OECD Reviews of Innovation Policy

LUXEMBOURG

OECD

OECD Reviews of Innovation Policy

Luxembourg

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 30 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

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

Also available in French under the title:
Examens de l'OCDE des politiques d'innovation
LUXEMBOURG

© OECD 2007

No reproduction, copy, transmission or translation of this publication may be made without written permission. Applications should be sent to OECD Publishing *rights@oecd.org* or by fax 33 1 45 24 99 30. Permission to photocopy a portion of this work should be addressed to the Centre français d'exploitation du droit de copie (CFC), 20, rue des Grands-Augustins, 75006 Paris, France, fax 33 1 46 34 67 19, *contact@cfcopies.com* or (for US only) to Copyright Clearance Center (CCC), 222 Rosewood Drive Danvers, MA 01923, USA, fax 1 978 646 8600, *info@copyright.com*.

Foreword

This review of Luxembourg's innovation policy is part of a new series of OECD country reviews of innovation policy. It was requested by the Luxembourg authorities, represented by the Ministry of Culture, Higher Education and Research (MCESR) and was carried out by the OECD's Directorate for Science, Technology and Industry (DSTI) under the auspices of the Committee for Scientific and Technological Policy (CSTP).

The review draws on a background report prepared by the Luxembourg Ministry of Culture, Higher Education and Research and on the results of a series of interviews with major stakeholders in Luxembourg's innovation system. The review was drafted by Gernot Hutschenreiter (Science and Technology Policy Division, DSTI, OECD) and Fritz Ohler (consultant to the OECD; Managing Director of Technopolis Austria) under the supervision of Jean Guinet (Science and Technology Policy Division, DSTI, OECD).

Table of Contents

Overall Assessment and Recommendations 9

Main strengths and weaknesses of Luxembourg's innovation system 9
Strategic goals and guiding principles for government action 10
Recommendations 13
Improving governance 13
Improving complementarity between public research organisations and agencies 14
Improving connectivity within the innovation system through a new initiative 16

Chapter 1. Introduction 17

Chapter 2. Key Features of Luxembourg's Innovation System 21

2.1 Indicators 21
2.1.1 The R&D core of the innovation system 21
2.1.2 Innovation processes and outputs 25
2.1.3 Innovation in services 38
2.1.4 Business sector R&D and innovation: policy challenges and recommendations 39
2.2 The evolution of science, technology and innovation policy in Luxembourg 43
2.2.1 The "go abroad" approach and the lack of absorptive capacity 43
2.2.2 Luxinnovation: Awareness of innovation and focus on SMEs 44
2.2.3 The establishment of CRPs 44
2.2.4 A coherent approach to establishing a fully fledged public research system 44
2.2.5 Increasing public funding of R&D, strong commitment to the Lisbon strategy 45
2.2.6 Need and room for improvement and adaptation 46

Chapter 3. Public Governance of Luxembourg's Innovation System 49

3.1 Luxembourg's research and innovation policy system: main components and interactions 49
3.1.1 Ministry of Culture, Higher Education and Research 50
3.1.2 Ministry of the Economy and Foreign Trade 53
3.1.3 Ministry for the Middle Class, Tourism and Housing 55
3.1.4 Ministry of State, Media and Communication Service 56
3.1.5 Interaction between ministries 56

3.2 Promotion of R&D in the public sector: The National Research Fund (FNR) 58
3.2.1 Objectives, mission and tasks of the FNR 58
3.2.2 Structure of the FNR 59
3.2.3 Approach used to select priority research programmes 60
3.2.4 Collaboration between the Board of Administration and the Scientific Council 61
3.2.5 Programmes carried out by the FNR 62
3.2.6 Beneficiaries of the FNR's intervention 68
3.2.7 Accompanying measures 69
3.2.8 International co-operation 70
3.2.9 FNR's budget 2001-10 and future directions 71
3.2.10 Concluding observations on the FNR 73
3.3 Promotion of business R&D and technological innovation 74
3.3.1 Financial measures 74
3.3.2 Financing institutions 77
3.4 Promotion of public-private partnerships for innovation, industry-science relationships and technology transfer 80
3.4.1 Collaborative R&D in the CRPs 80
3.4.2 Industry-science relationships in FNR-funded programmes and projects 82
3.4.3 Cluster programmes 84
3.4.4 Technology transfer 86
3.5 The role of intermediary organisations: Luxinnovation 88
3.5.1 Setting up R&D projects 88
3.5.2 Starting an innovative business 89
3.5.3 Promotion of the ECOSTART enterprise and innovation centre 89
3.5.4 Gate2Growth: the European gateway for high-growth businesses 89
3.5.5 Organisational innovation/management techniques 90
3.5.6 The Luxembourg portal for innovation and research 90
3.5.7 Concluding observations on Luxinnovation 90
3.6 Internationalisation of R&D 91
3.6.1 European Framework Programme for Research and Technological Development 91
3.6.2 EUREKA 92
3.6.3 European Space Agency (ESA) 95
3.6.4 European Trend Chart on Innovation 96
3.6.5 Internationalisation: The "Grande Région" and beyond 97
3.7 Intellectual property rights 98
3.8 Awareness 99
3.8.1 Luxembourg portal for innovation and research 99
3.8.2 One mission of the FNR: to promote scientific culture and raise public awareness 99
3.8.3 The Technology Watch Centre 100

3.9 Public governance of Luxembourg's innovation system: policy challenges and recommendations 100
3.9.1 A critical appreciation of the past 101
3.9.2 The Ministry of Culture, Higher Education and Research and related ministries: the hub of policy making 105
3.9.3 Luxinnovation 113
3.9.4 The National Research Fund (FNR) 114
3.9.5 Promotion of business R&D and technological innovation: integration and stronger focus 118
3.9.6 Internationalisation of R&D 121
3.9.7 An ad hoc Advisory Board for Science and Technology Policy 123

Chapter 4. The Public Research System (Public Research Organisations and Higher Education Institutions) 125

4.1 Financing and governing the CRPs: changes in the funding rationale 126
4.2 Gabriel Lippmann Public Research Centre 127
4.2.1 Materials Analysis Laboratory (LAM) 128
4.2.2 Unit for Research on the Environment and Biotechnology (CREBS) 129
4.2.3 Unit for the Research, Study and Development of IT (CREDI) 129
4.2.4 Concluding observations on CRP Gabriel Lippmann: heterogeneity in thematic areas, orientation and performance 130
4.3 Henri Tudor Public Research Centre 131
4.3.1 Concluding observations on CRP Henri Tudor 133
4.4 Public Research Centre for Health 135
4.4.1 The research institute 135
4.4.2 The Health Institute (Centre for Health Studies) 136
4.4.3 The biotechnology institute (biotechnology business accelerator) 136
4.4.4 Concluding observations on CRP Santé 137
4.5 CEPS/INSTEAD 138
4.5.1 Concluding observations on CEPS/INSTEAD 139
4.6 University of Luxembourg 140
4.6.1 Faculty of Science, Technology and Communication (FSTC) 141
4.6.2 Faculty of Law, Economics and Finance (DEF) 141
4.6.3 Faculty of Humanities, Arts and Educational Science (FLSHASE) 142
4.6.4 Concluding observations on the University of Luxembourg 143
4.7 The role of the public research system (University of Luxembourg and the CRPs) in the development of human resources for science and technology (HRST) 144

4.8 The public research system: challenges and recommendations 146
4.8.1 Maintaining workable relations: performance contracts..... 147
4.8.2 Understanding the CRPs' business models, portfolios, and assets: strategic audits..... 148
4.8.3 Technology and knowledge transfer: talent, mobility, firm start-up, weak ties to industry..... 149
4.8.4 Closing the gap between public and private sector research: industry-science relationships, public-private partnerships..... 151
4.8.5 The University of Luxembourg and the role of the CRPs 155
4.8.6 The social sciences-economics-law cluster 157

References..... 159
Acronyms..... 161

OVERALL ASSESSMENT AND RECOMMENDATIONS

The Luxembourg government's objectives for further strengthening and developing the public research base as a springboard for more innovation-led growth are ambitious but realistic. Public R&D expenditure has grown substantially in recent years, and the government is strongly committed to additional investment in R&D to bring the ratio of public R&D expenditure to GDP closer to the level of other OECD countries with a comparable income level.[1]

The public institutions for funding, supporting and performing research and innovation – the National Research Fund (FNR), Luxinnovation, the public research centres (CRPs), and especially the University of Luxembourg – are relatively young. The innovation system is not yet fully developed. In some respects it is still unbalanced and needs to be adjusted to guarantee efficient use of an increase in public investment in R&D and innovation. At the same time there is great potential for future development, which is enhanced by a consensus among all relevant actors on the objectives and also the need for change in the institutional set-up and steering mechanisms.

Main strengths and weaknesses of Luxembourg's innovation system

- *Good framework conditions for innovation*. Overall, Luxembourg offers researchers and innovators favourable framework conditions owing to a central geographical position within the European Research Area and its privileged access to neighbouring dynamic clusters in the "*Grande Région*", a stable macroeconomic environment, a reliable legal framework, an experienced financial system, etc. However, in today's intensified global competition to attract and retain knowledge-intensive activities, the fine tuning of framework conditions for innovation, in Luxembourg as in any other OECD country, should be a continuous process. Above all this entails improved co-ordination of policies in areas such as macroeconomic management, education, competition, corporate

1. Specifically, the government of Luxembourg aims at doubling public research and innovation expenditure by 2009 (relative to the level prevailing in 2006).

governance, labour markets, energy, banking and financial markets, and intellectual property rights (IPRs), etc.

- *Strong building blocks.* Luxembourg has some strong players in industrial research and can be an attractive location for business R&D. In addition, over recent decades Luxembourg has built a number of well-performing public research units. The creation of the University of Luxembourg is a major achievement which enriches the country's research landscape and increases its options for the future.
- *Structural weaknesses and imbalances.* The process of setting up the new university is far from complete and has proved more difficult than expected. An adequate pattern of specialisation and division of labour between the new University of Luxembourg and the previously established public research organisations has still to emerge.
- *Weak governance.* The governance of research and innovation is as yet insufficient to guarantee public research institutions' optimal contribution to the development of the national innovation system. Objectives and strategies for public research institutions are largely absent. This hinders, for example, the use of new governance instruments such as performance-based steering mechanisms and the adoption of advanced evaluation practices.

Strategic goals and guiding principles for government action

Experience in OECD countries demonstrates that: *i)* the government has a vital role in promoting innovation-driven growth since innovation processes are affected by endemic market and systemic failures that must be corrected; and *ii)* government promotion of innovation requires different policies as part of an overall coherent strategy. The government of Luxembourg has the additional task of completing the setting-up of the institutions, especially university which makes up the innovation systems of advanced market economies.

The overriding objective of Luxembourg's innovation policy should be to strengthen the basis for sustainable long-term growth by facilitating the gradual substitution of "sovereignty niches" by "competence niches", building on the latter in the initial phase of the transformation process. This involves three main interrelated strategic tasks:

- Building a knowledge infrastructure which can support better exploitation of existing comparative advantages in knowledge-intensive manufacturing and services, as well as the development of new advantages through improved interaction between knowledge providers and users.

- Providing all innovation actors with appropriate incentives and institutional frameworks for seizing opportunities.
- Reinforcing the public research system's capacity to contribute to innovation and human resource development, notably through improved steering and financing mechanisms.

In accomplishing these tasks, some critical pitfalls should be avoided:

- *Crowding out private investment.* Growing investment in public research should not impair the development of the market for technological services or substitute for increased business R&D efforts.
- *Misallocation of public investment.* Disappointing social returns on public investment in R&D could result from a bias in the allocation criteria in favour of research topics with little relevance to societal or economic needs. The thinning out of public support could also lead to research teams and projects of sub-optimal size. Given its size, Luxembourg cannot develop its research base across the board but should instead set priorities in science and technology.
- *Duplication of effort in some research areas and neglect of others.* An unclear division of labour and lack of co-operation among public research organisations could lead to wasteful duplication of effort in some research fields and underinvestment in others.
- *Human resource bottlenecks.* If increased public investment in R&D is not matched by a parallel qualitative and quantitative development and the attraction of human resources in science and technology (HRST), it will not yield the expected national benefits.

To this end, policy should be subject to some key guiding principles:

- *A broad approach to innovation.* The reinforcement of the "R&D core" of the innovation system should be pursued as part of an overall strategy to enhance innovation capabilities throughout the economy, including in non R&D-based manufacturing, and especially the financial sector.
- *Quality/relevance/critical mass.* Reconciling these three objectives entails some concentration of limited resources in areas in which Luxembourg's capabilities can match opportunities in national and global innovation networks, active involvement of research end-users in defining research priorities, and rigorous selection of research projects and teams eligible for public support.
- *International openness.* Maximisation of national benefits from public investment in research will not be achieved by maximising the share of

domestic actors in innovation processes. Participation in the national innovation system by foreign individuals, firms and other knowledge organisations, as well as access to foreign markets for research outputs generated in Luxembourg, will remain critical to success.

- *Linking research to education.* Developing the research capabilities of the University of Luxembourg to make it the backbone of the public research system will be decisive, but the CRPs will also have a role to play in improving the training of HRST through and for research.
- *Adaptive policy making.* Bringing the still nascent Luxembourg innovation system to a new level of performance along a sustainable development trajectory will not occur all at once. At this stage government should use both "push and pull" steering mechanisms. It should give direction and impetus to the desired changes through appropriate contractual arrangements, institutional frameworks and funding levels and procedures. It should also make expectation of future evaluation part of the incentives that determine the response of the different actors in the innovation system.
- *A participatory approach.* Building a shared vision among all private and public actors of what should be collectively achieved is a prerequisite for the successful formulation and implementation of a government policy that attains the right balance between top-down and bottom-up initiatives.
- *Advanced governance principles.* A clear distinction should be made between policy formulation and policy implementation, and the latter should be accomplished using the right mix of a range of proven instruments: co-ordination, competition (*e.g.* competitive funding), co-operation (*e.g.* joint research projects); and performance-based steering mechanisms (*e.g.* performance contracts, funding criteria).

These principles should be applied with due consideration to some specific features of Luxembourg, notably:

- The country's size means that only a limited number of people can be involved without creating conflicts of interest or becoming overwhelmed by competing tasks in the governance of the innovation system, which should therefore be simplified to the maximum extent possible.
- The age of public research institutions differs. CRPs have been in operation for a couple of decades while the university has not had time to develop a constituency of research end-users. The university should be encouraged to play its full role in the development of industry-science

relationships in order to avoid a drift towards blue-sky projects with low social returns.

- Business R&D is highly concentrated in a few major companies. Broadening the business R&D base, mainly through technology-based start-ups and new foreign direct investment (FDI), should be an important objective to secure increased demand for inputs from the growing public research sector.
- Luxembourg has a large services sector (including banking and insurance) which is dominated by subsidiaries of multinational companies. Policies to ensure that the needs of services firms are appropriately addressed by the national innovation system ought to be consistent with the global innovation strategy of firms' headquarters.

Recommendations

Improving governance

- *Clarify the role of actors.* To build an effective innovation system, the role of the actors in Luxembourg's research and innovation system needs to be adapted to the tasks. It will therefore be necessary to separate more clearly the functions of policy formulation and implementation and to periodically assess the role of actors involved in the governance of innovation policy.
- *Improve co-ordination.* To ensure efficient use of increased public investment in research and innovation, the government will need to improve co-ordination among policy actors, including among the major ministries in charge of R&D policies (MCESR and MECE), and aim at better horizontal co-ordination of sectoral policies.
- *Improve strategy formulation and management capabilities.* Increased public investment and the growing sophistication of Luxembourg's innovation system require reinforcement of the capacity to formulate strategies and manage their implementation. This applies in particular to the ministries in charge whose staff should be increased. In addition, more use should be made of external advice in managing the process of change.
- *Establish an Advisory Board on S&T Policy.* In view of the tasks to be accomplished to build up Luxembourg's innovation system over the

coming years, consider the establishment of a temporary Advisory Board on Science and Technology Policy to be chaired either by the prime minister or by one or several ministers.[2] Its main task would be to monitor progress towards the implementation of the government's agenda for strengthening Luxembourg's research base, advising the government and initiating complementary studies and evaluations. The Board's members should have a strong background in business, science and innovation policy. A sufficient number should be non-residents who can bring experience from outside Luxembourg. In view of limited resources, an existing body, such as the Inter-ministerial Co-ordination Committee for Research and Technological Development, could provide the secretariat for the Advisory Board.

- *Set science and technology priorities.* Building up the research base in Luxembourg requires a number of discretionary investment decisions which make a purely bottom-up approach insufficient. The ongoing foresight study should be used to derive priorities for such decisions. In the meantime, consultations with end-users of research, in preparation for the launch of competence centres (see below), could provide useful information for sharpening priorities for research in the university and the CRPs.

Improving complementarity between public research organisations and agencies

Complementarity should be ensured in four dimensions of research: the field, the nature, the relation to education and commercialisation. This can be achieved above all through improved steering of public research institutions and agencies and redefining the roles of Luxinnovation and FNR.

- *Steering of public research institutions.* Enhancing accountability and ultimately efficiency requires a clear mission statement for each public research institution and agency; these mission statements should be derived from strategic audits of the respective institutions. The current contractual arrangements between the government and public research institutions (*e.g.* the multi-annual programmes of CRPs) should be replaced by state-of-the-art performance contracts.

2. Following, for example, the model of the *Comité Permanent de l'Emploi* or the *Comité de Conjoncture*.

- *A new role for Luxinnovation.* Luxinnovation plays an important role in Luxembourg's innovation system, especially for linking business enterprises and public sector research and ensuring greater participation of small firms in innovation. To maintain quality of services in an environment of growing demand, Luxinnovation's current portfolio of activities should be streamlined and its organisational capabilities strengthened. Luxinnovation should play a key role in extending the reach of innovation policy to the services sector (*e.g.* in the area of financial services) and to other activities in which innovation is not directly based on R&D (see the example of the proposed centres of competence below).

- *Entrusting the National Research Fund with all project and programme-based funding.* The FNR currently has difficulty fulfilling a very broad mandate that mixes strategic and implementation functions. At the same time, FNR has developed competences that should be used in any restructured governance system. Accordingly, the government should consider focusing the role of FNR on funding research via programmes and projects. This means that all project-based research funding of the CRPs and the University of Luxembourg would be transferred to the FNR to make better use of the FNR's expertise in evaluating research projects. This will help increase scientific quality and contribute to aligning public research with overall goals and strategies. The FNR should also play an important role in evaluating and funding the proposed centres of competence (see below).

- *Linking research to education.* This is a fundamental task of the University of Luxembourg which should be facilitated by the establishment of research schools able to attract talented doctoral and post-doctoral students. However, the CRPs should play a complementary role by emphasising doctoral and post-doctoral training in their research units and ensuring mobility of a highly skilled and trained workforce to the business sector.

- *Promoting a coherent internationalisation strategy.* Internationalisation – in the *"Grande Région"* and beyond – is of central importance for the performance of Luxembourg research institutions. Internationalisation should be a key evaluation criterion for measuring the performance of public research institutions. At the same time, performance contracts should ensure that the internationalisation strategy of public research institutions is in line with their mission.

Improving connectivity within the innovation system through a new initiative

A historically weak public research system has prevented the development of buoyant industry-science relationships in Luxembourg. Rapid development of such a system creates new opportunities but does not by itself create all the conditions for the formation of such linkages. In addition to the current, rather scattered, project-based support measures, the launch of a more ambitious programme should be considered. On the basis of OECD countries' experience, public/private partnerships (P/PPs) for innovation are the best institutional framework for increasing the intensity and quality of industry-science relationships in areas of strategic interest for the economy.

- *Launching a centres of competence programme.* To extend public-private interaction in research and innovation to sustainable, long-term strategic linkages, a programme of centres of competence should be launched. Centres of competence are P/PPs that are goal-oriented, long-term contractual arrangements between public research institutions and business firms that serve the needs of both sides. There is rich international experience that can be used in designing and implementing a programme that would fit the particular needs of Luxembourg.

Chapter 1

INTRODUCTION

Luxembourg enjoys the highest GDP per capita in the OECD area, *i.e.* almost twice the EU15 average (Figure 1.1). GDP growth, at 5.2%, has been among the highest in the OECD area over the period 1995-2004 (Figure 1.2). It has been higher than in Germany, France, the Netherlands and Belgium since the 1980s. It peaked in the late 1980s and early 1990s and has levelled off somewhat since then (to 3.4% in the period 1998-2003).

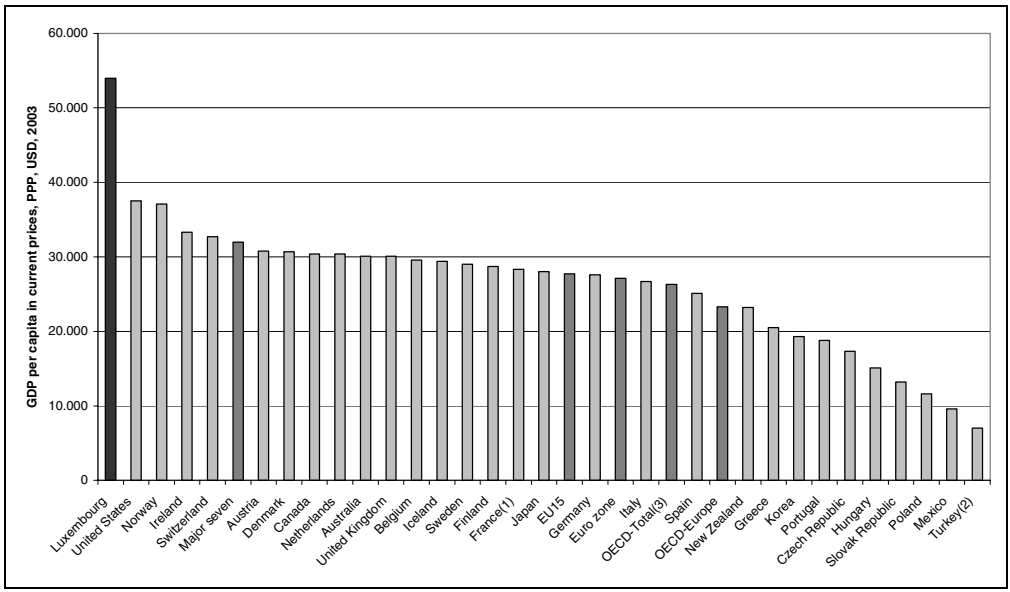
Growth in the financial sector has been particularly strong, especially between 1986 and 1994. The financial sector, along with the transport, storage and communications sector, has contributed significantly to overall economic growth. A large part of the difference in growth between Luxembourg and neighbouring countries is attributable to these two sectors.

There is a considerable degree of uncertainty about the future growth of these sectors. While they may continue to grow relatively rapidly for some time, it is not unlikely that the growth differential will flatten out and eventually disappear. The government would therefore be well advised to prepare for a transition to a different pattern of growth.

Enhancing innovation will play a major role in this transition through higher productivity and the development of new and improved products and services either in areas of established economic strength or in new areas that can contribute to a diversification of Luxembourg's economy. During this transition current "sovereignty niches" will gradually be replaced by "competence niches". This will require increased investment in R&D. At present, Luxembourg's R&D intensity is still below the EU15 and EU25 averages and even further below the OECD average of 2.2% (Figure 1.3).

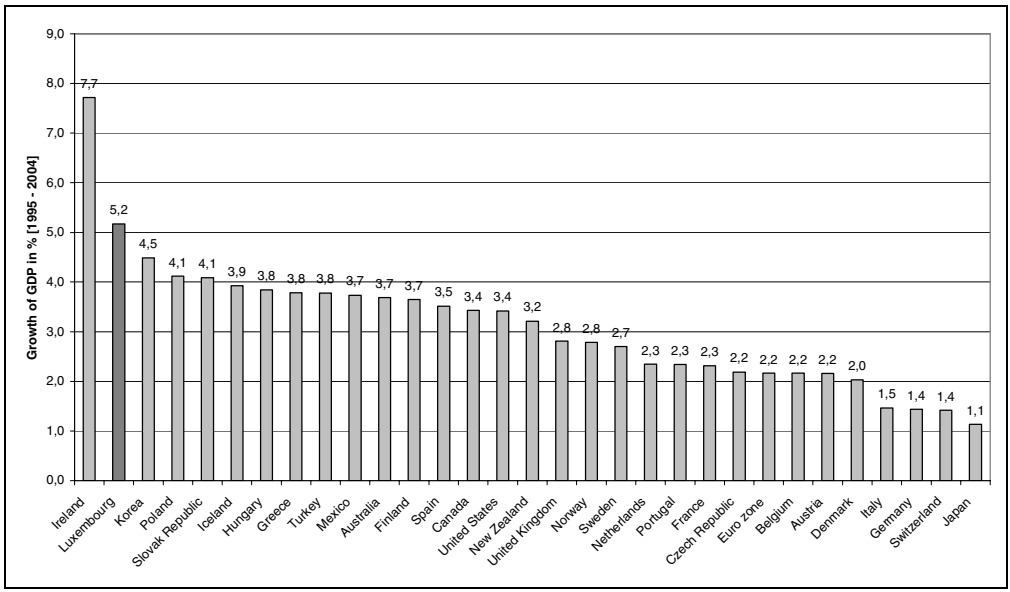
The main objective of this review is to support this transition process by assessing Luxembourg's science, technology and innovation policy and the governance of Luxembourg's public research system. It weighs the current strengths and weaknesses of Luxembourg's innovation system, focusing on the governance of public research with a view to ensuring that additional public investment will yield the expected economic and social benefits.

Figure 1.1. GDP per capita, 2003, USD, based on current purchasing power



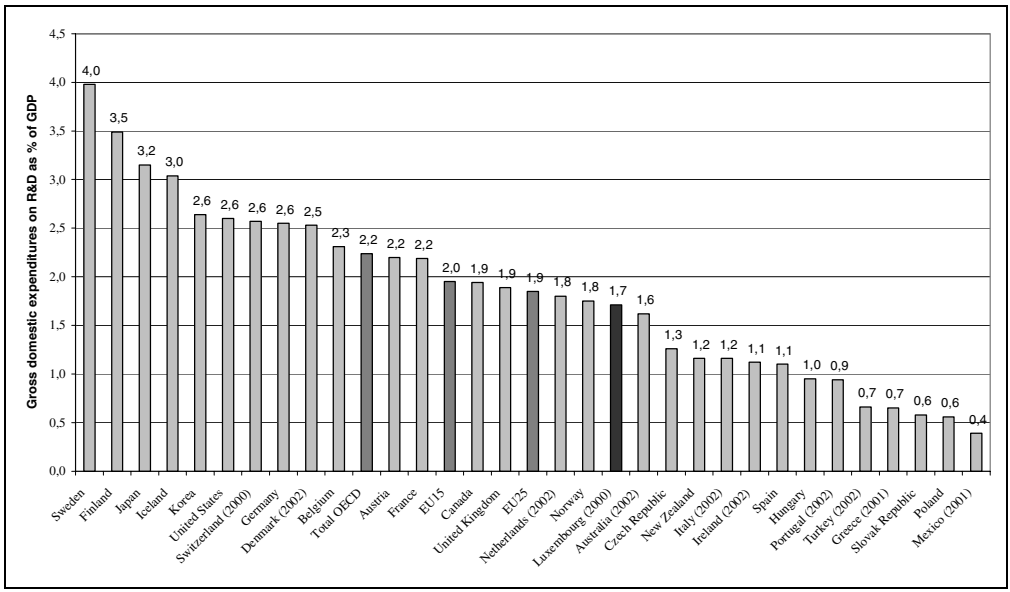
Source: OECD, National Accounts of OECD Countries, Main Aggregates, Volume 1, updated October 2005.

Figure 1.2. Growth of GDP in %, 1995-2004



Source: OECD Productivity Database, July 2005.

Figure 1.3. R&D expenditures as % of GDP, 2003 or latest available year



Source: OECD, MSTI database, May 2005.

Chapter 2

KEY FEATURES OF LUXEMBOURG'S INNOVATION SYSTEM

2.1 Indicators

2.1.1 The R&D core of the innovation system

In spite of its favourable economic performance, Luxembourg's investment in R&D has been rather modest. This has been due to the absence of a significant public research sector as well as to the specific characteristics of the sectors that contribute most to the country's economic growth. In 2000, gross expenditure on research and development (GERD) reached 1.71% of GDP, of which 90% from the private sector. In 2003, R&D expenditures increased to 1.78% of GDP with a slightly increased share for the government sector (Table 2.1). Moreover, almost two-thirds of private expenditures are made by just a few companies.

Table 2.1. Domestic expenditure on R&D by performing sector, 2000, 2003

	2000			2003				
R&D performing sector	Million EUR	%	% of GDP	Million EUR	%	% of GDP	Growth (%)	Growth of % of GDP
Industry	337.0	92.6	1.58	379.4	89.0	1.58	13%	0.00
Public sector	26.0	7.1	0.12	44.9	10.6	0.19	73%	0.07
Higher education	0.9	0.3	0.01	1.5*	0.4	0.01	67%	0.00
Total	363.9	100.0	1.71	425.8	100.0	1.78	17%	0.07

Source: STATEC, MCESR, CEPS/INSTEAD, 2001, cited after Statnews, *Informations statistiques récentes* (2005).

The relationship between private and public expenditure on R&D appears somewhat unbalanced. The business enterprise sector finances the lion's share of R&D (about 80% in 2003) and performs 89% (2003) of total R&D (Table 2.1). The contribution of the public sector is comparatively small. Together with Greece and just ahead of Mexico, Luxembourg has one of the lowest ratios of public expenditure to GDP in the OECD area (Figure 2.1).

However, between 2000 and 2003, R&D in the public research sector and the higher education sector grew rapidly (by 73% and 67%, respectively, see Table 2.1). This increase reflects the government's strong commitment to increase the ratio of R&D expenditure to GDP from 0.08% in 1999 to 0.3% by 2004 (reached in fact in 2005). The planned increase in the ratio of public expenditure on R&D to GDP in the coming years may move Luxembourg into the first quartile of the EU25, and above the OECD average.

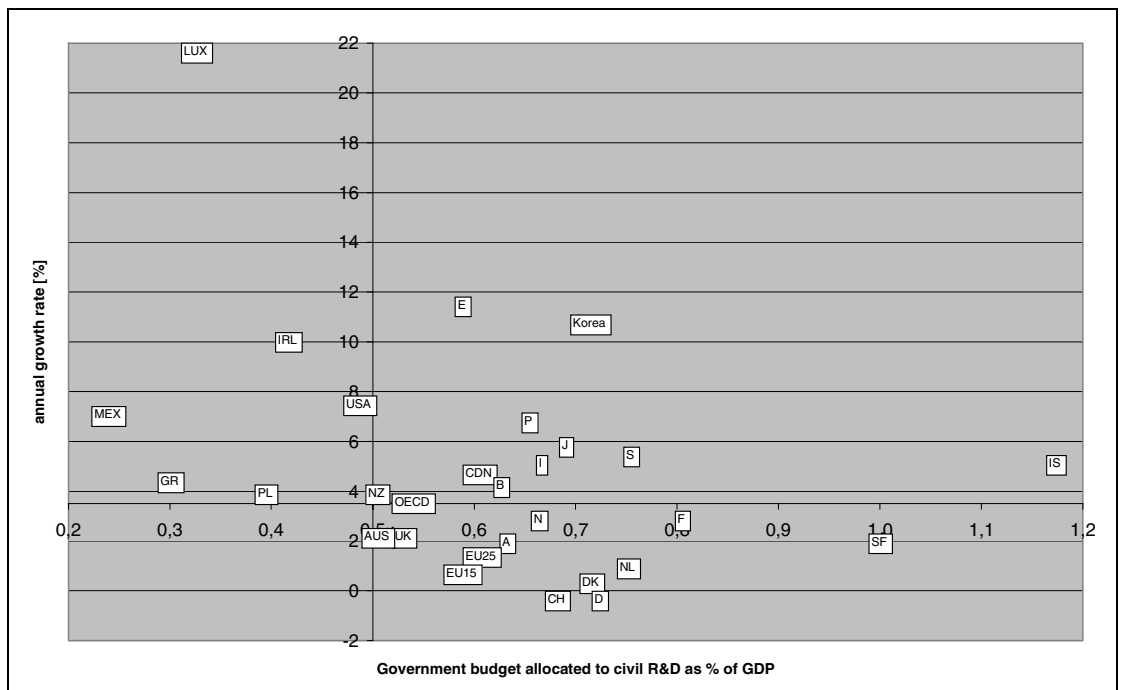
As described elsewhere in this report, the increase in public R&D expenditure was accompanied by a number of institutional innovations, the first of which was the establishment of the National Research Fund in 1999 and of the University of Luxembourg in 2003.[3] These institutional innovations have provided the basis for Luxembourg's additional investment in R&D.

While the level of business-financed R&D is average, its share in total R&D expenditure is very high. Business-funded R&D expenditure (as a percentage of value added) is slightly above the EU average (Figure 2.2). For comparison, the leading countries are Sweden (more than twice the OECD average), Finland and Japan.

For a small open economy such as Luxembourg, technical progress and innovation will rely mostly on R&D activities performed outside the country. However, R&D plays a dual role. First, investment in R&D leads directly to useful new scientific and technological knowledge. A second aspect of *own* R&D is that it increases the ability to absorb existing knowledge from other sources, including from sources abroad.

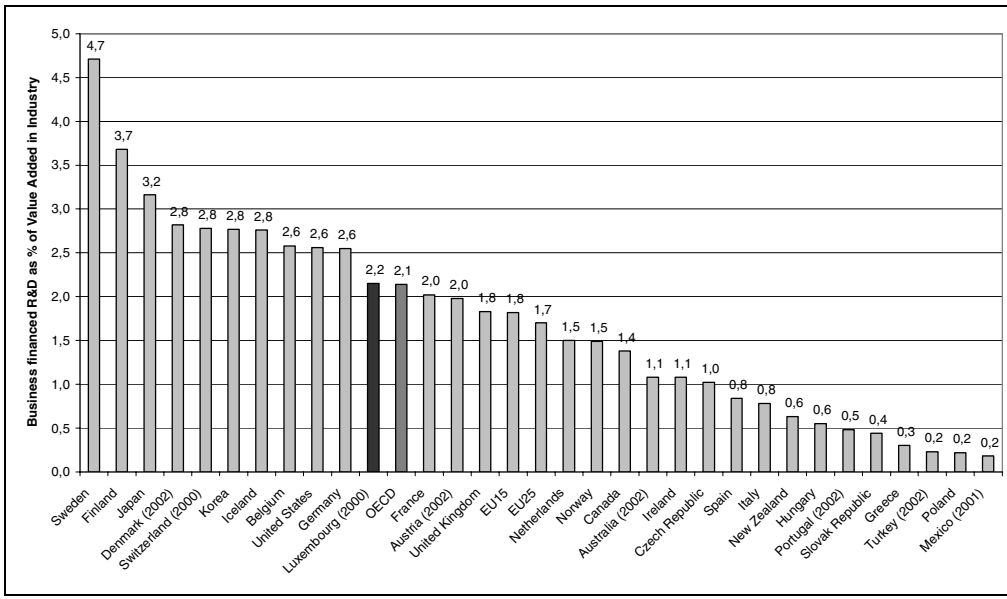
3. For details see Section 3.2 on the FNR and Section 4.5 on the University of Luxembourg.

Figure 2.1. Government budget allocated to civil R&D as % of GDP, annual growth in %, 2000 PPP USD, 1995-2005 or nearest available year



Source: OECD (2006*b*).

Figure 2.2 Business financed R&D as % of value added in industry, 2003 or latest available year



Source: OECD, MSTI database, May 2005.

