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BETTER POLICIES FOR BETTER LIVES

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Foreword

The OECD Review of Lithuania's Innovation Policy 2016 is part of a series of OECD country reviews of innovation policy.* It was requested by the Lithuanian authorities, represented by the Ministry of Economy and was carried out by the OECD Directorate for Science, Technology and Innovation (DSTI) under the auspices of the Committee for Scientific and Technological Policy (CSTP).

The purpose of this review is to obtain a comprehensive understanding of the key elements, relationships and dynamics that drive the Lithuanian innovation system and the opportunities to enhance it through government policy. More specifically, the review:

- provides an independent and comparative assessment of the overall performance of the Lithuanian innovation system
- recommends where improvements can be made within the system
- formulates recommendations on how government policies can contribute to such improvements, drawing on the experience of other OECD countries and evidence on innovation processes, systems and policies.

The review is intended to be relevant to a wide range of stakeholders in Lithuania, including government officials, entrepreneurs and researchers, as well as the general public. It also aims to use the OECD communication channels to provide an accessible and comprehensive presentation of the Lithuanian innovation system and policy to a global audience.

A draft version of the Overall Assessment and Recommendations was presented for a peer review to the Working Party for Innovation and Technology Policy (TIP) of the CSTP in December 2015, with the participation and contribution of Marius Skarupskas (Vice Minister of Economy of the Republic of Lithuania).

The review was led by Gernot Hutschenreiter, Head, Country Innovation Policy Reviews Unit, (Science and Technology Policy Division [STP], DSTI, OECD). The review report was drafted by Giulia Ajmone Marsan, Alistair Nolan and (from January 2016) Pluvia Zuniga (all Science and Technology Policy Division [STP], DSTI, OECD) with contributions from Patries Boekholt (consultant to the OECD; Technopolis, the Netherlands) and Jari Romanainen (consultant to the OECD; Technopolis, Estonia) under the supervision of and with contributions from Gernot Hutschenreiter (STP, DSTI, OECD). Yana Vaziakova (STP, DSTI, OECD) provided statistical support and web-based research.

The review draws on the results of a series of interviews with a wide range of major stakeholders of the Lithuanian innovation system during a fact-finding mission in September 2015. The preparation of the fact-finding mission by the OECD team was supported by a background report which was commissioned for this review by the

* www.oecd.org/sti/innovation/reviews.

Lithuanian authorities. This report– entitled *Initial Assessment of Lithuanian Innovation Policy* – was prepared by a team of Lithuanian experts of the association "Knowledge Economy Forum": Edgaras Leichteris, Mantas Jonauskis, Monika Petraitė, Mantas Vilys, Arturas Jakubavičius and Giedrė Stumbrytė. The background report contains a broad range of valuable information that is widely drawn upon in this report.

The review has benefited from comments and additional information received from stakeholders in Lithuania, the TIP peer review – in particular Lucie Núñez Tayupanta (Department of Research and Development, Ministry of Education, Youth and Sports, Czech Republic) and Kirsti Vilén (Enterprise and Innovation Department, Ministry of Employment and the Economy, Finland) who contributed by acting as peer reviewers at the TIP meeting – and distinguished experts in the field.

The review owes much to the support and co-operation of the Lithuanian government officials, in particular Dimitrijus Kucevičius (Director, Innovation Department, Ministry of Economy and delegate to the CSTP and TIP), Aurelija Kazlauskienė (Head, Innovation Policy Division, Innovation Department, Ministry of Economy) and Donata Gustaite (Chief Official, Innovation Policy Division, Innovation Department, Ministry of Economy) who provided background information and organisational support throughout the review, including for the fact-finding mission of the OECD team to Lithuania. Together with officials from the Business and Science Co-operation Division, Innovation Department of the Ministry of Economy and from the Department of Studies, Science and Technologies of the Ministry of Education and Science they also provided valuable comments on drafts of this report.

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Abbreviations and acronyms

AQS	Automated queries system
BEEPS	Business Environment and Enterprise Performance Survey
BERD	Business expenditures on research and development
BIF	Baltic Innovation Fund
BPLE	Business practical learning enterprises
CCIC	Chamber of Commerce, Industry and Crafts
CEE	Central and Eastern Europe(an)
CIS	Community Innovation Survey
CPVA	Central Project Management Agency
ECI	Economic Complexity Index
EEN	Enterprise Europe Network
EIF	European Investment Fund
EMU	Economic and Monetary Union
EPF	Entrepreneurship Promotion Fund
EPO	European Patent Office
ERDF	European Regional Development Fund
ESA	European Space Agency
ESF	European Social Fund
ESFA	European Social Fund Agency
ESIF	European Structural and Investment Funds
EU	European Union
EUC	Erasmus University Charter
EUR	Euro
EUREKA	Raising the Competitiveness of European Business through Technology
EUTM	European Union trade mark
FDI	Foreign direct investment
FP	Framework programme
FP6	6th Framework Programme
FP7	7th Framework Programme
FTE	Full-time equivalent
FTMC	Centre for Physical Sciences and Technology
GDP	Gross domestic product

GEM	Global Entrepreneurship Monitor
GERD	Gross expenditure for research and development
GOVERD	Governmental intramural expenditure for research and development
GVC	Global value chain
HE	Higher education
HEI	Higher education institution
HERD	Higher education expenditure for research and development
IC	Information and communication
ICT	Information and communications technology
INVEGA	Investment and Business Guarantee Institutions
IP	Intellectual property
IPR	Intellectual property right
IPTAS	Creation of a legal environment for pre-commercial procurement
IT	Information technology
JEREMIE	Joint European Resources for Micro and Small Enterprises
KEF	Knowledge Economy Forum
KSU	Klaipeda State College
KTU	Kaunas University of Technology
LAS	Lithuanian Academy of Science
LEED	Local Economic and Employment Development
LEI	Lithuanian Energy Institute
LIA	Laser Institute of America
LIC	Lithuanian Innovation Centre
LMT	Research Council of Lithuania
LVPA	Lithuanian Business Support Agency
LTVCA	Lithuanian Private Equity and Venture Capital Association
MFP	Multifactor productivity
MITA	Agency for Science, Technology and Innovation
MNE	Multinational enterprise
MOSTA	Higher Education Monitoring and Analysis Centre
MSTI	Main Science and Technology Indicators
NATO	North Atlantic Treaty Organization
NGO	Non-governmental organisation
NUTEK	Swedish National Board for Industrial and Technical Development
OECD	Organisation for Economic Co-operation and Development
OHIM	Office for Harmonisation in the Internal Market
OSA	Optical Society of America
PCP	Pre-commercial procurement

PCT	Patent co-operation treaty
PhD	Doctor of Philosophy
PISA	Programme for International Student Assessment
PMO	Prime minister's office
PMR	Product market regulation
PNAS	Proceedings of the National Academy of Sciences
PPP	Purchasing power parity
P/PP	Public-private partnership
PRI	Public research institute
PSC	Point of single contact for services and products
R&D	Research and development
RCA	Revealed comparative advantage
RCD	Registered community design
RCL	Research Council of Lithuania
RDI	Research, development and innovation
RIO	Research and Innovation Observatory
RIS3	Research and Innovation for Smart Specialisation Strategy
RTO	Research and technology organisation
SBA	Small Business Act
SBRI	Small Business Research Initiative
SBIR	Small Business Innovation Research
SKVC	Lithuanian Centre for Quality Assessment and Higher Education
SME	Small and medium-sized enterprise
SMIT	Strategic Council for Research Development and Innovation
SOE	State-owned enterprise
S&T	Science and technology
STI	Science, technology and innovation
STEM	Science, technology, engineering and mathematics
STP	Science and technology park
SWOT	Strengths, weaknesses, opportunities and threats
TIVA	Trade in value-added
TTO	Technology transfer office
USD	United States dollar
VAT	Value added tax
VET	Vocational education and training
VL	Enterprise Lithuania

Executive summary

Strengthen innovation to further narrow the income gap

Following independence Lithuania has made much progress in developing the institutions and framework conditions of a modern market-based economy, which provided the basis for Lithuania's success in narrowing the gap with the more advanced countries in the OECD. While in 1995, Lithuania's gross domestic product (GDP) per capita stood at one-third of the OECD average, it exceeded two-thirds in 2015. Thanks to its economy's high degree of flexibility, underpinned by a generally favourable regulatory framework, Lithuania weathered the crisis of the late 2000s better than many peer countries.

