to assess the results.

The sponsorship of business incubators is a proven way of circulating knowledge in the form of spin-offs. Providing infrastructure and guidance increases the chances for the success of start-ups.

Luxembourg has a long tradition of profiting from international knowledge, a major facet of which has been, until recently, the necessity for students to attend foreign universities, where they form enduring relationships. Many students still study abroad and the University has implemented a policy that requires each student to spend a year studying in another university. The ATTRACT programme is a new effort to bring innovative knowledge resources to the Grand Duchy.

With the University of Luxembourg launched so recently, the Grand Duchy has largely lacked any native pool of research talent. Luxembourg researchers doing fundamental work either worked abroad or left research to assume administrative positions. Policies to enhance capacity by expanding human resources focus on easing visa requirements and allowing greater researcher mobility, especially from the eight new member states.

5.4 Assessment of policy opportunities and risks

Main policy opportunities	Main policy-related risks
<ul style="list-style-type: none"> • Development of programmes that make PPP attractive to SMEs 	<ul style="list-style-type: none"> • Numerically dominant foreign researchers circulate out of Luxembourg, along with their knowledge

A large proportion of researchers in Luxembourg are foreign. They are also present in Luxembourg on the basis of contracts that are limited to the life of the research project in which they are participating. The risk is that when the researcher leaves,

much of the knowledge leaves with him or her rather than circulates. This creates a brain drain in reverse.

5.5 Summary of the role of the ERA dimension

Because of its small size and the natural limit that imposes on knowledge circulation, Luxembourg relies heavily on its European ties for both knowledge inflows and knowledge outflows. An example is a typical project of CRPGL to develop a “plate-forme en protéomique”, which involved partners in Belgium, France, Austria, Norway and Portugal. Similarly CRP Santé’s project on the plant actin cytoskeleton included collaborators from France, Belgium, Germany and Israel.

6 - Overall assessment and conclusions

6.1 Strengths and weaknesses of research system and governance

The strengths and weaknesses of Luxembourg's NRS can be summarized in the table below.

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Luxembourg's GERD is low relative to the EU27; national commitment to Europe and the Lisbon agenda as well as a robust economy make raising that level a policy priority.
	Securing long term investment in research	Luxembourg's inaugurating a national university and constructing a "City of Science" reflect the government's long-term perspective. Targeting the logistics and medical device sectors as new niches for development indicate long-term goals for the private sector.
	Dealing with barriers to private R&D investment	While access to equity venture capital is limited in Luxembourg, the government has launched several initiatives to promote spin-offs and start-ups including creating business incubators and promoting entrepreneurship. Raising awareness of IP and a favourable fiscal environment for IP revenue increases Luxembourg's attractiveness for both new and established companies.
	Providing qualified human resources	Visa restrictions are being eased to support researcher mobility. A dependence on ex-national researchers can result in a brain drain rather than a brain gain if researchers return home.
Knowledge demand	Identifying the drivers of knowledge demand	The Foresight Study was a major initiative undertaken to identify up-to-date demand drivers involving all NRS stakeholders. Clusters also provide driver input. The focus on industrial to the neglect of service sector needs remains a weakness.
	Co-ordination and channelling knowledge demands	The specificity of FNR programmes are a system strength, while attention to European programmes such as FP7 also channel efforts. However, such a targeted focus can also mean missed opportunities.
	Monitoring of demand fulfilment	Tracking the growth of the ECO R&D funding programme indicates private sector demand fulfilment. Instituting a Performance Contract culture within the public participants of the NRS will help overcome weaknesses in governance and accountability.
Knowledge production	Ensuring quality and excellence of knowledge production	The quality of Luxembourg's knowledge production is a significant strength. Its targeted approach to research is both a strength and a weakness as it prevents dissipation of resources while limiting exploration of new opportunities.
	Ensuring exploitability of knowledge	Initiatives to actively develop public/private partnerships will enhance knowledge exploitation. Increased attention to IP will also support exploitation.
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	Greater harmonisation between the University and the CRPs is needed and will improve knowledge circulation. The presence of leading international research companies is a strength that will be further leveraged by the initiative to actively promote PPPs.
	Profiting from international knowledge	FNR programmes like INTER and the Accompanying Measures encourage the international participation of Luxembourg researchers, while ATTRACT brings in international expertise.
	Enhancing absorptive capacity of knowledge users	Absorptive capacity could be strengthened by increasing the participation of the dominant services sector and SMEs in public/private partnerships, as industrial sector currently dominates.

Overall, Luxembourg's policies are well co-ordinated. This in large part reflects Luxembourg's commitment to the Lisbon Agenda and genuine efforts on the

government's part to formulate policies to realise the Lisbon objectives. The OECD review, the Foresight Study and the concerted follow up to the recommendations of both indicate Luxembourg's determination to meet the challenges relating to its NRS.

Luxembourg's size is a strength rather than a limitation in this context as it means coherent policies are possible. The Superior Committee for Research and Innovation established last year will further ensure policy coherence and increase co-ordination between the private and public sectors.