Scientific publications are an immediate outcome of scientific research and are widely used as a measure of scientific performance. Decisions in science and technology policy are increasingly based on scientific performance. In an increasing number of scientific disciplines, the locus of publication (reflected by the so-called impact factor of the respective journal) counts even more than the publication itself.

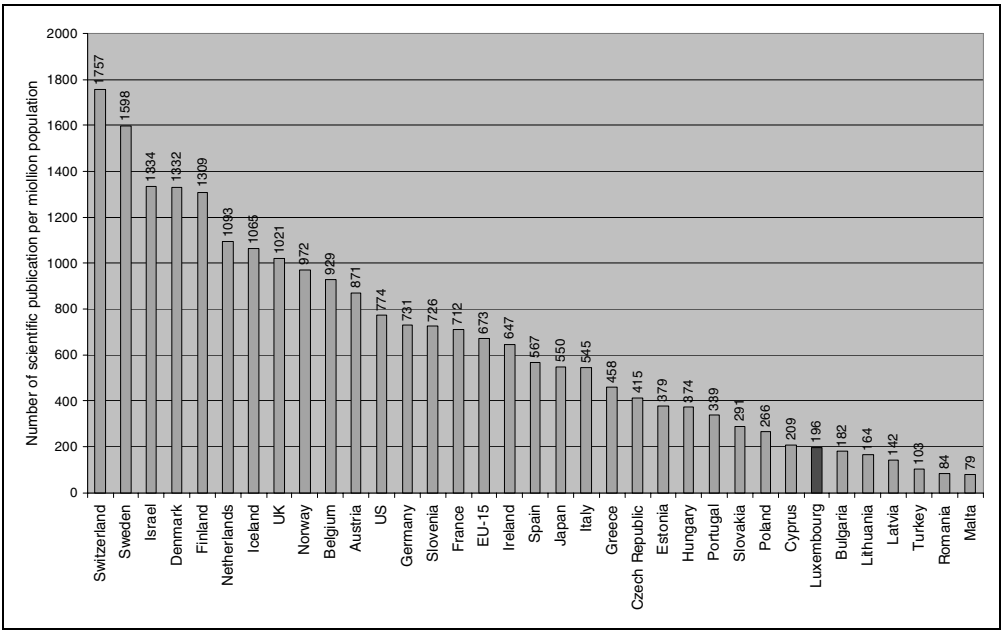
Small countries such as Switzerland, Sweden, Israel, Denmark, Finland, the Netherlands and Iceland lead in terms of the number of scientific publications per million population (Figure 2.3). However, a closer examination reveals that specialisation profile is more relevant than country size. Most of the leading countries have in fact a specific focus on the life sciences.

Luxembourg lags considerably behind, irrespective of the benchmark chosen. Scientific publications are mainly produced in public sector research institutions. Owing to the low level of government spending on (public) R&D in the past, the reasons for the low level of activity are evident. However, the situation is improving rapidly.

Between 1995 and 2002 growth in scientific publications attributed to Luxembourg has been quite strong (6.7% as compared to just 2.1%. for

EU15 as a whole). Luxembourg is catching up rapidly and the establishment of the University of Luxembourg will contribute to maintain this momentum.

Figure 2.3. Number of scientific publications per million population, 2002



Source: European Commission (2003), Sources of data: Publication data: FhG ISI, CWTS (treatments), population data: OECD: MSTI 2003/1, Eurostat: NewCronos.

2.1.2 Innovation processes and outputs

This section presents selected indicators of innovation processes and outputs. While these indicators can contribute to the understanding of the innovation system, it is also important to recognise their limitations. Their use can be problematic for a number of reasons. In the case of Luxembourg, a small economy with very specific features and patterns of comparative advantage, innovation indicators will sometimes be influenced by factors unrelated to research and innovation (*e.g.* the strong presence of company headquarters in Luxembourg). In addition, indicators may be volatile,[4]

4. There appear to be, for example, substantial discrepancies as regards the shares of innovating firms between the results of the last Community Innovation Survey (CIS3) and recently published first results of the CIS light (Statnews, 2006).

owing to small populations or to recurrent changes in methodology, for example, and there are numerous problems of international comparability.

For the main objective of this report – which is to examine the governance of science, technology and innovation policy and of major elements of Luxembourg's public research and higher education system in order to make recommendations for improvement – an indicator-based approach is of limited use.

2.1.2.1 A summary profile

A summary view of the innovation performance of Luxembourg as presented in the framework of the European Innovation Scoreboard (Figure 2.4) shows a small share of science and engineering (S&E) graduates, a low level of public R&D expenditures, and a small share of employment in medium-high technology manufacturing (which is mirrored by a large share of knowledge-intensive services). On the other hand, Luxembourg has a large share of new-to-the-market product sales, non-technology-based innovations, and foreign patents/community trademarks.

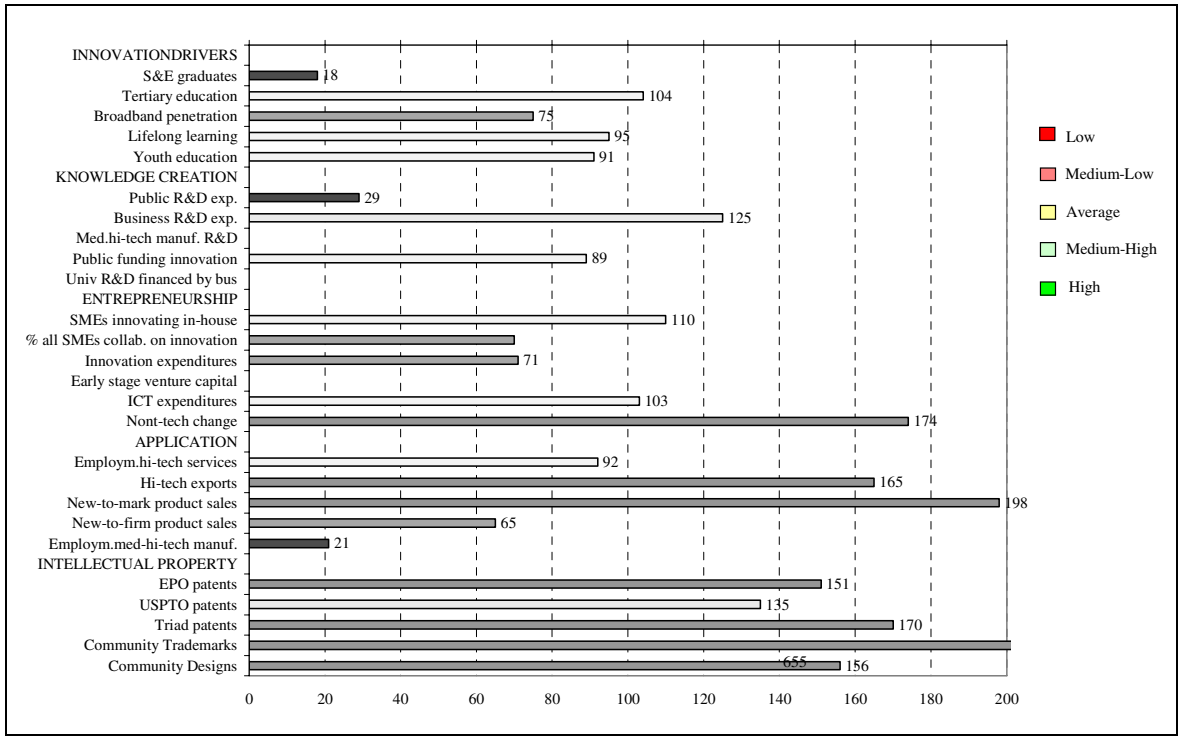
Overall this profile is influenced by certain specificities of Luxembourg such as the recent establishment of the university and the strong presence of headquarters of international firms.

Hollanders and Arundel (2005) provide additional information on the sectoral innovation performance[5] of Luxembourg's economy (Figure 2.5)[6] which leads to the following observations:

5. Innovation performance is measured by the Innovation Sector Index (ISI), constructed as a composite indicator of the following 12 indicators: share of employees with higher education, share of firms that use training, R&D expenditures as a percentage of value added, share of firms that receive public subsidies to innovate, share of firms innovating in-house, share of SME co-operating with others, innovation expenditures as a percentage of total turnover, share of total sector sales from new-to-market products, share of total sector sales from new-to-firm but not new-to-market products, share of firms that patent, share of firms that use trademarks, share of firms that use design registrations. For details see Hollanders and Arundel (2005).

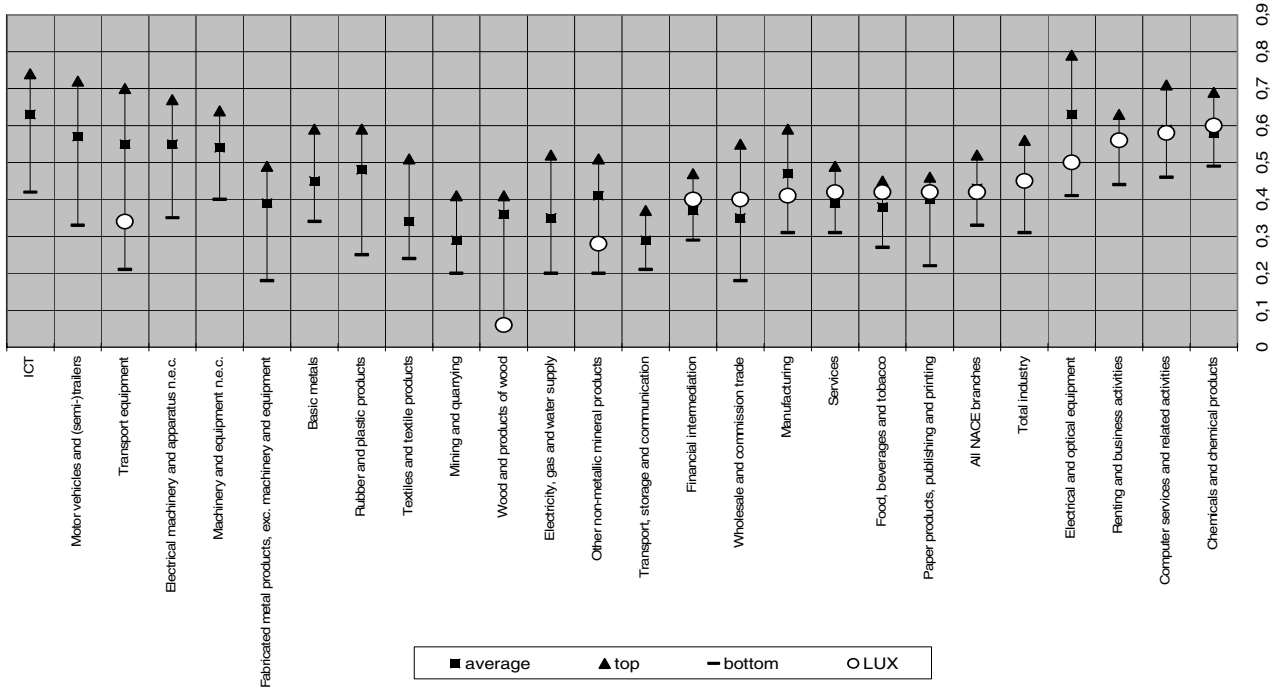
6. It should be noted that data are missing for about one-third of the sectors, including those with a leading position at the European level, such as Information and communication technologies (rank 2 out of 25 at European level), Motor vehicles (rank 5), Transport equipment (rank 7), Electrical machinery and apparatus (rank 8), Machinery and equipment (rank 9).

Figure 2.4. Innovation performance of Luxembourg (relative to EU average), 2005



Source: Arundel and Hollanders (2005).

Figure 2.5. Sector innovation performance of Luxembourg (relative to EU average), 2005



Source: Hollanders and Arundel (2005).

- Overall innovation performance of Luxembourg's industry is close to the European average.
- The most innovative sectors are Chemicals and chemical products, Computer services and related activities, Renting and business activities (excluding real estate), and Electrical and optical equipment.
- Chemicals and chemical products is the only sector with a high level of innovation performance at the European level and in which Luxembourg is above the European average.
- Luxembourg is lagging in innovation-intensive sectors such as Electrical and optical equipment, Computer services and related activities.
- Luxembourg shows innovation performance above the European average mainly in sectors that are on average weak innovation performers in Europe: Paper and paper products, publishing and printing, Business services, Food products, beverages and tobacco, Financial intermediaries, Wholesale trade and commission trade, and Transport, storage and communication.

This indicates that Luxembourg may have a specific advantage in innovation in areas where other European countries are not as innovative. Services industries which have been central to Luxembourg's economic performance – including financial intermediaries and transport, storage and communications – feature in this context.

2.1.2.2 Innovating firms

The Third Community Innovation Survey[7] provides more detail on innovative activities (Table 2.2):

- Almost half of the firms in both manufacturing and services perform "some significant innovative activities".
- One out of three small firms, two out of three medium-sized firms and more or less every large firm in the manufacturing sector can be labelled "innovative".
- Overall, the services sector shows a pattern similar to that of the manufacturing sector. However, compared to manufacturing, a higher share of

7. Warner (2003). Recently published first results of the CIS light (Statnews, 2006) deviate from CIS3 results reported here.

small firms and a smaller share of medium-sized and large firms in the services sector carry out innovations.

Table 2.2. Innovating firms by economic sector and size, 1998-2000

	Innovating firms (#)	Innovating firms (%)
Manufacturing sector		
10-49	82	35
50-249	45	63
250 +	34	96
Subtotal	161	47
Services sector		
10-49	308	41
50-249	120	49
250 +	30	86
Subtotal	458	44
Total	**619**	**45**

Source: Warner (2003).

A comprehensive view of innovation needs to recognise that the implementation of new management styles and techniques can be essential enablers for technological innovation or *vice versa*. There is evidence that firms performing technical innovation (innovators) perform more non-technical innovation than non-innovators (Table 2.3). The latter are also engaged in various types of non-technical innovation.

2.1.2.3 Co-operation in innovation

Co-operation is a very important feature of advanced research and innovation systems. In many OECD countries, innovation policy attempts to encourage various forms of co-operation in innovation. Table 2.4 indicates the multi-faceted world of co-operation by firms.

Table 2.3. Non-technical innovations, 1998-2000

	Small (10-49)	Medium (50-249)	Large (250+)	All sizes
INNOVATORS				
Manufacturing sector				
Strategy	60	58	70	62
Management	50	83	89	67
Organisation	45	58	73	55
Marketing	45	67	35	49
Aesthetic change	40	33	35	37
Service sector				
Strategy	63	66	66	64
Management	72	78	70	73
Organisation	74	77	73	75
Marketing	36	40	63	39
Aesthetic change	41	32	63	40
NON-INNOVATORS				
Manufacturing sector				
Strategy	9	6	0	8
Management	38	37	0	38
Organisation	32	24	0	31
Marketing	9	19	0	10
Aesthetic change	6	0	0	0
Service sector				
Strategy	35	57	0	39
Management	47	57	0	49
Organisation	51	55	0	51
Marketing	25	33	0	27
Aesthetic change	20	25	0	21

Source: Warner (2003).

Table 2.4. Main partners of innovating, co-operating firms by sectors and size (%, multiple counts allowed), 1998-2000

	Small (10-49)	Medium (50-249)	Large (250 +)	All sizes
Manufacturing sector				
Other enterprises within the enterprise group	50	80	82	75
Suppliers of equipment, material, components or software	80	40	82	66
Clients or customers	0	60	45	33
Competitors and other enterprises from the same industry	40	0	9	18
Consultants	0	40	18	19
Commercial laboratories/R&D enterprises	20	20	45	26
Universities or other higher education institutes	0	20	54	21
Government or private non-profit research institutes	0	0	27	7
Service sector				
Other enterprises within the enterprise group	74	94	61	79
Suppliers of equipment, material, components or software	74	63	62	70
Clients or customers	56	43	44	51
Competitors and other enterprises from the same industry	40	33	63	40
Consultants	56	53	56	55
Commercial laboratories/R&D enterprises	6	8	7	6
Universities or other higher education institutes	21	25	7	21
Government or private non-profit research institutes	12	10	0	10

Source: Warner (2003).

- Suppliers play a dominant role as partners in co-operation (66% in the manufacturing sector, 70% in the services sector) but a smaller role in providing major input into the innovation process (34% and 29%, respectively).
- Large firms in the services sector co-operate with competitors (two out of three).
- Consultants enjoy quite strong demand for their services: more than 50% of services firms hire external consultants but only 19% of manufacturing firms.

- Government or private non-profit research institutes are not among the most frequent partners in innovation but nevertheless play an important role, at least for some clients (*e.g.* universities for large manufacturing companies).[8]

2.1.2.4 Patent indicators

Patent indicators not only indicate patterns of technological change, they also measure activities that are closely associated with competitiveness in specific international markets.

Figure 2.6 provides an overview of applications at the European Patent Office (EPO). Luxembourg's position is quite good, as it ranks 6th among the EU15. In terms of growth, Luxembourg's position is even better (19.7%). Countries growing at a faster pace (Turkey, Iceland, the Czech Republic, Ireland) lag far behind Luxembourg. Luxembourg also performs favourably with respect to the number of patents granted at the US Patent and Trademark Office (USPTO) (96.5 patent applications per million population or a ranking of 8th after the United States, Japan, Switzerland, Sweden, Israel, Finland and Germany in 2002)[9].

Luxembourg also has a large share of co-patenting with international co-inventors. As with foreign trade, the intensity of this kind of cross-border co-operation tends to be inversely related to a country's size. In Luxembourg, 57% of patents involve foreign co-inventors; Belgium and Ireland follow with shares above 30% (Figure 2.7). Partly owing to the structure of ownership, the Czech Republic and Hungary also have quite high shares of patents involving foreign co-inventors (31% and 27%).

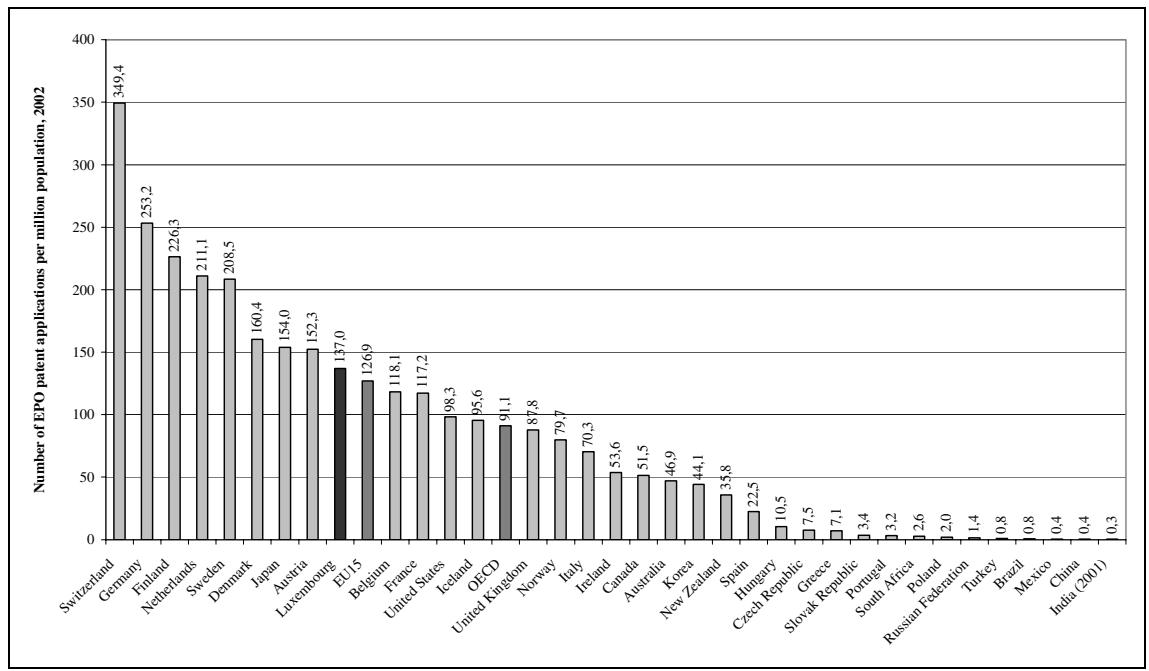
As mentioned above, Luxembourg's favourable position is to some extent related to the number of firms incorporated in Luxembourg, *e.g.* for fiscal reasons. Their research departments may be located elsewhere but because their headquarters are in Luxembourg the patent is attributed to Luxembourg.

---

8. A number of countries have responded to a general trend of decreasing relevance of government research institutes by introducing more explicit arrangements, typically labelled "competence centres".

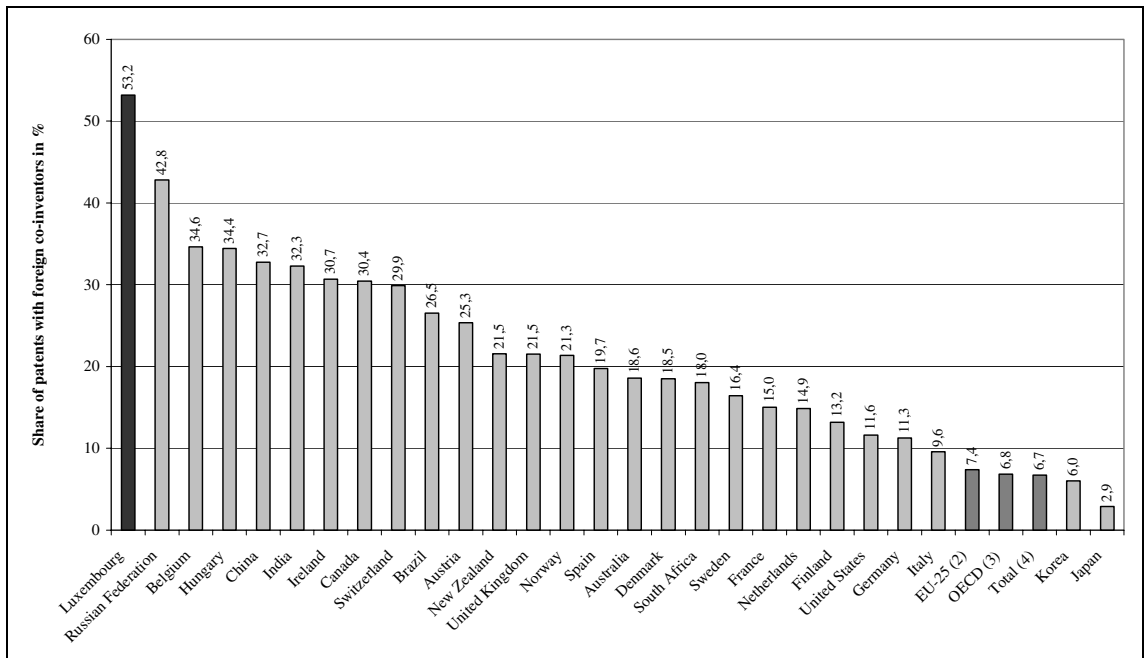
9. In absolute terms, the number is low (not more than 40 patents) compared to about 100 000 for the United States.

Figure 2.6. Patent applications at the EPO per million population, 2002



Source: OECD, Patent and R&D Databases, March 2005.

Figure 2.7. Share of patents with foreign co-inventors, 1999-2001



Source: OECD, Patent Database, March 2005.

2.1.2.5 Human resources for science and technology

Highly skilled people are of key importance in enabling innovation. The evidence on HRST (human resources in science and technology) in Luxembourg is somewhat inconsistent. The European Innovation Scoreboard gives the share of S&E graduates (in the population aged 20-29); in Luxembourg, it is far below the European average. This is due to the particular situation of tertiary education.[10] However, the share of the population with tertiary education (in the population aged 25-64) is slightly above the European average (Figure 2.4). Luxembourg's share of researchers in employment comes close to the OECD average (Figure 2.8).[11]

The increase in public R&D expenditure is paralleled by a substantial increase (Table 2.5) in public sector research personnel (+57%) and researchers (+45%). At the same time, the number of researchers in the business sector has declined slightly.

Luxembourg has successfully accommodated increased demand during the period of expansion (2000-05). The foreseen increase in public funding of R&D in the years to come will create additional demand. The University of Luxembourg will have an important role to play in balancing supply of and demand for human resources for science and technology.

Table 2.5. Researchers per sector, 2000 and 2003

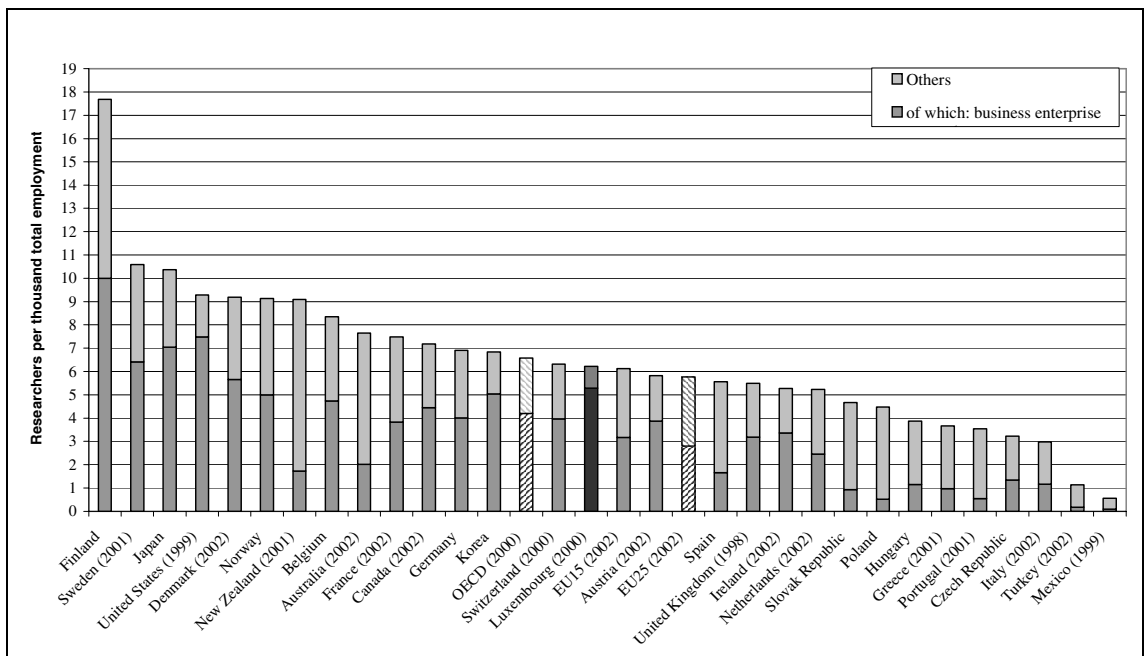
	2000			2003			
Performing sector	**Researchers (FTE)**	**%**	**Research personnel**	**Researchers (FTE)**	**%**	**Research personnel**	**%**
Industry	1 399	85.0		1 338	81.8	3 213	86
Public sector	225	13.6	303	325	16.7	476	13
Higher education	22	1.3		30*	1.5	35	1
Total	**1 646**	**100.0**		**1 693**	**100.0**	**3 724**	**100**

FTE = full-time equivalent. *Source*: STATEC, MCESR, CEPS/INSTEAD, *2001, cited after Statnews (2005).

10. Prior to the foundation of the University of Luxembourg, Luxembourg students had to get their university education and diploma abroad. For this reason, and since registration of a higher education diploma is not compulsory in Luxembourg, there are no reliable national statistics on science and engineering graduates.

11. Note, for example, that, about two-thirds of the total staff at the CRP Henri Tudor and in the Luxembourg-based Technical Centre of Goodyear are foreigners.

Figure 2.8. Researchers per 1 000 total employment, 2003 or latest available year



Source: OECD, MSTI database, May 2005.

2.1.3 Innovation in services

In all OECD countries, innovation in services has been generally neglected in the past. Innovation in services relies primarily on non-R&D inputs which are difficult to measure. Historically, science and technology policy tended to focus on the manufacturing sector, where most formal R&D took place. Today, owing to the importance of the services sector in modern economies, innovation in this sector is increasingly attracting the attention of both researchers and policy makers. The OECD contributes to efforts to understand drivers of innovation in the services sector and the role of public policy to promote it (Tamura, 2005).

Given the structure of Luxembourg's economy and the contribution of services to its economic performance, innovation in services is a key issue for Luxembourg. Luxembourg ranks fifth in terms of the share of knowledge-intensive services in total gross value added (41.3%) and nearly half (48.9%) of total employment is accounted for by knowledge-intensive services, considerably more than in the EU15 on average (37.3%)

Luxembourg plays a major role as an international financial centre. Many banks and important investment trusts have settled there, as its fiscal legislation, which dates back to 1929, favours banks and holding companies. Initially, private banking emerged as the core activity of Luxembourg's financial sector. A number of factors, including a rigorous bank secrecy laws, a strong reputation for property rights protection, and financial liberalisation, contributed to this situation. Later, administration of mutual funds became a major activity and reinforced Luxembourg's position as a prime European centre for all forms of personal investment. The timely transformation of an EU Directive into national law has boosted the industry. Luxembourg has more than 14 000 domiciled holding companies, some 8 500 investment funds, and 220 banks; these form the greatest concentration of banking in the European Union. In addition, major media companies have their headquarters and (part) of their operations in Luxembourg (SES Global, SES Astra, Skype Technologies, RTL Group); Luxembourg is also an attractive location for the logistics industry.

Overall, these industries are highly innovative in terms of developing new products and services and changing their modes of production and delivery, and they recruit highly skilled people to enable these innovations. According to recently published results of the CIS light survey, Luxembourg's services firms have the highest share of products new to the market in total turnover among 16 European countries for which data are available (Statnews, 2006).

At the same time, they do not perform R&D in a traditional way. Value added typically derives from new combinations of, for example, innovative legal solutions or business processes with advanced technology. Luxembourg's science, technology and innovation policy has already started to specifically address innovation in the services sector. A prominent example is the Luxembourg School of Finance. Additional efforts should be made to overcome current obstacles and bottlenecks (*e.g.* rather weak endowment of specialised ICT research capacities in eBusiness solutions, etc.) or to develop long-term relations between research institutions and companies in these industries. The programme of competence centres proposed later in this report could make a major contribution to this effort.

Awareness of the role and needs of the services sector should be further improved, and its representation in the governing and advisory bodies of innovation policy institutions should be increased.

It would be worthwhile to set up an inter-ministerial task force aimed at: a deeper understanding of innovative activities in this sector, the identification of opportunities, and identification of the need for and the warranted form of public support. Luxinnovation should play an important role in this respect.

2.1.4 Business sector R&D and innovation: policy challenges and recommendations

The business sector has been the backbone of R&D in Luxembourg. Its R&D expenditures seem to be stable over the last years, in contrast to increases in the public sector in terms both of funding and performance. As far as innovation behaviour is concerned, the business sector in Luxembourg shows a number of specificities which deserve policy attention:

- *While a large number of firms exhibit some significant innovative activities, R&D activities are concentrated in a few large international firms operating in traditional sectors.* Two-thirds of private R&D expenditures are due to the three or four biggest research performers. Innovation includes both technical and non-technical innovation. Research and innovation policy has to address both the world of incremental, improvement-oriented, non R&D-based innovation and the world of organised, systematic, research-based technological change in which trained people (conducting in-house R&D) and strong relations to external sources of knowledge are key factors. The big R&D performers mainly source knowledge in the *Grande Région* or worldwide.

- *Policy and the public research system have not sufficiently addressed innovation in the services industries.* While the outstanding contribution of services companies, *e.g.* in the financial or media sector, to the performance of Luxembourg's economy is widely acknowledged, their role as innovators is less recognised. As in other OECD countries, most policy initiatives are still aimed at manufacturing and related research fields. Most instruments are either bottom-up and tend to reinforce established R&D-intensive industries (*e.g.* the R&D incentive scheme, the portfolio of Luxinnovation and of the CRPs), or are thematically oriented towards traditional industries (CRPs, clusters). New modes of interaction are required. Increasing awareness and an improved knowledge base are a pre-condition for further policy action.

- It would thus be worthwhile to follow two related strategies: *i)* conduct a foresight study to better understand the workings of the respective sector(s), their innovation behaviour, bottlenecks and need for policy action; *ii)* implement support measures, mainly through adaptation of the existing set of instruments and institutions. The CRPs and in particular the University of Luxembourg would play a crucial role in this context. As a first attempt, setting up a cluster programme would be helpful since this would contribute to an integrated approach involving all relevant actors. Luxinnovation is well-suited to act in this area.

- *Establishment of stronger, long-term links between private and public research: implementation of competence centres.* While industrial firms demonstrate a high degree of satisfaction with existing funding mechanisms, the links between business and public-sector research are still rather weak (ad hoc, short-term, mainly supported through project-based national or EU funding). In the long run, the establishment of stronger, long-term links is desirable for both sides. To achieve this, consider the establishment of so-called competence centres[12] in two or three areas. The involvement of the University of Luxembourg should be mandatory to secure the link to development of human resources (PhD students, post-docs, industrial PhD programme).

- *Focus on the "Grande Région"*. Luxembourg firms are to a large extent oriented towards international markets. Moreover, there is a common understanding among major stakeholders that the *Grande Région* (Greater Region) is the "home market" of Luxembourg firms. It will thus be

12. See Section 4.7.4 for details.

important to adapt policy instruments (with an element of collaboration, *i.e.* the R&D incentive scheme, the cluster programmes, programmes of the FNR, some services from Luxinnovation) to serve networks and joint projects with "foreign" firms and research organisations.

- *Strengthen the cluster approach.* The cluster approach has proven effective in linking different stakeholders and programmes on a large scale. In their present form, however, clusters do not meet these broad requirements. Consider mobilising stakeholders to support the enlargement of the cluster concept to integrate a larger number of actors, support services, etc., in order to address the problems and opportunities of a larger number of firms across sector boundaries.

- *Improve the information for evidence-based innovation policy.* While efforts have already been made in this respect, it is necessary to further develop the statistical base and competence in innovation studies in Luxembourg.[13] Consider implementing a multi-annual research programme involving research teams from Luxembourg and international experts with three goals: to produce up-to-date empirical evidence about the performance of the Luxembourg innovation system, particularly in the business sector; to monitor (policy-induced) changes in the innovation system; and to build competence in the field of innovation and related policy studies, preferably in co-operation with international partners.

13. Allegrezza (2005) sets out an agenda for requirements concerning data collection as well as research in the field of innovation. A number of studies are under way or in preparation. As one example, the observatory of competitiveness (Ministry of Economics and Foreign Trade) has launched a research project to measure productivity and explore its determinants. The project has two components: *i)* innovation and R&D studies based on data from matched files from Community Innovation Surveys and national accounts at individual level; *ii)* business demography and survey of business creators. The project is carried out by Statec and CRP Henri Tudor. A special project dealing with measuring output and productivity in the banking sector has been proposed to FNR. This project is supported by the Central Bank, Statec and the Luxembourg School of Finance at the University of Luxembourg.

Table 2.6. Milestones in science, technology, and innovation policy in Luxembourg

Year	Milestone
1981	First government budget outlay in support of industrial R&D
1984	Creation of Luxinnovation: the national agency for the promotion of research and innovation
1987	Framework law on public sector research
	Foundation of the CRP Gabriel Lippmann
	Foundation of the CRP Henri Tudor
1988	Foundation of the CRP Santé
1989	CEPS/INSTEAD becomes a public establishment under the supervision of the Ministry of State
	Framework law on private sector research
1996	Framework law on higher education
1997	Amendment of the Framework law on private sector research
1998	Launch of the Technoport Schlassgoart pilot project
1999	Creation of the National Research Fund (FNR)
1999	Implementation of the Ministry of Culture, Higher Education and Research
	Decision to increase public spending for R&D from 0.08% to 0.3% of GDP by 2004
2000	Launch of the first four FNR programmes (SECOM, NANO, EAU, BIOSAN)
2002	Launch of the VIVRE programme of the FNR
	Foundation of the Virtual Resource Centre for Knowledge about Europe
	Implementation of Cluster Policy
2003	Law on the establishment of the University of Luxembourg
	Creation of the University of Luxembourg
	Launch of the TRASU and SECAL programmes of the FNR
	Implementation of the "Luxembourg Portal for Innovation and Research"
2004	Adhesion Agreement to ESA
	Launch of the PROVIE programme of the FNR
	Decision to increase public spending for R&D from 0.3% to 1.0% of GDP by 2010
	Framework law on middle class sector research
2005	Full member of ESA
	National Reform Plan in the framework of the Lisbon Strategy

Source: Ministry of Culture, Higher Education and Research; CRP Henri Tudor.