But Lithuania is also facing challenges. The gap in income per capita is still large, and the speed of convergence to the OECD average level of income has slowed in recent years. To close the income gap with the leading countries – which is largely accounted for by lagging productivity – Lithuania has to improve its innovation capability substantially. While EU membership has resulted in qualitative changes in its innovation system and a step-change in the availability of funding – including from European Structural Funds – Lithuania's innovation performance, notably business innovation, remains low overall.

Foster the quality of human resources for innovation

Innovation performance critically depends on highly skilled human resources, and Lithuania shows strengths in this area, e.g. regarding tertiary education attainment. However, skill mismatch appears to be high. Moreover, demographic trends are unfavourable and have been exacerbated by a substantial brain drain; the working population is decreasing overall.

Skill mismatches can be reduced by improved information on skills needed and encouraging dialogue between higher education institutions (HEIs) and business in the development of tertiary education curricula and programmes. Strengthening and extending measures promoting the development of the vocational education and training (VET) system are also beneficial in this regard.

Attracting highly-skilled foreigners – including students and researchers – remains a challenge; the number of foreign students in Lithuania is among the lowest in Europe. One way to attract and retain talent from abroad, including non-EU citizens, consists of expanding the offer of post-doctorate studies and facilitating access to visas and work permits for foreign scientists.

Improve public governance of the innovation system

Lithuania has made progress in developing its research and development (R&D) and innovation policy governance. The development of Research and Innovation Strategies for Smart Specialisation (RIS3) – which included a process for establishing policy priorities engaging key stakeholders including industry – and the Innovation Development Programme 2014-20 can be seen as important milestones. However, innovation system governance still shows a number of weaknesses.

Lithuania lacks horizontal science, technology and innovation (STI) policy co-ordination, which was particularly evident in the design and implementation of the Valleys Programme. Weak co-ordination between ministries has contributed to a fragmentation of policies, instruments and their delivery; however, the establishment of the Strategic Council for Research Development and Innovation (SMIT) was a step forward. Reinforcing the council's strategic role, e.g. in reviewing the STI policy mix and the institutions involved in its implementation, would help to sharpen strategic orientation and improve policy coherence. It will be important to link R&D and innovation, societal challenges and economic opportunities.

Further efforts will be needed to enhance co-ordination at operational levels. The large number of agencies responsible for a plethora of support programmes and instruments makes the R&D and innovation support system fragmented and difficult to access and use by businesses. Its impact can be increased by consolidating institutions and support schemes where overlaps exist, and by adopting a more industry and society need-based approach.

There is a need to nurture a stronger culture of evidence-based STI policy making and to use principles of good practice in policy evaluation. Ministries would benefit from building their in-house strategic intelligence competences while options for strengthening the development and use of high-quality strategic intelligence across the STI system should be explored.

Foster innovation in the wider business sector

Raising the currently low innovation capabilities of Lithuanian businesses deserves priority attention. Against the country's unfavourable demographic trends, innovation is the most important sustainable driver of long-term productivity and income growth.

Within the STI policy mix, there has been a strong emphasis on research and science-driven innovation. Much effort has been put to developing infrastructures supporting R&D and innovation (Valleys, open access centres, technology centres, science parks, etc.). Business support measures have focused on two main target groups: companies already active in R&D and innovation, and potential high-growth start-ups. There is a need to assist a much larger range of companies to become involved in innovation and R&D. This will entail improving the participation of SMEs in policy programmes through a number of measures.

Improving the policy mix to expand the range of support to other forms of innovation activity – such as organisational innovation and to other sectors (services) – are also relevant lines of action. The extent to which the apparent mismatch might be closed through shifts in policy, including policy towards financing, must be further examined.

Strengthen the contribution of universities and public research institutes (PRIs)

The HEI and PRI sectors have been reformed over recent years; institutional funding was complemented by competitive funding. Yet, their scientific performance in terms of international co-publications, publications in peer-reviewed journals and citations are relatively poor. A recent international research assessment of research groups showed that some are strong national players with international recognition, but there were no strong international players among Lithuanian research actors. Even though large investments have provided the research sector with a good research infrastructure, this has still to be translated into internationally attractive research. Across all scientific domains research management was considered inadequate. The collaboration between public research and the business sector is still weak, some positive exceptions and a number of initiatives regarding commercialisation notwithstanding. In view of the relatively large number of HEIs, but also science parks etc., some consolidation should be considered to achieve advantages of scale and scope.

Chapter 1.

Overall assessment and recommendations

This chapter presents an overall assessment of Lithuania's innovation system and policy, reflecting the key findings of the review. It identifies strengths and weaknesses and key issues for innovation policy, and develops specific policy recommendations for improving Lithuania's performance in science, technology and innovation.

Achievements and challenges – upgrading the economy and strengthening the role of innovation

After gaining independence in 1990 – together with the two other Baltic states, Estonia and Latvia – Lithuania embarked on two important integration processes: political and economic integration into the European Union (EU), and military integration into the North Atlantic Treaty Organization (NATO). European integration culminated in Lithuania's accession to the European Union in 2004. On 1 January 2015, Lithuania also joined the Economic and Monetary Union (EMU), widely known as the euro area. At present, Lithuania is in the process of accession to the Organisation for Economic Co-operation and Development (OECD), following an official invitation by the OECD Council. Already the process of accession and a fortiori membership to the European Union had a profound impact on Lithuania's economy, and the institutional setup and framework conditions under which it operates. It also triggered profound changes in the Lithuanian innovation system, including in the modes of steering and funding of science, technology and innovation (STI). The process of accession to the OECD offers another important opportunity for Lithuania to strengthen its position in, and integration into, the global economy, and to benefit from OECD experience and peer review processes in various areas, including STI.

While in 1995 Lithuania's gross domestic product (GDP) per capita (USD 8 920) stood at approximately one-third of the OECD average (USD 27 396), it exceeded two-thirds of this benchmark (69%) in 2015 (USD, constant prices and 2010 PPP). Lithuania's macroeconomic performance after independence has been very favourable overall. Lithuania's GDP per capita stands at USD 28 809 (USD, 2015, current prices and purchasing power parity [PPP]), compared to an OECD average of USD 40 144. The country has made much progress in catching up, thereby rapidly narrowing the gap between Lithuania and the advanced countries in the OECD and the EU. While in 1995, Lithuania's GDP per capita stood at one-third of the OECD average, it exceeded two-thirds in 2015. Like other countries, Lithuania was hit hard by the crisis beginning in 2008. Together with the other two Baltic states, Lithuania recorded one of the sharpest contractions of economic output in Europe (close to 15% of GDP in 2009). Thanks to the relatively high degree of flexibility of the economy, underpinned by a generally favourable regulatory framework, the Lithuanian economy rebounded quickly, however.