Achieving greater harmonisation between the CRPs and the University will resolve issues relating to co-ordination and coherence³². This was one of the OECD recommendations and efforts in this regard are underway.

6.2 Policy dynamics, opportunities and risks from the perspective of the Lisbon agenda

Policy-related opportunities and risks as they pertain to the Lisbon agenda are highlighted below. To tangibly demonstrate its support of Lisbon, an increasing proportion of the national budget is allocated to research activities, growing from €28 million in 2000 to €215 million in 2009, as per Table 5 above. However, it should be noted that in all policy statements committing to Lisbon goals, the government notes that targets are, not unreasonably, subject to economic performance. Obviously if the current economic crisis increases unemployment and shrinks the tax base beyond certain levels, resources originally intended to meet Barcelona objectives may be diverted.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	Commitment to, as well as fiscal ability to, meet Lisbon goals.	Change in economic environment could impact availability of government resources.
Knowledge demand	Consideration of European, as well as national, research themes when formulating research agenda.	NRS (benign) neglect of services sector which is dominant in Europe as well as Luxembourg.
Knowledge production	Greater collaboration and knowledge transfer between public and private sector research efforts. Better identification and exploitation of IP	Lack of harmonisation within the NRS causes dissipation of effort and resources.
Knowledge circulation	Development of programmes that make PPPs attractive to SMEs	Numerically dominant foreign researchers circulate out of Luxembourg, along with their knowledge.

6.3 System and policy dynamics from the perspective of the ERA

Luxembourg's geographic position between France, Germany and Belgium, its reliance on a foreign workforce and its hosting a significant number of EU institutions means the European dimension is rarely absent from any societal sphere, including research. Its size also requires ERA collaboration to realise many projects. Up to the present all Luxembourg university graduates received their degrees from foreign

³² These include overlaps in research topics and economies to be achieved by consolidating administrative functions.

institutions while a large portion of its university faculty has been drawn from ERA establishments.

Luxembourg is a full member of ESA and participates in ECRIM and other European research associations. Its CRP Santé partners in projects with the WHO. CRP activity reports and FNR programme reports detail the broad extent of Luxembourg's ERA involvement. The Nanobeams Network of Excellence, under CRPGL and the University of Luxembourg is a good example of Luxembourg's ERA connectivity. In addition, Luxinnovation works with the local companies to support participation in research programmes under FP7, ESA, EUREKA, etc. The ESA Solar Sails project that includes participants from Belgium, France and Germany, as well as two public research centres, is a good example from the private sector.

Luxembourg also attracts European partners. CEPS/INSTEAD hosts colleagues from throughout the ERA with its socioeconomic data collections while CRPGL's NanoSIMS³³ also draws researchers from all over the continent.

Knowing it needs ERA collaboration to achieve critical mass in many of its research efforts, Luxembourg's NRS is as actively engaged with ERA as the nation is with Europe as a greater whole.

³³ A NanoSIMS is an ion microprobe. Refer to http://presolar.wustl.edu/nanosims/ns_groups.html.

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List of Abbreviations

AAGR	Average Annual Growth Rate
BERD	Business Enterprise Expenditure on R&D
CEPS/INSTEAD	Centre d'Etudes de Populations, de Pauvreté et de Politiques Socio-Economiques / International Network for Studies in Technology, Environment, Alternatives, Development
CRP	Centre de Recherche Publique / Public Research Centre
CRPGL	Centre de Recherche Publique Gabriel Lippmann / Public Research Centre Gabriel Lippmann
CRPHT	Centre de Recherche Publique Henri Tudor / Public Research Centre Henri Tudor
CRP Santé	Centre de Recherche Publique Santé / Public Research Centre Health
FNR	Fonds National de la Recherche / National Research Fund
GBAORD	<u>Government Budget Appropriations or Outlays for R&D</u>
GERD	Gross domestic expenditure for R&D (as a percentage of GDP)
ECO	<u>Ministère de l'Economie et du Commerce extérieur / Ministry of the Economy and Foreign Trade</u>
ICT	Information and Communications Technology
LIASIT	Luxembourg Advanced Studies in Information Technology
MCESR	Ministère de la Culture, de l'Enseignement supérieur et de la Recherche / Ministry of Culture, High Education and Research
NABS	Nomenclature for the analysis and comparison of scientific programmes and budgets
NRS	National Research System
NRP 2007	Implementation Report 2007 for the National Plan for Innovation and Full Employment
PPP	Public/Private Partnership
SNCI	Société Nationale de Crédit et d'Investissement / National Society for Credit and Investment

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Abstract

The main objective of ERAWATCH country reports 2008 is to characterise and assess the performance of national research systems and related policies in a structured manner that is comparable across countries. The reports are produced for each EU Member State to support the mutual learning process and the monitoring of Member States' efforts by DG Research in the context of the Lisbon Strategy and the European Research Area. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. The reports are based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

This report encompasses an analysis of the research system and policies in Luxembourg.

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