2.2 The evolution of science, technology and innovation policy in Luxembourg

Science, technology and innovation policy, involving specialised institutions, specific regulations, dedicated budgets, etc., and public-sector research in particular, are fairly recent in Luxembourg. The country has long lacked a number of basic elements of what is commonly conceived as a fully fledged innovation system, such as a university sector, public research organisations and government programmes that promote both private and public research. Over the past two decades, Luxembourg has undergone remarkable changes, building up a wide range of specialised institutions and putting in place favourable legal and regulatory frameworks. Table 2.6 provides an overview of the evolution of Luxembourg's science, technology and innovation policy from the early 1980s to the present.

These developments have been accompanied by a rapid increase in public expenditure on R&D, from 0.08% to 0.3% of GDP in the period 1999-2004, and the government is strongly committed to additional investment in R&D and innovation in the years to come.

2.2.1 The "go abroad" approach and the lack of absorptive capacity

In a historical perspective, science, technology and innovation policy making in Luxembourg began in the 1980s. Before that time, Luxembourg mainly relied on a principle that had some merits: "Go abroad!" The five staff members of the Department of Research and Innovation at the Ministry of Culture, Higher Education and Research studied in four different countries. Two-thirds of the Luxembourg-based Technical Centre of Goodyear is recruited from abroad, and most of the remaining third at least obtained their degree abroad. The establishment of Luxembourg's own university was delayed for many years because of reliance on this approach. Moreover, as regards industrial R&D, the policy approach was long dominated by the steel industry and represented "industrial" rather than "research and innovation" policy. What the "go abroad!" approach in higher education and in public research did not sufficiently provide was "absorptive capacity"[14] in both research and education institutions and firms.

14. "Absorptive capacity" refers to the fact that persons, institutions, even (innovation) systems need a certain level of own research activity in order to identify, appraise and adopt externally generated knowledge.

2.2.2 Luxinnovation: Awareness of innovation and focus on SMEs

Things began to change when Luxembourg established Luxinnovation in 1984, an agency for supporting innovation in a wide range of services, which addressed SMEs in particular. This type of institution was the exception rather than the rule at that time, and in fact, only became widespread in the late 1980s and 1990s. The establishment of Luxinnovation can be conceived as a manifestation of an increased awareness of the growing role of "innovation" and of SMEs.

2.2.3 The establishment of CRPs

Truly large steps were taken in 1987 and the following years, when Luxembourg passed a framework law on public sector research, which led to the establishment of the CRP Gabriel Lippmann and the CRP Henri Tudor in 1987 and of the CRP Santé in 1988. Although not a CRP under the framework law, the transition of CEPS/INSTEAD from a private non-profit into a public establishment under the supervision of the Ministry of State in 1989 is worth mentioning. From the point of view of establishing public research capacities, the process of institution building ended in 2003, when the University of Luxembourg was established.

As regards their thematic profiles, two of the three CRPs reflect mainstream technological fields: information and communication technologies; materials, energy and environment. With the wisdom of hindsight – and thus not to be misinterpreted as criticism – some things could have been done differently. First, it would have been an interesting alternative to establish the centres consecutively in order to overcome the problem of running a set of similar, partly overlapping units. Second, public research organisations are now under pressure to define their place between university and industry. Accordingly, most of the more recent organisational approaches attempt to address these two issues more explicitly. Third, training of young researchers and transfer of technology through mobility either in the academic or in the industrial sphere is now high on the agenda. It should be noted, however, that there was no strong need to reflect on a tailor-made configuration of public research capacities at that time, in Luxembourg or in other countries.

2.2.4 A coherent approach to establishing a fully fledged public research system

The creation of a public research system was a further major step in the establishment of a complete research system. In some respects Luxembourg paved the way for the implementation of two major institutional innovations

in 1999: the establishment of the FNR and the Ministry of Culture, Higher Education and Research. At that time, the FNR had basically a single type of client, the CRPs, which received and still receive the lion's share of allocated funding.[15] This is somewhat surprising, as the CRPs should have been governed directly by the ministry with the power and opportunity to shape the CRPs' composition and agenda, not least through funding.

When one puts the creation of the CRPs, the FNR, the Ministry of Culture, Higher Education and Research, and eventually the University of Luxembourg in perspective, a coherent strategy for establishing the building blocks of a complete public research system emerges. Even if this was not an explicit plan of political actors, the period from the late 1980s to the early 2000s can be seen as a process evolving at reasonable pace, with a high degree of coherence, and which left sufficient room for improvement and adaptation.

2.2.5 Increasing public funding of R&D, strong commitment to the Lisbon strategy

With the establishment of the Ministry of Culture, Higher Education and Research in 1999 the then new government decided to increase government expenditure for R&D from 0.08% of GDP to 0.3% over the period 1999-2004. This target was in fact achieved in 2005. The present government decided in 2004 to continue along this growth path and to further increase public funding of R&D from 0.3% to 1.0% between 2005 and 2010. This would boost Luxembourg into the top level of OECD countries (as can be seen in Figure 2.9).

In autumn 2005 the government published the "National Plan for Innovation and Full Employment 2005-2008", which indicates strong commitment to the Lisbon strategy and the Barcelona target. The document was prepared following an extensive consultation process involving all major political and societal actors to address pressing issues and develop specific actions. Accordingly, the "National Plan" can be considered an excellent basis for policy making and priority setting in the coming years.

15. Before the creation of the University of Luxembourg in 2003 the FNR's mission was thus *de facto* restricted to funding the three CRPs.

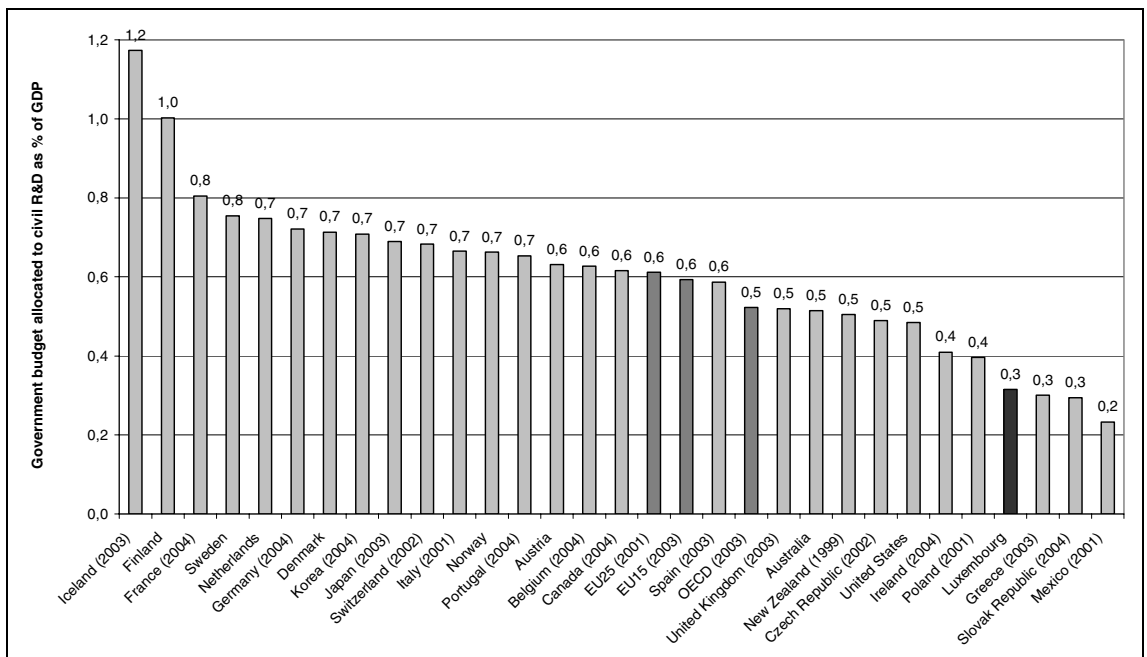
2.2.6 Need and room for improvement and adaptation

Making efficient use of increased public R&D expenditure requires improvement and adaptation, mainly in the area of (policy) governance and management. The process of establishing the CRPs, the FNR, the Ministry of Culture, Higher Education and Research, and the University of Luxembourg, which constituted major steps towards a full-fledged institutional system, can also be interpreted as a process that has led to a system with a high degree of self-referentiality and lock-in. From another perspective, the Ministry of Culture, Higher Education and Research "owns" both the CRPs and the University of Luxembourg as its research performers, and the FNR as its funding arm in addition to its own funding. Moreover, the beneficiaries of the FNR have a voice in the advisory boards of the FNR, and this systematically leads to institutional lock-in.

While there is need for improvement and adaptation there are also viable opportunities for change. The main lines of action will be to rethink the governance of the CRPs, to give a new role to the FNR, and to support and provide long-term good will for the newly established University of Luxembourg. All these actions will have significant repercussions on the Ministry of Culture, Higher Education and Research and the related governance mechanisms and tools.

All these improvements aim ultimately at a single goal, which represents, from the perspective of the various institutions, both a danger and an opportunity. From the perspective of the Luxembourg economy and society, the goal is to open the public research institutions more systematically to economic and societal actors and needs.

Figure 2.9. Government budget allocated to civil R&D as % of GDP, 2005 or latest available year



Source: OECD, MSTI database, May 2005.

Chapter 3

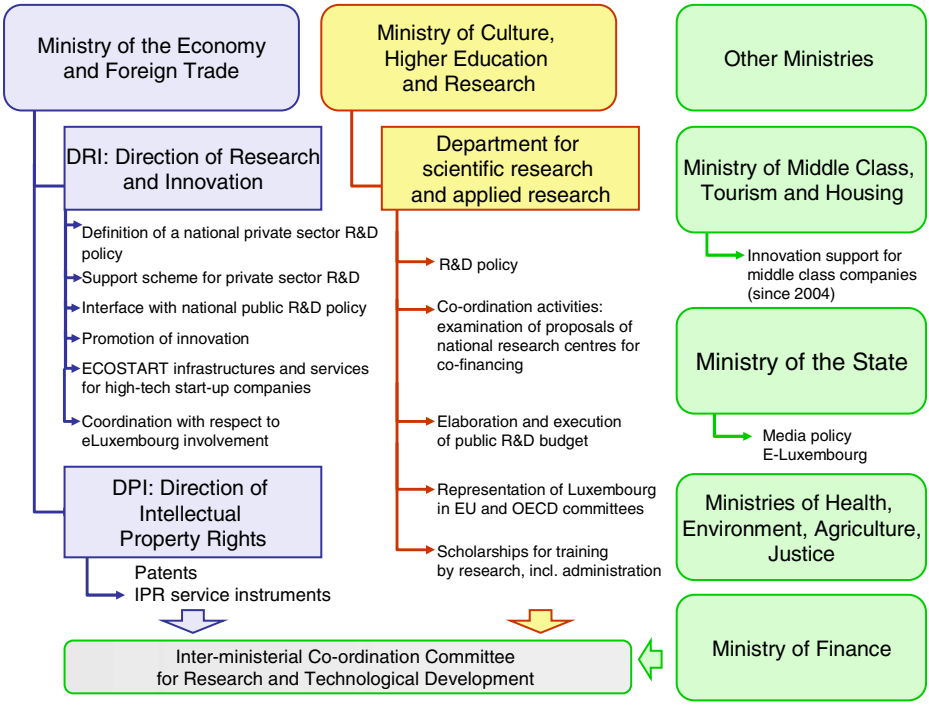
PUBLIC GOVERNANCE OF LUXEMBOURG'S INNOVATION SYSTEM

3.1 Luxembourg's research and innovation policy system: main components and interactions

Luxembourg's research and innovation policy is quite recent and has undergone a number of changes in the last decade. The two major actors are the Ministry of Culture, Higher Education and Research and the Ministry of the Economy and Foreign Trade. Other ministries (Ministry of Middle Class, Tourism and Housing; Ministry of Health; Ministry of the Environment; Ministry of Agriculture, Viticulture and Rural Development; Ministry of State, Media and Communication Service; Ministry of Finance) are generally involved in a more peripheral way. In particular they act as specialised policy institutions (*e.g.* the Ministry of Health for health issues, in particular for the CRP Santé). The Ministry of Finance is involved through its participation in the Inter-ministerial Co-ordination Committee for Research and Technological Development and in the budgetary process. Figure 3.1 provides an overview.

Because the government recognised the need for co-ordination at the ministry level, the Inter-ministerial Co-ordination Committee for Research and Technological Development (CIRD) was created, It was established by law and consists of high-level members of the Departments of Research, of Higher Education and of Culture of its ministry; the Department of Innovation of the Ministry of the Economy and Foreign Trade; of the Ministry of Finance; of the Ministry of Health; and of the Ministry of State. The committee meets from two to four times a year and mainly concentrates on overarching issues and high-level co-ordination such as budgeting. It deals rarely with bilateral co-ordination, *e.g.* to ensure that food safety policy and research in the field of food safety (a priority area of the FNR) are adequately co-ordinated.

Figure 3.1. Public policy actors in research and innovation policy

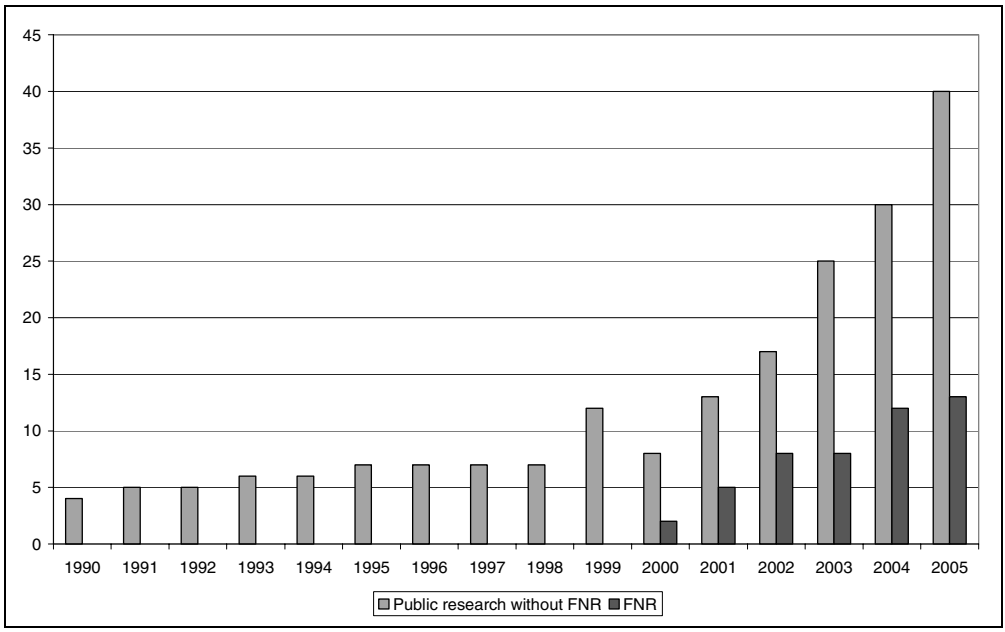


3.1.1 Ministry of Culture, Higher Education and Research

In its present form, the Ministry of Culture, Higher Education and Research was established in 1999. Figure 3.2 shows the shift in Luxembourg's research policy as reflected in the rapid increase in government funding of public R&D from 1999/2000. It reflects the establishment of the FNR and earmarked budgets at the disposal of the Ministry of Culture, Higher Education and Research.

The organisational units responsible for research and higher education are the Department of Research and Innovation and the Department of Higher Education.

Figure 3.2. Government funding of public R&D, million EUR (1990-2005)



Source: R. Kerger, "Luxembourg's Research Landscape", paper presented at a CREST meeting, 23 May 2005.

3.1.1.1 The Department of Research and Innovation

The staff of the Department of Research and Innovation of the Ministry of Culture, Higher Education and Research numbers eight persons (six plus two administrative staff). The department is the main actor for research and technology policy. In 2004 the Department for Research and Innovation covered the following areas:

- Public research policy in the fields of scientific and applied research: related inter-ministerial co-ordination.
- Scientific and technological co-operation at inter-regional, international and European level: co-ordination and implementation.[16]
- *Fonds National de la Recherche* (FNR).

16. Competitiveness Council including FP6, the preparation of FP7, Research Working Group, CREST, OMC networks, COST, JRC, all the Programme Committees of FP6, ESFRI, Helsinki Group, ESA Council and Committees, several OECD committees.

- Commissariat of the public research centres (Gabriel Lippmann, Henri Tudor, Santé), as well as of CEPS/INSTEAD and the Virtual Centre for Knowledge in Europe (CVCE).
- Technology transfer and innovation: promotion of entrepreneurship, promotion of technology and innovation-based firm start-up.
- Human resources: scholarships for training and research, mobility.
- Co-ordination of Luxembourg's policy with respect to the European Space Agency (ESA).[17]

Moreover, the department prepares the national R&D policy agenda and ensures its implementation. A major share of the department's activities has involved the co-ordination of funding of the three CRPs, CEPS/INSTEAD and the CVCE. In the past the CRPs were funded on a project basis, but a new policy has been implemented to fund programmes on the basis of contract agreements on the one hand and of a limited number of pre-selected areas on the other.

While most policy-related tasks are carried out by institutions such as the FNR, the CRPs, Luxinnovation, etc., some are carried out in the department, in particular the "training through research fellowships" which support graduates holding doctoral and post-doctoral degrees who are involved in high-quality research projects with an exploitation potential in Luxembourg. The predecessor of the Ministry of Culture, Higher Education and Research was a founding member of Luxinnovation.

Finally, the Department of Research and Innovation represents Luxembourg in international committees, in particular at the EU and the OECD, and, as already indicated, at ESA.

3.1.1.2 The Department of Higher Education

The department is responsible for the development and continuity of Luxembourg's higher education sector. It has raised awareness of Luxembourg's higher education sector among Luxembourg society and of its development potential at national, European and international level.

The department was heavily involved in preparing draft legislation for the creation of the University of Luxembourg and in introducing post-graduate training. It is also active at the European level in the context of the

17. Two of the eight people are involved full-time in ESA matters.

Bologna Process and at international level in the framework of the Campus Europa project (European University Foundation project).

The department is also responsible for documentation on national and international higher education and manages public financial support for higher education through its Centre for Documentation and Information on Higher Education (CEDIES).

3.1.2 Ministry of the Economy and Foreign Trade

The Ministry of the Economy and Foreign Trade is primarily responsible for policy regarding Luxembourg's economic competitiveness. Its priorities include the following four areas: enterprise, technology and competitiveness; regional economic development; research and technological development, technology transfer and innovation; and industrial and intellectual property rights.

Within the General Directorate of Business, Economic Development and Foreign Commerce of the Ministry of the Economy and Foreign Commerce, the Department of Research and Innovation is in charge of technology and innovation policy. It has a staff of four (plus one administrative staff). Generally, technology and innovation policy aims to encourage Luxembourg companies to increase their R&D and innovation efforts, in close co-ordination with activities to promote entrepreneurship and firm creation. The following activities of the ministry address business enterprises directly:

- Awareness activities for industrial research and innovation.
- Information about national and European measures and programmes and instruments.
- Promotion of individual technological competences and aggregate "poles of competence".
- National and international networking of companies, research centres and universities to facilitate exchange of technologies and co-operation.
- Financial encouragement of individual or co-operative R&D projects.[18]
- A business innovation centre called ECOSTART was recently created to act as an incubator for companies in the start-up phase and to provide

18. For details see Section 3.3.

office space for companies in their development phase and for foreign companies seeking to establish themselves in Luxembourg.

These activities are provided through the ministry and through related external institutions such as Luxinnovation (whose board is currently chaired by the Ministry of the Economy and Foreign Trade), the National Portal of Innovation and Research, ECOSTART, the cluster programme or Information Society initiatives.

Financial support for innovation projects can be provided on the basis of the framework law on development and economic diversification of July 1993, of which Article 6 addresses stimulation of business R&D. Both innovation projects and projects aimed at creating or widening research capacities are eligible for funding. Public funding is expected to provide an incentive to take the risk inherent in technological development. Applications must be submitted prior to undertaking research activities. Funding takes the form of subsidies which can be complemented by innovation credits provided on favourable terms by the SNCI, the national company for credit and investment.[19] According to the assessment of the technological risk involved, funding ceilings vary between 25% and 75%. Additional incentives of 5%, 10%, 15% or 20% may be provided to SMEs for transnational collaboration, for participation in the European framework programmes or EUREKA, or for wide diffusion of results.

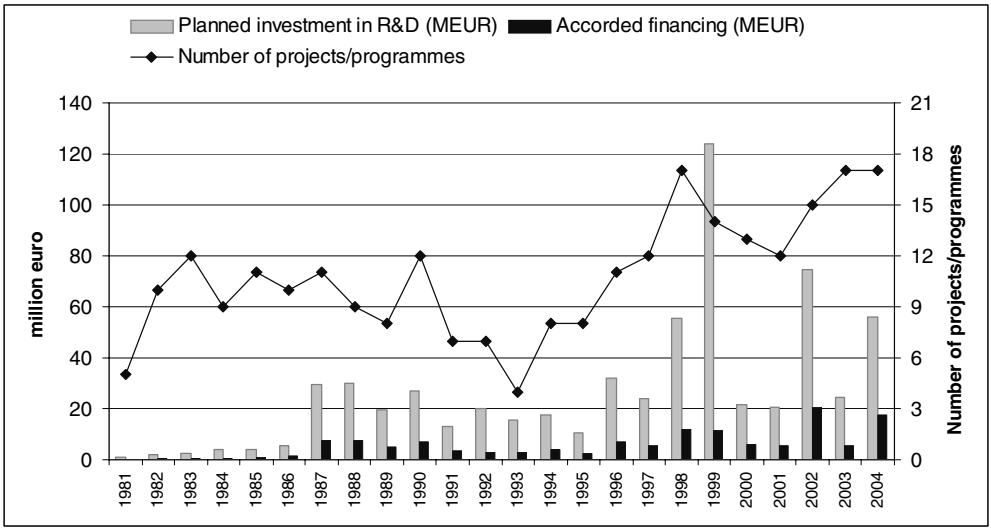
Figure 3.3 indicates that the number of projects or programmes funded annually varies between four and 17, with an annual budget reaching up to EUR 20 million.

As indicated above, the Ministry of the Economy and Foreign Trade is represented on the Board of Administration of the National Research Fund, in the CRPs and in Luxinnovation (currently as chair). For its part, the Department for Research and Innovation of the Ministry of Culture, Higher Education and Research is represented in the Special Inter-ministerial Advisory Board, foreseen under Article 14 (2) of the framework law on development and economic diversification of July 1993 concerning the evaluation of private-sector research and innovation projects applying for support based on Article 6 of that law. While it is clear that the level of commitment differs from case to case, the presence of these actors on the respective boards ensures a certain level of information exchange and agenda shaping.

19. For details see Section 3.3.2.

As regards policy intelligence (foresight activities, background papers, identification of policy needs, etc.), the Department of Research and Innovation strongly relies on the services of Luxinnovation. This is due in part to staff shortages within the department.

Figure 3.3. Evolution of the number of projects, expenses in R&D and funding



Source: www.eco.public.lu/

3.1.3 Ministry for the Middle Class, Tourism and Housing

The Ministry of Middle Class, Tourism and Housing is responsible for policy for the commercial development of Luxembourg's skilled craft companies. With the recent adoption of the framework law that creates a measure for co-financing R&D in SMEs, this ministry will play a more important role in the future.

With respect to R&D and innovation the ministry has issued an "Action plan for small and medium-sized enterprises 2001-2006",[20] which takes over from the 1996-2000 initiative. Its overall aim is to create a supportive environment for SMEs. Special attention is given to the creation of enterprises and the training of the business managers. Its goals are:

20. See *www.mcm.public.lu/en/plan/plan01-06/index.html*

- To simplify formalities and reduce administrative charges.
- To efficiently restrain unfair competition.
- To maintain a tax environment that is favourable to the spirit of enterprise, in particular a reduction of the tax charge on enterprises from 37.45% to 30%.
- To reinforce financial support in favour of enterprises.
- To accompany enterprises' efforts in matters of training.
- To reconcile enterprises and the environment.
- To ensure that legislation concerning work and social charges is favourable to growth and employment.
- To maintain and reinforce the ability of Luxembourg enterprises to compete, among others by adapting public contracts to SMEs, setting up incubators and promoting and supporting quality.

3.1.4 Ministry of State, Media and Communication Service

The task of the Media and Communication Service – the part of the Ministry of State that is of relevance in the present context – is to support the minister and to devise and to implement media policy in Luxembourg. As part of the country's economic diversification, the Media and Communication Service is also responsible for promoting the Grand Duchy as a European audiovisual and communications centre. To fulfil its mission, it works in close co-operation with the Ministry of the Economy and Foreign Trade and the Ministry of Foreign Affairs. In addition, the Ministry of State has for a long time supervised CEPS/INSTEAD. With the inauguration of the new government in 2004 the responsibility for CEPS/INSTEAD was transferred to the Ministry of Culture, Higher Education and Research.

Moreover, the Media and Communication Service was in charge of implementing the eLuxembourg project until 2004 and was thus involved in a number of initiatives, among them the "Luxembourg Portal for Innovation and Research" (*www.innovation.public.lu*). This is now the responsibility of the Ministry of Civil Service and Administrative Reform (*Ministère de la Fonction publique et de la Réforme administrative*).

3.1.5 Interaction between ministries

To better co-ordinate research and innovation policy, an Inter-ministerial Co-ordination Committee for Research and Technological Development was set up in 1987, based on the Framework law on public sector research. It is

composed of representatives of the Ministry of Culture, Higher Education and Research, of the Ministry of the Economy and Foreign Trade, of the Ministry of Finance, of the Ministry of State and of the Ministry of Health. It has the following tasks:

- To prepare a report on R&D-related activities financed directly by the various ministries.
- To submit a proposal for the annual or multi-annual R&D programme.
- To submit a co-ordinated proposal regarding budget allocations and expenditures of the CRPs.
- To submit a budget proposal concerning the budget allocation for the "training through research" fellowships.
- To give its opinion on any other question concerning inter-ministerial co-ordination as regards R&D.

The committee has some influence on research and innovation strategy, notably owing to its task of formulating a co-ordinated proposal on R&D budget allocations in the public sector. Moreover, representatives of the ministries in the committee are directly involved in the implementation of research and innovation policy.

In 2003, the government set up an inter-ministerial working group with members of the Ministries of Culture, Higher Education and Research, of Economic Affairs and Foreign Trade, of the Middle Class and of the Ministry of Finance, to elaborate and design in a co-ordinated way a multi-annual action plan in the spirit of the European Commission's Action Plan "More Research for Europe". This working group has been dissolved.

Apart from their direct interaction at the ministerial level, ministries and other policy actors collaborate on or co-ordinate their specific agendas in various other ways. For example, the Board of Administration of the FNR includes delegates not only from the supervising Ministry of Culture, Higher Education and Research but also from the Ministry of the Economy and Foreign Trade, the Ministry of Health and the Ministry of Finance. The CRPs follow the same pattern by including – in a selective way – the Ministry of the Economy and Foreign Trade and the Ministry of Health, Finally, joint ownership of Luxinnovation by the Ministry of the Economy and Foreign Trade, the Ministry of Culture, Higher Education and Research, the Ministry of the Middle Class, Tourism and Housing, FEDIL, the Chamber of Commerce and the Chamber of Skilled Crafts is worth mentioning.

Although all of these institutions are formally governed by boards which generally represent a wide range of institutional actors, they typically have a single "owner". For the CRPs, the University of Luxembourg and the FNR, the "owner" is the Ministry of Culture, Higher Education and Research. The Ministry of the Economy and Foreign Trade considers itself responsible for Luxinnovation. Responsibility for ESA affairs is assigned, merely for historical reasons, to the Ministry of Culture, Higher Education and Research.

3.2 Promotion of R&D in the public sector: The National Research Fund

The law of 9 March 1987 set the framework conditions for a substantial research plan at national level. However, even under these supportive framework conditions, public spending on R&D remained at a rather low level until 1999. Only after a slowdown in 2000 did public expenditure on R&D increase significantly (Figure 3.2).

In 1999, two major decisions were taken, one by the government in office from 1994 to 1999 which led to the creation of the National Research Fund, and one by the 1999-2004 government to increase public R&D expenditure as a share of GDP from 0.08% to 0.3% by 2004.

In 2000, the FNR started to define research priorities. These address specific areas and operate as programmes that typically last for seven years. The programmes aim at scientific excellence and have well-defined opportunities for socioeconomic outcomes at national level. Parts of the programmes are elaborated in co-operation with the private sector and require active participation by industry.

3.2.1 Objectives, mission and tasks of the FNR

The FNR was set up under the Law of 31 May 1999 to stimulate research activities in Luxembourg. Its role is to create new competence and knowledge, strengthen existing competence and knowledge, and develop national and international synergies in order to increase the attractiveness of Luxembourg as a scientific and economic site of excellence.

Its mission is twofold and addresses two separate areas. Its primary mission is to receive, manage and use funds and donations of public or private sources to promote public-sector research and technological development at the national level. At the same time, it is an active player in

Luxembourg's research system through its participation in ongoing discussions of the orientation of national R&D policy, as expressed in the following tasks:[21]

1. To develop proposals relating to the objectives of national R&D policy.
2. To suggest priority actions to reach these objectives.
3. To develop, on the basis of the chosen objectives, multi-annual activity programmes and contribute to the establishment of a multi-annual R&D programme at the national level.
4. To ensure, through the allocation of the funding at its disposal, the implementation of the multi-annual activity programmes and related follow-up.
5. To ensure systematic and regular evaluation of the results obtained, in order to allow any necessary readjustment of priorities.
6. To promote the efficient co-ordination of national R&D activities and Luxembourg's participation in international R&D co-operation programmes.
7. To present to the minister responsible for scientific and applied research, on its own initiative, proposals, suggestions and information regarding the implementation of national R&D policy.

This comprehensive set of tasks implies that the FNR is not merely an instrument for implementing government policy. It has a broad role which extends well beyond the task of developing and running its own programmes. This is particularly the case with respect to tasks 1, 2, 6, and 7.

3.2.2 Structure of the FNR

The FNR is a public establishment with scientific, financial and administrative autonomy. It is governed by a Board of Administration, advised and assisted by the Scientific Council. The Board of Administration consists of:[22]

21. *Journal Officiel du Grand-Duché de Luxembourg*, *Recueil de Legislation,* A – No. 88 6 July 1999.

22. Ibid.

- One member, nominated by each of the ministers concerned, whose areas of responsibility cover scientific research and applied research, higher education, industrial research and development, technology transfer or the budget.
- Two members nominated by the Council of Government after consultation with the other ministers involved in R&D.
- Six members from the private sector recognised for their competence in the field of R&D nominated by the government.

The Scientific Council assists the Board of Administration as a consultative body on scientific matters. It consists of:

- A representative of each public research centre (CRP Henri Tudor, CRP Gabriel Lippmann, CRP Santé).
- A representative of the CEPS/INSTEAD.
- Two representatives of the University of Luxembourg.
- Persons external to the bodies mentioned above, from Luxembourg or abroad,[23] selected on the basis of their competence. Their number exceeds by one that of the bodies listed.

3.2.3 Approach used to select priority research programmes

The FNR performs its core operations – funding research activities – on the basis of multi-annual priority research programmes. The selection of research programmes is thus critical to the performance of the FNR, and to this end the FNR has adopted a procedure that makes active use of existing research capabilities, mainly represented by the CRPs, assisted by international experts. The FNR thus matches existing capabilities with future opportunities by involving institutions and individuals in defining priority research programmes. The procedure used to select priority research programmes is as follows:

23. Four of the six experts are from abroad; however, in most cases, they are expatriate Luxembourgers.

- Consultation of public bodies, research institutes and actors from the private sector for ideas for a new research programme.[24]
- Selection by the FNR of new priority areas.
- Detailed proposal worked out by a group of experts and the FNR; consultation of the Scientific Council and of international experts for advice before adoption of the final text; if necessary, opportunity study.[25]
- Proposal by the FNR to the government via the Ministry of Culture, Higher Education and Research to support a new multi-annual programme.
- Adoption of the new programme by the Government Council and signature of a contract between the government and the FNR (signed by the Minister of Research and the Minister of Finance).
- Call for project proposals.

The FNR employs criteria for the selection of priority research programmes which match existing resources and capabilities in Luxembourg with opportunities for scientific progress and socioeconomic value. The criteria used for programme selection are: scientific quality, socioeconomic value, mobilisation of national resources, realistic in the context of Luxembourg, budget breakdown.

3.2.4 Collaboration between the Board of Administration and the Scientific Council

Procedures for the selection of multi-annual programmes and research projects are organised so that they cannot operate independently. They have specific and complementary roles. Both bodies meet consecutively, within two weeks' time to carry out their specific tasks (see Figure 3.4). While the

24. Except for the first call for programme proposals in 2000, where only the CRPs were asked, the FNR tries to involve all stakeholders, including the private sector, in the programme definition process. Proposals from the private sector are still scarce. It may look as though the programmes were defined to support the CRPs but it is mainly a reflection of the low commitment of industry. In the planned foresight study, the FNR will try to more actively involve industry in the process of programme definition. Likewise, increased co-ordination of financing instruments with the Ministry of the Economy should improve the impact of FNR programmes on the private sector.

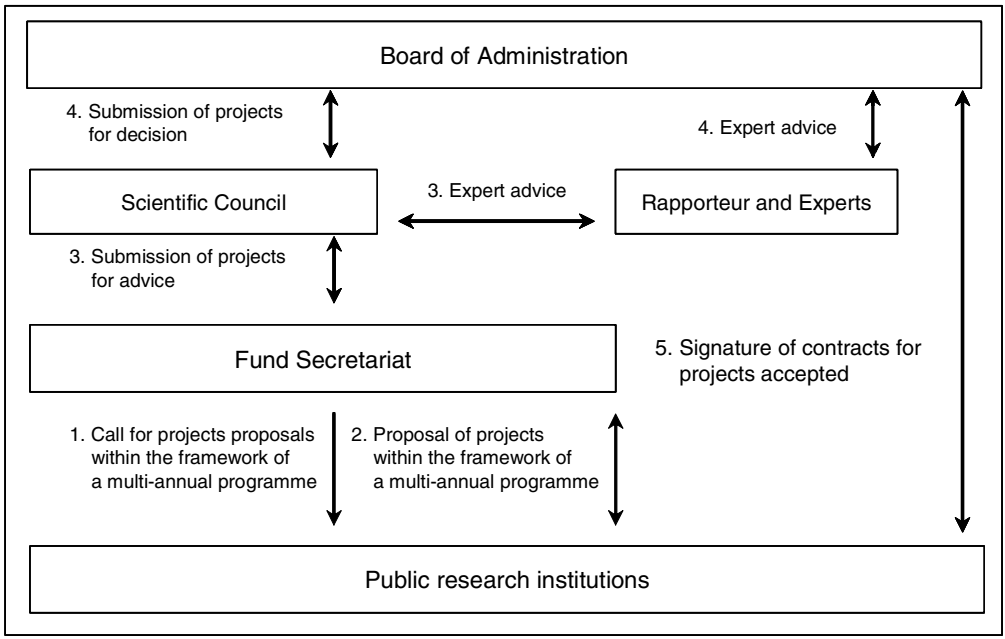
25. Such exercises were actually performed for the SECAL and the TRASU programme. Currently, the FNR is conducting a foresight exercise.

core task of the Scientific Council is to give advice, that of the Board of Administration is to decide upon project funding and to propose programmes to the government.