Still, productivity gaps are large and Lithuania has a long way to go to catch up completely with the OECD average level of per capita income, let alone with the most technologically-advanced OECD countries. The speed of convergence to the OECD average level of income has slowed somewhat in recent years, compared to the pre-crisis years in the 2000s. To close the income and productivity gap with the leading countries in the European Union and the OECD – which is largely accounted for by lagging productivity – Lithuania's innovation capability has to be improved substantially.

Lithuania has a very small domestic market. However, being an open economy well integrated in the European Single Market and the world economy has allowed Lithuania to mitigate disadvantages of small domestic market size. Continued investment in an effective and up-to-date transport and communications infrastructure is essential for reaping the benefits of trade openness by facilitating access to major markets.

Lithuania faces important challenges in the near and longer term: demographic trends are unfavourable and these are exacerbated by a substantial brain drain; the working population is decreasing and there are signs of important skill mismatches; and the

country's innovation performance is low overall, despite important investments made in the context of EU membership and support from EU Structural Funds. To close the income and productivity gap with regard to the leading economies of the European Union and the OECD, Lithuania's innovation capability has to be improved substantially. Raising the current low innovation capabilities of Lithuanian businesses deserves priority attention. In view of Lithuania's unfavourable demographic trends, productivity increases are critical to increasing income per capita – and innovation is the most important sustainable driver of long-term productivity growth. This highlights the importance of a coherent and persistent STI policy in Lithuania.

Main strengths and weaknesses of Lithuania's research and innovation system today

Table 1.1 presents a strengths, weaknesses, opportunities and threats (SWOT) analysis of Lithuania's research and innovation system.

Table 1.1. **SWOT analysis of the Lithuanian innovation system**

Strengths	Opportunities
– Strong macroeconomic performance, leading to convergence – Largely favourable framework conditions for innovation and entrepreneurship – Favourable conditions for the establishment and development of start-ups – High share of tertiary graduates, including in science and technology (S&T) – Increased openness, transparency and stakeholder involvement in STI policy formulation – New research infrastructures – Pockets of research and innovation strength in some areas, e.g. photonics (lasers, photoelectronics, LEDs) and biotechnologies – Improved research system governance – Improved regulatory framework for commercialisation of public research – Growing small and medium-sized enterprise (SME) participation in the European Union's 7th Framework Programme for Research and technological development for 2007-2013 FP7) and Horizon 2020, and participation in EU networks	– Increase policy attention on research and innovation – Focus on strengthening innovation capabilities in a wider range of firms – Improve horizontal policy coherence and co-ordination (e.g. between the main ministries in charge of STI) – Make business participation a permanent feature of STI policy making – Provide better support for business innovation by upgrading competences of STI public sector policy makers – Reform the research sector (e.g. more competitive funding, international peer review, streamlining) to increase international competitiveness – Improve the contribution of universities/public research organisations to innovation – Pay more attention to societal challenges in STI policy – Make more effective use of research infrastructure – Use research potential created by the "Valley" programmes and open access centres – Enhance integration with international innovation networks – Better use the opportunities of Horizon 2020
Weaknesses	**Threats**
– Specialisation in low/medium technology industries – Very low business activity/investment in R&D and innovation – Low absorptive capabilities of many businesses – Few links between research institutions and businesses – Fragmentation and lack of co-ordination in STI policy making and implementation accompanied by cumbersome legal procedures – Weak evaluation culture and strategic intelligence on innovation policy – Demand-side policies are under-utilised – Too many sub-critical actors in the higher education institutions (HEI) sector striving for the excellence of fundamental research, while paying less attention to applied research – Technology transfer and research commercialisation unconnected to university/PRO culture – Weak international STI linkages	– Unfavourable demographic trends and continued difficulty in attracting and retaining highly-skilled workers in the face of mounting global competition – Decreasing numbers of graduates and PhDs – Stagnation of business investment in R&D and innovation – Decline of EU funding for STI and limited ability of Lithuania to support innovation programmes from the national budget – Failure to adapt STI governance to evolving needs

Key issues and recommendations

Taking account of the SWOT analyses set out in Table 1.1, and the strategic tasks to be addressed by innovation policy, this report has identified a number of key issues and policy recommendations.

Provide favourable framework conditions for innovation

Good framework conditions are essential for innovation. Research shows that framework conditions that affect innovation include: openness to international trade and foreign direct investment (FDI), competitive markets for goods, services and labour; a transparent, fair, non-punitive and predictable system of corporate taxation; a propitious macroeconomic environment; bankruptcy legislation that facilitates resource reallocation while properly protecting creditors; institutions and regulations which impose minimal burdens for doing business; ease of business access to finance; and a system of education and training which efficiently balances skill supply and demand.

Since independence in 1990, and the country's entry into the European Union in 2004, Lithuania has eased product market regulation (PMR) in order to increase competition. By 2013, the PMR index for Lithuania was 1.52, which is in line with the OECD average, and at the same level as Sweden (1.52) and Chile (1.51). Some aspects of the regulatory framework in Lithuania are more market-friendly than in the average OECD country. This includes the degree of state involvement in business operations and the complexity of regulatory procedures. However, as highlighted in the recent OECD Regulatory Policy Review of Lithuania, further assessment is needed to understand to what extent well-designed regulatory policies are implemented in practice.

According to the World Economic Forum's Global Competitiveness Report 2015-16, Lithuania ranks 36 out of 140 countries, just behind Indonesia and ahead of Portugal. Based on the indicators used in that report, Lithuania performs well with respect to the education of its population, its market efficiency and technological readiness. In 2014, for instance, 96% of firms in Lithuania had Internet access, a share comparable to the EU average. However, the same World Economic Forum report suggests that the country lags behind with respect to the efficiency of its institutions, the development of domestic financial markets and labour market efficiency. The inefficiency of government bureaucracy is held to be the most problematic factor for doing business.

Lithuania is now in the top 20 of the World Bank Doing Business ranking. Lithuania has recently implemented important reforms to facilitate the creation of new businesses. For example, according to the World Bank report, between 2005 and 2015 the number of days it takes to register a business has decreased from 26 to 3.5, and the cost to start a business as a share of income per capita has declined by approximately 80%. Lithuania has also simplified bankruptcy procedures over the last ten years, even though insolvency procedures still take more time to be finalised (2.3 years on average) than in the average OECD country (1.8 years). In recent years, Lithuania has considerably strengthened the framework conditions for innovation. However, challenges in some areas remain.

An area where Lithuania needs improvement, as highlighted by the OECD PMR indicators, concerns the restrictions on employing non-EU workers. These restrictions may not only prevent domestic companies from recruiting, they may also discourage the relocation of firms from outside the European Union to Lithuania. At 15%, the statutory rate of corporate income tax is low, and a reduced tax rate of 5% for companies with less than ten employees and EUR 300 000 income per year is also in place.

Another factor affecting competition is the large size of the informal economy. Despite a decrease in recent years, Lithuania's informal economy is one of the largest in the European Union (by some estimates being in the range of 17% to 26% of GDP). In 2013, respondents to the EBRD-World Bank Business Environment and Enterprise Performance Survey (BEEPS) highlighted the operations of competitors in the informal sector as a barrier to their activities.

Difficulties in access to finance are also an obstacle to entrepreneurship. Lithuania ranks 91 out of 140 countries for ease of access to loans, according to the World Economic Forum Global Competitiveness Report 2015-16. In addition, 16% of firms that participated in the BEEPS survey identified access to finance as an obstacle to their activities, a figure that is higher than in Estonia (5%) and similar to Latvia (15%). It is particularly concerning that firms encountering problems in accessing credit in Lithuania are generally small firms with higher levels of labour productivity. Access to finance can as a consequence be a constraint for the growth of high-potential firms. The relatively recent development of a venture capital sector can partly address these problems: the establishment of the Joint European Resources for Micro and Small Enterprises (JEREMIE) holding fund, a joint effort of the Ministries of Economy and Finance of the Republic of Lithuania and the European Investment Fund (EIF), and the Baltic Innovation Fund (BIF), a joint initiative of EIF and the three Baltic states, are steps in the right direction. A promising recent development is the creation in 2014 of Nextury Ventures, a 100% privately owned venture capital fund. Nevertheless, even in OECD countries where the venture capital sector is most developed, only a tiny minority of all firms receives venture finance. Accordingly, attention must be given to the full range of instruments and policies required to address access to both equity and debt among firms most likely to face access constraints.

Many firms in Lithuania consider infrastructure supply to be below OECD average standards. And limits on the compatibility of the transport, electricity and gas networks with those in the rest of Europe may hinder competition and raise costs for Lithuanian firms. A range of reform initiatives and public investments are under way which will help to mitigate some of these problems.

Recommendations

- Encourage the development of mature system of equity and debt finance to tackle the lack of investment in high-potential growth firms. Explore possibilities to further develop the business angels sector and examine opportunities to enhance the quality of firms' investment proposals (so-called "investment readiness"), through, for instance, support by mentors and content experts.
- Continue to make bankruptcy procedures more rapid and less costly.
- Continue to improve the regulatory framework, paying particular attention to the efficiency of government institutions.
- Monitor the impact of the current corporate tax regime and ensure it does not create obstacles to the growth of young innovative firms.
- Monitor the effects on Lithuanian firms of the reform initiatives and public investments aimed at addressing infrastructure deficits.

Foster the quality of human resources for innovation

Innovation performance critically depends on highly-skilled human resources. Lithuania shows strengths in this area. For instance, the share of the population aged between 20 and 29 who are enrolled in tertiary education (albeit decreasing) and the share of the working-age population with a tertiary education are well above EU averages. However, there are indications that skill mismatch is high. According to the Research and Higher Education Monitoring and Analysis Centre (MOSTA), in 2013 36% of employed bachelor graduates held positions that did not require a higher-level qualification. MOSTA recently also found that the short-run returns to university education were low compared to other types of education (i.e. vocational and college education). The skill mismatch can be partly explained by the fact that traditional industries dominate Lithuania's business sector, both in terms of value added and export specialisation. These industries are generally characterised by a larger share of jobs without specific skill requirements.

There is scope for improvement of student performance in secondary education. According to the OECD/PISA survey 2012, Lithuanian students score below the OECD average in all three surveyed areas: mathematics (494 for the OECD on average, as compared to 479 for Lithuania), reading (496 across the OECD as compared to 477 for Lithuania), and science (501 across the OECD and 496 in Lithuania). Students in the two other Baltic states performed above Lithuanian students: 491 in mathematics, 489 in reading and 502 in science in Latvia and 521 in mathematics, 516 in reading and 541 in science in Estonia. In mathematics, the performance of Lithuanian students has decreased since the first round of participation in the OECD/PISA survey.

Nearly 35% of Lithuanian firms cite an inadequately educated workforce as a major or severe obstacle to their activities. Other sources suggest that firms consider the availability of skilled graduates and/or workers insufficient. To address some of the skill mismatch in the business sector, the Lithuanian government has reformed the vocational education and training (VET) system. In particular, it established sectoral practical training centres which are open to VET and higher education (HE) students and business sector employees. According to the OECD's Policy Note on Youth in Lithuania, additional measures might include direct subsidies or tax advantages for firms participating in VET activities.

The problem of skill shortage and mismatch is exacerbated by the large outflows and limited inflows of skilled people from and to the country. More than 8% of Lithuania's domestic tertiary-educated population emigrated in the first decade of this century (prior to 2011), a share higher than in comparable eastern European economies. Most immigrants are returning Lithuanian citizens. Attracting highly-skilled non-Lithuanians from abroad – including students and researchers – remains a challenge. The number of foreign students in Lithuania is among the lowest in Europe. The share of non-EU doctoral students is particularly low – at close to 0% – compared with the EU average of 24%.

Lithuania has put in place a number of initiatives and programmes to promote the participation of Lithuanian researchers in international research activities and attract researchers and students from abroad. These initiatives include: grants to conduct visiting periods in research institutions abroad; inviting researchers from abroad to spend time in Lithuania; the development of joint study programmes with foreign institutions; and awards to Lithuanian researchers that perform research activities abroad.

Recommendations

- Strengthen the human resource base for innovation in order to supply businesses with the skills they need to become more innovative. Map the skills needed by Lithuanian companies and encourage dialogue between HEIs and the business sector in the development of tertiary education curricula and programmes.
- Strengthen and extend measures promoting the development of the VET system with a view to meeting business sector needs.
- Address the relatively low performance of students in secondary education relative to their peers in the OECD.
- Foster linkages between Lithuanian researchers and research units abroad (e.g. through sabbaticals, visiting periods abroad [exchanges], or joint research programmes). These measures should target both young researchers and senior research staff.
- Continue addressing the problem of brain drain and lower barriers to attracting and retaining talent from abroad, including non-EU citizens. In the case of attraction of researchers, this can take the form of expanding the offer of post-doctorate studies and facilitating access to visas and work permits for foreign scientists.

Improve public governance of the innovation system: agenda setting, co-ordination and strategic intelligence

Lithuania has clearly made progress in developing its R&D and innovation policy governance, especially during recent years. The requirements of and guidance from the European Commission related to EU Structural Funds has been instrumental in this development, first through the "Lisbon strategy" and subsequently through "smart specialisation".

The recently launched EU Structural Funds period (2014-20) prominently features "smart specialisation", and development of Research and Innovation Strategies for Smart Specialisation (RIS3) was a requirement for receiving funding. For the first time, the process for establishing policy priorities was interactive and attempted to engage all key stakeholders, including industry. The process was based on an extensive and systematic analysis of Lithuania's economic sectors and research competences. This represented an important step towards evidence-based policy making. Stakeholder consultation was made part of the design of new or adapted schemes. The adoption of an evidence-based approach and increased transparency were in line with the requirements of the European Commission, which had to approve RIS3. RIS3 and the more transparent and evidence-based approach are also conducive to a more balanced R&D and innovation policy. For instance, the development of the Smart Specialisation Strategy contributes to achieving a better balance between developing research competencies and addressing industry needs. It also introduced a more application-oriented approach, including in addressing societal challenges. The strategy likewise includes plans to introduce pre-commercial procurement (PCP) as a new demand-side policy measure. Implementation of the strategy is shared between the Ministry of Economy and the Ministry of Education and Science.

Many of the main RIS3 policy objectives and challenges had been identified in, and are part of, the Lithuanian Innovation Development Programme 2014-20. The Innovation Development Programme – a continuation of the Innovation Strategy 2010-20 – aims to mobilise state resources for improving Lithuania's innovativeness and developing a

competitive economy based on knowledge, technology, qualified human resources and smart specialisation. Implementation of the Innovation Development Programme is shared by nine ministries and six agencies and other public bodies.

Lithuania has engaged many stakeholders in the RIS3 process, co-ordinated by the Ministry of Education and Science and the Ministry of Economy. As occurred with RIS3, the Innovation Development Programme attempted to introduce R&D and innovation into the agenda of other ministries. Indeed, the drafting process involved a host of ministries and agencies, although there was no commensurate involvement of non-governmental organisations (NGOs) and business. Overall however, RIS3, as well as the Innovation Development Programme, can be seen as important milestones in R&D and innovation policy making in Lithuania. However, despite the progress made, the governance system still has a number of weaknesses which need to be addressed.