3.2.5 Programmes carried out by the FNR

Nine national multi-annual priority programmes are currently under way. Table 3.1 provides an overview. Four programmes (SECOM, NANO, EAU, BIOSAN) started in 2000, *i.e.* one year after the establishment of the FNR. In 2002, VIVRE and in 2003 TRASU and PROVIE (an extension to BIOSAN) and SECAL started operation. INTER was launched in 2006. Accordingly, FNR has distributed its programmes over time, by not starting all programmes at once, it can respond as necessary to new opportunities or needs. Table 3.2 provides an overview of the allocated funding under the respective programmes.

Figure 3.4. FNR procedure for project selection



Source: FNR, Annual Report 2004.

Table 3.1. Programmes carried out by the FNR

Programme	Duration	Budget (EUR)	Calls	Details
Security and Efficiency of New Practices in e-commerce (SECOM)	2000-07	7.5 million (13%)	Calls in 2001 and 2004: 9 projects selected. 3rd call in 2005.	To better master the new contexts of electronic co-operation, the SECOM programme will undertake integrated research on the safety of electronic exchange and on the efficiency of new organisational models and software for electronic co-operation.
New Materials and Nanotechnology (NANO)	2000-08	6.7 million (11.6%)	1st call in 2001: 3 projects selected (EUR 6 million). 2nd call planned in 2005: (available: EUR 700 000).	The NANO programme aims at creating a European centre specialised in the characterisation of materials on the nanometre scale. The characterisation of a material (plastic, metal, glass, and biological tissue or cell) may be analytical, morphological or functional.
Sustainable Management of Water Resources (EAU)	2000-07	5 million (8.7%)	1st call in 2001: 8 projects selected. 2nd call in 2005.	The general objective of this programme is to establish in Luxembourg a pool of excellence in the field of water, capable of grasping the complex mechanisms of the natural water cycle, of evaluating the means to protect water resources and water quality, to develop the most appropriate and the least expensive innovative technologies for control and water purification and to fight against wasting water. Five priority areas: Quality of surface waters and aquatic ecosystems, Hydrological functioning of rivers, Protection of ground water, Advanced technologies for water management, Socio-economic aspects of water resource management in view of a sustainable development.
Biotechnology and Health (BIOSAN)	2002-08	6 million (10.4%)	1st call in 2001: 7 projects selected.	The purpose of BISOAN is to contribute to the qualitative improvement of prevention, detection and treatment of cancer and cerebro- and cardiovascular diseases and to develop new strategies for the specific modulation of the immune system. Six priority areas: Cancer, Cardio- and cerebro-vascular diseases, New strategies for immunology intervention, Medical aspects of ageing (new extension), Development of expression libraries for the functional and topographical targeting of complex biological systems, Epidemiology. Intelligent data-processing environments in the field of health.

.../...

Table 3.1. Programmes carried out by the FNR *(continued)*

Programme	Duration	Budget (EUR)	Calls	Details
Extension of the Biosan Programme: Medical Aspects of Ageing (PROVIE)	2004-08	2.5 million (4.3%)	1st call in 2003: 4 projects selected.	The aim of PROVIE is to study the epidemiological, psychosocial and biological aspects of the neurodegenerative diseases of old age in Luxembourg and view them against the broader European canvas. Priority will be given to projects which are multidisciplinary and interactive, involving players from different specialist backgrounds: *i)* To improve the skills of the biomedical community in Luxembourg and the transfer of knowledge concerning pathologies linked to ageing of the brain, *ii)* To correlate medical, epidemiological, psychosocial and biological aspects, *iii)* To improve the prevention of cerebro-vascular accidents (strokes), *iv)* To acquire innovative detection methods for neurodegenerative diseases, depression, sleep disorders and chronic pain in the elderly, *v)* To devise new specific treatment strategies for the above pathologies, *vi)* To improve the care of the patients and their families, *vii)* To develop new therapies
Living Tomorrow in Luxembourg (VIVRE)	2002-09	12 million (20.8%)	1st call 2002: 14 projects selected. 2nd call at the end of 2005 (deadline 15/03/2006), further calls planned for 2006 and 2007: Participation of the VIVRE programme in ESF – EUROCORES (European Collaborative Research Projects in the Social Sciences).	VIVRE defines several thematic priorities within the social sciences and humanities in order better to understand the challenges that the Luxembourg nation and society will have to face: *i)* the evolution of the Luxembourg population, from a demographical, social, cultural and historical point of view, *ii)* the development of human resources, *iii)* the educational and training system, *iv)* the era of information and communication and its consequences for society, *v)* the place of a small country like Luxembourg in the *Grande Région*, the European Union and a global world, with a specific focus on the perspectives of the Luxembourg financial market, vi) the organisation of "space", town and country planning.

…/…

Table 3.1. Programmes carried out by the FNR *(continued)*

Programme	Duration	Budget (EUR)	Calls	Details
Surface treatments (TRASU)	2003-2008	6 million (10.4%)	1st call in 2003: 1 project Following the first call for project proposals in 2003, 2 projects were submitted and later assessed by international experts. Many Luxembourg companies and national as well as international academic partners joined. FNR has decided to merge these two projects into one, in order to better develop new competences.	Each selected project must include research in surface treatments by a public institute, characterise and analyse the obtained results, co-operate with at least one industrial partner, and co-operate with an Institute outside of Luxembourg.
Food Safety (SECAL)	2003-2008	6 million (10.4%)	1st call in 2003: 6 projects selected	The aim of SECAL is to develop a body of scientific expertise and resources in Luxembourg in matters of food safety, serving all the actors involved, such that the base of scientific knowledge can be widened and new methods of surveillance and risk avoidance can be developed. Priority will be given to the following areas of research, ranging from risk assessment to the study of prevention strategies: Traceability of foods (including genetically modified organisms-GMOs); Chemical and microbiological quality of food (including drinking water); Impact on human health and consumer protection. .../...

Table 3.1. Programmes carried out by the FNR *(continued)*

Programme	Duration	Budget (EUR)	Calls	Details
INTER	2006-2011	6 million (10.4%)		The general aim of INTER is to enhance international co-operation, to develop new international partnerships, to facilitate participation in international initiatives for co-operative funding of projects with partners from several countries, and to increase the scope and impact of current domain-specific programmes. The main utility of INTER will be the added flexibility by which the FNR can support Luxembourg research in the priority domains of the FNR, and permit access to the various funding initiatives that present themselves in the European context and worldwide. A multinational approach will help reach critical mass and visibility within Europe and elsewhere as well as help solve transnational issues. INTER may facilitate access to specialised equipment or databases not readily available to the Luxembourg research communities. In particular, the social and medical sciences projects will have a huge gain from the richness and diversity of European society, when made accessible through international co-operation. Finally, INTER will help build synergies between research centres in Luxembourg and outside Luxembourg and thus increase competitiveness of research in Luxembourg on an international level.

Source: FNR, Annual Report 2004, *www.fnr.lu* A total of EUR 51.7 million has been earmarked for the period 2000-07 (except for INTER), of which EUR 43 million (83%) had been contracted by 2004 (Table 3.2).

Table 3.2. Allocation of FNR funding by programmes, 2000-04

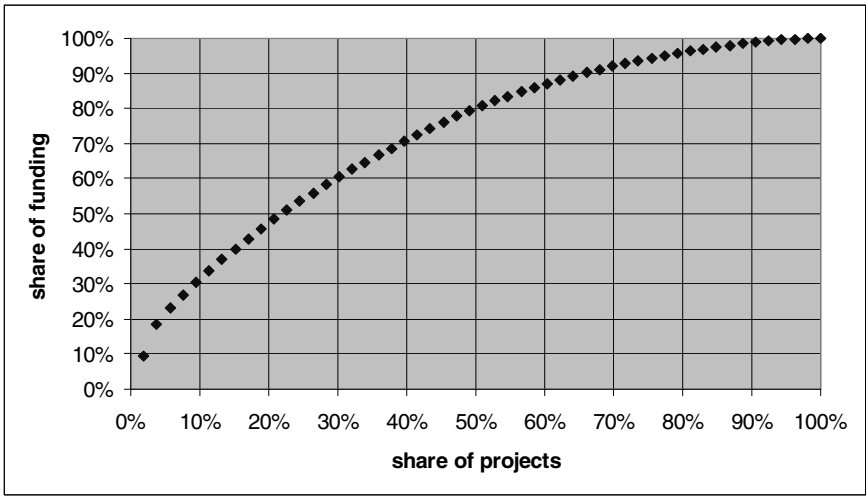
Programme	Co-ordinating institutions	Project budget* [EUR]	Programme	Co-ordinating institutions	Project budget* [EUR]
SECOM	CRP Gabriel Lippmann	1 200 000	**PROVIE**	CRP Santé	1 250 000
	CRP Gabriel Lippmann	1 499 957		University of Luxembourg	530 000
	University of Luxembourg	800 000		CRP Santé/Central Hospital	75 000
	CRP Henri Tudor	1 499 978		CRP Santé/Central Hospital	315 000
	CRP Henri Tudor	1 000 000		**Sub-total**	**2 170 000**
	University of Luxembourg	399 147	**VIVRE**	CEPS/INSTEAD	440 000
	CRP Henri Tudor	540 000		University of Luxembourg	316 472
	University of Luxembourg	151 378		University of Luxembourg	100 000
	CRP Gabriel Lippmann	229 900		University of Luxembourg	310 000
	Sub-total	**7 320 360**		University of Luxembourg	500 000
NANO	National Health Laboratory	1 139 069		University of Luxembourg	260 000
	CRP Gabriel Lippmann	860 931		CRP Santé	210 000
	CRP Gabriel Lippmann	4 000 000		University of Luxembourg	120 000
	Sub-total	**6 000 000**		CRP Gabriel Lippmann	998 486
EAU	CRP Gabriel Lippmann	809 971		National Museum of Natural History	250 000
	CRP Gabriel Lippmann	750 000		National Museum of Natural History	390 000
	CRP Gabriel Lippmann	800 000		CRP Gabriel Lippmann	449 924
	Service Géologique	57 760		CEPS/INSTEAD	250 000
	CRP Henri Tudor	386 899		University of Luxembourg	220 000
	CRP Henri Tudor	579 765		**Sub-total**	**4 814 882**
	CRP Henri Tudor	920 235	**TRASU**	CRP Henri Tudor	4 000 000
	CRP Henri Tudor	500 000		CRP Gabriel Lippmann	2 000 000
	Sub-total	**4 804 630**		**Sub-total**	**6 000 000**
BIOSAN	CRP Santé/Central Hospital	558 570	**SECAL**	CRP Henri Tudor	800 000
	CRP Santé/Central Hospital	184 927		CRP Henri Tudor	1 200 000
	CRP Santé/Central Hospital	490 000		CRP Santé	1 199 980
	CRP Santé	1 100 000		CRP Gabriel Lippmann	983 437
	CRP Santé/Central Hospital	720 000		CRP Gabriel Lippmann	848 716
	CRP Santé	1 400 000		National Health Laboratory	849 400
	National Health Laboratory	1 546 503		**Sub-total**	**5 881 533**
	Sub-total	**6 000 000**	**Total**		**42 991 905**

* Note: In this table, the whole project budget is imputed to the co-ordinating institution. Financial contributions to partners are not detailed.
Source: FNR, Annual Report 2004, *www.fnr.lu*

3.2.6 Beneficiaries of the FNR's intervention

The allocation of FNR funding is highly concentrated: 50% is allocated to 25% of the largest projects, two-thirds of overall funding to one-third of the projects, 80% of funding to 50% of the projects (Figure 3.5).

Figure 3.4. Concentration of FNR funding



Source: FNR, Annual Report 2004, *www.fnr.lu*

FNR beneficiaries are the CRPs created on the basis of the Law of 9 March 1987, the public institutions of higher education created by the Law of 11 August 1996 on the reform of higher education, *i.e.* the University of Luxembourg, the CEPS/INSTEAD and the bodies, services and public institutions authorised to undertake research activities as well as development and technology transfer activities in their fields of competence, with a view to promoting scientific progress and technological innovation.

Table 3.3 provides an overview of the allocation of FNR funding over the period 2000-04. It clearly indicates the strong position of the three CRPs. Three-quarters of FNR's funding goes to the three CRPs. Thus the policy of the CRPs and that of FNR are *de facto* strongly interconnected. This has implications for the adjustment of policies and policy processes. The University of Luxembourg, too, has attracted a certain share of the funding, in part because it took over competences and activities from its constituent institutions.

The dominant position of the CRPs is in line with the FNR's role in the co-ordination of the CRPs. The first project, with two CRPs collaborating, was financed by the FNR and many have since followed. The Scientific Council with representatives from the major public research organisations should play an important role in co-ordinating research activities within its own realm, *i.e.* the funding of research.

Table 3.3. Allocation of FNR funding by beneficiaries, 2000-2004

Institution	Allocation (EUR)	Share
CRP Gabriel Lippmann	15 431 322	36%
CRP Henri Tudor	11 426 877	27%
CRP Santé	5 159 980	12%
University of Luxembourg	3 706 997	9%
National Health Laboratory	3 535 472	8%
CRP Santé/Central Hospital	2 343 497	5%
CEPS/INSTEAD	690 000	2%
National Museum of Natural History	250 000	0.6%
National Museum of History and Art	390 000	0.9%
Geology Service	57 760	0.1%
Total	**42 991 905**	**100%**

Source: FNR, Annual Report 2004, *www.fnr.lu.*

3.2.7 Accompanying measures

In addition to financing research, the FNR supports accompanying measures in order to reinforce awareness, mobility, networking, etc., as part of the general framework of scientific research in Luxembourg. The budgets earmarked for accompanying measures increased from EUR 190 000 in 2001 to EUR 760 000 in 2004. In that year, FNR selected a total of 134 activities from the 150 proposals submitted (almost 90%). Table 3.4 provides an overview of measures, proposals and allocated budgets in 2004.

Although the budget earmarked for accompanying measures may be considered somewhat limited, the activities supported, together with those for international co-operation, contribute both to accomplishing the core research activities and to keeping up with international developments.

Table 3.4. Accompanying measures, 2004

	Number of proposals received	Number of proposals accepted	FNR contributions (EUR)
Promotion of scientific awareness, international scientific co-operation or national R&D co-ordination	16	13	152 460
Active participation of novice researchers in scientific conferences	41	39	39 115
Organisation of scientific conferences in Luxembourg	46	40	380 180
Scientific publication/publication of a doctoral thesis	26	25	53 576
Preparation of EU projects	1	1	10 000
International mobility of researchers	20	16	115 219
Training in IPR/training in management for research projects	0	0	0
Science festival (no science festival in 2004 but in 2005)	0	0	0
Total	**150**	**134**	**750 552**

Source: FNR, Annual Report 2004, *www.fnr.lu.*

3.2.8 International co-operation

The FNR represents Luxembourg in international organisations and funds relevant activities. Because Luxembourg can only cover a small number of fields in research and higher education, international co-operation, mobility of students and researchers, and prioritisation of activities are key to the performance of the overall research system. Since all dimensions of research and research policy are concerned, international co-operation addresses a wide range of actions and goals.

- European Science Foundation (ESF): membership since 2002.
- European Research Area Networks (ERA-NET): membership since 2003, three ERA-NET in the field of Materials (ENMatSSA), ERA-NET Neuron, ERA-NET ERA-AGE .
- European Research Consortium in Informatics and Mathematics (ERCIM), with a high degree of Luxembourg involvement.
- International Council for Science (ICSU): membership since 2005.
- European Union Research Organisations' Head of Research Councils (EUROHORCS).

- USE-MAT: National Science Foundation – Europe since 2003. The FNR collaborates with the US National Science Foundation (NSF) in the Materials World Network.

Over the past years the international dimension of the FNR's activities was addressed on a case-by-case basis within the thematic programmes or partnerships and participations listed above. Early in 2006 the FNR launched the INTER programme, which is explicitly aimed at international co-operation and enhancing the scope of the research portfolio mainly through networking and transnational collaboration.

3.2.9 FNR's budget 2001-10 and future directions

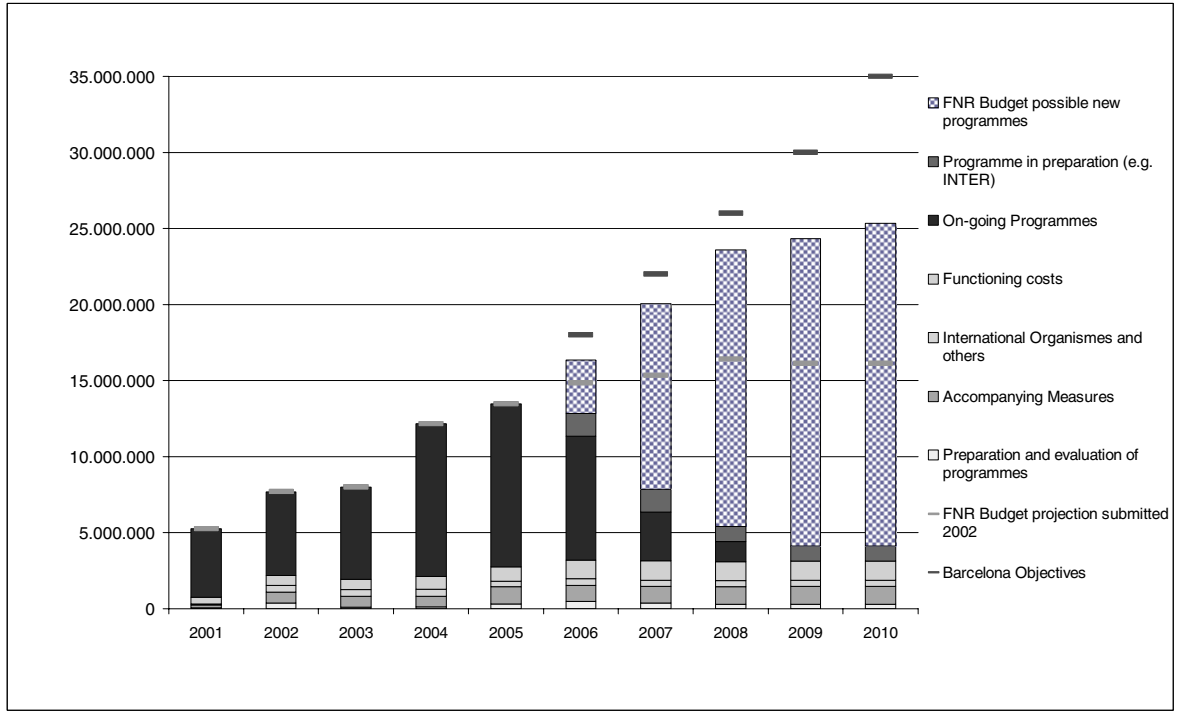
Luxembourg's government envisages increasing public funding of R&D to GDP from 0.3% in 2005 to 1.0% in 2010. As a major actor in the field, the FNR is planning its future budgets accordingly. Figure 3.6 provides an overview. The qualitative aspect deserves attention as well. The FNR is strictly following a policy of allocating funds via programmes. Present programmes do not have much room for individual bottom-up projects and this should continue in order to avoid dispersion of activities due to specific priorities of the applying institutions.

To address the increasing importance of international collaboration in research, the FNR launched the INTER programme early in 2006. The programme aims at facilitating the participation of public research organisations in international initiatives for co-operative funding of projects with partners from several countries.

Finally, the FNR is currently conducting a foresight exercise with the following aims:

- Identification of research domains in the public sector of short- or long-term socioeconomic interest for Luxembourg's society.
- Developing new FNR programmes in these domains, with programme priority axes and objectives, clarification and dissemination of strategic aims of FNR programmes among stakeholders, consolidation of communication networks among stakeholders, evidence that FNR programmes take into account the views of the government, the public and private-sector interest groups.

Figure 3.6. FNR's past and future budget, 2001-10 (EUR)



Source: FNR.

3.2.10 Concluding observations on the FNR

The FNR was established in 1999 and started work in 2000. Its accomplishments are quite impressive and provide a basis for the following critical appraisal.

- The FNR has adopted a large number of good practices on how to govern and manage its business as a research fund, *i.e.* defining programmes, organising calls for proposals, appraising and selecting funding applications, managing peer review processes, monitoring progress, and dealing with financial issues. As regards funding, the FNR should take on a bigger role in the future. Specifically, parts of government funding of the CRPs and the University of Luxembourg should be handed over to the FNR. In addition, the evaluation and funding of the recommended centres of competence[26] should be taken over by the FNR since it has the required skills.
- The FNR's legal scope is quite broad.[27] Its four tasks ensure the FNR a very prominent role in shaping Luxembourg's research policy, especially since all relevant institutions are represented in the FNR. In the past the FNR has exhibited a rather hesitant attitude towards taking an active role. The fact that it is currently carrying out a foresight exercise, however, indicates a certain attempt to broaden the FNR's scope and agenda.
- The basic model for FNR's business is funding of research of high scientific quality that is "new to the world". Furthermore, it is the FNR's policy that individual projects should not be generated purely bottom-up but should emerge from prioritised thematic fields. Thus priority setting typically refers to research fields but not, for instance, to the improvement of specific institutional arrangements, funding instruments or bottlenecks in the overall research system. Advanced research and technology policy, however, involves both thematic and structural considerations. The scope of the FNR should be even wider. The FNR has demonstrated that its criteria and procedures aim at the selection of projects which are not only "excellent" in terms of scientific quality but also "relevant" in terms of economic and/or social impacts. Taking into account future

26. For details see Section 4.8.4.

27. See Section 3.2.1 on the objectives, mission and tasks of the FNR at the beginning of this chapter.

institutional circumstances in Luxembourg's research system, significant changes in the FNR's role and operational set-up are suggested:

- Taking more actively into account the specific missions, strategies and (agreed) goals of the individual institutions (CRPs, University of Luxembourg, *etc.*).
- Addressing specific structural gaps and opportunities in Luxembourg's research and innovation system as a starting point for planning programmes and thus overcoming the orientation towards prioritised thematic fields.[28]
- These two enlargements imply greater flexibility in programme planning in terms of criteria, programme duration, target groups and partners, such as the Ministry of Health or the Ministry of Agriculture in the case of food safety.

- The role of FNR is to fund research. While it is appropriate to enlarge its portfolio in terms both of volume and type of programmes, further inclusion of non-funding elements overstretch the institution on the one hand and, in the long run, hollow out the role of the government on the other. Basically, each policy (recommendation) would be perceived mainly as a funding problem. Moreover, responsibility for the advancement of specific organisations would lead directly to a conflict between policies to advance such institutions or linkages between institutions on the one hand and funding responsibilities on the other.

3.3 Promotion of business R&D and technological innovation

3.3.1 Financial measures

3.3.1.1 The R&D incentive scheme

In accordance with the amended law of 27 July 1993 aimed at fostering economic development and diversification and improving the economy's overall structure and regional balance, the Ministry of the Economy and Foreign Trade has set up an R&D incentive scheme designed to co-finance

28. In fact, the FNR has some experience with this type of programme planning. The programme "Living Tomorrow in Luxembourg" (VIVRE) is this type of problem-oriented R&D. Likewise, INTER concerns specific structural weaknesses in the overall research system.

R&D investment of general economic interest. The scheme addresses industrial companies and service providers with a significant impact on economic development and private research centres and seeks to stimulate the development of R&D activities in these organisations.

Co-financing covers fundamental research as well as industrial research and pre-competitive development. The R&D incentive scheme takes the form of a grant. The co-financing rate varies according to the type of activities: up to 75% for fundamental research, up to 50% for industrial research, and up to 25% for pre-competitive development. An increase from 5% to 25% is possible when the research activity is carried out by an SME, the activity involves cross-border co-operation, monitoring activities or feasibility studies preceding research, and if the R&D activities are carried out in the southern, eastern or northern regions.

The R&D incentive scheme has become the main financing instrument for R&D projects in the business sector. Table 3.5 provides an overview of the allocation of R&D support and shows that 90% of public funding of private R&D is allocated to the metal transformation and the chemical and para-chemical industries. Service industries such as finance, banking and media are weakly represented.

Table 3.5. R&D support scheme: allocation by sectors, 2004

Sector	Allocation
Chemical and para-chemical	49.19%
Metal transformation	40.77%
Electric and electronics	5.79%
Informatics	2.19%
Communication and telecommunication	1.68%
Business services	0.34%
Other	0.04%

Source: Ministry of Economic Affairs and Foreign Trade.

Allocated funds vary from year to year since they depend on the projects of a few big companies. Of the 17 projects supported in 2004, six (35%) were introduced by SMEs, two of which were start-ups, and eight (47%) were high-risk and long-term ("industrial research" projects). Three projects (18%) emerged from new information and communication technologies. Two (12%) were new cluster projects and eleven (59%) requested the advice of Luxinnovation. These figures, from the annual report of the Ministry of

the Economy and Foreign Trade, illustrate a more balanced situation. In May 2004 a new framework law was adopted, creating a general framework of aid schemes for SMEs.

3.3.1.2 Innovation loans

The Grand-ducal regulation of 8 February 1983 authorised the National Company of Credit and Investment (*Société nationale de crédit et d'investissement*, SNCI[29]) to intervene in the financing of R&D projects carried out by industrial or service companies provided they have significant impact on economic development. This financing, in the form of a loan, is designed to co-finance expenses directly related to R&D projects involving the launch of a new product or service or the development of new production or marketing processes, on the condition that these expenses lead to the creation of assets depreciable over a period of more than one year.[30] Innovation loans carry a fixed interest rate which is lower than the market rate. They have a maturity of 3-5 years, depending on the duration of the R&D project. The loan generally covers 25% of total eligible costs of the R&D project.

3.3.1.3 Fiscal measures

Innovative firms may benefit, under certain conditions, from three types of tax incentives, none of which is specific to investment in R&D and innovation. The government decided to decrease tax rates applicable to companies significantly in order to improve their competitiveness. This measure, which lowered the tax rate from 27.27% to 22%, took effect on 1 January 2002.[31]

29. The SNCI is a banking institution governed by public law and specialised in providing medium- and long-term financing to Luxembourg businesses.

30. European Trend Chart on Innovation, Annual Innovation Policy Trends and Appraisal Report, Luxembourg, 2004-2005.

31. It is, however, a generally open question whether and to what extent general tax policy has an impact on (increased) R&D and innovation activities. To be on the safe side, tax deductions can be considered a climate factor.

3.3.1.4 Concluding observations on financial measures

- Luxembourg uses a number of financial measures. The most prominent is the "R&D incentive scheme" which has mainly benefited larger firms, primarily in traditional industries. In 2004 it was adapted to better address smaller firms. The scheme seems to be highly attractive to companies with a certain level of R&D activities. Total annual funding is between EUR 10 million and EUR 20 million, which is in the same range as funding by the FNR.
- Co-operation does not in itself lead to increased funding, unless it is cross-border. It will require detailed investigation to understand the consequences of this lack of additional incentives for collaboration within the recently established clusters and, in particular, with the CRPs. However, the Ministry of the Economy and Foreign Trade considers, and the eight cluster projects, implemented in recent years confirm, that the cluster programme was meant, among other things, to incite companies to co-operate on generic, mid- to long-term projects of higher quality and shared risk, which can be considered as "industrial research" and are per se eligible for higher support (up to a maximum of 50%) under Article 6 (3).
- There is no explicit measure or attempt to address firms in the services sector, in particular those in the financial and media industry, with their different behaviour with respect to research, innovation, adoption of external knowledge, etc.

3.3.2 Financing institutions

Luxembourg's financial sector is marked not only by very high density of banks but also by its activities in compensation, insurance and reinsurance funds. The presence of a highly developed financial sector is reflected in the financing of innovation and research activities. First, private institutes offer a multitude of products and services responding to the financials needs of company start-ups and investment in innovative firms. Second, public and semi-public institutes provide credit to SMEs and large companies intending to invest or settle in Luxembourg.

3.3.2.1 The National Credit and Investment Society (SNCI)

SNCI is a public bank specialised in the financing of medium- and long-term projects of Luxembourg companies through investment credits, credits for firm creation and takeovers, and credits for exportation.

3.3.2.2 The Luxembourg Society of Capital Development for SMEs Ltd (CD-PME)

CD-PME was created in October 1998. It is held by SNCI (50%) and five other private banks. Its role is to provide financing to SMEs in Luxembourg for realising innovative projects with opportunities to increase employment.

3.3.2.3 The cross-border development fund (EUREFI)

EUREFI derives from a joint initiative of the EU and several private partners from Belgium, France and Luxembourg to accompany SMEs in their effort to establish their company close to common borders between these countries in order to enhance cross-border activities.

3.3.2.4 Technology and science parks, incubators

The Technoport Schlassgoart is an incubator for technology companies. It was created in 1998 as an organisation of the CRP Henri Tudor with the support of the Ministry of Culture, Higher Education and Research, the Ministry of the Economy, the European Regional Development Fund and the ARBED Group, a leading steel producer. It is dedicated to existing and future start-up firms and offers its facilities in an efficient business environment enhanced by backup services such as secretarial services and Internet connections. Technoport Schlassgoart has a strong focus on ICT and new media and hosts 26 companies (2005). The incubator offers a range of services which are organised in three programmes:

- *Pre-commercial.* Developing business plan, feasibility study or proof of concept. This programme provides (for a period of four months) complete office infrastructure, access to networks and a management team. The programme is free and the application process takes just one hour.
- *Start-up.* Services for company start-ups which can take advantage of modern business infrastructure, networks and services such as management coaching, assistance with access to financing, and management and administrative support. Indirect benefits from increased credibility, attractive working environment (seminars, related companies, access to CRP Henri Tudor).
- *High growth network.* Management support through team, network and tailor-made services.

In addition to the incubator run by the CRP Henri Tudor, the CRP Santé has plans to run a facility called "Biotechnology Business Accelerator", which aims primarily to provide start-up and established biotechnology companies with counselling services and networking.

The *Cité des Sciences, de la Recherche et de I'lnnovation* is currently one of the government's lead projects. It will use industrial wasteland in the south of the country. It is based on the concept of interaction of various activities on a single site, gathering together higher education (University of Luxembourg) and research institutes (CRPs) as well as innovative start-ups and technology-based companies and also creating new institutions and infrastructures.

Hosingen relay centre "*Op der Hei*" – located in the north – aims to provide accommodation for innovative businesses (skilled-craft business or industrial companies investing in new production techniques or services) in their start-up phase to help them limit expenses during the first years of their existence.

The Ministry of the Economy and Foreign Trade inaugurated in 2003 the ECOSTART enterprise and innovation centre located in Foetz. This centre has a twofold aim: to support promoters of innovative projects at the idea stage and to provide ongoing assistance up to the start-up phase; and to provide temporary accommodation (relay centre) for domestic and foreign businesses in the development stage seeking a temporary foothold in Luxembourg. An extension to double the Foetz centre to 8 000 m² (of which 6 250 m² for shop floors) is under construction and is scheduled to open in 2006. Furthermore, the government has agreed on a third ECOSTART centre to be located in the *Cité des Sciences, de la Recherche et de l'Innovation* in Esch-Belval, to be opened in 2008. Luxinnovation has responsibility for promoting the ECOSTART infrastructure and supporting the high-technology start-ups based there with their innovation services and their "START" network, involving CD-PME, SNCI, the Chambers of Commerce and of Skilled Crafts.

3.3.2.5 Concluding observations on technology parks and incubators

- Luxembourg has established – recently – a number of technology parks and incubators. All emphasise "soft" measures, such as business support, counselling and networking, rather than the physical premises. In this regard they all represent good practice.
- However, there is some doubt whether all these centres can realistically expect to recruit experienced managers in the field and to pay them adequately. Managing as many of the centres as possible under a single

management team and branding would be a preferred strategy for achieving higher impact.

3.4 Promotion of public-private partnerships for innovation, industry-science relationships and technology transfer

3.4.1 Collaborative R&D in the CRPs[32]

A constituent element of the CRPs is their orientation towards the needs of industry: The law of 1987 on the organisation of research and technological development in the public sector and the transfer of technology and scientific and technological co-operation between the public sector and companies foresees the co-financing of R&D projects carried out by public bodies.

Links between industry and public research organisations have been high on the agenda since the origins of public research. Many research projects of the CRPs are collaborative by nature, involving groups of industrial partners. While CRP Henri Tudor carried out only a comparatively small share (18.5%) of projects entirely financed by the private sector, 70% of its projects involved companies as partners, 34% of all projects had partnerships with government departments and agencies, and 29% with research centres or universities. This shows that projects with companies as partners are to a high degree funded by the ministries, by the FNR or by the European Union. Contract research in a strict sense is the exception rather than the rule and thus is missing a "market test".

CRP Henri Tudor performs a high rate of technology transfer with potentially high impact owing to the direct involvement of partners in the projects. Moreover, CRP Henri Tudor performs a wide range of other activities aimed at dissemination and transfer: training courses, conferences and thematic events. CRP Santé and CRP Gabriel Lippmann follow the same pattern of creation and transfer of knowledge.

Collaborative research is an attractive mode of interaction between producers and users of knowledge. It is, however, not the only one. Empirical evidence, notably from innovation surveys, shows that contributions by public research organisations and universities to innovation are rather weak in terms of enabling or radical solutions. What is more relevant, however, and may have a higher impact, is mobility of people – the

32. For details on CRPs see Chapter 4.

contribution of public research organisations relies on "talent" rather than on "technology" – and assistance with "problem solving", where specialised know-how is rarely required.

3.4.1.1 Concluding observations on collaborative R&D in the CRPs

- The volume of financing of collaborative R&D in the CRPs indicates that joint research activities between industry and public institutions on the one hand and the CRPs on the other (as well as the University of Luxembourg, mainly in the future) have a potentially high impact.
- At the same time, this type of interaction is mostly ad hoc, short-term, opportunity-driven, content-oriented and to a much lesser extent long-term and oriented towards strategic goals. Moreover, given the heterogeneity of individual units, subjects and partners, it is difficult to follow general strategies.
- It is thus recommended to carry out a thorough analysis to better understand technology and knowledge transfer, competence building through co-operation,[33] and the role of mobility of human capital.
- Specifically, it is worthwhile exploring an alternative funding model whereby only (consortia of) firms, and not public research institutions or universities, are eligible for public funding. In this model, the public research institutions or universities simply act as fully financed suppliers to the firms (consortia). The firms' decision to contract out research activities then directly depends on the attractiveness of the (public) research supplier in the knowledge market. As a side effect, this model protects the basic funding of the public research institutions against hollowing out through co-financing of funded projects and introduces a healthy element of competition.

33. Knowledge does not simply flow from research institutions to companies. While solutions typically follow the indicated direction, public research institutions often have insufficient understanding of the problems faced by business enterprises and the requirements for "solutions". Fruitful collaboration thus includes an exchange of knowledge, not just a delivery of solutions.

Table 3.6. Industrial and academic partners in the TRASU programme

Industrial partners	Academic/public partners
Ateliers Nic Georges, Luxembourg	CRP Henri Tudor, Luxembourg
Balzers, Luxembourg	CRP Gabriel Lippmann, Luxembourg
Ceratizit, Luxembourg	Fraunhofer Institute for Surface Engineering and Thin Films, Braunschweig, Germany
Ceodeux-Puretec, Luxembourg	VITO, Flemish Institute of Technological Research, Mol, Belgium
Circuit Foil, Luxembourg	Université du Luxembourg
Ewald Giebel, Luxembourg	Laboratoire de Science et Génie des Surfaces (LSGS – Ecole des Mines de Nancy), Nancy, France
Galvalange, Luxembourg	Laboratoire de Physique des Milieux Ionisés (LPMIA – Université de Nancy), Nancy, France
Goodyear Technical Centre, Luxembourg	Laboratoire de Chimie du Solide Minéral (LCSM – Université de Nancy), Nancy, France
Novellis (Pechiney Eurofoil Lux)	Laboratoire de Génie des Procédés Plasma et Traitements de Surface (LGPPTS-ENSC), Paris, France
TrefilArbed, Luxembourg	Laboratoire Interdisciplinaire de Spectroscopie d'Electrons (LISE – Université de Namur), Namur, Belgium
	Unité de Physico-Chimie et de Physique des Matériaux (PCPM – Université de Louvain la Neuve), Louvain, Belgium
	University of Saarbrücken, Germany

Source: FNR, Annual Report 2004, *www.fnr.lu*.

3.4.2 Industry-science relationships in FNR-funded programmes and projects

A public-private partnership element is built into the organisational structure of the FNR as well as into programme selection. Six out of the twelve members of the Board of Administration are nominated by the government from among personalities in the private sector recognised for their competence in the field of R&D.[34] As regards programme selection, most programmes have an explicit industry orientation: New Materials and Nanotechnology (NANO), Surface Treatments (TRASU), Security and

34. This also holds for the CRPs.

Efficiency of New Practices in e-commerce (SECOM) but also parts of Biotechnology and Health (BIOSAN), Food Safety (SECAL), and Sustainable Management of Water Resources (EAU).

An outstanding example of public-private partnerships in research is provided by the TRASU programme. Following the first call for programme proposals in 2002, Luxinnovation and FEDIL submitted, on behalf of the SURFMAT cluster, a set of ideas for surface treatments. Those ideas were taken over by the CRP Henri Tudor and CRP Gabriel Lippmann, which submitted, following the first call for project proposals in 2003, two projects which were assessed by international experts. Many Luxembourg companies and national as well as international academic partners joined in. At the end, the FNR decided to merge the two projects, in order to develop new competences. The project eventually had funding of EUR 6 million and lasted over 3.5 years. Table 3.6 provides an overview of the industrial and academic partners.

3.4.2.1 Concluding observations on industry-science relationships in FNR-funded programmes and projects

TRASU provides in many regards a reference for future policies and programmes, including some elements of good practice:

- *A stronger focus on academia-industry partnerships* in general going beyond mere (supply-side, *ad hoc*) funding of projects carried out in the public research sector.
- *Involvement of firms.* A number of firms were involved in the TRASU programme, and they made a long-term commitment of more than four years (preparation time plus duration of the programme). This can be seen as a good test of the feasibility of long-term strategically oriented joint public and private research.
- *International networking.* There was quite strong involvement of academic and public research partners from neighbouring countries. In the longer term, however, it is also important to involve foreign companies. Firms should primarily be attracted by the expectation of participating in the creation of a joint pool of knowledge, specialised equipment, trained personnel and work routines. Domestic firms can receive public support and (non-domiciled) foreign firms should at least be eligible to co-operate at their own expense.
- *The Grande Région.* Cross-border collaboration, primarily within the *Grande Région* but also beyond, is of high importance. In the long term this can provide an excellent basis for joint policy making to create

balanced incentives for partners from all countries to participate in a joint project.

3.4.3 Cluster programmes

In the coalition agreement of 1999, the government emphasised the need to promote centres of technological expertise using existing resources. The Cluster Programme of the then Ministry of the Economy was launched in November 2001. Consultation with Luxembourg companies in 2000 highlighted their needs and provided a basis for setting priorities. The programme's aim is to form industrial partnerships involving the sharing of complementary technological expertise and potentially leading to co-operative projects in the field of R&D and the development of new economic activities. The main advantages of this co-operation are easy access to shared competences accompanied by facilitated dissemination of technologies and the sharing of the costs of technological risks. Currently, three clusters are in operation.[35]

3.4.3.1 InfoCom cluster (information and communication technologies)

There is a well-developed sector for information society technologies in Luxembourg. The InfoCom cluster aims to foster co-operation and initiate specific projects in the telecommunications sector. It brings Luxembourg companies together on shared topics, including multimedia and diffusion of broadband technologies. Twelve members joined the initiative in 2005.

3.4.3.2 SurfMat technology cluster (surface treatment and new materials)

To foster synergies in the field of surface finishing and coating, several Luxembourg-based companies launched the "Surface treatment and new materials" (SurfMat) cluster. Its activities include mapping the needs and expertise of companies in the field of new materials, in particular surface finishing and coating, and capitalising on this information to induce synergies.

The 38 companies forming the cluster at present are divided into working groups that seek above all to exchange information and find ways to enhance technological capabilities through collaboration. The member

35 New thematic areas are in the pipeline: automotive technologies, biotechnology, process technologies.

companies recognise the benefits generated by the cluster and the practical, proactive support of Luxembourg's industry.

3.4.3.3 AeroSpace cluster (aeronautics and aerospace technologies)

A specific opportunity for collaboration emerged from Luxembourg's membership in the European Space Agency (ESA), in particular with respect to participation in the ARTES (Advanced Research in Telecommunications Systems) programme.[36] Furthermore, Luxinnovation is involved in the Interreg project "Cross-border aerospace co-operation" launched in 2003. The project aims to develop regional co-operation (Lorraine-Wallonia-Luxembourg) in the aeronautics and space sectors. A specific goal is to benefit from European aeronautics and space business, in particular by participating in calls from key clients in the aeronautic and space sectors (Airbus, ESA, Eurocopter, *etc.*).

To promote aeronautics and aerospace technologies, Luxinnovation joined the "Luxembourg Aeronautics and Space Industry Group" (GLAE) in 2005. The creation of this group follows Luxembourg's admission to ESA. GLAE seeks to be the main interface with the Luxembourg government. It addresses questions relating to the initiatives to be undertaken by state authorities in the framework of ESA programmes and the establishment of space policy in Luxembourg.

3.4.3.4 Concluding observations on clusters

- Luxembourg is a latecomer in cluster policy. The decision to address groups of actors (mainly companies) and their interrelations is a great achievement in the development of Luxembourg's innovation policy.
- There is, however, a danger of running the cluster programmes as entities that are only weakly connected to other programmes, institutions and private-sector services. To maintain the initial non-eligibility of the CRPs in the cluster programme would have been counterproductive in the long run. The recently implemented eligibility of the CRPs and the University of Luxembourg does not, however, necessarily mean that they will simply offer their services to the (member) companies. There is also an opportunity for the CRPs to better understand the problems and challenges of firms and how to address them through projects.

36. See Section 3.6.3 on ESA.

- The cluster approach provides ample opportunities for collaboration and co-ordination, provided that collaboration and co-ordination take place not only at the level of projects between firms and research institutions but also at the level of policy institutions and policy making.

3.4.4 Technology transfer

3.4.4.1 CRPs as key institutions in technology transfer

Most technological knowledge is transferred between companies through trade (supplier-customer relationships), mobility of trained people, *etc.* The CRPs constitute an explicit policy instrument, as one of their missions is to transfer technology between the public research sector and private firms. The CRPs also serve as an instrument in the industrial orientation of FNR programmes and funding since they receive 75% of FNR funding. In terms of government policy, these two mechanisms play a key role in encouraging and supporting technology transfer.[37] In addition, two further activities are worth mentioning.

3.4.4.2 Membership in Technology Innovation Information (TII)

Technology Innovation Information (TII) is a European association of professionals in the field of technology transfer. With almost 300 members from the public and private sectors of 30 countries, this non-profit association seeks to facilitate the dissemination of information, generate technology transfer and initiate innovation and research projects. The TII network is aimed at organisations involved in R&D, intellectual property, transfer of expertise, prototyping and development of new products, innovation management, and support for spin-offs and start-ups.

3.4.4.3 Luxembourg-Trier-Saarland Innovation Relay Centre (IRC)

The Innovation Relay Centre (IRC), created and supported by the European Commission, is a European network of specialists in technology transfer. The IRC acts as intermediary for companies, providing them with access to Europe's innovative technologies and scientific and technological potential. In Luxembourg, Luxinnovation co-ordinates the Luxembourg-Trier-Saarland transnational IRC, enabling companies to benefit from the network's technological opportunities on a daily basis. Through the IRC,

37. See Section 3.4.1 for the role of CRPs and 3.4.2 for the FNR.

companies can search for the specific technologies they need to innovate or promote their own expertise and meet potential partners.

3.4.4.4 Concluding observations on technology transfer

There are many modes of technology transfer and learning. Most technology transfer takes place through trade, human mobility and collaboration. Apart from these broad channels for technology and knowledge flows, two mechanisms are in operation in Luxembourg, and a number of specific aspects and measures deserve attention:

- *Cluster programmes can address groups of companies* and other actors, and benefit from existing services, competences, networks, funding, etc., through tailor-made access and a combination of support functions. It is crucial, however, not to run cluster programmes as specific small-scale programmes weakly connected with other programmes, institutions and private-sector services.
- *CRPs are key institutions in technology transfer.* Most technology transfer is based on publicly funded projects in which a specific type of research, collaboration, is preferred and transfers technology and knowledge. Direct contract research is the exception rather than the rule. Moreover, collaboration is mainly *ad hoc*, short-term and opportunity-driven. A strategic reorientation in at least the following three directions would given the CRPs a sharper profile:
  - More long-term, strategically oriented R&D.
  - More direct contract work with firms/public institutions without public funding.
  - A stronger active commitment to mobility of human capital, which is actively pursued to some extent by CRP Henri Tudor
- *Single-purpose technology transfer institutions should be avoided.* The integration of the Luxembourg-Trier-Saarland Innovation Relay Centre into Luxinnovation is an adequate solution. Generally, all specific services, funded under programmes of different ministries or EU programmes should be integrated into and promoted as a single comprehensive set of services, mainly directed to SMEs. This creates higher visibility and thus effectiveness and minimises confusion and thus loss of attention.

3.5 The role of intermediary organisations: Luxinnovation

Founded in 1984, Luxinnovation is the National Agency for Innovation and Research. In 1998, it became an Economic Interest Group (EIG) under the supervision of the Ministry of the Economy and Foreign Trade, the Ministry of Culture, Higher Education and Research, the Ministry of the Middle Class, Tourism and Housing, FEDIL, the Chamber of Commerce, and the Chamber of Skilled Crafts.

Luxinnovation acts as a first-stop shop and offers business enterprises and organisations free services, including information and assistance on all aspects of innovation, research, technology transfer and business start-ups; identification of the needs of each party before launching a project; advice on the choice of instruments and partners. Luxinnovation also devises and manages a number of pilot projects, including the cluster programmes, the Luxembourg Innovation Observatory and the Luxembourg Portal for Innovation and Research. At the international level, the agency is involved in a host of networks, including the European Space Agency, the European Network of Innovation Relay Centres, the 6th Framework Programme for Research and Development (FP6), EUREKA and the Leonardo da Vinci II programme. Finally, Luxinnovation provides information to the government and international institutions (European Trend Chart on Innovation, Report on Research and Innovation) and to the wider research and innovation community (Luxembourg portal for innovation *www.innovation.public.lu*).

3.5.1 Setting up R&D projects

Luxinnovation offers advice and information to businesses and research centres wishing to undertake a research and innovation project in a national or international context, in particular under the EU Framework programmes or ESA.[38] It helps them identify their needs in order to devise, carry out and run their project. Assistance mainly covers financial assistance and partnering.

38. In this regard Luxinnovation acts as national contact point on behalf of the Ministry of Culture, Higher Education and Research.

3.5.2 Starting an innovative business

Luxinnovation helps to promote innovative entrepreneurship in Luxembourg. It provides tailor-made assistance to entrepreneurs wishing to locate in Luxembourg: partnering; information and advice on financing, administrative formalities, accommodation,[39] partner search; assistance in drawing up a business plan; and a support network for the creation of innovative businesses, in particular the Network for Entrepreneurship "1, 2, 3, Go". Furthermore, it launched an information campaign "*Trau Dech, mach dech selbststänneg*" to increase public awareness of entrepreneurship, among young people in particular.

3.5.3 Promotion of the ECOSTART enterprise and innovation centre

In 2003 the Ministry of the Economy and Foreign Trade inaugurated the ECOSTART enterprise and innovation centre located in Foetz to support Luxembourg entrepreneurs at the idea stage and to provide assistance up to the start-up phase, as well as to provide temporary accommodation for domestic and foreign businesses at the development stage seeking a temporary foothold in Luxembourg.

3.5.4 Gate2Growth: the European gateway for high-growth businesses

Gate2Growth is a European Commission programme intended to stimulate the setting up of new high-growth companies. It encourages the creation of a community of entrepreneurs, investors and service providers and offers project promoters and their teams the opportunity to benefit from tools, infrastructure and support services throughout Europe. Luxinnovation has been appointed regional contact point of the European Gate2Growth network.

39 With a specific focus on the two business incubators, the Technoport Schlassgoart in Esch/Alzette and the ECOSTART Centre in Foetz.

3.5.5 Organisational innovation/management techniques

Innovation is not only technological. The structure of a company and the way in which it manages its business also play a critical role in the innovation process. Accordingly, Luxinnovation promotes innovation management techniques. The Agency is also a founding member of the Luxembourg Movement for Quality (MLQ).[40]

3.5.6 The Luxembourg portal for innovation and research

The Luxembourg portal for innovation and research, located at *www.innovation.public.lu*, was launched in 2003 as part of the eLuxembourg government action plan for the information society. It is dedicated to all aspects of R&D and innovation in Luxembourg and addresses all players in the field.

3.5.7 Concluding observations on Luxinnovation

- Luxinnovation has a long tradition. Its impressive service portfolio reflects a large part of what has been on the agenda of innovation policy during the last 10 to 15 years: raising awareness, support for company start-ups, incubation, collaboration, clusters, technology transfer, innovation management, quality management, Internet portals and innovation and technology studies.
- Although Luxinnovation has a broad set of owners, its principal owner is the Ministry of the Economy and Foreign Trade which currently chairs the Management Council. In the course of time, the ministry has developed a close working relationship with Luxinnovation for policy intelligence services and policy recommendations which from time to time conflicts with Luxinnovation's role as an agency.

40. MLQ was founded in 2001 by the Chamber of Commerce, the Chamber of Skilled Crafts, the CRP Henri Tudor, FEDIL, the Association of Luxembourg Hospitals and Luxinnovation. MLQ supports initiatives to enhance quality, environment and security in Luxembourg, provides companies and organisations with quality management tools, organises the Luxembourg Award for Quality and represents QM initiatives at European and international level. While Luxinnovation contributes to awareness raising and promotion, CRP Henri Tudor has played a major role in the specification and set-up of the Luxembourg Movement for Quality.

- Although Luxinnovation has a rather large target group and a broad range of partnerships, tensions with other actors in the research and innovation system are apparent and may be detrimental to the full development of the services and capabilities of Luxinnovation. In part, these tensions are due to overlapping areas of activity, *e.g.* both Luxinnovation and CRP Henri Tudor are involved in provision of services such as innovation management techniques, incubators, innovation studies, creating and managing networks and platforms which are similar at least at the level of labelling and marketing.
- Luxinnovation is an essential institutional resource. At the same time its current portfolio of services seems very broad and should be adjusted. A strategic review is recommended to align mission, priority setting and actual portfolio. It is advisable to link the review of Luxinnovation with the suggested review of CRP Henri Tudor.

3.6 Internationalisation of R&D

3.6.1 European Framework Programme for Research and Technological Development

The Sixth European Framework Programme for Research and Technological Development (FP6) is the European Commission's main instrument for financing research in Europe. With a budget of EUR 17.5 billion, FP6 extends over the period 2002-06. It seeks to contribute to the creation of a genuine European Research Area (ERA).

While participation in EU programmes is perceived in some respects ambivalently by some organisations in other countries, Luxembourg still seeks to link up to European projects and initiatives as much as possible. At the same time, the CRPs and most of the public-sector research units are well connected to the international research community. Most of these ties are strong and can be sustained beyond *ad hoc* partnerships. In some cases, teams from Luxembourg have been able to co-ordinate large-scale projects or major parts of them.

CRP Henri Tudor appears to have a strong tendency to join European projects. Of its total portfolio of 103 projects carried out in 2004, 35 are European projects, funded under a broad range of programmes and funding regimes: FP5, FP6, ESA, LEONARDO, INTERREG, FSE Objective 2 and FSE Objective 3 programmes. It is also involved in four networks of excel-

lence.[41] The other centres are also well connected, however not necessarily to EU projects but through other funding schemes. The difference in EU participation may be due to a higher degree of thematic congruence between the European Framework programmes and the portfolio of CRP Henri Tudor.

The CRP Gabriel Lippmann has a comparatively small number of European-funded projects but a high level of international collaboration: Out of a total of 64 international projects just eight are (co)funded by the EU. *Biotechnologies forestières et agricoles*, for example, only runs international projects. Just two out of eight are EU-funded. Likewise, CRP Santé has an impressive number of international partners, with funding mainly from sources other than EU programmes. CRP Gabriel Lippmann co-ordinates the Network of Excellence "Nanobeams" and CRP Santé has a high level of involvement in the integrated project "Angiotargeting".

Table 3.7 provides a detailed overview of Luxembourg's participation in the FP6. It is noteworthy that the success rate is skewed; this may be due to the small number of applications per programme (except for ICT). In total, however, overall success rates are quite close to the European average: 18.4% (Luxembourg) as compared to 20.2% (EU) with respect to the number of proposals accepted, 19.9% (Luxembourg) as compared to 21.9% (EU) in terms of funding volume.

Some specific programmes deserve being considered in more detail. Although ICT accounts for a high share of applications by Luxembourg firms and research centres from (131 submitted proposals) the number of successful proposals and the volume of funding is rather poor. The same is true of the Life Sciences Programme. At the same time, Luxembourg has quite a successful record in the Nanotechnologies Programme, in the Energy and Sustainable Development Programme, in the Joint Calls (4, 6a, 6b) and Scientific Support to Policies.

3.6.2 EUREKA

Founded in 1985, the intergovernmental initiative EUREKA aims at increasing productivity and competitiveness in the industries and economies of its current 36 full members and associate countries. To that end, EUREKA seeks to encourage international co-operation on industrial R&D projects.

41. See Section 4.3 on CRP Henri Tudor.

Table 3.7. Participation in the 6th EU framework programme, 2002-May 2005

	Number of proposals				Volume of proposals (k€)			
	Submitted	Accepted	Success rate (%) (LU)	Success rate EU	Submitted	Accepted	Success rate (%) (LU)	Success rate EU
Pr. 1: Life Sciences	23	3	13.0	26.3	8 189	122	1.5	22.9
Pr. 2: ICT	131	19	14.5	20.5	34 117	3 781	11.1	21.9
Pr. 3: Nanotechnologies	22	6	27.3	11.3	6 088	3 580	58.8	13.6
Pr. 4: Aerospace	0	0	n.a.	34.9	0	0	n.a.	38.8
Pr. 5: Food Quality and Safety	8	0	0.0	22.2	988	0	0.0	18.0
Pr. 6: Energy, Sustainable Development	12	5	41.7	27.8	979	0	0.0	24.3
Pr. 7: Citizens and Governance	10	1	10.0	17.0	489	62	12.7	13.3
Joint Calls (2+3)	3	0	0.0	19.8	642	0	0.0	14.7
Joint Calls (4, 6a, 6b)	13	8	61.5	28.4	9 681	4.892	50.5	31.7
Scientific Support to Policies	6	2	33.3	10.7	308	138	44.8	20.4
SME	42	0	0.0	12.9	4 070	0	0.0	11.7
INCO	8	1	12.5	19.0	1 255	47	3.7	15.7
Specific Research Activities for SMEs	7	5	71.4	54.4	700	292	41.7	54.1
Research and Innovation	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Human Resources	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Research Infrastructures	10	3	30.0	35.1	2 694	986	36.6	43.7
Science and Society	6	1	16.7	20.3	415	122	29.4	21.4
Euratom	3	2	66.7	65.8	93	43	46.2	75.4
Total	**304**	**56**	**18.4**	**20.2**	**70 708**	**14 065**	**19.9**	**21.9**

Source: Ministry of Culture, Higher Education and Research.

Luxembourg's co-operation on EUREKA projects is limited. The total budget of Luxembourg participants in 2005 was about EUR 3 million, of which EUR 2 million from cluster and innovative projects started in 2004-05. Luxembourg's new project volume amounts to less than 1% of the figure for the Netherlands and to less than 2% of the figure for Belgium. The value of Luxembourg's current EUREKA project participation is about 0.006% of GDP which corresponds roughly to 10% of the share for the Netherlands (0.064%) and 12% of Belgium's share (0.05%).

According to the information provided on the EUREKA website, there is just one current EUREKA project with a Luxembourg partner (with a total budget of EUR 0.9 million). Up to now 17 Luxembourg organisations, six of which were SMEs, have participated in 15 EUREKA projects. A further project with partners from Luxembourg was launched at the end of December 2005.

Funding schemes available in Luxembourg for funding EUREKA projects are the "R&D incentive scheme" of the Ministry of the Economy and Foreign Trade and the "innovation loans" provided by the SNCI.[42]

3.6.2.1 Concluding observations on participation in EU programmes and EUREKA

- Luxembourg is still catching up in terms of participation in EU programmes in general and EUREKA in particular.
- The CRPs, in contrast, show quite satisfactory – in some units even impressive – performance as far as major or lead roles in networks of excellence or integrated projects are concerned.
- Performance across specific programmes is somewhat uneven, with rather poor performance in ICT and Life Sciences but a quite successful record in the Nanotechnologies and in the Energy and Sustainable Development Programme, in the Joint calls (4, 6a, 6b) and Scientific Support to Policies.
- Internationalisation of R&D should not be restricted to EU programmes. Some units of the CRPs have quite lively international activity outside mainstream EU programmes and this should be appreciated as broadening the base of Luxembourg's international activity.
- As a general rule, responding to opportunities for international co-operation should follow a clear strategic orientation. The cost-benefit balance tends to be negative if participation in Community programmes is merely conceived as an opportunity to generate additional income.

42. *www.eureka.be/contacts/member.do?memId=LU*

3.6.3 European Space Agency (ESA)

After five years of collaboration as a co-operating state in ESA's optional ARTES (Advanced Research in Telecommunications Systems) programmes 1, 3, 5 and 8, Luxembourg became a full member of the European Space Agency in 2005. Luxembourg has acquired experience in space matters through its involvement in Intelsat, Eutelsat and Eurocontrol, as well as through its national activities linked to space.

ARTES consists of several elements, each covering a particular area of telecommunications such as on-board processing, multimedia/global information infrastructure, advanced mobile systems, tele-education, telemedicine, teleconferencing and data exchange. The programme aims at improving the competitiveness of European industry on world markets for communications missions and promoting new services for advanced communications systems. ARTES also provides support to other application programmes (navigation and Earth observation) through specific actions.

With its full membership in ESA, Luxembourg can use one of its strengths, satellite services, to play a more active role in European space and related infrastructure and development. Membership in ESA requires mandatory financial contributions to the basic programme and provides opportunities for countries to participate in optional programmes. Small countries, in particular, tend to have a more specific profile of competences and needs. Participation in ESA gives them full access to a wide range of policy planning, specification, production and operation opportunities that do not exist outside ESA. Luxembourg has seized this opportunity in the recent past. This can be considered a specific measure taken to catch up in the field of innovation and technology.

3.6.3.1 Concluding observations on membership in ESA

- To fully benefit from ESA membership requires adequate support infrastructure to diffuse information, to support firms and research organisation in their bids, and to keep pace with ESA policy making and administration.
- The establishment of the Luxembourg Aeronautics and Space Industry Group (GLAE) and the intermediary role of Luxinnovation provides an opportunity to bundle the specific needs and opportunities of Luxembourg firms and research organisations in order to participate in ESA's procurement processes and to influence and shape policy decisions.

3.6.4 European Trend Chart on Innovation

The European Trend Chart on Innovation is a tool launched by the European Commission in 2000 for actors in the area of innovation in EU member states. Its goal is to provide regularly updated data and statistics on innovation policies, evidence and trends in the European Union, and to facilitate the exchange of best practices. To achieve these objectives, the European Trend Chart on Innovation operates three complementary lines of actions:

- The preparation of the annual European Innovation Scoreboard (statistical information based on a specific set of indicators).
- An annual account of innovation policy measures taken by each member state (based on national "correspondent reports").
- The organisation of four workshops a year with national innovation policy makers.

Luxembourg participates in the Trend Chart initiative via Luxinnovation and the Ministry of the Economy and Foreign Trade.

3.6.4.1 Concluding observations on the European Trend Chart on Innovation/policy intelligence

- Luxembourg still has a rather poor policy intelligence infrastructure. Most reporting to the European Commission or the OECD is ad hoc. In the medium term a more permanent infrastructure should be established.
- Good practice suggests a twin structure: a permanent infrastructure in Luxembourg on the one hand and foreign partners selected ad hoc on the other. A natural candidate for the permanent infrastructure is CEPS/ INSTEAD, which has the required track record in the social sciences and economics as well as in policy advice. Foreign partners would provide linkages to international networks and experience.
- The content and scope of policy intelligence should primarily be based on a clear understanding of the needs of policy making. Accordingly, the most promising situations arise when capable suppliers meet equally capable and demanding customers/policy makers.

3.6.5 Internationalisation: The "Grande Région" and beyond

3.6.5.1 The "Grande Région"

The *Grande Région* is both a reality and a vision. Luxembourg is currently carrying out a number of small initiatives such as Interreg projects and ERA-Nets, which are well suited for cross-border policy collaboration, specific framework agreements for cross-border collaboration with neighbouring regions, cluster programmes, an innovation relay centre initiative and projects under FNR programmes.

At the same time there are voices pleading for extending the target area for a number of policy measures. The challenge for policy making will be to think of the *Grande Région* as the target area for specific programmes and instruments. Given the size of Luxembourg, all programmes with an element of collaboration potentially qualify for cross-border collaboration.

3.6.5.2 Luxembourg as a location for internationally active companies

Luxembourg hosts a number of manufacturing firms that are active on global markets. Prominent among them are Arcelor, Goodyear, Delphi, Paul Wurth, TDK Recording Media Europe and DuPont de Nemours. There are also international companies in to the media and communication sector (SES Global, SES Astra, Skype Technologies, RTL Group), the transport sector (CargoLux) and, of course, in the banking and insurance sector. These internationally active firms are a potentially important target group for specific policy actions and initiatives for a number of reasons:

- They conduct the major part of private R&D and contribute significantly to the knowledge base of the country and the *Grande Région*. Creating a beneficial environment for these firms helps to secure their presence and thus contributes to sustained economic development. This requires above all favourable framework conditions.
- Through their presence on international markets, these firms provide ample opportunities for specialised suppliers. As these firms tend to source globally, a firm's supplier status can be viewed as a benchmark for competitiveness. As a consequence, such firms provide both market opportunities and opportunities for learning.
- International companies often act as partners of technology-based start-up companies, and mergers often result.

- These companies can operate as brokers for specific goods and services, provided the environment is conducive to efficient exchange of information. Information networks tend to become more tacit and informal as such goods and services are more research-based or consist of R&D services. Strong working relationships are essential for benefiting from co-operation with multinational companies in the field of R&D.
- Such companies create job opportunities. In addition, Luxembourg hosts a number of European institutions such as the Court of Justice of the European Communities, the European Court of Auditors, the European Statistical Office (Eurostat), the Publications Office and the European Investment Bank.

Overall, the benefits derived from the country's openness can be increased by public investment in research and education.

3.7 Intellectual property rights

In Luxembourg, intellectual property issues are covered by the following regulations:

- The Patent Law of 20 July 2000, with several subsequent amendments to take better account of users' needs and to rectify provisions that were not consistent with international law, specifically EU law.
- The Luxembourg patent, which has a maximum duration of 20 years from the date of submission, is a patent for registration only with no patentability check of the invention. This characteristic ensures rapidity and simplicity.
- The law of 18 April 2001 covers copyright, related rights and databases.
- Trademarks are regulated by the Uniform Benelux Law, which took effect on 1 January 1971.
- For biotechnological inventions, EPO rules apply.

To stimulate and encourage companies (especially SMEs) to register patents, the Ministry of the Economy and Foreign Trade (Department of Intellectual Property Rights) has created two new measures:

- *The short-term patent.* The main differences between the classic patent and this "short-term" patent are the duration of protection and the cost. This six-year patent does not require submission of a research report, whereas the 20-year "classic" patent does. The classic patent offers a higher level of legal security.

- *Online registration of patents and copyrights.* This project aims at facilitating and speeding up the patent and copyright registration process.

Luxinnovation has been involved in an EU project entitled "Linking Innovation and Intellectual Property (LIIP)", co-financed under FP5 and co-ordinated by CRP Henri Tudor, to highlight the importance of intellectual property for innovative companies. Luxembourg is represented in the project by the Ministry of the Economy and Foreign Trade, the Technology Watch Centre[43] (at CRP Henri Tudor) and Luxinnovation.

3.8 Awareness

In the past, research and innovation policy did not have a high profile in Luxembourg. The Luxembourg government is making efforts to increase awareness in several audiences and target groups.

3.8.1 Luxembourg portal for innovation and research

The Luxembourg portal for innovation and research[44] was launched in July 2003. It is dedicated to all aspects of R&D and innovation in Luxembourg and aims at all R&D players – research centres, individual researchers, private labs, innovative companies – both to increase global awareness of Luxembourg as a location for advanced technology and to federate the R&D community in Luxembourg.

3.8.2 One mission of the FNR: to promote scientific culture and raise public awareness

One of the FNR's missions[45] is to promote scientific culture and raise public awareness of science in the country. To this end, in October 2005, for the fifth time, a science festival was organised. Over one week, more than 20 000 people visited a series of exhibitions, workshops, conferences and events. Science festivals will continue to be organised on a regular basis. The Young Scientists Association, apart from its annual contest, organises – in collaboration with the Ministry of Education – the "Mini Researcher" contest to encourage pupils' interest in science and technology. In the "Science

43. See *www.brevet.lu*.

44. *www.innovation.public.lu*

45. See Section 3.2 on the FNR.

Club" scientific workshops dedicated to teenagers are organised with various partners.

In addition to funding research projects, the FNR supports accompanying measures[46] in order to reinforce the general framework of research in Luxembourg. These include the promotion of scientific awareness, national R&D co-ordination, international scientific co-operation and organisation of scientific conferences in Luxembourg as well as TV spots.

3.8.3 The Technology Watch Centre

The Technology Watch Centre, initiated by the CRP Henri Tudor, has been in operation since 1996. It offers companies services in research, analysis and information management, patent watch, standards watch and Internet watch, organisation of watch systems and economic intelligence within companies; patents and intellectual property; scientific and technical documentation and documentary research. The Technology Watch Centre is also involved in training. Courses on patent and standards information research on the Internet are organised on a regular basis.

3.8.4 Concluding observation on awareness

Luxembourg has done much to promote scientific culture and openness to science and technology. A series of decisions at government level since the late 1990s and the Lisbon-Barcelona document launched in late 2005 reflect this increased awareness (see Box 3.1).

3.9 Public governance of Luxembourg's innovation system: policy challenges and recommendations

Luxembourg's research and innovation system, which started from an embryonic form in the second half of the 1980s, has developed two decades later into a more or less full-fledged institutional system. Luxembourg has undergone a catch-up process by adopting, on the basis of a sound rationale, a number of state-of-the-art policies. Against the background of ongoing and envisaged future initiatives in the area of R&D and innovation, this section assesses, in the form of a "critical appreciation", historical developments, deliberate choices, circumstances, path dependencies and lock-ins on the

46. MA1: Promotion of scientific awareness, international scientific co-operation or national R&D co-ordination.

one hand and future opportunities on the other. This "critical appreciation" provides the basis for recommendations.

3.9.1 A critical appreciation of the past

3.9.1.1 Catch-up in institution building

Starting from a rather low level of financial resources for R&D and a lack of specialised institutions, Luxembourg has succeeded in building a wide range of specialised institutions: *laws and regulations* on the one hand and *organisations* on the other. As regards laws and regulations, the following are among the most relevant: framework law on public sector research (1987); framework law on private sector research (1989); framework law on higher education (1996); law on the creation of the FNR (1999); law on the establishment of the University of Luxembourg (2003); and the framework law on middle class sector research (2004). On the other hand, the establishment of Luxinnovation, the CRPs, the National Research Fund, the Ministry of Culture, Higher Education and Research, and the University of Luxembourg are the most important institutional innovations.

3.9.1.2 Luxembourg's effort to meet the Lisbon strategy

Luxembourg has fully endorsed the Lisbon strategy and the Barcelona target. In 2003 the government set up an inter-ministerial working group to design a multi-annual action plan in the spirit of the European Commission's Action Plan, "More Research for Europe". In November 2005 Luxembourg published its "National Plan for Innovation and Full Employment 2005-2008" (see Box 3.1) which provides a clear and consistent orientation. The "National Plan", which touches on broad political and societal issues and focuses on specific actions, has been adopted and has received strong support from a broad range of political, institutional and societal actors.

As regards research and innovation policy, the "National Plan" addresses two fundamental issues, the creation of knowledge ("reinforcement and extension of physical R&D capacities") and the use of knowledge ("facilitation of innovation"). The more specific strategies can help meet these overall goals as they address all relevant aspects of the innovation system. Accordingly, co-ordination both at the operational level (performing research, teaching, consulting, etc.) and at the management and governance level are key ingredients of the future implementation of the "National Plan".

Box 3.1. Towards Barcelona and Lisbon:
National Plan for Innovation and Full Employment, 2005-2008

The "National Plan for Innovation and Full Employment 2005-2008" sets out how Luxembourg intends to comply with the aims of the revised EU Lisbon Strategy. In submitting the action plan to the European Commission, Luxembourg fulfils the requirement, set when the Lisbon Strategy was relaunched, for each country to inform the Commission of the steps it intends to take to achieve the Lisbon goals.

In the field of innovation and research, Luxembourg's National Action Plan identifies two main guiding principles and defines a number of measures. To increase and improve R&D investment, in particular in the private sector, with a view to establishing a European knowledge area, the following measures are considered essential:

- *Reinforce and extend physical R&D capacities, to be achieved by:*
  - Encouraging the extension of private research centres and the development of public research infrastructures in a limited number of advanced sectors such as plastic materials and plastics, production processes and treating or coating of surfaces, automobile applications, information technologies and communication, environmental technologies, logistics, biotechnology, law, economics and finance.
  - Reinforcing promotion abroad to encourage the implementation of R&D activities or the creation of research centres.
  - Considering fiscal incentives for R&D.
- *Increase human resources in R&D by:*
  - Facilitating the immigration of researchers (including non-EU citizens).
  - Training young teachers to generate an early interest in science.
  - Promotion of mobility between sectors, in particular between the public and the private sector.
- *Increase of R&D activities, to be achieved by:*
  - Ensuring a co-ordinated approach to the definition and implementation of public research (leading to a limited number of research fields).
  - Encouraging public research centres to specialise in relevant subject areas.
  - Increasing public expenditure on private R&D projects.
  - Setting up new instruments to stimulate R&D efforts, in particular for SMEs.
- *Generate greater synergies between public and private capacities, to be achieved by:*
  - Developing "competence centres" involving the private sector, located at the university and at public research centres.
  - Efficiently co-ordinating public and private financing instruments.
  - Involving public research organisations in clusters.

.../...