Strengthen agenda setting and strategic policy coherence

Evidence on Lithuania's strengths and weaknesses was used to develop the research and innovation RIS3. STI policy has been given more focus and the opportunity has been created for more co-ordination between ministries and agencies. RIS3 seems to be accepted widely as one of the main strategic documents for research and innovation. The proof of whether or not RIS3 is supporting a more focused and coherent policy will be its success in changing the wider mix of policies contained in the Operational Programme 2014-20, the measures taken in implementing the Innovation Development Programme, and the Ministry of Science and Education's plans in relation to research and innovation transfer. As many measures are currently still in development, or have just started, it is too early to assess these outcomes.

It will be crucial for Lithuania that the RIS3 serve as a guiding principle for the further implementation of European Structural and Investment Funds (ESIF) programmes during 2014-20. It is also crucial that Lithuania build bridges between R&D and innovation, societal challenges and economic opportunities by better aligning different strategic documents such as the Innovation Development Programme, the National Programme for the Development of Studies, Scientific Research and Experimental (Social and Cultural) Development Programme for 2013-20.

Even though – as mentioned – the RIS3 process was a step in the right direction, policy making and implementation is often hampered by rather cumbersome legal procedures that may be rooted in Lithuania's administrative culture. In addition, strategies in the area of STI policy sometimes set overly optimistic and sometimes unrealistic targets. Evidence of this can be found in several studies and evaluations. The objective to raise gross expenditure for research and development (GERD) intensity (gross expenditure on R&D as a percentage of GDP) to 1.9% by 2020 is an example. As the current level is 1.0%, and little progress has been made over recent years, this objective seems unrealistic. Unrealistic targets undermine the credibility of R&D and innovation policy, and fail to provide guidance and encourage stakeholder commitment. Indeed, instances of weak industry commitment to government-led initiatives can be interpreted as being partly caused by this fact. Achieving this commitment requires credible policies with ambitious but realistic objectives.

Improve horizontal policy co-ordination

A lack of co-ordination was particularly evident in the design and implementation of the Valleys Programme, which was meant to be a programme focused on university-business co-operation and the support of innovative new business development, but became a

programme primarily supporting the public university and research sector. More and better co-ordination, including with business representatives, at the design and early implementation phase might have increased the chance to achieve the original objectives of the programme. A lack of co-ordination has also been evident in the development of science parks, for example via the Inogeb programmes, which contributed to a proliferation of science parks and incubators. The new approach to science and technology parks (STP) policy (as foreseen in the guiding document of the Lithuanian government as of 25 February 2015) might help to improve co-ordination, if the additional STP tasks foreseen are developed within the wider context of changes in the technology transfer tasks of universities and research centres. This new approach should take into account the need for professional capabilities and private sector incentives. Successful science parks across the world have proved that these are necessary for developing business opportunities.

The establishment of the Strategic Council for Research Development and Innovation (SMIT) was a step forward. The council, chaired by the prime minister, consists of representatives of the ministries in charge of STI development, the Research Council of Lithuania (LMT), the Agency for Science, Innovation and Technology (MITA), science and HEIs, business, social and economic partners, and independent experts. The council has been involved in approving RIS3 but does not seem to take an active and strategic role in examining the Lithuanian policy mix or the set of institutions involved in the implementation of STI policy. Strengthening the council's role in these directions could help to sharpen the strategic orientation of Lithuania's innovation policy and improve coherence.

The establishment of MITA in 2010 – by both the Ministry of Economy and the Ministry of Education and Science – is also a promising development as regards horizontal co-ordination. However, the largest support programmes for innovation, financed through ESIF, are not managed by MITA but by the Central Project Management Agency and the Lithuanian Business Support Agency. This limits the reach of MITA in the business sector.

A lack of a systemic STI policy approach together with often cumbersome legal procedures and weak co-ordination between ministries has contributed to a fragmented mix of policies, policy instruments and implementation structures. It is evident from the examples given above – and confirmed by earlier studies and evaluations – that STI policy co-ordination in Lithuania is far from sufficient in any of these dimensions. Ensuring better policy coherence – horizontal, vertical and over time – requires a significant co-ordination effort. Corrective efforts have been made (e.g. in establishing SMIT and MITA) but co-ordination remains weak both at strategic and implementation levels. Learning, for instance, from the RIS3 process and reinforcing the role of SMIT (or a reorganised council), may improve co-ordination at the strategic level. However, further efforts will be needed to enhance co-ordination at operational levels too, notably between agencies and programmes and instruments.

Reducing the fragmentation of institutions and support schemes

The institutions and arrangements currently in place for implementing STI policies are highly fragmented. The large number of agencies responsible for a plethora of schemes makes the R&D and innovation support system complex and difficult to access and use, especially for businesses. One indication of this is the relatively poor uptake of schemes, such as the generous R&D tax incentive. The awareness of various schemes among their key target enterprise groups is low and many choose not to apply to participate because of administrative costs and uncertainty regarding the tax reduction eventually granted. Furthermore, the prevailing administrative practice supports strict implementation with very little flexibility, which is poorly suited for R&D and innovation

activities which are inherently risky. Fragmentation, combined with these weaknesses in policy implementation, is likely to reduce the impact of STI policies.

Fragmentation and the resulting need for co-ordination of policy implementation may be reduced by consolidating institutional structures. The merging of agencies and schemes could be based on functional or target group similarities and complementarities. Consolidating around functional complementarities is more typical in most countries and probably also easier to adopt in Lithuania. Consolidating around target groups is more demanding as it often requires the resulting agencies to manage several different types of schemes. However, merging agencies based on target group similarities leads to more in-depth knowledge of that group, better understanding of impact, and stronger evidence for designing and revising schemes in the future. This approach is also easier to handle for businesses, since they only need to interact with one or a limited number of agencies.

Improving strategic intelligence

There is a need to foster the emergence of a stronger culture of evidence-based STI policy making. Ministries would benefit significantly from building their in-house competences related to strategic intelligence. Use of independent external expertise is a viable and often necessary option, but its value is likely to remain limited without sufficient in-house competences. A step-change in this regard would be the systematic monitoring and analysis of support to business R&D innovation across different agencies and support schemes which currently seem to be unavailable.

The evidence-base developed in the context of the RIS3 process, together with other strategy processes, studies and evaluations, provide a solid base for further developing STI-related strategic intelligence in Lithuania. The role of MOSTA in gathering evidence for the use of decision makers has been important in this regard, and MOSTA has been able to strengthen its own capabilities. Strategic intelligence with regard to business innovation activities appears underdeveloped. Developing the required integrated business intelligence within the Ministry of Economy might be considered, as this ministry co-ordinates the many agencies collecting relevant information. Nevertheless, this still poses the question of how to link together strategic intelligence across the whole research and innovation system.

Recommendations

- Consider launching a systematic review of all STI-related programmes, possibly under the aegis of a reinforced strategic council. This would help to find an appropriate balance, for instance between public funding for fundamental research, applied research and business innovation, or the balance between supporting high-tech companies and innovation followers.
- In future strategy and policy design, draw on the experience of the RIS3 process and other research and innovation-related strategies, and aim at adopting an open, transparent, participative and evidence-based approach. Make specific efforts to enhance regular stakeholder participation, notably of industry.
- Launch an institutional reform of STI policy implementation by improving co-ordination, and consolidate agencies and support programmes where overlaps exist. Establish an appropriate approach (functional, target group-specific, or other) for programmes and adopt a more industry and society need-based approach within the consolidated implementation structure and in the design of consolidated schemes.