Box 3.1. Towards Barcelona and Lisbon:
National Plan for Innovation and Full Employment, 2005-2008
(continued)

• *To facilitate innovation in all its forms, the following measures are considered essential:*

- Promotion of R&D and innovation investment by means of the "alliance for innovation" initiative (proactive approach of businesses; multi-annual innovation programmes).
- Promotion of intellectual property awareness, thus highlighting the importance of intellectual property rights and improving access to patenting information.
- Strengthening national and cross-border co-operation between businesses and research centres by extending the geographical scope of existing technology clusters and regional research centres and by setting up new clusters specialising in other priority areas, while at the same time better promoting European R&D programmes.
- Facilitating business set-up and development by extending the accommodation infrastructure for innovative businesses and considering new fiscal incentives for investment by (and in) new innovative businesses.
- Work of the ("Start") network with SNCI/CD-PME, Luxinnovation and the Chambers of Commerce and of Skilled Crafts.
- Creation of the new "ECOSTART III[47] enterprise and innovation centre in Belval-West.

Source : Government of the Grand Duchy of Luxembourg (2005).

It will be a challenge for the coming year or two to identify and implement the most appropriate instruments for achieving co-ordinated action while limiting efforts at co-ordination and, in particular, the number of co-ordinating bodies.[48] Actors' inherent tendency to stick to their vested interests, strategies and practices and to create complex intermediate structures must be seen as a potential danger. Yet, the "National Plan" is a valuable resource in the political process and provides a basis for timely implementation of policies based on better understanding of the issues involved and the consensus achieved during the consultation process.

47. The Ministry of the Economy and Foreign Trade changed the designation from ECOSTART II (to include the extension in Foetz) to ECOSTART III.

48. This report can be viewed as a contribution to identifying proper co-ordination mechanisms and levels.

3.9.1.3 Luxembourg's research and innovation system is fairly complete with respect to its primary institutional set-up

Luxembourg's research and innovation system is fairly complete with respect to its primary institutional set-up. Moreover, specific policies (see the "National Plan" above) and actions for achieving the Lisbon and Barcelona targets have been defined and implemented. It will thus be an important policy issue for the next three to seven years whether or not existing institutions are able to sustainably support the increased importance of science, technology and innovation in terms both of expenditure and political priority.

In many respects, Luxembourg's science, technology and innovation policy achieved high standards over the past decade. This is particularly true for individual actors, instruments and approaches. As regards the overall architecture, there is, however, a need for further improvement. At the same time, the prospects are good. On the one hand, there is a sense of urgency among the relevant stakeholders in the country's research and innovation system and thus a high level of awareness of the need for change. On the other, there is an expectation for growth, which in itself can be conducive to change.

3.9.1.4 New growth, improvement and adaptation

Based on a forward-looking assessment of Luxembourg's future economic development under changing framework conditions, the government has embarked on an ambitious effort to improve the country's capabilities in science, technology, and innovation. It has already taken significant steps to meet this objective and has committed to increasing the share of public R&D expenditure in GDP from the current 0.3% to 1.0%. Most future steps will be improvements and adaptations, mainly at the level of individual actors and in some cases at the level of the architecture of the system and thus of the relationships among these actors. There is no clear need to establish new institutions.

3.9.1.5 Some historically determined patterns: division of labour

Although research and innovation policy in Luxembourg has a rather short history, there are a number of historically determined patterns. The most salient case is the distribution of labour between the Ministry of the Economy and Foreign Trade and the Ministry of Culture, Higher Education and Research, which is characterised by insufficient collaboration and co-ordination.

Insufficient collaboration does not necessarily reflect a low degree of readiness to collaborate. It reflects instead the circumstances during the period of institution building from 1999 when a number of institutions were established: the National Research Fund (FNR), the Ministry of Culture, Higher Education and Research, and finally the University of Luxembourg. Moreover, there were far-reaching policy decisions, such as full membership in ESA and the government's decision to raise public expenditure on research. These are all examples of the typical business of "research ministries" and related institutions. However, because Luxembourg lacked such institutions and policies, there were reasons to concentrate on core issues and minimise interaction with other institutions and thus collaboration and co-ordination.

Striving for autonomy in the pioneering phase shaped the definition of the policy agenda and the specification of policies in some respects, and will continue to do so in the future. At the same time, institutions like the CRPs or the FNR, to name the most important, are encouraged to be active in areas with high socioeconomic relevance and therefore require a certain degree of collaboration and co-ordination at various levels, in particular between the Ministry of Culture, Higher Education and Research and a range of sectoral ministries such as economy, health, state and environment. This leads to the quest for the appropriate instruments and level of collaboration and co-ordination.

The major conclusions to be drawn from the short history of policy institutions in Luxembourg and related institutional behaviour are as follows: Policy institutions generally tend to remain separate, in particular in environments where it is difficult to appropriate the benefits of collaboration. Therefore, future action should keep in mind that policy collaboration and co-ordination need to be enforced top-down to some extent.

3.9.2 The Ministry of Culture, Higher Education and Research and related ministries: the hub of policy making

In many instances a small country has to have an agenda which differs little from that of a larger country. This is particularly true for the country's representation in international committees and decision-making bodies.[49] Likewise, policy makers have to invest time and effort to keeping up with recent developments with respect to the international debate on research and innovation policy and, as far as the European Union is concerned, with

49. See footnote 16.

respect to deliberations and decision making, in particular regarding the next framework programme. Moreover, membership in ESA is time-consuming and runs the danger of displacing priorities.

Given the small number of key personnel in the Department of Research and Innovation in the Ministry of Culture, Higher Education and Research,[50] there are a number of risks and stress factors. One is the risk of policy gaps. Another is the workload and the pressure on the staff who must handle the full panoply of positions on a large number of (national) boards and (international) councils and committees. The planned increase in R&D expenditure and the increase in related tasks are likely to make these problems more pressing.

As regards the relationship between the Ministry of Culture, Higher Education and Research and the Ministry of the Economy and Foreign Trade, a specific division of labour has been established. Likewise, there is a *de facto* separation of tasks and responsibilities within the Ministry of Culture, Higher Education and Research. Given the significant changes in Luxembourg's research and innovation system and in the wider (European) context, the established division of labour does not appear well-suited to meet future challenges and opportunities. To name the most obvious issues:

- The establishment of the University of Luxembourg and its orientation towards becoming a research university requires sound collaboration between the Department of Higher Education and the Department of Research and Innovation in the Ministry of Culture, Higher Education and Research. The design and implementation of performance contracts between the university[51] and the ministry should act as a platform for collaboration between the two departments. This would considerably alleviate the work of both the ministry and the university as performance contracts can provide long-term stability in budgeting and planning.
- In the past, the separation of the policy agendas of the Ministry of Culture, Higher Education and Research and the Ministry of the Economy and Foreign Trade created specific policy gaps, in particular concerning (joint) research and innovation policies involving collabora-

50. Currently there are eight (6+2) staff in the Department of Research and Industry of the Ministry of Culture, Higher Education and Research and even fewer in the relevant department of the Ministry of the Economy and Foreign Trade.

51. Not only with the university, but also with the CRPs. See Chapter 4.8.1 and, in particular, Box 4.1 on performance contracts.

tion between the public and the private research sector. Although some of these gaps have been compensated for in the past through the day-to-day work of a number of boards (FNR, CRPs, Luxinnovation), more systematic and proactive joint policy making is called for. The most urgent and at the same time most promising areas are the promotion of more systematic, long-term linkages between the public research sector, including the university, and private-sector research in Luxembourg and the *Grande Région*; and joint policy with respect to incubators and technology centres.

While the weak relationships between the Ministry of Culture, Higher Education and Research and the Ministry of the Economy and Foreign Trade tend to create policy gaps, relationships with and involvement of other ministries can be considered as "unexploited opportunities". There may be fruitful opportunities for enhancing policy collaboration and co-ordination, in particular in the field of education and culture, to consider Luxembourg as a location for and a prime example of a multicultural, multilingual society and related research and policy issues. Related issues include civil society, health, environment and food safety. The last of these offers a good example of what policy collaboration should be. Scientific or applied research in the field of food safety plays a minor role in terms of economic and societal impact. The more relevant aspect is the definition and implementation of regulations (for example traceability of foods) and standards and the building of capacity in firms for adopting food safety standards and related technologies. Again, joint policy making by the ministries responsible for research, the economy and health is called for. The VIVRE programme of the FNR ("Living tomorrow in Luxembourg") also concerns a wide range of sectoral policies. In addition, collaboration by various ministries should contribute to better visibility of science, technology and innovation in the political debate and among the public. In practical terms, the Inter-ministerial Co-ordination Committee for Research and Technological Development can play a role, specifically in adopting an agenda, ensuring managerial responsibility and resources, and acting as a "sounding board" for the management team. It is, however, not the place to co-ordinate content and practical work.

In the past, policy collaboration and co-ordination were implemented mainly through (joint) memberships on boards (FNR, CRPs, Luxinnovation, etc.) and committees (Inter-ministerial Co-ordination Committee for Research and Technological Development). In the future, a stronger focus on governance issues might be appropriate. As regards governance functions, Box 3.2 highlights areas which should be considered important.

Box 3.2. The critical functions of governance

The national innovation system approach has proved successful in addressing countries' (institutional) architecture of constituent actors, their relationships and interdependencies, and in particular their history and thus path dependencies within the system, including the governance system. At the same time, this approach warns against simply copying governance mechanisms that have evolved in different contexts. Instead, it is helpful to understand governance of research and innovation as a collection of functions. This allows those who design governance systems to decide which functions are necessary in the specific context of an innovation system and to consider alternative techniques for performing each function.

Setting priorities

While faith in detailed planning has generally been lost, most countries find it important to set broad national priorities in research and innovation. An important role for governance of research and innovation is to create an arena where priorities can be discussed and set. This may benefit from additional activities, such as a foresight exercises or various other forms of studies and consultation, but in the end someone has to decide what to do. The involvement of key ministers is helpful in this context.

A referee

Related to the need to agree and set directions is the need for a referee within the governance system which often is the arena of conflict and clash of cultures between research and R&D/innovation. The Finnish model is widely admired, not least because – with the prime minister chairing the Science and Technology Policy Council – there is a strong incentive to resolve conflicts before they reach the Council. In other governance systems there is no decisive referee function. The UK's chief scientific advisor and the minister of education in the Norwegian and Swedish systems have this authority to some extent but their decisions can always be challenged.

Horizontal co-ordination

Horizontal co-ordination is often needed to deal with change, such as the emergence of new technological opportunities. Arrangements to cope with these needs are therefore often rather specific, focusing on the actors that need to be co-ordinated, rather than using a broader, general-purpose forum such as a standing interagency committee. Such specific co-ordination mechanisms tend to fall into four categories: cross-ministry/agency programmes; inter-agency co-operation agreements; *ad hoc* co-ordination; and use of planning processes and procedures that require co-ordination.

An alternative to co-ordination is to build larger institutions with wider responsibilities. This does not always work because internal co-ordination is not necessarily more effective than external co-ordination. Inappropriate framework conditions can undermine even internal co-ordination. As a consequence, the creation of a "single ministry" is not a superior solution *per se*.

…/…

Box 3.2. The critical functions of governance *(continued)*

Co-ordinating the production of knowledge

In the innovation systems view, different types of knowledge – different disciplines, some more fundamental and some more applied – are interrelated. There is therefore widespread interest in designing governance systems and research and innovation funding schemes that bring them into contact. While it is likely that funding structures and governance can promote contacts across disciplines and different types of research it is worth recalling that other parts of the innovation system also self-organise cross-disciplinarity and interaction between fundamental and more applied research. Major companies work on a daily basis on solving design and integration problems across multiple disciplines. Likewise, some of the most interesting university research groups span disciplines or are a mixture of disciplinary and interdisciplinary research.

Policy intelligence

The governance system needs to provide and to have access to intelligence. Analytical resources are needed to generate evidence for policy making. There is a range of divisions of labour among ministries and agencies but there a tendency for the party that does the programme design to own the analytical resources. Sometimes this has led to questions about whether small ministries have the capability to be effective principals for their agencies. It seems likely that – in analogy to many industries – the most innovative situations are those in which capable suppliers meet equally capable and demanding customers. This calls for distributing intelligence across the whole research and innovation funding system.

Guiding agents towards socially desirable goals

There is evidence for widespread integration of beneficiaries and other stakeholders in the governance of research and innovation agencies. Generally, the research community dominates research councils while other stakeholders are more important in innovation and R&D agencies. Industrial representatives normally come from the largest and technologically most capable companies, though innovation agencies tend to ensure that the SME sector is also represented. Agencies in almost all OECD economies are moving towards being steered *via* some kind of performance contract with their parent ministries. Accompanying this movement is a growing emphasis on management by objectives and on reporting on the impact of agencies' activities. Objectives set for R&D and innovation agencies may be more specific and involve some degree of earmarking of funds. In general the relationship between ministries and their agencies is "arm's length". There is extensive dialogue and sharing of information in some cases but ministries rarely involve themselves in how agencies propose to reach their objectives, beyond agreeing on plans and annual reports.

Enhancing the profile of research and innovation

Making research and innovation policy issues more visible in policy debates and therefore improving their position in the struggle for resources is not stated as an explicit goal of governance. Nonetheless, this is achieved *de facto* in countries like Finland and Norway where there is active involvement in the highest levels of co-ordination.

Source: Arnold *et al.* (2003).

There are indications of an increasing undersupply of strategic capabilities at government and ministerial level owing to a staff shortage in departments on the one hand, and on the other, the delegation to and accumulation of major parts of strategic capacities by other (major) actors. Particular roles are played in this context by the FNR but also by Luxinnovation and the CRPs. As regards the FNR, its objectives, mission and tasks clearly represent a considerable concentration of power which is, in practice, not fully exploited. In the long run delegation of "strategic work" often leads to a hollowing out of ministries with respect to their strategic capacities and autonomy of action.[52]

However, two mitigating factors have to be taken into account. First, in the past, research and innovation policy actors at government level deliberately delegated a considerable share of power to institutions such as the FNR, Luxinnovation and CRPs, thereby keeping government lean. This may be seen as an expression of the general political style of the country. Second, there are indications of a high degree of informal relationships among major stakeholders in Luxembourg's research and innovation system, which compensates to some extent for the loss of power. Beyond the importance of personalities and informal relations is, some doubt can remain about the ability of Luxembourg's culture of informality to effectively change the architecture and governance of the system, and to achieve coherence and cope with the challenges arising from the substantial increase in public expenditure on R&D in the coming years. The most relevant issues to be tackled by Luxembourg's government in the near and mid-term future are summarised in Box 3.3.

52. Conducting a foresight exercise, such as the one currently being carried out, is certainly a sensible and important activity. However, it should preferably have been launched by the government, specifically by the Ministry of Culture, Higher Education and Research, possibly in collaboration with the Ministry of the Economy and Foreign Trade, rather than by the FNR. Issues such as education and training, regulation, procurement of research (*e.g.* in the field of environmental research or health studies) are concerned and are not among the areas of competence of the FNR. This does not imply that as a general rule the FNR should refrain from carrying out foresight activities or other types of exercises aiming at increasing its strategic capabilities.

Box 3.3. Increasing governance capabilities: issues and recommendations

Setting priorities and directions

Setting priorities is one of the most critical issues on the agenda of governments. It has been shown that in certain phases of the development of innovation systems it is appropriate to set more detailed thematic priorities, which can be oriented towards scientific disciplines, technology fields or (societal or economic) problems, while in other phases it may be more advisable to exert governance through the implementation of processes, principles or values. Sometimes it is possible to set directions through "shared visions".

A number of directions and priority setting processes either currently exist or are recommended in this report. The most powerful tool is the performance contracts to be agreed between the ministry, the CRPs and the University of Luxembourg, but also with the FNR. Based on preparatory activities such as foresight exercises, evaluations or strategic audits, directions can be set for a period of three to five years. A quite valuable by-product of performance contracts is the reduction of variety among the targeted organisations and thus better visibility and a better profile (a lack of which is an aspect of the problems addressed by priority setting).

Moreover, the FNR has established a suitable procedure for setting priorities within its own remit. What can be learned from this is that priority setting is of a participatory character, and is a succession rather than a "big bang" every five years.

Someone has to decide. The felt need for priority setting also has to do with a certain delegation of power and decision making to performers (CRPs, University of Luxembourg) or agencies (indicated by the fact that the FNR is conducting a foresight exercise or that Luxinnovation is carrying out policy studies, while at the same time a potential beneficiary of the policy recommendation). Deciding upon performance contracts based on a preparatory evaluation, audits and foresight exercises will also significantly reduce the need for additional priority setting.

Horizontal policy co-ordination: systematic collaboration between public and private research, enhancement of clusters

Co-ordination of policies addressing the business sector and the public research sector should be improved considerably. Strong elements should be the establishment of competence centres[53] and eligibility of the CRPs and the University of Luxembourg for the cluster programmes. A second, more opportunity-driven issue of policy co-ordination is to link research and innovation policy and institutions with sectoral policies (health, environment, agriculture, education).

…/…

53. For details see Chapter 4.8.4 and Box 4.2 on competence centres.

Box 3.3. Increasing governance capabilities: issues and recommendations *(continued)*

Vertical steering: performance contracts

As mentioned, the implementation of outcome-oriented governance mechanisms, in particular the use of performance contracts to govern the CRPs, the University of Luxembourg and Luxinnovation, is recommended. Furthermore, joint programme planning for performance contracts with the FNR, considered here as an agency competent in planning and implementing programmes, would lead to benefiting from international good practice.

Attention to goals and related performance contracts contributes directly to efficient allocation of the planned increase in public R&D expenditure. In particular this relates R&D expenditures to desired scientific, economic and societal outcomes. Stronger involvement of industry and sectoral policies and related institutions in research and innovation will help to increase the range of research users.

While universities always produce some economic and societal effects (in the first place through their graduates), public research institutions risk "forgetting" the users of their research work. Goal-oriented priority setting at the level of the CRPs and the FNR can effectively help to reduce blind spots.

International programmes: overcoming opportunity-driven participation through goal-oriented, proactive linking

Specific attention should be paid to the managerial consequences of Luxembourg's increased participation in international programmes, in particular those of the EU and ESA. In general, it is recommended to proactively link actors from Luxembourg (firms, research centres, *etc.*) to international programmes rather than promote EU programmes and actions.[54] A good and successful example is Luxembourg's strong position in ESA's ARTES programme. Close collaboration between research performers and policy makers or their representatives on programme committees is critical. As a consequence, co-ordination of national and international programmes and related projects can benefit from common goals.

Policy intelligence

Apart from the fact that Luxembourg is often poorly represented in international comparisons (OECD databases such as MSTI, the EU Trend Chart and the European Innovation Scoreboard), analytical resources to generate evidence for policy making have hardly been a limiting factor, especially since a bottom-up approach has been the dominant mode in policy making. In the future, a more goal-oriented approach will require sound understanding of the work of the respective actors, their problems and needs. Whatever the sources of intelligence, the critical factor is the creative tension between capable suppliers and equally capable and demanding customers. It may be appropriate for government to partly outsource policy intelligence to agencies operating at arm's length or to external advisors. Acting as a capable and demanding customer will nevertheless be indispensable.

54. In Finland, TEKES runs a specialised unit, whose main tasks are to identify opportunities for Finland's industry and research institutions to benefit from international R&D programmes and intergovernmental research organisations such as ESO, CERN, EMBL, ESA, etc., and to influence and shape priority setting in the respective policy committees.

3.9.3 Luxinnovation

Founded in 1984, Luxinnovation is one of the oldest institutions in Luxembourg dealing with R&D and innovation. It has accumulated an impressive portfolio of services and it has promoted a number of advanced concepts in innovation policy (partnering, clusters, technology and innovation management, counselling, business planning, etc.). Furthermore, it has contributed to linking Luxembourg better to EU policy initiatives. However, the expansion of Luxinnovation's portfolio of activities raises two types of issues: First, it is doubtful if in an environment of growing demand for innovation-related services Luxinnovation can maintain the quality of its contribution without some streamlining. Second, the role of Luxinnovation as a provider of innovation support services may increasingly conflict with some of its other functions and with that of other actors (see Box 3.4).

Box 3.4. A new role for Luxinnovation: issues and recommendations

Some built-in conflicts in Luxinnovation's portfolio

Luxinnovation's portfolio reveals some areas of potential conflict. In particular, the provision of specific policy intelligence services such as the preparation of Luxembourg's part of the European Trend Chart on Innovation as well as the Report on Research and Innovation may conflict with Luxinnovation's role as a provider of innovation support services.

Luxinnovation has particularly strong relationships to the Ministry of the Economy and Foreign Trade. These strong links not only reflect the ministry's formal position but also a strong working relationship with the ministry. Luxinnovation acts among other things as an outsourcing partner to the ministry for intelligence services. This may weaken its position *vis-à-vis* other actors, particularly when it conducts assessment-type policy studies in fields in which it is perceived to have a vested interest.

Some of these conflicts should be resolved by establishing specific capacity in the field of innovation research and related services within one of the research institutions or the University of Luxembourg. At the same time, it may be attractive to collaborate with foreign partners on various subjects and occasions and to invite independent organisations not based in Luxembourg and with specific competences to asses the innovation system on a regular basis (*e.g.* every five years).

There are obvious overlaps between CRP Henri Tudor and Luxinnovation since a number of services are provided by both institutions, in particular with respect to incubator, cluster and platform services.

Auditing the pertinence, portfolio and position within the institutional system

It might be worthwhile investigating in more detail: *i)* the pertinence of the portfolio of services provided by Luxinnovation (and by CRP Henri Tudor), and, even more importantly, its role in the overall institutional set-up (present and future); *ii)* the specific contribution of Luxinnovation to overcoming the gap between private- and public-sector research; *Iii)* the future role of Luxinnovation in extending the reach of innovation policy to the services sector (*e.g.* in the area of financial services) and other activities in which innovation is not directly based on R&D (see below the example of the proposed centres of competence).

3.9.4 The National Research Fund (FNR)

The FNR has some peculiarities. First, in its core mission of funding research the FNR operates exclusively on the basis of multi-annual programmes. There is, for good reason, no room for projects and activities generated bottom-up. Second, there is a high degree of symmetry in decision making between the Board of Administration and the Scientific Council,[55] both at the level of planning and selection of programmes and at the level of selection of individual projects. Third, the target group is limited to public research and higher education institutions. Private sector research is not – at least not directly – addressed. Fourth, the FNR, although formally endowed with a high degree of autonomy, actively seeks advice, co-ordination and coherence with other stakeholders. Fifth, in contrast to other national research agencies, both the Administrative Board and the Scientific Council are open to non-residents[56] (four out of twelve and five out of thirteen, respectively). The nomination of the members is in principle largely determined by government. However, a closer look reveals a strong presence of beneficiaries in the Scientific Council (six out of 13).

While many other national research agencies put comparatively little effort into monitoring the progress of funded projects, the FNR has taken the opposite route. In order to appreciate its above-average effort, it is useful to recall that the FNR funded 52 projects with total funding of EUR 43 million during the first five years of operation. The projects are multi-annual and involve groups of researchers. As a by-product of its monitoring and assessment, the FNR has accumulated experience and evidence on target groups (or has at least the opportunity to do so), which puts them in a position to improve both its own performance and that of the overall (public) research system. The FNR has distributed its programmes reasonably over time and avoided starting all programmes at once.

55. Although the Scientific Council does not formally take decisions, it contributes significantly *de facto* to the outcomes of the decision-making body, the Board of Administrators.

56. Most of the non-residents have their roots in Luxembourg. However, what is of interest in the present context is that they introduce experience, practices and values from other countries and research systems. Moreover, they enjoy a higher moral authority as they are not beneficiaries of the FNR.

At first sight, the beneficiaries of FNR funding are restricted to public research and higher education institutions. However, in the Surface Treatments Programme (TRASU), the target group is enlarged to include industrial companies and research organisations abroad.[57] Likewise, as the Food Safety Programme (SECAL) clearly indicates, research is funded not only to produce knowledge but also to build capability in fields of national priority. Finally, the target group of the FNR is not restricted to beneficiaries of the prioritised programmes. Indeed, accompanying measures as well as participation in international, in particular European, programmes and scientific bodies demonstrate the instrumental role of the FNR with respect to its mission.

The FNR appears able to play a dominant role in the public research system for the following reasons: most of its funding is allocated to the public research/higher education institutions; the procedures for selecting programmes and projects can ensure high-quality standards; major stakeholders of Luxembourg's research system, in particular the major beneficiaries, are represented in advisory functions; and all stakeholders in research, in particular all potential beneficiaries, are invited to submit ideas for new research programmes.

The FNR's work in carrying out its tasks creates – and concentrates within the FNR – a wealth of information and experience about research performers, the conduct of research and outcomes. This leads to asymmetry between the funding agency and the relevant government departments to the detriment of the latter. This general tendency is amplified by the nature of the process of identification and selection of new programmes, which is mainly bottom-up, putting research performers in a preferred position.

There are strategies for overcoming this asymmetry. Governments are well-advised to maintain and manage a strong hold on: basic intelligence activities: formulating and negotiating performance contracts; conducting monitoring, evaluation, and foresight exercises; maintaining a professional attitude, in particular maintaining a certain distance between the principal (government) and the actor (research organisations, universities, *etc.*), specifically through a limited duration for holding supervisory functions.

57. The FNR cannot fund private companies. Within the TRASU programme, there are project partners from industry, but only the public partners are funded through the FNR.

The powerful legal status of the FNR, its specific approach to defining priority areas which supports the needs and priorities of stakeholders/ beneficiaries, the allocation of 75% of its funding to only three institutions, and its accumulated information about the content and performance of the research activities funded lead to a number of conclusions, which are different aspects of one strong general observation: the FNR is *the* backbone of Luxembourg's public research policy in terms of scientific quality. Accordingly, the major stakeholders in Luxembourg's research and innovation system are in favour of extending the agenda and role of the FNR with respect to the following functions. First, the FNR should allocate all government project-based funding to the CRPs, CEPS/INSTEAD, and presumably in the future to the University of Luxembourg, making full use of its accumulated skills. Second, the FNR should serve as a platform for agenda setting and translating needs, trends and opportunities into research programmes. Third, the FNR's advisory function (presently for its own operations) should be enlarged to become a kind of National Science Council.

At present, however, the FNR is neither in a position to take over these powerful new roles nor does this appear desirable. Given the envisaged increase in public R&D in the medium term and a number of (historical) imperfections in the overall governance of Luxembourg's research and innovation system, the role and profile of the FNR in the system of R&D funding and even more in programme selection and priority setting, need to be adapted so that it can fully contribute to the ambitious goals of increasing public funds for R&D during the coming years and transforming the overall research and innovation system.

The future institutional development of FNR might include the adaptations spelled out in Box 3.5.

Box 3.5. Broadening the scope of FNR: issues and recommendations

Definition of programmes, agenda setting and research infrastructure policy

Since research organisations and universities often suffer from ill-defined goals, it is recommended to make use of performance contracts between government and these organisations to spell out goals, expected outcomes and strategies more precisely.

Since major shares of FNR funding are allocated to a rather small number of beneficiaries, it is both desirable and manageable to link funding decisions explicitly to the strategies and goals of the funded institutions. Integrating the strategies and goals of the funded institutions as additional funding criteria necessitates a change in the project appraisal and decision-making criteria and processes. Basically, there is a need to appraise funding applications against both scientific advancement ("quality") and contribution to the goals and strategies of the funded institution ("relevance").

Particular attention can be paid in this model to the question of funding the research infrastructure.[58] An integrated approach should help to overcome the implicit criticism of funding research infrastructure via the FNR. Likewise, it would be possible to link investments in infrastructure and capacity building to outcome-oriented funding.

Enlargement of scope of funding schemes: transferring project funding from the ministry to the FNR

Project funding from the Ministry of Culture, Higher Education and Research, in particular to the CRPs, CEPS/INSTEAD, and the University of Luxembourg, should be transferred to the FNR. FNR has professional staff capable of managing projects, in particular through the involvement of peers. For its part, the ministry can direct its attention to the implementation and execution of performance contracts. This separation of roles can help to overcome a number of built-in conflicts, mainly between the ministry and the performing institutions by separating the negotiation of performance contracts from ensuring their accomplishment (through funding).

Addressing the private and institutional sector

The FNR addresses the private sector or public institutions such as hospitals, museums, or educational institutions indirectly, but it also addresses regulations (*e.g.* food safety) and societal needs (*e.g.* ageing, migration). It would be worthwhile considering broadening the range of beneficiaries in research programmes with explicit and strong links between public- and private-sector research or partnerships with institutions.

Composition of the boards and the secretariat

Depending on the extension of the functions and scope of FNR, it may be appropriate to rethink the composition of the boards and the staffing of the secretariat. As a general rule a more entrepreneurial attitude might be useful in order to introduce more proactive elements into the overall performance of the FNR. In view of the suggested broadening of the type of funded research as well as the institutional enlargement towards greater variety, a change in the composition, in particular of the Scientific Council, should be considered. Special attention should be paid to greater involvement of research users, from both the public and the private sector. …/…

58. There is some degree of ambiguity in the definition of research infrastructure: what is part of a research project for the CRP may be conceived as research infrastructure for an industrial partner.

Box 3.5. Broadening the scope of FNR: issues and recommendations *(continued)*

Relationships between FNR and the government: performance contracts

Government, particularly the Ministry of Culture, Higher Education and Research as the prime "owner" of the FNR, should exert a strong influence on its contributions to the country's overall goals. A multi-annual performance contract seems an appropriate means of communicating and negotiating the roles, contributions and visions of the various actors. Given Luxembourg's overall goal of increasing the ratio of public R&D expenditure to GDP during the next years, performance contracts can serve as a powerful link between the government and the FNR on the one hand and funding contracts – which explicitly refer to the strategies and goals of the funded institutions – on the other.

Restriction of FNR's role to funding

The FNR's role is funding research. While it is appropriate to enlarge its portfolio in terms of volume and type of programmes (not only thematic fields but also structural issues), inclusion of non-funding tasks would overextend the institution and – in the long run – hollow out the role of government. Basically, policy (recommendations) would be perceived mainly in terms of funding problems. The priority of issues unrelated to funding would tend to be downscaled.

Finally, in the framework of performance contracts between government and the FNR and the performing institutions as the dominant governance instrument, there is a strong need for an "independent" institution able to decide exclusively on the basis of quality and relevance without interference from other obligations and considerations.

3.9.5 Promotion of business R&D and technological innovation: integration and stronger focus

Luxembourg has a rather generous support scheme for individual companies which tends to benefit firms that carry out R&D activities on a regular basis. However, the propensity to collaborate on R&D and innovation projects is comparatively low among research performers and at the policy level. Instead, most projects involving companies and public sector research institutions are carried out on the basis of public funding which – for good reason – prefers networks of firms and thus a certain type of collective research in terms of content and appropriation regime.

Because both sectors are in some sense quite well served, opportunities for collaboration are far from fully exploited. In particular, the public research sector is largely opportunity- or supply-driven and has stronger ties to its peers and weaker ones to local industry. Thus, both parties have weak incentives to direct their attention to the other side.

A further characteristics is the high degree of specialisation in the allocation of public funding to private R&D (about 90% goes to the metal transformation and the chemical and para-chemical industries). Finally, the absence of dedicated measures to address the service industry, in particular the media/telecommunications and financial sectors, may be considered a further indication of a hands-off policy as regards public promotion of business R&D.

Promotion of public-private partnerships for innovation, industry-science relationships and technology transfer has not been high on the agenda of science, technology and innovation policy as far as explicit instruments and schemes are concerned.

However, when one looks at details of programmes launched by the FNR or at the mission of the CRPs, a different pattern emerges, which indicates a significantly higher level of collaboration or at least of orientation towards the needs of industry. Moreover, recent developments indicate a reorientation of policy. Increased attention to incubators and technology or science parks as well as the introduction of the concept of technology clusters are evidence of Luxembourg's attempt to gradually adopt instruments that address relations and intermediary functions and thus linkages in the innovation system rather than individual actors.

Accordingly, it will be useful to focus on issues addressing coherence, co-ordination and a more comprehensive policy approach which draws on the systems approach in research and innovation. Future policy can thus be measured against how it meets the challenges set out in Box 3.6.

Box 3.6. An integrated approach to business R&D and innovation: issues and recommendations

Co-ordinated adoption of approaches already implemented in innovation policy

The proposed approach can be summarised as follows. Priority is given to improved co-ordination of innovation policy measures already implemented, such as incubators, technology and science parks, technology clusters/platforms, innovation management techniques, etc. Lower priority is given to the implementation of new concepts (except for the competence centres; see Section 4.8.4 and Box 4.2).

Clusters, networks and platforms: alignment of institutional setting and expectations

Clusters, networks and platforms can be powerful but are often overestimated. In Luxembourg, there is a certain tension between two dominant actors, Luxinnovation and the CRP Henri Tudor, which compete for recognition and partners or customers. Advanced clustering goes far beyond a support service operated by two "cluster managers" and should include the whole range of relevant actors. The fact that the CRPs were not eligible in the first phases of cluster activities owing to their overwhelming presence provides some insight into the difficulties cluster managers have to deal with.

A test case for the strength of the cluster approach is its application to the financial and media industry and to the *Grande Région*.[59] Regarding the tensions between Luxinnovation and CRP Henri Tudor, a top-down-led mediation process should result in clarification of their respective agendas. This should be possible since both institutions are advised to rethink their portfolios and to refrain from too readily adopting new services. …/…

59. The *Grande Région* provides an excellent test of pertinence: all concepts should be double-checked with respect to possible extension to the greater region.

Box 3.6. An integrated approach to business R&D and innovation: issues and recommendations *(continued)*

Aligning the governance and management of technology parks and incubators

Luxembourg has established a number of technology parks and incubators. All centres emphasise "soft" measures – business support, counselling, networking – rather than the physical premises. This is good practice. However, there is some doubt as to whether each centre can realistically expect to recruit experienced specialists in the field, let alone to pay them adequately. Management of as many of the centres as possible by one management team and branding would be a worthwhile strategy for higher impact.

Exploring the status and future role of non-traditional sectors (banking, finance, insurance, media)

Luxembourg is well-known as an international financial marketplace. In contrast to other locations such as Zurich, most banking and insurance companies located in Luxembourg are subsidiaries and governed from their headquarters abroad. In the medium or long term Luxembourg's position as a favourable location will be jeopardised by the alignment of European financial sector regulations. Most relevant actors are aware of this and urge creativity and action. A case could be made for conducting a comprehensive foresight study to better understand the future challenges to this sector and the potential contribution from research and higher education. An integrated and long-term policy approach would be appropriate.

Winning established and new sectors as partners of CRPs and the University of Luxembourg

It is recommended to include major traditional manufacturing industries (metal transformation, chemical and para-chemical industry) as well as the service industries (such as media, banking and finance) as partners of the CRPs and the University of Luxembourg. The systematic involvement of the major traditional and new industries should be considered a top priority in future programme planning, particularly for FNR programmes with CRPs and the University of Luxembourg as partners. This should be given priority at all levels and in all institutions.

Establishment of competence centres

Parts of the CRPs show strong performance in R&D and in the management of (larger) projects. Furthermore, some have a strong orientation towards the needs of industry or society, which finds its realisation in projects and platforms but also in the mobility of staff from the CRPs to industry and *vice versa*. These established links should provide the basis of centres of competence[60] with a long-term horizon, a strong role of industry in the definition of priorities, mixed public-private funding and strong management. Defining the content and specifying the strategic set-up of such collaboration is not a trivial matter and requires time and creativity.

Key challenge: addressing the *Grande Région*

Public and private-sector research should not stop at the country's borders. Instead, Luxembourg should make a virtue of its small size through funding schemes that allow cross-border collaboration, above all within the *Grande Région*. FNR, the CRPs and the University of Luxembourg should be motivated to enter cross-border relationships. Performance contracts can easily address these issues.

60. For details see Box 4.2.

3.9.6 Internationalisation of R&D

Most researchers are from abroad in both the public and private sectors. Luxembourg's economy is highly internationalised, not only in traditional manufacturing industries (mainly the metal transformation, chemical and para-chemical industries) but also in the services sector (media, financial industry). A number of European institutions are also located in Luxembourg.

Some research actors are deeply involved in EU projects, and others have become active in international research funded from other sources. Just a few groups rely on domestic partners and their funding. Major parts of private-sector research are carried out by firms that are oriented towards international markets.

In terms of contract research and recruitment of engineers, Luxembourg-based firms are well-placed to benefit from major academic resources located in Aachen, Karlsruhe, Stuttgart, Metz, Strasbourg, Liege, Louvain and Eindhoven.[61]

The fact that a significant part of Luxembourg's research community's international linkages is based on two pillars – EU funding and other distributed sources – should be considered a strength, as this provides some protection against vulnerability due to excessive dependency on too few sources.

For participation in EU programmes, Luxembourg's success can be considered average. A closer look at success rates for specific programmes compared to the European average, however, reveals an above-average rate in some major programmes (nanotechnologies, energy and sustainable development), while they are quite poor in the fields of ICT (131 proposals submitted, 19 approved for funding) and life sciences (23 proposals submitted, three approved for funding). This sheds some light on the performance of the different institutions and organisations.[62]

---

61. See the Luxembourg-based Goodyear Technical Centre, which employs 960 staff (and growing), of which 450 have a higher education background (PhD, degree, polytechnic). The distribution of recruitment by country is as follows: Belgium (33%), Luxembourg (33%), France (18%), and Germany (6%).

62. There are procedural differences between ESA and EU programmes. In spite of the competitive bidding procedures, the principle of fair return in the long term operates for ESA programmes but not for EU framework programmes, for which competition is quite fierce.

Membership in ESA provides opportunities not only through tenders and contracts but also as a means of dialogue between industry on the one hand and representatives of research and innovation policy and the domestic research and higher education institutions on the other. The decision to set up a cluster programme in space technologies is a good starting point for an enlarged and more diversified approach to prevent a unidirectional supplier position to ESA.

Issues and recommendations concerning the internationalisation of R&D are summarised in Box 3.7.

Box 3.7. Internationalisation: issues and recommendations

Participation in EU and other international programmes

The major policy implication of participation in EU and other international programmes is selectivity in utilisation of international programmes by both research performers and policy makers. Selectivity should be based, as much as possible, on prior goals and related strategies. Where suitable, performance contracts can help in this regard, in terms of relationships between the Ministry, the CRPs, the University of Luxembourg, etc. Luxembourg has successfully applied this principle in the case of ESA (the ARTES programme) or in the Nanotechnologies programmes of FNR and the EU.

The *Grande Région*

To derive maximum benefit from its position within the *Grande Région* is a major challenge and opportunity for Luxembourg's industrially oriented research community and its industry at large. This includes increased trade and collaboration among firms from Luxembourg, Germany, France, Belgium and the Netherlands. The challenge for research and innovation policy is to support industry through specialised institutions: CRPs and the University of Luxembourg, FNR and Luxinnovation. The test case, in particular for the CRPs, is to put their numerous networks and platforms to work, which means to increase direct contract research, which can be considered a reliable indicator of the attractiveness of the services they offer. On the side of policy institutions and related policy making, Luxembourg should actively direct its attention to the *Grande Région* as a policy-making target area. This requires a committed extension of funding programmes as well as support actions (such as clusters) to include "foreign" firms and related institutions. The European Commission's ERA-NET programme should act as a laboratory for cross-border collaborations.

An integrated approach to internationalisation

R&D in the private sector is performed by a rather small number of internationally active companies. In an era of global mobility this concentration creates some risks for Luxembourg as a location for R&D. At the same time these companies provide ample opportunities which are not fully exploited. To make good use of these opportunities requires an integrated approach. This includes jointly addressing big companies, their suppliers, the CRPs and the University of Luxembourg as the major performers of R&D and innovation and the relevant policy instruments as support structure. The cluster programmes, programmes aimed at internationalisation (EU Framework Programmes, ESA, etc.) but also funding of larger projects via the FNR and performance contracts should actively address the larger context and thus reflect the strategies of the beneficiaries. Collaboration at the level of policy institutions is critical in this regard.

3.9.7 An ad hoc Advisory Board for Science and Technology Policy

There are indications of an increasing undersupply of strategic capabilities at government and ministerial level, notably in the departments in charge of R&D and innovation. The main reason is a shortage of staff. Other actors, such as FNR, Luxinnovation and the CRPs, partly fill the gap. However, this tends to lead to a confusion of roles and conflicts of interest.

Given the envisaged increase in public expenditure on R&D and the necessary adaptations in the governance system in the coming years, it would be advisable first to increase the staff of the ministries in charge of the formulation and strategic assessment of policy and second to establish an independent, *ad hoc* Advisory Board on Science and Technology Policy that would either report to the Prime Minister or jointly to the Minister of Culture, Higher Education and Research and the Minister of the Economy and Foreign Trade.

Its main task would be to monitor progress in the implementation of the government's agenda for strengthening Luxembourg's research base, giving advice to the government and initiating complementary studies and evaluations. Finally, it could contribute to higher visibility of research and innovation in the political debate and among the general public. The Board's members should have a strong background in business, science and innovation policy. A sufficient number should be non-residents who bring with them experience obtained outside Luxembourg. Specifically, the following criteria should be used for selecting members: no management and decision-making function in Luxembourg; no beneficiary of funding or other public resources or support; high credibility and reputation; and good knowledge of the Luxembourg research and innovation system.

Due to limited resources, an existing body such as the Inter-ministerial Co-ordination Committee for Research and Technological Development could provide the secretariat for the Advisory Board.

Chapter 4

THE PUBLIC RESEARCH SYSTEM (PUBLIC RESEARCH ORGANISATIONS AND HIGHER EDUCATION INSTITUTIONS)

Public research is fairly new in Luxembourg. The law of 9 March 1987 set the framework conditions for a substantial research plan at national level. Before 1987 public research and higher education were confined to the Centre Universitaire (CUNLUX), the Higher Technology Institute (IST), and the Higher Institute for Educational Studies and Research (ISERP), which were mainly responsible for education and training of engineers and teachers. Research was also carried out in the Central Hospital of Luxembourg and the National Museum of Natural History.

Under the 1987 law, three major CRPs were created: CRP Gabriel Lippmann, CRP Henri Tudor and CRP Santé under the responsibility of the Ministry of Culture, Higher Education and Research. The centres have developed their capacities in a number of areas considered to be of national economic interest. The CRPs also host laboratories for PhD students in co-supervision with universities, mainly from abroad but also – and increasingly – with the University of Luxembourg.

In addition, CEPS/INSTEAD (*Centre d'études de population, de pauvreté et de politiques socio-économiques*) is also under the responsibility of the Ministry of Culture, Higher Education and Research after having been under the Ministry of State until 2004. CEPS/INSTEAD was created in 1978 as a private non-profit research institute and creates and uses databases to carry out studies on population, poverty and socioeconomic policies. It provides one of the few large infrastructures in the social sciences in Europe.

Table 4.1 provides an overview of Luxembourg's public research institutions. The rest of this chapter describes the three CRPs (Gabriel Lippmann, Henri Tudor, Santé), CEPS/INSTEAD and the University of Luxembourg in more detail.

Table 4.1. Public research institutions in Luxembourg

Centre		Founded
Centre Universitaire du Luxembourg*	*www.cu.lu*	1974
Higher Technology Institute*	*www.ist.lu*	n.a.
Higher Institute for Educational Studies and Research*	*www.iserp.lu*	n.a.
Centre Hospitalier de Luxembourg	*www.chl.lu*	1975
Centre d'études de population, de pauvreté et de politiques socio-économiques	*www.ceps.lu*	1978
Scientific Research Centre of the National Museum of Natural History	*www.mnhn.lu/recherche*	1982
CRP Gabriel Lippmann	*www.crpgl.lu*	1987
CRP Henri Tudor	*www.tudor.lu/*	1987
CRP Santé	*www.sante.lu*	1988
European Centre for Geodynamics and Seismology	*www.ecgs.lu*	1988
Robert Schuman Centre for European Studies and Research	*www.cere.etat.lu/*	1990
Luxembourg Institute for European and International Studies	*www.ieis.lu*	1990
Institute for Educational and Social Studies	*www.iees.lu*	1990
National Health Laboratory	*www.lns.etat.lu*	1992
Banque centrale du Luxembourg	*www.bcl.lu/en/index.php*	1998
Virtual Centre for Knowledge in Europe	*www.cvce.lu*	2002
University of Luxembourg	*www.uni.lu*	2003

* University of Luxembourg since 2003.

Source: *www.innovation.public.lu*

4.1 Financing and governing the CRPs: changes in the funding rationale

The CRPs rely on the following sources of funding:

- An annual financial contribution from the state budget, awarded according to the R&D priorities laid down by the government and the programme of activities proposed by each CRP.
- Annual financial contributions from the state budget, reserved for carrying out missions determined by prior agreement between the government and the CRPs.

- Contributions disbursed for R&D projects carried out on a contractual basis with other research centres, companies and bodies or institutions, both national and international.
- Funding via calls for project proposals from the National Research Fund (FNR).[63]
- Donations and legacies, in cash or in kind.
- Revenue from management of their assets.
- Revenue from the transfer of rights of ownership or the granting of a licence.

In a major policy innovation, from 2004 the funding rationale of the Ministry of Culture, Higher Education and Research changed from essentially project-based financing to a broader approach including institutional financing, based on performance indicators and related performance contracts. At present, the ministry has a comprehensive set of more than 60 indicators covering mainly scientific and technological competencies, the potential for the transfer of competencies, communicative and managerial competencies, in particular for human resources, scientific and technological infrastructures and financial matters.

4.2 Gabriel Lippmann Public Research Centre

Founded in 1987, the CRP Gabriel Lippmann is a public organisation involved in applied scientific research and technological development, as well as technology transfer and high-level training. Currently it employs over 80 researchers, researchers-teachers and postgraduate trainees. Its activities are aimed at strengthening Luxembourg's economy by creating new technological expertise and by transferring this know-how to companies.

The CRP Gabriel Lippmann focuses on three major areas: innovative materials technology, in particular nanotechnologies and related instrument development; sustainable management of natural resources; and information society technologies. In the very recent past it decided to establish a Research Laboratory for Automotive Equipment. The Economic Law Laboratory – formerly part of the CRP Gabriel Lippmann – has developed

63. As can be seen from Table 4.3, 75% of total funding was allocated to the three CRPs.

its own profile over time and was recently merged with the University of Luxembourg.

Table 4.2. CRP Gabriel Lippmann: departments, staff, projects, and publications, 2004

	Number of staff	Number of projects (mainly multi-annual)	Number of publications
Materials Analysis Laboratory (LAM)	16	9	18
Unit for Research on the Environment and Biotechnology (CREBS)	45	35	148
Unit for the Research, Study and Development of IT (CREDI)	22	20	8
Laboratoire de Recherche en Equipements Automobiles (LEA)*			
Total	**83**	**64**	**174**

* In preparation.

Source: CRP Gabriel Lippmann, *www.lippmann.lu*

4.2.1 Materials Analysis Laboratory (LAM)

The Laboratory for the Analysis of Materials started its activities in 1992. LAM is an analytical laboratory specialising in characterisation and failure analysis. The objective is to equip LAM with sophisticated instruments run by highly specialised scientists with a view to close collaboration between industries and LAM. Through the use of state-of-the-art equipment and techniques, LAM has built up expertise in the analysis of materials at atomic level in order to improve them or develop new ones.

Supported by the NANO programme of the FNR, LAM became a European centre specialised in the characterisation of a wide range of materials (metals, semiconductors, glasses, ceramics, polymers) at nanometre scale. Since 2001, the laboratory has been equipped with a NanoSIMS; the CRP Gabriel Lippmann is one of five laboratories worldwide operating this type of equipment.[64] In its research activities the laboratory puts special emphasis on the development of scientific apparatus. Since obtaining the NanoSIMS, it collaborates in Luxembourg and abroad, with more than 100 companies, ranging from SMEs to multinational companies such as Alcatel, Honeywell,

64. The others are the Harvard Medical School, the Curie Institute in Paris, the University of Washington and the Max Planck Institute for Polymer Research in Mainz.

L'Oréal, Solvay, Goodyear, Pechiney Eurofoil and TDK at levels ranging from services to long-term research projects. LAM is co-ordinator of the FP6 Network of Excellence "Nanobeams".

4.2.2 Unit for Research on the Environment and Biotechnology (CREBS)

The study of ecosystems, hydro-climatological monitoring and agro-biotechnology are covered by the Unit for Research on the Environment and Biotechnology. It has a particular focus on Forest and agricultural bio-technology (BIOFAR), Aquatic and terrestrial ecosystems (ECOSAT), Geo-hydrosystems and spatial planning (GEOSAT).

CREBS has a total staff of 45 (each unit 15 staff) and is well connected both internationally and nationally (41 partners from 15 countries and the EU, 24 national partners). It runs a total of 35 mainly multi-annual projects with an average size of several man-years. The unit's output is quite impressive (169 publications in 2004 including conference proceedings).

4.2.3 Unit for the Research, Study and Development of IT (CREDI)

This unit of the CRP Gabriel Lippmann, with a staff of 22, focuses on co-operative informatics based on ICT, e-commerce and knowledge management and is engaged in both research and technology transfer on a wide range of topics.[65] CREDI also co-ordinates high-level training courses and seminars held by the research centre.

CREDI is entirely oriented towards domestic partners: eleven private and ten public partners, two scientific partners (CRP Henri Tudor, University of Luxembourg). Publication performance is rather poor (eight in 2004, three in 2003 and three in 2002), and mainly consists of conference pro-ceedings.

65. Computer supported co-operative work (CSCW), decision support, e-business, e-government, e-learning, knowledge management, natural language processing (NLP).

4.2.4 Concluding observations on CRP Gabriel Lippmann: heterogeneity in thematic areas, orientation and performance

- The orientation of the individual units of CRP Gabriel Lippmann differs widely in terms of thematic areas, geographic coverage, type of partners and type of intellectual. The units are generally above critical size.
- While three of the four units represent established research fields in more or less all industrialised countries, the Economic Law Laboratory (LDE) was more unusual. Luxembourg had lacked capacity in this important field. The establishment of the LDE at one of the CRPs was a rational choice. The LDE was recently transferred to the University of Luxembourg.
- The Materials Analysis Laboratory sees its role as providing an advanced infrastructure, focused on a rather narrow range of research priorities. While it seeks to compete on a world scale, in particular through the establishment of the NanoSIMS facility, its scientific performance in terms of publication is quite poor. Its role as a co-ordinator of the FP6 Network of Excellence "Nanobeams" is likely to result in close relationships with the project partners. At the same time this requires a considerable amount of time and attention.
- LAM is in a somewhat unbalanced situation. It is operated by a team of 16 employees, and its publication performance is moderate (2004: 18, 2003: nine publications, mainly conference proceedings). However, the laboratory is well connected to domestic and international industry. There is a certain danger of drifting into an advanced research infrastructure that will be outdated in a few years owing to a diminishing ability to keep pace with developments in the field. At the same time, LAM has the potential to create international visibility for Luxembourg. Circumventing the infrastructure trap and keeping scientific performance high is more a question of leadership than of government policy, and thus is an issue for the unit and the CRP Gabriel Lippmann.
- A strategic audit of CREDI should provide a better understanding of its low scientific performance and offer a basis for deciding on the options available (reorientation, merger with CRP Henri Tudor, or even spin-off as a private company without basic funding from the government).
- CREBS has many aspects of a high-performing unit. It performs excellently in the role and mission of a specific type of research that is socially relevant but cannot be provided by the private sector or by a typical university department and is thus best organised as a public research organisation. CREBS has a proper mix of national and international

projects and demonstrates that international research does not necessarily have to be EU-funded. Its publication output is quite impressive.

4.3 Henri Tudor Public Research Centre

Founded in 1987, the CRP Henri Tudor primarily seeks to promote technological innovation in the private and public sector. To this end, it offers a wide range of services and activities, including R&D projects, technology transfer, technological assistance and advice, training and high-level skills. The main organisational units, characterised by their size, projects, and publications, are listed in Table 4.3.

In 2004, as can be seen from Table 4.3, the CRP Henri Tudor participated in 103 projects, among them 37 co-financed by the Ministry of Culture, Higher Education and Research, six co-financed by other Ministries, 35 European projects, in particular in the context of FP5, FP6, ESA, LEONARDO, FEDER, INTERREG, FSE Objective 2 and FSE Objective 3 programmes. Nine projects were financed by the FNR in the context of multi-annual research programmes, and 19 projects were financed 100% by the private sector or public departments.

Among its projects, 70% are implemented in direct partnership with companies or groups of companies, 34% in partnership with public departments or bodies and 29% in partnership with research centres or universities (a project may involve more than one partnership). Four actions were launched in 2004 in the FP6: CRP Henri Tudor co-ordinates a technical group in the network of excellence INTEROP (Interoperability Research for Networked Enterprises Application and Software); is a member of the directorate of the network of excellence CMA (Complex Metallic Alloys); co-ordinates the FP6 STREP project CASSEM (Composite and Adaptive Structures: Simulation, Experimentation and Modelling); and participates in the NAVOBS (a support measure to boost the business prospects of GMES and telecom satellites through focused and innovative RTD work involving SMEs).

Table 4.3. CRP Henri Tudor: departments, staff, projects and publications

		Number of projects in 2004						
	Staff	Total	MCESR	Other ministries	FNR	EU	Private sector	Publica-tions
Laboratory of industrial technologies and material science (LTI)	52	21	9			7	5	15
Centre for Innovation through Information Technologies (CITI)	90	32	17	1	2	9	3	40
Resource Centre for Environmental Technologies (CRTE)	13	11	1	2	4	3	1	8
Resource Centre for Health Care Technologies (CR SANTEC)	20.5	11	1	1	3		6	3
Centre of information technology resources for construction (CRTI-B)	2	1	1					3
Lifelong learning for technological innovation (SITec)	17	17	6	2		7	2	
Centre for technology observation and norms	10	8	2			4	2	6
Incubator for Innovative Technology Enterprises of Technoport Schlassgoart	3.75	2				2		
Total	**208.25**	**103**	**37**	**6**	**9**	**32**	**19**	**75**

Source: CRP Henri Tudor, Annual Report 2004.

The CRP Henri Tudor is well integrated in the international community, through its projects and its expertise. Researchers at the centre took part in 18 evaluation committees for international scientific conferences, four scientific evaluation committees for international research programmes and one normative evaluation committee, as well as in national and international orientation committees.

Its activities in training include doctoral training. In 2004, the Centre trained 16 doctoral students and became a member of a European doctoral college in the field of new materials and their characterisation. It also co-organises two ongoing diploma courses with the University of Luxembourg

and foreign universities, and 35 researchers at CRP Henri Tudor participated in university training in Europe.

A characteristic of the CRP Henri Tudor is its volume and range of activities aimed at dissemination and transfer: 148.5 days of training were organised, with 93 different courses and cycles involving 932 participants. The two diploma courses represented 79.5 days. Two European scientific networks held their annual conferences at CRP Henri Tudor, which also organised 79 thematic events.

CRP Henri Tudor initiated and manages the "Technoport Schlassgoart" technology incubator. It began operation in 1998 as a pilot project and has been in full operation since 2001.[66]

It is a quite complex knowledge organisation and hierarchical entity. Its activities cover R&D, technological expertise and consultancy, innovation networks and platforms, high-level training, master's degree training in co-operation with universities, science-based business incubation, and doctoral research. In terms of its technology areas, CRP Henri Tudor covers information and communication technologies and information society technologies (45%), materials and industrial technologies (35%), technologies for the environment (10%), and health care technologies (10%).

Given the range of activities and services distributed over four fields of competence, CRP Henri Tudor is hierarchically organised in eight departments (see Table 4.3) with 25 sub-units: three service centres, 12 innovation platforms and ten scientific units.

4.3.1 Concluding observations on CRP Henri Tudor

- The CRP Henri Tudor is by far Luxembourg's largest public research centre, not only in terms of employees and budget but also its range of activities, internal complexity and relations with the outside world. It has the strongest links to the private sector. Moreover, it represents a broad concept of "innovation", which is not restricted to R&D but also includes standards and thus measurement and testing, training and consulting, sometimes aimed at finding the right management approach or organisational set-up. CRP Henri Tudor can thus be considered a rich resource that provides both (technological) knowledge and management capacity.

66. For details see Chapter 3.3.2.4.

- Given this background and its past achievements as well as the envisaged increase in public funding of R&D, the future of CRP Henri Tudor looks bright as far as financial resources are concerned. At the same time, as an organisational entity it faces a number of problems, most of which are endogenous. To make good use of the growth opportunities it would be appropriate to address these challenges. They include:
  - Its complex internal organisational structure makes branding and communication difficult.
  - It runs a large number of projects (see Table 4.3). Most are not fully financed (this is also true for the other CRPs), and this typically induces complicated cross-financing between basic funding and project funding and thus tensions concerning the management responsible for allocation of resources as well as project managers and others (this is again also true for the other CRPs). These tensions are aggravated by the complex organisational structure.
  - The CRP Henri Tudor has a broad portfolio of activities and services, mainly opportunity-driven rather than the outcome of explicit goal setting and strategic choice. As a consequence, different modes of service, client groups, organisational settings, cultures and orientations co-exist, and this creates tensions and makes communication difficult.
  - It is involved in a number of external conflicts and tensions which are beyond the immediate responsibility of its management and boards. These conflicts and tensions are built into the overall architecture of Luxembourg's institutional system. In particular there is a manifest conflict with Luxinnovation over a number of innovation-related services including cluster platforms. But there are also tensions with other CRPs regarding the thematic or structural portfolios (*e.g.* ICT and materials both in CRP Henri Tudor and in CRP Gabriel Lippmann, incubator functions in CRP Henri Tudor, Luxinnovation, and in CRP Santé,[67] health-related technologies both in CRP Henri Tudor and in CRP Santé). In most of these regards top-down clearing is required. Competition cannot be expected to

67 Although the incubator function of CRP Santé has only been announced, it deserves attention and increases complexity.

resolve these tensions and in particular to lead to adjustment of the respective portfolios.

– CRP Henri Tudor's portfolio and staff (but also those of other CRPs) have the potential for company start-ups. There should be a strong commitment to spin-off activities.

4.4 Public Research Centre for Health

The CRP Santé was established in 1988, based on the regulation of 18 April 1988 in the framework of the law of 9 March 1987. It is linked to the National Health Laboratory and is under the dual supervision of the Ministry of Culture, Higher Education and Research and the Ministry of Health. Its role consists in co-ordinating and organising research in health, medicine and human biology, in improving the public health sector and in contributing to economic development. Transfer of know-how and technology is high on its agenda.

The CRP Santé is guided by a Board of Directors, constituted mainly of representatives of the Luxembourg health organisations and ministries (research, economy, health). The Scientific Advisory Board advises the Board of Directors and is composed of internationally reputed personalities.[68] Its mission includes providing advice on the general objectives of CRP Santé; defining its scientific policy, in particular for individual laboratories and their research programmes; evaluation of the laboratories, research projects (pre- and post-project) and researchers.

In 2004 the CRP Santé employed 101 regular staff, 31 fellowship researchers, and 17 fellowship students. In 2004 11 doctoral theses were defended at CRP Santé.

The CRP Santé was restructured in 2000. Its activity now rests on four pillars: the research institute, the health institute, the biotechnology institute/ incubator and general administration.

4.4.1 The research institute

In its role as research institute, the CRP Santé covers the whole range of fundamental, clinical and applied health research. The institutes and laboratories are listed in Table 4.4.

68. From France (4), the United States (1), Israel (2), and the United Kingdom (1).

Table 4.4. The research units at CRP Santé

Unit	Number of employees	National partners	International partners
Laboratory of Molecular Biology, Genetics and Modelling (LMBGM)	14	5	7
Stralux: Laboratory for Immunogenetics, Allergology and Plant Molecular Biology	18	4	5
The Norlux Laboratory for Neuroscience Research	n.a.	n.a.	12
Laboratory of Cardiovascular Research	5	4	3
Laboratory of Haemato-Cancerology and Cellular Therapy	8	5	6
Laboratory of Retrovirology	12	1	12
Institute of Immunology (associated with the National Health Laboratory)	30	11	36
Laboratory of Toxicology (associated with the National Health Laboratory)	5	2	7
Total	**(149)**	**(> 32)**	**88**

Source: CRP Santé, Annual Report 2004.

4.4.2 The Health Institute (Centre for Health Studies)

During 2000, CRP Santé established the Centre for Health Studies which comprises:

- Epidemiology and Technology Transfer Services.
- The Analysis Service of Health Systems and Services.
- The Centre for Prevention, Research, European Studies and Evaluation in the Field of Health.
  - European Monitoring Centre for Drugs and Drug Addiction.
  - European Medicine Evaluation Agency.
- The legal department.

4.4.3 The biotechnology institute (biotechnology business accelerator)

In 2000 the CRP Santé decided to create a "business accelerator" in the biotechnology area, primarily to encourage companies in the start-up phase but also to support well-established enterprises. Accordingly, the biotechnology business accelerator's role is to provide a counselling service and in-house and external guidance for innovative companies in the start-up phase for a given period.

In fact, the foreseen business accelerator has not yet been implemented. This is not a disadvantage since a joint undertaking involving all CRPs and the University of Luxembourg would be more effective in many regards. In particular, the marketing and management of the incubator would allow higher levels of professionalism owing to a larger number of candidates.

4.4.4 Concluding observations on CRP Santé

- CRP Santé's organisational structure has evolved over time. This reflects both a "natural" life cycle in research organisations and the increased attractiveness of CRP Santé for external partners in terms of research and the growing role of research-based services for the health sector. This broad spectrum, in terms of scientific research, valorisation of outcomes and provision of services, is also well reflected in the diversified portfolio of funding institutions, which includes a number of specialised funds dedicated to combating specific diseases.
- Generally, the CRP Santé is well endowed to carry out internationally competitive research and to provide specific health-related services. Basically three favourable factors underpin its position:
  - The high share of scientifically trained staff (PhDs). Many have a double training (PhD+MD), which ensures a sound match with hospitals, in particular with the National Health Laboratory and the Hospital Centre.
  - CRP Santé has developed long-standing partnerships with both national and international research institutions, hospitals and international organisations.[69] Finally, it is strongly involved in the FP6 integrated project "Angiotargeting" (budget of EUR 6 million) which shows its reputation and high visibility.
  - It has chosen a comprehensive strategy covering the entire research life cycle – fundamental research, clinical research, (economic) exploitation – and also issues such as health studies and related services.
- From the point of view of the CRP Santé it might be rational to establish an incubator at the CRP Santé level. From the perspective of the overall

69. For example the partnership of the Institute of Immunology with the WHO, or the Centre for Health Studies as partner for the European Monitoring Centre for Drugs and Drug Addiction of the European Commission.

system one may question this. There are at least three other incubators, the most prominent of which is associated with CRP Henri Tudor, the Technoport Schlassgoart. Since it is of key importance to achieve critical mass at the incubator level in order to recruit professional managers, a merger of the various incubator functions is recommended.

4.5 CEPS/INSTEAD[70]

CEPS/INSTEAD originates from a private non-profit organisation founded in 1978 for comparative, cross-national research on persistent poverty in industrialised countries under the framework of the First European Community Programme to Combat Poverty. As a result of the continuous development and extension of its national and international research activities, the centre was given the legal status of a public establishment (law of 10 November 1989), with scientific, administrative and financial autonomy under the responsibility of the Ministry of State. It was handed over to the Ministry of Culture, Higher Education and Research in 2004. The Centre's missions as defined by law are:

- To conduct and organise cross-sectional and longitudinal studies of populations, poverty and socio-economic policy.
- To create, manage and utilise databases with nationally and internationally comparable scientific data.
- To develop instruments of analysis, modelling and simulation for socio-economic policy.
- To develop and improve data processing tools, within the sphere and subject matter envisaged by the law.
- To create and maintain inter-regional and international research and information networks with regard to technology, environment, alternative development and development.
- To organise, at the postgraduate level, training relevant to the proposed research.

70. *Centre d'Etudes de Populations, de Pauvreté et de Politiques Socio-économiques*/ International Network for Studies in Technology, Environment, Alternatives, Development.

CEPS/INSTEAD produces microdata (fieldwork) and microdatabases, ensures comparability of complex microdata sets from different countries, and is committed to developing networks for research and for training in research. Over the last decade it has strengthened its structure and human resources to become, in accordance with its legal mission, a training centre and a school for advanced research in the fields of social and economic sciences. The so-called IMPALLA programme is organised jointly by CEPS/INSTEAD and the Department of Sociology of the University of Leuven (Belgium) in association with Tilburg University (the Netherlands), University of Nancy II (France) and University of Luxembourg. CEPS/INSTEAD has established a research infrastructure and related capabilities and services that would be unlikely to be established in a university environment.

4.5.1 Concluding observations on CEPS/INSTEAD

- CEPS/INSTEAD can be considered as an international research infrastructure in the fields of social sciences and economic analysis. It has established a large number of international relationships with individual countries (including the United States and Russia) and international organisations such as the World Bank or the EU/Eurostat. Moreover, CEPS/INSTEAD is a training centre, in particular for young researchers from the new EU member states, candidate countries and developing countries.
- CEPS/INSTEAD manages a budget of about EUR 7 million, of which EUR 5 million is financed by the Luxembourg government, and EUR 2 million by contract work and the FNR. Some of the EUR 5 million from the government is spent for performing regular work for the government and public administration. This mix of basic funding and contract research creates difficult situations for all parties. A clear distinction between basic funding (and thus autonomy of use) and contract-based provision of specific services (and thus clear ownership on the user's side) would help increase transparency and autonomy.
- There are indications of the presence of unexploited assets owing to an excessive orientation towards the production and improvement of databases and not enough attention to social research, policy studies and consulting.
- Accordingly, two actions are recommended. One is to investigate in more detail whether assets are underexploited. The other is to establish stronger and more systematic collaboration and networking with users of the databases at both the academic and institutional level.

4.6 University of Luxembourg

The foundation of the University of Luxembourg in 2003, based on the law of 12 August 2003, creates a new awareness of Luxembourg's higher education sector and highlights its development potential at national, European and international level. From the outset, the University of Luxembourg had a clear mission, laid down in law, to be organised as a research-based institution. This is reflected in its founding principles:[71]

- The primary focus should be research and, in this regard, the university should develop a few niches in which it can serve the interests of Luxembourg and achieve international recognition.
- In that major research advances are most likely to be achieved by teams of researchers from different disciplines, priority should be given to the establishment of a small number of major interdisciplinary centres.
- In order to avoid traditional compartmentalisation, only a few academic faculties are to be established.
- The university must recognise a societal responsibility to contribute, where possible, to public policy development; such responsibility pertains not only to law and social sciences but also in such disciplines as life sciences and IT.
- In keeping with the research focus of the university the main degrees are to be research-oriented, *i.e.* masters and doctorates.
- The University of Luxembourg is to offer a small number of undergraduate degree programmes at the bachelor's level which are broadly based, learner-centred and require students to spend some time abroad.
- A special emphasis is to be put on mobility of students and researchers. Research activities are to be implemented through research projects on a contractual basis with other research institutions and with industry. For students it is compulsory to spend a year abroad.
- As for CRPs and the FNR, representatives from industry are members of the administration boards of the university.

71. *www.cedies.public.lu/DOCUMENTATION/Formulaires/University_of_Luxembourg_ Guidance_ booklet_for_faq_and_concerns.pdf*

Today, the University of Luxembourg has three faculties: the Faculty of Science, Technology and Communication; the Faculty of Law, Economics and Finance; the Faculty of Humanities, Arts and Educational Science. The selection of the first and third faculty has a clear historical basis. Prior to the establishment of a full university, two "higher institutes" – the *Institut Supérieur de Technologie* and the *Institut Supérieur d'Etudes et de Recherches Pédagogiques* (ISERP) – provided engineers and teachers. In other fields Luxembourg students went abroad. The *Centre Universitaire* has acted as a clearinghouse for accreditation, *etc.*

4.6.1 Faculty of Science, Technology and Communication (FSTC)

The FSTC offers all three levels of training according to the Bologna architecture, including phase-out programmes.

- *Bachelors level:* Engineering and Computer Science, Sciences and Engineering, Life Sciences (including a certificate of higher education in Medicine and Pharmacy).
- *Masters level:* Information and Computer Sciences, Mathematics (in association with the University of Metz), Specific Training in General Medical Practice for trainee doctors. In addition, the FSTC transitionally provides teaching in subjects to be phased out of the programme: Industrial Engineering training and the second year DPCU – University First Cycle Diploma – in Physics and Mathematics.

Research is structured around five research units: Computer Science, Engineering, Mathematics, Physics and Life Sciences. In 2004, the FSTC's research staff published 70 articles and conference abstracts with editorial board, eight (chapters of) monographs and monograph editions, and one patent. The 2005 budget for research projects totalled EUR 4.63 million.

As of 1 June 2005, the FSTC has 46 academic staff (31 research-lecturers and 15 lecturers; 5 women and 41 men; 27 Luxembourgers, 11 Germans, 4 Belgians, 3 French and 1 Austrian).

4.6.2 Faculty of Law, Economics and Finance (DEF)

The Faculty of Law, Economics and Finance is the result of the fusion of three departments of the former University Centre: the department of law and economic science, the department of administrative studies and informatics, and the department offering complementary courses in Luxembourg law and business auditing. The DEF is confronted with a number of post-merger problems, mainly on the education side, in particular to rationalise educational venues and simplify logistics, to adapt to the Bologna process

and to cope with the multilingual nature of education. Particular attention is paid to international co-operation with partner universities to guarantee mobility of students in the bachelor courses and especially at the master's level. The DEF has recently agreed on joint activities with the Luxembourg-based European Court of Justice.

Research in the DEF is clustered around five labs: IDT (Institute of Transnational Law), CREA (Applied Economics Research Unit), LSF (Luxembourg School of Finance), SMA (Services in Applied Mathematics) and CESI (Institute of Complex Enterprise Systems). The DEF's research staff published a total of 11 papers in 2004 (not counting those of LDE).

The DEF hosts the Economic Law Laboratory (LDE), formerly at the CRP Gabriel Lippmann and transferred to the University of Luxembourg in 2005. Its research profile covers updating of Luxembourg legislation, above all to integrate aspects linked to the use of ICT. The key task of the LDE involves the modernisation of the legal and regulatory infrastructure of the Luxembourg economy. Its research aims at evaluating current legislation in order to assess its appropriateness with regard to the actors involved and the ambitions of the state. In addition, it seeks to identify areas in which the adoption of a secure and attractive legal framework would be beneficial to the development of economic activity.[72]

As of 2004, the DEF (without counting LDE staff) has one director, two project leaders, four researchers, ten associate researchers, of which five women and 12 men.

4.6.3 Faculty of Humanities, Arts and Educational Science (FLSHASE)

The Faculty of Language and Literature, Humanities, Arts and Education brings together a wide range of areas and courses. The education and training courses and the research topics of the FLSHASE are central to the societal changes and challenges of Luxembourg (demographic and migratory changes, sociological changes, changes in economic and ethical paradigms, historical, cultural and linguistic evolution, cross-border rami-

72. LDE has prepared various legal initiatives which have already been passed: the law of 31 March 2000 concerning the effects of a proviso of cancellation of property in contracts of sale and modifying certain features of the commercial code; the law of 14 August 2000 related to electronic commerce; the law of 27 July 2003 on trust and fiduciary contracts; the law of 22 March 2004 related to securitisation; the law of 17 May 2004 related to competition.

fications, etc.). The FLSHASE aims at the implementation of the following fundamental principles:

- Interdisciplinarity, in particular the study of the functioning and development of society in general and of Luxembourg in particular by sharing results from different disciplines.
- Linkages between education and training and research.
- International co-operation with other universities based, on the one hand, on a set of co-operation agreements which guarantee the mobility of students, teachers and researchers and, on the other hand, on carrying out research projects on an international scale.
- The multilingual nature of education: this characteristic of Luxembourg society is reflected both in study programmes and in research and constitutes an advantage for attracting students from abroad.
- Coaching, in the form of the tutorial system, contributes to individualised training; university education is aimed at the development of academic and professional skills according to personalised programmes.