- Consider establishing a common information platform for following up users (applicants and beneficiaries) and monitoring R&D and innovation support across agencies and schemes. This would provide critical information for policy design and evaluation and facilitate the integration of all relevant monitoring data into one database and thereby follow beneficiaries and their results in a more comprehensive way, which would provide a solid basis for impact analysis. In parallel, the development of a virtual one-stop-shop (single entry point) for potential beneficiaries would ease access to an otherwise complex support system.
- Explore the strengths and weaknesses of different options for strengthening the development and use of high-quality strategic intelligence on the science, research and innovation system.
- Follow principles of good practice in policy evaluation. Among other things, this entails making explicit a commitment to policy evaluation at the highest level, mandating evaluations when public funding is provided, insisting on developing data and evaluation strategies as a pre-requisite for the start of programmes, using a mix of evaluation methods (according to the nature of the policy or programme concerned, including evaluation by external and international experts), and committing to public diffusion of evaluation findings of publicly-funded programmes.

Better balance the policy mix, fostering innovation in the wider business sector

Lithuania's R&D and innovation policy mix of the last decade has featured a relatively large number of policy measures encompassing education, research and innovation, the environment, labour and infrastructure. R&D and innovation have been further supported by efforts to establish favourable and stable conditions for R&D and innovation activities, with a special emphasis on access to equity finance.

Within the policy mix, there has been a strong emphasis on research and science-driven innovation. Most funding schemes supporting business R&D and innovation were in some way linked to research and research infrastructures (for example InoKlaster LT+, innovation vouchers, and national high-technology and biotechnology programmes).

It is therefore not surprising that business R&D and innovation support measures have focused on two main target groups: companies already active in R&D and innovation, and potential high-growth start-ups. Enterprises already engaged in R&D are likely beneficiaries of both the schemes aimed at business R&D activities and infrastructure (Intelektas LT and LT+) and the R&D tax incentive. They may also be the indirect beneficiaries of the research infrastructures, although this depends strongly on the match between industry needs and the underlying interests for developing specific research infrastructures. Start-ups and innovative companies are also the main beneficiaries of equity funds set up with the EIF (JEREMIE and the BIF).

There are only a limited number of smaller-scale measures for companies outside the two target groups mentioned. These include support for technical feasibility studies and innovation support services (InoCekiai, Inogeb LT, Asistentas). Support for incremental innovation, firm training (for the adoption of new technologies and innovation) as well as non-technological forms of innovation (i.e. development or improvement of new business models and organisational and managerial practices) are also currently absent in the business innovation policy mix.

While there has also been some effort to develop relevant infrastructures and related services to support research and innovation activities among a wider range of enterprises

(Inogeb LT-2), they have been technology-push oriented. Even the measures that could be targeted at raising companies' R&D and innovation capacities (through employment of R&D personnel) focuses on knowledge-intensive SMEs, not potential new R&D and innovation performers. The rationale focuses on enhancing researcher employment, rather than increasing the number of companies able to become R&D and innovation performers.

As already mentioned, business R&D and innovation started to receive more attention towards the end of the last EU Structural Funds period (2007-13), especially during preparation of the new period (2014-20). The main challenge is the relatively small number of companies in Lithuania engaged in R&D and innovation (Box 1.1). The policy mix should reflect the fact that raising awareness of the importance of R&D and innovation, facilitating competence building and the absorptive capacities of companies, and other measures aimed at increasing the number of companies capable and willing to engage in R&D and innovation, are vital for Lithuania's competitiveness.

The R&D and innovation policy mix has some visible gaps. Efforts to develop demand-side measures for supporting innovation have only been initiated recently. Policies show very little recognition of the importance of organisational or service-sector innovation. The current policy framework lacks support mechanisms for basic forms of innovation and technology diffusion in SMEs, in spite of the documented difficulties of this group of firms in engaging in innovation activities and innovation performance, as opposed to large firms and European peers. In addition, apart from export and FDI promotion and the EUREKA programme, international collaboration is seldom featured or recognised in business-oriented R&D and innovation support schemes.

Much effort has been put to developing infrastructures supporting business R&D and innovation (Valleys, open access centres, technology centres, science parks, etc.). However, the group of targeted businesses remains small compared to the investment in these infrastructures. There is an urgent need to assist a much larger range of companies to become involved in innovation and R&D in order to make good use of the support infrastructure and justify its further development in the longer term. This will entail improving the participation of SMEs in policy programmes through, for instance, support for project preparation (e.g. assisting SMEs in the drafting of applications for individual and collaborative projects with research institutions) and enhancing policy awareness (e.g. campaigns and involving SME chambers in the promotion of policy instruments). Improving the policy mix to expand the range of support to other forms of innovation activity such as organisational innovation and to other sectors (services) are also relevant lines of action. The extent to which the apparent mismatch might be closed through shifts in policy, including policy towards financing, must be further examined.

There are some signs, however, that in the new EU Structural Funds period the match between the business R&D and innovation landscape and policy is improving. Schemes such as innovation vouchers, and co-financing support for protecting intellectual property, international certifications, and various other "soft" measures providing innovation and business support services (e.g. technology auditing, marketing and design services, technical assistance to address specific problems including quality issues, production process and automation, information systems and environmental compliance), are likely to reach potential R&D and innovation performers. Cluster initiatives can also be effective in this respect, if they are industry-driven and carefully designed.

Box 1.1. **Innovation-related features of Lithuania's business sector**

Lithuania's manufacturing sector mostly consists of low- and medium-low-technology industries. The share of these industries in manufacturing output exceeds 80%. Lithuanian manufacturers have predominantly specialised in the production of raw material-intensive goods (e.g. food, fertilisers, and refined petroleum products) and labour-intensive goods (e.g. textiles, clothing, wood products, and furniture). Medium-high and high-technology industries are growing (5% to 7% annually according to Eurostat), but their contribution to the economy is still low by international standards (high-tech exports account for only 5.8% of total exports).

The share of R&D personnel is below the EU average, but increased over the last decade (from 6.6‰ to 8.6‰ of total employment). The increase is primarily due to an increase in researchers of approximately 30%. The number of business R&D personnel has recorded a similar trend.

The share of innovative companies in the total business population is one-third (compared to one-half among European innovation leaders). Only 20% of SMEs are innovative, while countries classifiable as European innovation leaders record more than twice that share. Average innovation expenditure per company is low at EUR 86 000 (1.4% of turnover), especially compared to innovation leaders (where the equivalent figure is EUR 1 million, or more than 3% of turnover).

Innovation in Lithuanian business enterprises is largely non-R&D-driven. Innovative activities are mostly of an incremental character and focus on productivity increases, often related to process innovations and market innovations. Acquisition of equipment and software account for 70% of total innovation expenditure, while among European innovation leaders the share is 5-15%. The structure of innovation expenditure indicates that the majority of innovative companies are catching up by transferring technology, mostly from abroad. To some extent this may also be related to the strong emphasis on R&D infrastructures, tangible investments and access to finance in R&D and innovation policy during the 2007-13 period.

Only 15.7% of Lithuanian SMEs innovate in-house. Accordingly, patenting activities are limited. The number of patent co-operation treaty (PCT) patent applications is 0.9 per billion GDP, which is less than 25% of the EU average (3.9) and about 10% of the figure seen in European innovation leaders (10). Co-operation on business R&D and innovation is rare. Only 8.8% of innovative SMEs collaborate in their innovation activities. In addition to limited business R&D and collaboration, and a low number of enterprises engaged in R&D-driven innovation, science-based entrepreneurship and patenting activities remain low. Given that public sector R&D accounts for the major part of GERD, the knowledge transfer gap is a particularly serious concern. While several policy measures are in place to address the gap, impact is limited and focuses on start-ups and a small number of R&D-intensive companies.