In 2004 the FLSHASE had 72 research lecturers in charge of 1 162 students and 300 student teachers (on-the-job training).

4.6.4 Concluding observations on the University of Luxembourg

- The establishment of a university in Luxembourg was overdue and is a major contribution to the Luxembourg institutional landscape. The decision to create a research university is well-founded but its implementation has to overcome obstacles caused by the merger of established structures with new ones. In particular, the change of focus from education and training to research will create serious tensions for the organisation.
- The biggest challenge for the University of Luxembourg is to keep its momentum in building international connections in the areas of education and research. Recruitment of high-quality staff and rigorous selection of projects and partners will be essential to achieve and maintain international visibility and attractiveness. Maintaining high standards in education and research requires strong partnerships and support from relevant stakeholders, primarily from the Ministry of Culture, Higher Education and Research and the FNR but also from industry.

- The University of Luxembourg has taken the Economic Law Laboratory (LDE) over from the CRP Gabriel Lippmann. In the wake of this sound transfer a number of additional ideas for changes have arisen. Whatever the reaction, each merger has to systematically address the education and training requirement, in particular for the training of young researchers.
- The Faculty of Law, Economics and Finance can be considered a bridgehead to the financial and legal sectors, both of which have a specific profile in the Luxembourg economy. The further development of this potential should be high on the agenda of all parties concerned: the University of Luxembourg, supporting institutions such as Luxinnovation and the FNR, the respective ministries as well as actors in these sectors themselves.

4.7 The role of the public research system (University of Luxembourg and the CRPs) in the development of human resources for science and technology (HRST)

Attracting research personnel and undertaking research (including university-industry collaboration) will take time. According to the Rector of the University of Luxembourg,[73] by 2010 some research areas will have been selected for intensive development. The university should then be in a position to attract top scientists. By 2015 selected students should come from throughout the world to do their Master's or PhD degree in these two or three areas.

The University of Luxembourg has taken on most of the recommendations of the "Code of Conduct for the Recruitment of Researchers" published by the EC in March 2005,[74] particularly as regards collaboration with other research institutions such as the CRPs whenever possible. The number of students is currently about 3 400 (2006), and is expected to increase to 4 600 (2010) and to 6 200 (2015).

The University of Luxembourg aims at providing 40 bachelor's and master's programmes by 2015. These should generally be bilingual: French-German in the bachelor's courses plus English in the master's courses in which a share of students will come from beyond Luxembourg's neighbouring countries. At least one-quarter of the master's programmes should

73. Tarrach (2005).

74. European Commission (2005).

be conducted mainly in English. Master's degrees will generally have high development priority. Mobility, above all within the *Grande Région*, will be a key feature of learning at the University of Luxembourg.[75]

Further demand for researchers will come from the CRPs, most notably from an increase in long-term, strategically oriented collaboration with industry (in competence centres).[76] This type of research and the related organisation (which should always involve universities as partners) typically has an impact on all partners and their relationships. This type of organisation can be implemented quickly since major decisions, including long-term funding, are made *ex ante*. Experience suggests that a competence centre can move from a start-up phase to full scale in 1-2 years, involving between 50 and 100 researchers directly and about the same number indirectly, *e.g.* in partner organisations. The best strategy for attracting (young) researchers is to attract well-known researchers. Competence centres have performed well in this regard. Based on the assumption of two or three competence centres (thus 100-150 researchers, 150-250 research personnel) and growth of the University of Luxembourg from currently about 150 researchers (nearly 500 personnel in total) to about 300 researchers (total of 860) in 2010,[77] an increase of 150 (360) jobs in the university, the total number of newly created research jobs will be 250-300, including support staff of 500-600.

The future growth of research and increased demand for research personnel will induce strong demand for supportive actions. The National Grant System (*bourses de formation-recherche*) allocates funds to doctoral and postdoctoral students, independently of their citizenship, for scientifically excellent research projects on the condition that the project is linked in some way to Luxembourg (the research is performed or partly performed in Luxembourg and/or the results of the research are expected to have an impact at the national level). This grant system aims at attracting highly trained scientists.

Moreover, in 2002, an innovative pilot grant project called LIASIT (Luxembourg International Advanced Studies in Information Technologies) was set up in the field of IT research. Its aim is to build a strong partnership between academic research and the private sector and to strengthen inter-

75. Tarrach (2005).

76. See Section 4.8.4 on competence centres.

77. Tarrach (2005).

national co-operation in IT-related R&D. The doctoral projects are co-organised, supervised and financed by public and private partners. At the end of the pilot phase, the LIASIT model is likely to be extended to other sectors.

These two types of support measures directly address one of the most critical points in the overall research system, PhD students and post-doc researchers. They contribute a great deal to academic research and their support and supervision, not to mention "domain leadership", are critical factors in the attractiveness of research and higher education institutions. Thus, the further development of doctoral programmes (LIASIT as a pilot) and associated research schools will be essential, not least through involvement of the proposed competence centres.

4.8 The public research system: challenges and recommendations

Several observations suggest an integrated approach in the public research sector, including the CRPs and the University of Luxembourg, because: these institutions are "owned" and funded by the same ministry; they are engaged in research areas which partly overlap, while at the same time there are gaps, *e.g.* research addressing the needs of the services sector; all actors are involved in some way in higher education; all are eligible for FNR funding; and a joint approach would help to define and shape the national research and innovation system (setting of thematic priorities, implementation of specific instruments, quality policy, internationalisation) and thus contribute to favourable conditions for effective use of increasing of public expenditure for R&D.

The building of a strong public research system calls for strengthening the governance of the research and innovation system. At present there seems to be a lack of explicit and binding strategy at various levels of governance, and sometimes confusion between strategy and implementation.

Fresh money provides additional resources for R&D and innovation. Additional funding at the same time requires – in order to guarantee efficiency – changes in the innovation system and related processes.

4.8.1 Maintaining workable relations: performance contracts

In the past, the CRPs[78] were mainly steered through basic funding plus funding of a number of individual projects. This had a rather modest impact on the CRPs as the projects were mainly automatically accepted. However, they created a considerable workload for the ministry. In recent years the CRPs have been invited to develop and negotiate multi-annual programmes which have to integrate an extensive list of performance indicators. For the future, it is recommended to replace the current arrangements by state-of-the-art performance contracts, which include the elements outlined in Box 4.1.

Box 4.1. Governance of CRPs and the University of Luxembourg: performance contracts

Full coverage of all types of desired outcomes and achievements

These contracts can take many forms: a certain share of direct contract work with firms; a certain number of publications, lectures, patents, academic degrees; a certain share of income from FNR in order to demonstrate a high level of scientific quality of proposals and related work; a certain level of mobility of staff, preferably exchange with industry; a certain number of spin-off firms, *etc.* The ministry here has a privileged position for mandating "relevance" to the Luxembourg economy and society. Moreover, it can make use of the results of foresight exercises, which can be carried out in the run-up to negotiations on performance contracts.

Restriction to types and levels of outcomes and achievements that can plausibly be influenced by the managers of the centres

This is *the* key to use of performance contracts as a workable governance and management tool. It requires, however, a high degree of autonomy on the [art of the top management and strong resistance to the temptation of "micromanagement".

CRPs/university should have the right of first proposal

This is a reasonable principle as most of the required intelligence is located at the performing institutions. Moreover, to give the right of first proposal to performers also maintains a high degree of autonomy on the side of the CRPs and the university. For its part, the ministry should make use of external reviews, evaluations and/or foresight exercises to catalyse the negotiation process between funders and performers.

Multi-annual time horizons with a certain balance of specific outcomes and achievements over time

If there is over-performance in some indicators and lack of the desired level in others, trade-offs between indicators and between years should be permitted, provided the individual indicators are within a certain range.

…/…

78. If not otherwise stated CEPS/INSTEAD is included among the CRPs.

Box 4.1. Governance of CRPs and the University of Luxembourg: performance contracts *(continued)*

Simplicity of the contract, easy to communicate to stakeholders

Experience reveals that sophisticated indicator systems do not necessarily increase governance capabilities, let alone act as an instrument for facilitating orientation of relevant stakeholders.

A limited number of highly self-explaining indicators

Knowledge organisations always tend to make things complicated. Reducing complexity from time to time enhances manageability. Moreover, restriction to a small number of self-explaining indicators helps prevent corruption, which typically occurs when using complex sets of (artificial) indicators.

Excellent achievement should be rewarded

While the main message of this principle is rather obvious, its contribution to governance emerges from the underlying causality: bonus follows achievement. As an added value the implementation of this principle contributes to building critical mass, to developing a clearer remit and portfolio, and better visibility as it contributes to increase existing strengths.

External evaluation

Performance contracts are the outcome of a negotiation process between funders/owners and performers. While the preferences and priorities of the two parties are ensured to a high extent, all the more as consensus enjoys high esteem in the Luxembourg society, the outcome of research and teaching activities can nevertheless be poor. Thus a thorough external evaluation every four-seven years may be needed to adjust the content and structure of the performance contract and the ways in which the performance contract is used as a steering tool.

The performance contract as a management tool for the managers of the CRPs/university

Since all goals defined in the performance contract are inherently manageable, they act as a powerful governance instrument in the hands of top management vis-à-vis their division managers, deans, unit heads, etc., since the managers at the top of the overall organisation give these goals to the respective sub-units.

Finally, as regards workable relations between the Ministry of Culture, Higher Education and Research and the CRPs/University of Luxembourg, it is important to change the representatives of the ministries on the boards regularly to avoid too close relationships between the principal (the ministries) and the agents (management).

4.8.2 Understanding the CRPs' business models, portfolios, and assets: strategic audits

Over time, the CRPs have adopted and accumulated a number of mainly implicit "business models". Often, they have adopted new models without necessarily removing prior ones. The number and tacit character of the business models make it difficult to manage them and to fully understand their behaviour. There are, in fact, differences not only *between* the different

CRPs, there are even bigger differences in terms of culture, values, markets, reference groups, etc., *within* them.

To better understand the behaviour and thus the steering of the CRPs on both sides of the contract specification and negotiation process, it is recommended to carry out *strategic audits* for each CRP. The emphasis should be on understanding the business models used, identifying the centres' portfolios (of services) and main assets, identifying the centres' and their organisational units' most relevant reference groups ("customers" in a broad sense). Since the funding is essential to the business models, special attention should be devoted to issues of cross- and co-financing. For reference groups, the role of FNR-funded projects should be analysed, in order to understand whether or not these serve as standards for high scientific quality. The audit should be carried out as a self-audit and should be managed and completed by external experts, including specialists in the thematic areas concerned and experts with competence in the evaluation of public research institutions.

The immediate goal of these audits is to gain input for the specification and negotiation of performance contracts. The primary target groups are thus the management of the CRPs and the ministry, followed by the FNR, since CRPs are the major beneficiaries of the FNR. The ultimate goal of the exercise is to help redefine (and presumably simplify) the CRPs' missions and organisational structures and to clearly define their positions within the research and innovation system as a whole.

4.8.3 Technology and knowledge transfer: talent, mobility, firm start-up, weak ties to industry

Transfer of technology and knowledge is a permanent challenge for public research institutions and it is hardly ever satisfactorily achieved. The most widespread misunderstanding of the role of public and higher education research is to expect that it will furnish (science-based) technological solutions. Rather, its role consists in problem solving, and even more in training (young) people to perform research. Thus its main output is "talent" rather than the development of "technologies". Mobility of trained people to industry may be the most fruitful and at the same time the most underrated mode of transfer of knowledge and technologies.

A detailed look at the CRPs reveals a number of areas, teams and services, which are not optimally positioned within individual CRPs for technology and knowledge transfer:

- In some cases the activity could be performed as well without basic funding and should thus be a *candidate for a firm spin-off*, not least to prevent the crowding out of private R&D and innovation. The respective CRPs, particularly CRP Henri Tudor with a specialisation in the area,

should assist the candidates in preparing their future business. Performance contracts between the CRPs and the ministry should explicitly include such indicators and thus act as incentives for increased and systematic spin-off activities.

- It is inefficient to *run several incubators or incubator-type functions separately*. CRP Henri Tudor, like Luxinnovation, carries out many innovation support functions which should be integrated into one single incubator scheme. However, the incubator function of CRPs in general and of CRP Henri Tudor in particular should not be overestimated, unless it is part of an overall performance contract. In a first step, all incubator activities related to CRPs and the University of Luxembourg should be harmonised and unified under a central management.[79] In a second step, as it becomes clear that it will be not possible or wise in the present situation of public finances to operate a second incubator in Belval-West, a merger with ECOSTART should be envisaged. It is recalled in this context that in March 2006, the government approved the ECOSTART III project which will be implemented in Belval-West under the responsibility of the Ministry of the Economy and Foreign Trade, in collaboration with the Ministry of Culture, Higher Education and Research.

- There is *much project funding with weak industry involvement*. The most frequently used types of involvement are networks and platforms. The next logical step, which is to tighten the weak links, is often missing. Again, a shift of attention from input-oriented, mainly funding-based indicators and related models to more outcome-oriented performance goals and related indicators is recommended.

- *The CRPs can play an active role in knowledge transfer through the mobility of young researchers.* The model of the German Fraunhofer Society is highly attractive in this regard: Young people are hired directly after their diploma and climb a job ladder from junior researcher to leader of a medium-sized project. Within five years they finish their PhD studies and then leave the Fraunhofer Institute, often to work with the partner of their project. It seems worthwhile considering tightening career paths within the CRPs and adjusting to the Fraunhofer model which is attractive for the researchers as well as for the companies. To

79. Austria runs a programme which supports academic incubators (A*plus*B – Academia plus Business). Vienna, which has eight universities, operates a single incubator.

be attractive for the centre as well, arrangements like this have to be negotiated as part of the performance contract, which will help to make up for the loss of human resources. The proposed competence centres (see below) can be very productive in this regard, as exchange between the CRPs, the University, and business firms is an essential element.

4.8.4 Closing the gap between public and private sector research: industry-science relationships, public-private partnerships

The problems mentioned above are not specific to Luxembourg. In fact, they are omnipresent in public research institutions. An increasing number of – mainly smaller – countries (Australia, Austria, Canada, Estonia, Hungary, the Netherlands, and Sweden) have made efforts to change their overall approach to collaboration between public (academic) research and industrial research. The common elements of these different types of academia-industry collaboration, generally organised as public-private-partnerships (P/PPs), are: long-term orientation (five to seven years); contractual relationships between (typically five to ten) different partners from academia/public research institutions on the one hand and industrial partners on the other, who jointly define and carry out research that is financed by three parties: the industrial partners (cash and in-kind), the public partners (cash and in-kind), and the government (cash). These organisational arrangements have proven quite robust and, as a rule, have generally been appreciated by all involved parties. Learning is bidirectional and the outcomes offer a large variety of benefits. Management and long-term visions, and sometimes patience, are crucial.

Luxembourg could benefit from this type of research and research organisation, if it can obtain sufficient partnerships and support from industry. However, Luxembourg can also make a virtue of the disadvantage of a scarcity of potential industrial partners for long-term, strategically oriented research through the courageous step of including industrial and academic partners from outside Luxembourg. This step is courageous both because it is genuinely political (financing "foreign" firms) and because it mean collaborating with competitors (such as CRP Gabriel Lippmann with the University of Kaiserslautern).

In practical terms, two or three such competence centres should be implemented in the course of the next five years. Candidates may come from all of the CRPs as well as the University of Luxembourg. It may be paradoxical that departments and units of the CRPs that are close to industrial activities and have weak links to the academic world may be less favourable candidates than those with a strong foothold in the academic sector.

Apart from materials/nanotechnologies, ICT and life sciences – which are natural contenders in a competition for competence centres – the media, finance, (related) law, and social sciences should at least consider application. However, policy attention and marketing activities are required to mobilise these communities. In fact, a more committed approach would require taking on board representatives from the media, finance and law sectors. Given the role of these sectors in Luxembourg's economy it would be worthwhile setting up a task force to explore their needs and requirements in depth, to carry out some bottleneck analysis, to explore opportunities for collaboration in education and training and in research projects and programmes. Specific attention should be paid to the organisational set-up, especially since the banking sector already has some relevant structures. At the same time the regulation authority has developed some capacity for strategic intelligence. A year's work should make it possible to develop a master plan for research and education and training which reflects the needs and requirements of the banking, insurance and financial industry in Luxembourg. Luxinnovation should play a significant role in this exercise.

As regards the configuration and management of the competence centres, there is a wealth of evidence from Sweden, Australia, Canada, Austria, the Netherlands, more recently from Hungary and Estonia. All these countries share a core set of characteristics: long-term (five-seven years) but time-limited, contract-based involvement of research performers and research users (which are in most cases also research performers), a strong focus on management, clear orientation of the research activities in terms both of academic advancement and benefits for research users. Universities are essential, as they play a leading role in the training of young researchers. Size and organisational structure depend on circumstances and political style. The Dutch "Top Institutes" employ up to 150 staff, the Austrian "Christian Doppler Laboratories" are merely groups of five to seven staff – a younger professor with a group of PhD students and post-docs. The Swedish competence centres are well integrated to the hosting universities while their Austrian counterparts are established as limited companies with 40-90 staff.

Box 4.2. Competence centres

Their place in the national innovation system

Competence centres are a comparatively new form of university-(public research)-industry research alliance. They perform both fundamental and more applied problem-oriented research. Their long-term nature and funding allow them to have a structuring effect on innovation, generating common, use-oriented research agendas with a potential for significant socioeconomic impact.

As instruments of research and innovation policy, competence centres are peculiarly well suited to strengthening the systemic aspects of innovation communities and tackling market failure in respect of problem- or application-oriented research. Competence centres can be implemented at different scales and can address a range of industries and technologies. They are applicable only where there is some degree of industrial research capability. They typically focus on highly capable industrial and academic participants, typically medium-large companies and high-capability SMEs.

Objectives

In the context of Luxembourg, the major aim of competence centres is to provide a stable and conducive institutional framework for co-operation between CRPs, the University of Luxembourg and industrial firms on R&D projects that are of strategic importance for the partners and the Luxembourg economy as a whole.

Launch

The government defines the terms of reference (regarding the minimum number and identity of partners, their research field and agenda, and their readiness to commit the necessary resources), states the form, conditions and duration of its support (four-seven years to allow for ambitious R&D), and invites consortia (firms, CRPs and the University of Luxembourg) to submit proposals in the form of "business plans", together with the credentials of potential participants. As regards thematic orientation there are two main options: *i)* the government does not express any preference regarding technological fields; *ii)* the government selects specific technological areas eligible for support.

Centres should not be launched at the same time to avoid taking a "snapshot". It is preferable to launch smaller, more frequent calls so that the programme continually adjusts to needs.

Eligible participants

Private (large and small) firms, CRPs, the University of Luxembourg but also, maybe on a limited scale, foreign firms, research institutes and universities. Subsidiaries of foreign firms should be allowed and even encouraged to participate. A candidate consortium should comprise a minimum number of firms and at least one university.

Selection process

Selection should be a transparent competitive process, with clear criteria and impartial referees. The scientific quality of proposals should be assessed through an independent peer review. Peers (around six per proposal), including foreigners, should be selected by a joint panel of the FNR. Preferably, the economic and organisational dimensions should be assessed by a consultant company with international experience. The final decision, based on this dual evaluation, should be taken by the government.

…/…

Box 4.2. Competence centres *(continued)*

Organisation/management

There are two basic models:

- Virtual institutes with a lean organisation at the core and research carried out at the participating public research institutions and firms.
- Co-operative research labs where most activities occur at a central location.

Each model has advantages and disadvantages and the government should impose only minimal requirements. The choice should be made on a case-by-case basis, depending on the technological area and the capabilities of actors. Co-operative research centres or networks should be more than *ad hoc* contractual arrangements and have an institutional identity, and their governing board should enjoy a large autonomy in determining their detailed research plans. Wherever possible, industry should hold a majority of votes to ensure its commitment and avoid a drift towards research that will lack end-users.

Centre managers are very important and have to be acknowledged by both the research community and industrial participants. Often this is taken to mean that a centre manager has to have a track record as a researcher. In some cases the role is split between a scientific director and a commercial manager.

Financing

The basic principle is a tripartite arrangement with resources (in cash or in kind) coming from three sources: government, industry and public research institutions. There are different formulas but as a rule government subsidy should not exceed 50% and industry contribution should represent at least 20% (cash).

IPRs

A key requirement is that all participants should have the authority to negotiate IPRs. Whereas government should provide broad guidelines, detailed agreements should be left to participants. But the existence of a clear and firm agreement among participants should be a condition of eligibility in the selection process.

Monitoring and evaluation

Annual reports on activities should be mandatory. A light mid-term evaluation (after two-three years) should check progress in achieving stated goals. A full-fledged evaluation should be carried out after three-four years. Depending on the results, public support may/should be renewed for another term, reduced or withdrawn. There should be some degree of flexibility in that some pre-competitive research in important areas might deserve (more) permanent public support.

…/…

Box 4.2. Competence centres *(continued)*

Competence centre programmes

Country	Start date	Agency	Competence centre programme
United States	1985	National Science Foundation	Engineering Research Centres
Canada	1989	NSERC, CHIR, SSHRC	Networks of Centres of Excellence
Australia	1990	Ministry of Industry	Co-operative Research Centres
Sweden	1994	NUTEK/STEM/VINNOVA	Competence Centres
Netherlands	1997	Ministries OCW and EZ	Top Technological Institutes
France	1998	MENR/MINEFI	RNRT
Austria	1999	BMVIT/TiG, BMWA	Kplus, Kind, Knet, Christian Doppler Institutes
Hungary	2000	Ministry of Education	KKK Co-operative Research Centres
Estonia	2004	Ministry of Industry	Competence centres
Spain	2005	MST	CENIT

Source: OECD (2005, 2007); Arnold *et al.* (2004).

4.8.5 The University of Luxembourg and the role of the CRPs

After a period of incubation the University of Luxembourg's primary mission will be research and it will develop a few niches, in which it can serve the interests of the country and achieve international recognition. As regards research, a more detailed analysis of the FNR clearly indicates a fresh start for the new university at least in some areas. Given that a considerable share of faculty members are from abroad, there are good prospects for achieving international recognition as a research university.

The University of Luxembourg has competed for funding, in particular at the national level, and can therefore be considered both as a partner and a competitor for (public) funding. The thematic scope of the university is in some respects similar to that of the CRPs; in other regards it is complementary (in economics and finance and in the whole range of the Faculty of Humanities, Arts, and Educational Science).

The University of Luxembourg is developing at different paces across and within its faculties. The fact that some staff have been transferred from prior organisations may prove to be an obstacle to efficient development of a research university. At least two of those institutions were primarily oriented towards teaching rather than research.

Against this background, a number of recommendations can help to manage the most valuable resource in the innovation process, that is, people and particularly young people (Box 4.3).

Box 4.3. Some governance improvements to help the University of Luxembourg keep the momentum

The coming three to five years will be critical for the success of the university and its integration into the wider research system. This is not primarily a question of content and research themes but rather of the resolution of a number of management and governance problems. The following strategies may help.

Performance contracts

Many professors have no significant prior research experience. It is therefore difficult to integrate them into a university with a strong research orientation. The agreement on a performance contract between the university and (in order to consolidate the dual orientation of the University of Luxembourg) *both* the higher education and the research department of the Ministry of Culture, Higher Education and Research, would bolster the rector's position by transforming the overall performance contract into separate contracts to be negotiated with the respective deans.

Recruitment of new professors and post-docs

Recruitment is a crucial issue which must be dealt with immediately and will remain a dominant issue for many years. The outcome of the recruitment process is the key to the long-term performance of the units and the university as a whole. Currently, different recruitment strategies are considered. The most promising one is to look for professors aged 55 or more who are ready for a fresh start. This model might be combined with a visiting professors scheme (six-months stays and exchange of students, researchers, development of joint programmes and applications for international/EU funding). The rector will play a critical role in attracting the "55+ professors" who will be responsible for attracting post-docs, doctoral students, etc.

Competence centres

Research programmes instead of weakly connected individual projects should be defined and implemented. There is a wealth of experience with "competence centres" which tie together academic and industrial partners. The Faculty of Law, Economics and Finance is in a favourable position owing to the presence of strong potential partners in banking, finance, insurance and law. A task force should be established to set an agenda.

…/…

Box 4.3. Some governance improvements to help the University of Luxembourg keep the momentum *(continued)*

Definition and implementation of research schools

Close collaboration with the CRPs, particularly CRP Gabriel Lippmann, and partner universities from abroad is advisable. The FNR can play a supportive role in funding such research schools following an international evaluation. The University of Luxembourg should be encouraged to focus as much as possible on the higher level of higher education, *i.e.* Master's and PhDs. A joint (CRP + university) research school scheme should be considered the most attractive element in the system.[80]

Management resources

Academics tend to view management and administration as a cost that reduces time and resources spent for research and teaching. The University of Luxembourg should be supported by a strong rectorate with a generous endowment in terms of management resources (power, budget, staff, time, protection).

Closer links via department heads rather than mergers of (parts of) CRPs with the University of Luxembourg

Establish links between universities, not only the University of Luxembourg, and the CRPs at the level of department heads who preferably should be acting professors at universities with access to students and thus to future researchers.

4.8.6 The social sciences-economics-law cluster

The mission of CEPS/INSTEAD is in some regards comparable to that of the Economic Law Laboratory (LDE) at the University of Luxembourg, formerly at CRP Gabriel Lippmann. Likewise, CRP Santé conducts research in the field of health studies ("Centre for Health Studies"). All provide research-based services to the government and institutions in the areas of legislation, health, social welfare and economic development. There are some substantive arguments for a merger of at least the three-mentioned units into a research infrastructure devoted to the social sciences. However, there are also counterarguments, mainly based on history and on the type and quality of research, culture, identity and relationships to specific stakeholders.

80. The performance of the joint research school can be understood as an indicator of the effective functioning of the whole research system, as it addresses major critical processes: the university's increased research orientation, better linking of CRP-based research with research training, achievement of higher academic grades and thus a higher reputation and attractiveness of the academic location, and higher level of quality-based (basic) research owing to the role of PhD students in academic research.

It would nevertheless be worthwhile to aim at closer relationships between the different actors in fields such as social sciences, economics, law, cultural studies, etc., in order to achieve at least better visibility and a better standing in the overall research system. On the part of the ministry as well as of the FNR this would both require and allow more explicit policy making. Specifically, this type of research is characterised by the fact that its users are mainly located in the public sector while the others are part of important sectors of the Luxembourg economy: banking, insurance, *etc.* In the long term, the establishment of a genuine user-oriented or user-driven approach would be highly attractive for Luxembourg as an international, multicultural, multilingual location.

However, as mentioned, some factors may impede a more comprehensive approach. Given the foreseen increase in public money, it could be allocated on the basis of joint research programmes, long-term collaboration, even mergers, which, however, should not be high on the agenda. Foresight exercises and bottleneck analyses are important to better understand specific needs and requirements, existing resources and achievements, and organisational and cultural and provide better guidance to policy.

References

Allegrezza, S. (2005), Cahier économique du Statec sur l'innovation, in: *statec* (2005), pp 3-22.

Arnold, E., J. Deuten and J.F. van Giessel (2004), *An International Review of Competence Centre Programmes*, Technopolis.

Arnold, E. *et al.* (2003), *Research and Innovation Governance in Eight Countries. A Meta-Analysis of Work funded by the Ministry of Economic Affairs (Netherlands) and the Research Council of Norway*, Technopolis.

Arundel, A. and H. Hollanders (2005), Innovation Strengths and Weaknesses. European Trend Chart on Innovation, European Commission.

CRP Henri Tudor, *Welcome at CRP Henri Tudor*.

CRP Henri Tudor (2004), *Annual Report 2004*.

CRP Santé (2004), *Annual Report 2004*.

European Commission (2003), *Towards a European Research Area. Science, Technology and Innovation. Key Figures 2003-2004*. Brussels.

European Commission (2004), *European Trend Chart on Innovation, Annual Innovation Policy Trends and Appraisal Report*, Luxembourg.

European Commission (2005), *The European Charter for Researchers, The Code of Conduct for the Recruitment of Researcher*, Luxembourg.

Genevois, A.-S., U. Warner and V. Dautel (2005), "The Third Community Innovation Survey in Luxembourg", in s*tatec* (2005), pp. 83-128.

Government of the Grand Duchy of Luxembourg (2005), The Luxembourg "National Plan for Innovation and Full Employment 2005-2008", Report by the Grand-Duchy of Luxembourg to the European Union.

Hollanders, H. and A. Arundel (2005), *European Sector Innovation Scoreboard*. European Trend Chart on Innovation, European Commission.

Journal Officiel du Grand-Duché de Luxembourg (1999), Recueil de Legislation. A – No 88, 6 July.

Kerger, R. (2005), "Luxembourg's Research Landscape", paper presented at the CREST meeting. Mondorf-les-Bains, 23 May.

Ministry of Culture, Higher Education and Research (2003), *About Research*.

Ministry for the Middle Classes, Tourism and Housing, Action Plan for Small and Medium-sized Enterprises 2001-2006, *www.mcm.public.lu/en/plan/plan01-06/index.html*

National Research Fund Luxembourg, *Annual Report*, Luxembourg 2004. *www.fnr.lu*

OECD (2005), *Fostering Public-Private Partnership for Innovation in Russia*, OECD, Paris.

OECD (2006), *OECD Economic Survey of Luxembourg*, OECD, Paris.

OECD (2007), *Public-Private Partnerships for Innovation*, OECD, Paris, forthcoming.

OECD, Productivity Database, July 2005.

Statnews informations statistiques récentes (2005), n° 33/2005, 08/07/2005, En matière de R&D le Luxembourg peine à atteindre les objectifs de Lisbonne.

Statnews – informations statistiques récentes (2006), no 20/2006, Premiers résultats l'enquête CIS light: moins du tiers des entreprises innovent. Luxembourg.

Tamura, S. *et al.* (2005), "Promoting Innovation in Services", *Enhancing the Performance of the Services Sector*, Chapter 5, OECD, Paris.

Tarrach, R. (2005), University of Luxembourg, Strategic Framework for the Université du Luxembourg, 2006-09, 2010-2015. *White Paper*, wp2, 8 November 2005.

Warner, U. (2003), *The Third Community Innovation Survey*, Luxembourg.

Internet resources:

Internet portal for businesses: *www.entreprise.publib.lu*

Luxembourg Portal for Innovation and Research: *www.innovation.public.lu*

Luxinnovation: *www.luxinnovation.lu*

Ministry of Culture, Higher Education and Research: *www.mcesr.public.lu/*

Ministry of the Economy and Foreign Trade: *www.eco.public.lu/*

Ministry for the Middle Classes, Tourism and Housing: *www.mcm.public.lu/*

National Research Fund: *www.fnr.lu*

Acronyms

ARBED	Aciéries Réunies de Burbach-Eich-Dudelange
ARTES	Advanced Research in Telecommunications Systems
BIOSAN	Biotechnology and Health (FNR programme)
CD-PME	The Luxembourg Society of Capital Development for SMEs Ltd.
CEDIES	Centre for Documentation and Information on Higher Education
CEPS/INSTEAD	Centre d'Etudes de Populations, de Pauvreté et de Politiques Socio-économiques
COST	European Cooperation in the Field of Scientific and Technical Research
CREST	Community's Advisory Committee on Scientific and Technical Research
CRP	Centre de Recherche Publique
CUNLUX	Centre Universitaire
CVCE	Virtual Centre for Knowledge in Europe
EAU	Sustainable Management of Water Resources (FNR programme)
EIG	Economic Interest Group
EIS	European Innovation Survey
EPO	European Patent Office
ERA	European Research Area
ERA-NET	European Research Area Networks
ERCIM	European Research Consortium in Informatics and Mathematics
ESA	European Space Agency
ESF	European Science Foundation
ESFRI	European Strategy Forum for Research Infrastructures
EUREFI	Europe Régions Financement
EUROHORCS	European Union Research Organisations' Head of Research Councils
FEDIL	Fédération des Industriels Luxembourgeois
FNR	Fonds National de la Recherche
FP	Framework Programme
FSE	Fonds Social Européen
GDP	Gross Domestic Product
GLAE	Groupement luxembourgeois de l'aéronautique et de l'espace

ICSU	International Council for Science
ICT	Information and Communication Technologies
INTER	Promotion of International Co-operation (FNR programme)
IRC	Innovation Relay Centre
ISERP	Institut Supérieur d'Etudes et de Recherches Pédagogiques
IST	Institut Supérieur de Technologie (The Higher Technology Institute)
JRC	Joint Research Centre
LIASIT	Luxembourg International Advanced Studies in Information Technologies
LIIP	Linking Innovation and Intellectual Property
MCESR	Ministère de la Culture, de l'Enseignement supérieur et de la Recherche
MLQ	Mouvement luxembourgeois pour la Qualité
NANO	New Materials and Nanotechnology (FNR programme)
OMC	Open Method of Coordination
P/PP	Public-Private-Partnerships
PROVIE	Medical Aspects of Ageing (FNR programme)
SECAL	Food Safety (FNR programme)
SECOM	Security and efficiency of new practices in e-commerce (FNR programme)
SME	Small and Medium-sized Enterprises
SNCI	The National Credit and Investment Society
STI	Science, Technology, and Innovation
TII	Technology Innovation Information
TRASU	Surface treatment (FNR programme)
USE-MAT	Collaboration with the US National Science Foundation in their Materials World Network
USPTO	US Patent Office
VIVRE	Living Tomorrow in Luxembourg (FNR programme)
WHO	World Health Organisation

OECD PUBLICATIONS, 2, rue André-Pascal, 75775 PARIS CEDEX 16
PRINTED IN FRANCE
(92 2007 02 1 P) ISBN 92-64-01025-3 – No. 55567 2007

OECD Reviews of Innovation Policy

LUXEMBOURG

What are a country's achievements in innovation, and how does this relate to economic performance? What are the major features, strengths and weaknesses, of its innovation system? How can government foster innovation?

The *OECD Reviews of Innovation Policy* offer a comprehensive assessment of the innovation system of individual OECD member and non-member countries, focusing on the role of government. They provide concrete recommendations on how to improve policies that impact on innovation performance, including R&D policies. Each review identifies good practices from which other countries can learn.

Luxembourg enjoys the highest GDP per capita in the OECD area. Its economic growth has been dynamic over the past decade reflecting largely the performance of sectors, such as the financial industry, where Luxembourg has so far successfully exploited "sovereignty niches". To enlarge and consolidate the basis for sustained long-term growth, the government wants to promote through innovation the diversification of the economy towards new "competence niches". Reinforcement of an historically weak public-research system, including creation of the University of Luxembourg, is a key component of this new strategy. This review assesses the governance of Luxembourg's innovation system and suggests the reforms needed to ensure that additional public investment in R&D will yield the expected economic and social benefits.

The full text of this book is available on line via this link:
www.sourceoecd.org/enceIT/9789264010253
Those with access to all OECD books on line should use this link:
www.sourceoecd.org/9789264010253

SourceOECD is the OECD's online library of books, periodicals and statistical databases.
For more information about this award-winning service and free trials, ask your librarian, or write to us at **SourceOECD@oecd.org**.

OECD*publishing*
www.oecd.org/publishing

ISBN 978-92-64-01025-3
92 2007 02 1 P