According to the Innovation Union Scoreboard, Lithuania's overall innovation output is moderate compared to other EU28 countries, well below the EU average, and far behind European innovation leaders. Furthermore, there are no signs of a catch-up process.

It is commendable that Lithuania has introduced a voucher scheme. Such schemes can be useful in targeting the immediate needs of businesses in the area of innovation and R&D. They can help raise awareness among enterprises of services offered and lead to extended collaboration, once sufficient trust has been built. Vouchers can be designed to cover services offered by public research organisations, universities and private providers. This requires that the operating agency set the necessary code of conduct and rules for the voucher scheme and organise a certification of service providers, for example through a public tender process. This allows agencies to focus on operating schemes rather than growing the public sector by hiring experts providing services to companies. This approach

is worth considering in areas where sufficient supply of private services exists. Voucher schemes also have their limitations and pitfalls (such as becoming driven by the interests of the service provider rather than industry, especially if the provision is subsidised to 100%).

With respect to industry-oriented cluster and networking programmes, companies can launch collaborations related to their immediate business concerns, such as export promotion and short-term priority necessities such as training and firm upgrading. As they build trust and identify shared challenges, the collaboration might start to be extended to innovation and R&D, or other areas of strategic interest. As companies learn and gain in experience, their capabilities and willingness to collaborate with public research institutes is also likely to increase. Lithuania's R&D and innovation policy has to be better aligned to industry needs. The relatively low number of businesses currently able to engage in R&D and innovation indicates that public support measures should be better targeted. After the significant investments of recent years in building and modernising research infrastructures, support should now go more towards companies that may benefit from them. Support should consist of a mix of soft and hard measures, facilitating awareness, identification of innovation-related business opportunities, competence development, R&D and innovation activities, and commercialisation, exporting and growth.

With respect to innovation-oriented procurement, it is essential that competition in the tender process be preserved. The threat to competition in innovation-oriented procurement comes from the greater interaction and information exchange that can occur between the procurer and suppliers, relative to purely arms-length procurement. General government procurement can also be made more innovation friendly with little additional risk simply by specifying the goods and services to be procured in terms of their functionalities – what they will do when used – rather than in terms of pre-determined technical characteristics. Specific skills and capacities also need to be developed to implement innovation-oriented procurement successfully. And since procurement of innovation represents a significant change in public sector culture, it may be advisable to pilot the respective schemes before launching them in full scale.

Recommendations

- Improve policy outreach by focusing on increasing the share of R&D and innovation performers in the business sector. This will entail the following actions:
  - Provide assistance to firms (SMEs and young firms) in the preparation of proposals, especially for first-time applicants.
  - Introduce or strengthen competence-building schemes targeted to companies not yet engaged in R&D and innovation. These may include support for the insertion of skilled staff in business firms, use of external innovation support services, training and other competence-building activities.
  - Facilitate SMEs' connectivity with the innovation system, especially in the acquisition of human resources, e.g. facilitating links with the education and research system, and supporting hiring of new qualified personnel (e.g. engineers and technical personnel).
- Strengthen awareness-raising measures to reach a wider range of companies. These may include awareness of international market trends, new emerging technologies, changing industry structures and business models. Work with SMEs chambers and industry groups to promote and diffuse new policy instruments. Put

more emphasis on industry-needs-driven, low-barrier schemes to attract more companies to launch innovation activities that go beyond R&D (non-technological innovation and commercialisation). These could also include schemes encouraging companies to engage in organisational and service-sector innovation. Study the feasibility of integrating service and organisational innovation into existing support for business enterprises.

- Continue developing demand-side policy measures. The most promising might be public procurement of innovation. This mechanism, however, requires careful design and implementation, and it is therefore recommendable to conceive first a pilot programme before launching it in full scale. Develop a long-term strategy for the support of collaborative networking arrangements among firms. Support only those that have real industry involvement/commitment and a joint agenda for collaborative research, innovation and/or education and where the private sector shows readiness to invest time and resources in collaborative activities.
- If Lithuanian policy makers seek to expand cluster-related activities or support, the following generic observations should provide a degree of orientation:
  - Consider that clusters should be business driven and are a tool for co-ordination, not an end in itself. Their success depends on industry leadership and effective co-operation to address bottlenecks hindering competitiveness.
  - A policy on clusters should encourage dialogue and co-operation between firms and the public sector (particularly at local and regional levels of government). This dialogue could identify and lead to the development of inter-firm networks, an improved quality of government action (e.g. in co-locating complementary public investments, such as research facilities).
  - Government should work with existing and emerging clusters rather than trying to create entirely new clusters.
  - Policy makers should also assess the wider determinants of cluster success, which may in fact be the best targets of policy. Such determinants include transport, land-use planning, housing, the quality of public amenities and labour market policies.

Enhance the performance of the higher education (HE) sector

The research and HE sector has been reformed over recent years. Research funding now consists of institutional funding and a number of sources of competitive funding. The mostly international peer review for research units, using a wider set of performance criteria than merely publications, has been an important step towards aligning the Lithuanian research sector more closely with the international research community.

Relative to its population size, Lithuania has a large number of HEIs. In total Lithuania boasts 22 universities (of which 14 are state-owned and eight private) and 24 colleges (of which 13 are state-owned and 11 private). Since 2000, the HE sector has twice undergone significant reforms, starting with the reforms in 2000 introducing the European model binary education system (introducing bachelor's and master's degrees). A second reform was launched in 2009 modernising the HEI sector, introducing more competitive funding and enhancing the autonomy of universities.

The research institute sector has seen a significant restructuring as well. Today, Lithuania's research institute landscape comprises 13 state institutes. Before 2010 there were many more, which were recently merged or amalgamated with universities. Funding of the research institutes consists of basic financing for long-term R&D and the arts as well as competitive funding. Some of the research institutes have high international standing and take part in Horizon 2020 projects.

The scientific achievements of the Lithuanian universities and research institutes in terms of performance measures such as international co-publications, publications in peer-reviewed journals and citations are relatively poor compared to other EU countries. A recent international research assessment of Lithuanian research groups showed that some are strong national players with international recognition. But there were no strong international players among Lithuanian research actors. In most science domains the research groups were average national players. The research assessment found that many groups were strong national players with international potential in terms of societal and economic impact as well as in terms of infrastructure. This means that the large investments in research infrastructure in the previous EU Structural Funds cycle have provided the research sector with a good infrastructural basis. However, this has still to be translated into internationally attractive research. Across all scientific domains research management was considered weak.

The research assessment identified future potential in research groups across agricultural sciences, biological sciences, biomedicine, physical sciences, some pockets of the humanities and technological sciences. The assessment found that the large number of research institutions results in small research units which do not co-operate and which duplicate research themes. The research assessment exercise also found that the Research Council of Lithuania (LMT) should more systematically use independent international peer review in assessing research grants.

It is commendable that the second reform and modernisation has been put in place after the adoption of the new Law on Higher Education and Research (2009). Nevertheless, the objectives of advancing modernisation and achieving better performing HEI institutions seem to be hampered by the highly fragmented structure of the HEI and research institute sectors. The sub-critical size of many research units impedes the setting of strategic research priorities at the institutional level.

Additional changes are needed in the structure, incentives and culture of the public research sector in order to achieve a paradigm shift. Universities report directly to parliament rather than to the government. This makes structural change in the HE system more difficult to achieve and steer. Moreover, with decreasing student numbers, and institutional funding dependent on the number of students, there is a risk that competing universities will focus on the popularity of the degree courses rather than the provision of high-quality education and research matching the needs of the business sector.

Lithuania invested a considerable amount of funding in research and innovation in the previous EU Structural Funds period (2007-13). Much of this funding was allocated to the Valley initiative. While the objectives of the Valley can be applauded, the approach did lead to a new set of mechanisms and networks that were set up specifically to manage the Valleys across existing universities and research institutes. This added to the fragmentation and complexity of the overall system. The Valley initiative has made a positive contribution to upgrading the infrastructure of the universities and research institutes involved, but it has not changed the structural issue of a lack of co-operation between the publicly-funded research sector and the business sector.

The collaboration between public research and the business sector is still weak, some positive exceptions notwithstanding. A number of initiatives have been taken to improve collaboration. Much of the attention has been given to building technology transfer facilities and improving awareness and knowledge of intellectual property rights (IPR). These activities should be conducted as part of the university's or research institute's objective to engage with business and society in Lithuania. If the main goal is to acquire more funding for the universities or research institutes, the stakeholders should realise that very few HEIs across the world succeed in earning money from their technology transfer activities. It is contract research rather than technology transfer that has the potential to generate a significant additional income stream. A key mechanism used in Lithuania to improve the commercialisation of research is the establishment of science parks and local technology centres. These are available across the country. Lithuania has nine STPs. These seem to compete, on the one hand, for companies to locate their business at the park and, on the other hand, to compete for public support for technology transfer, IPR, start-up coaching and related activities. Some of these parks have a clear (technological) focus while others have a more generic profile. The Ministry of Economy is part owner of some of these parks, which potentially gives some parks a preferential position compared to parks with different ownership. There are indications that Lithuania has too many parks in relation to the potential number of residents. Of course, some regional technology parks might fulfil local functions that differ from those located in the more urbanised areas with key universities. The guidance document on STP as of February 2015 defines the specific roles and objectives of these parks and hence the role of government support in regard to these objectives. The (relatively few) international examples of very successful science parks show that professional and business-oriented functions need to be developed to conduct high-quality technology transfer services and that strong institutional support is needed at the highest level in the universities that host these parks. This needs a concerted policy approach from education, science and innovation policy.

Recommendations

- Consider consolidating the HE institutional landscape, including through possible mergers, so that advantages of scale and scope can be achieved. Currently, there are (too) many universities of sub-critical size, which prevents them from becoming visible and strong actors in international research and innovation networks. The current situation also stands in the way of building advanced research management capacity in the institutions, which is a requirement for the structural shift towards a modernised HEI landscape intended by the Law of Higher Education and Research.
- More generally, foster the research management capabilities of research institutions and of research units to prepare them for international co-operation (e.g. participation in Horizon 2020) and collaboration with the business sector.
- Provide incentives for HEIs to collaborate more closely in both education and research.
- Turn the international research assessment of Lithuanian research units into a systematic, built-in feature of the research system and apply a broad set of performance indicators which span research excellence as well as relevance and impact, including the contribution towards industry-academia partnerships and collaborations.

- Provide stronger incentives for research organisations to develop more systematic and professional technology transfer structures and activities. Require universities and other research organisations to develop technology transfer strategies and action plans with sufficiently ambitious objectives and indicators focusing on relevance and impact. Allocate part of basic funding, or part of funding from selected schemes (including infrastructure funding), based on the quality of technology transfer strategies and action plans, and later based on achieved results.
- Define the objectives, and ascertain the feasibility and long-term viability, of the portfolio of STP more clearly, in the context of the more professional and business-oriented services that universities need to develop and in line with the thematic specialisation defined in the RIS3.
- Steer the Valleys and open access centres towards better meeting industrial needs.

Supporting international knowledge linkages

While the internationalisation of Lithuania's STI activities has made progress in recent years, it still remains weak in a number of respects. For example, Lithuania produced 304 international scientific co-publications per million population in 2012, compared to a European average of 343. Lithuania's main scientific partners are large European countries such as Germany, France and the United Kingdom, or geographically close Nordic countries such as Sweden, Finland or Denmark. Cross-border co-operative patenting activity of Lithuanian companies is very low.

As expected, participation in European programmes represents much of the international activity of Lithuanian research actors. Most Lithuanian research and HEIs participate in European programmes. According to the final monitoring report for the European Union's Seventh Framework Programme for Research and Technological Development (FP7), the success rate of Lithuanian applicants (20%) was similar to the European average (20.5%). It is encouraging that participation in European programmes is increasing: the number of applications from Lithuanian companies was higher for FP7 than for Framework Programme 6 (FP6) and the success rate of SMEs also increased (18.9% for FP6 against 21.8% for FP7). As a result, the share of funding allocated to Lithuanian SMEs increased from 11.7% in FP6 to 29.7% in FP7.

International knowledge linkages are particularly important for small countries. In order to promote the international engagement of STI actors, the Lithuanian government has put in place initiatives to support scientific exchanges with foreign researchers and PhD students. In addition, HEIs have developed action plans to promote internationalisation, which include participation in international networks (such as the European University Association) and the development of joint study programmes with institutions abroad, as well as mobility programmes.

The internationalisation of the Lithuanian research and innovation system is enhanced by the implementation of the Programme for Brain Regain and Attraction which aims both at encouraging the re-immigration of Lithuanian researchers and attracting researchers from abroad. In addition there is government support for Lithuanian organisations to be represented in European Technology Platforms. These representatives are mostly from the country's technical universities.

There is still much scope and a great need for improvement to strengthen the international linkages of the science and innovation system. Reforming the HE sector is certainly an important element in a long-term strategy. Without a high-quality domestic

research base, support for internationalisation will have little effect. Measures were available in the previous Operational Programme that feature internationalisation. It is important that the measures be evaluated carefully to assess which (combination) of them has worked well, which measures did not have an impact and what gaps might still need to be addressed. Internationalisation should become a key strategic driver for the management of universities and research centres. This implies that measures should not only focus on individual researchers: they should also focus on embedding internationalisation in the research management of institutions.

International reviews of Lithuania's research actors have shown that there are pockets of potential international strength in some domains and institutes. RIS3 could help identify the domains in which international alliances are most likely. The lack of internal co-operation measures on the side of the business sector merits particular attention.

Recommendations

- Further promote participation in European and other international STI programmes by allocating more resources, targeting both public sector research institutions and firms.
- Consider developing an overarching national internationalisation strategy involving all relevant ministries and stakeholders to promote alignment of the internationalisation strategies of individual STI actors.
- Support opportunities and introduce incentives for international collaboration and engagement in selected R&D and innovation support schemes, in particular aimed at R&D and innovation performers in the business sector.
- Continue the support measures for internationalisation of the public research system. Draw lessons from the previous EU Structural Funds programming period from evaluations of past internationalisation support measures. Based on these lessons, decide what type of measures should be continued, which measures did not have an impact and what gaps still need to be addressed.
- Support institutional capacity building at universities and research centres to enhance internationalisation as a core element of institutions' strategies. RIS3 can help decide which domains offer the best opportunities for linkages with international R&D and business communities.

Chapter 2.

Economic performance and framework conditions for innovation in Lithuania

This chapter discusses Lithuania's macroeconomic performance and framework conditions for innovation. The first section presents macroeconomic developments before and after the crisis and sketches salient features of the Lithuania economy, patterns of structural change and productivity-related developments. The second section looks at the current state of framework conditions as they relate to entrepreneurship and innovation. The final section deals with infrastructures which are important to enterprise and innovation systems in a variety of ways.

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

After gaining independence in 1990 – together with the two other Baltic states, Estonia and Latvia – Lithuania embarked on two important integration processes: political and economic integration into the European Union (EU), and military integration into the North Atlantic Treaty Organization (NATO). European integration culminated in Lithuania's accession to the European Union in 2004. On 1 January 2015, Lithuania also joined the Economic and Monetary Union (EMU), widely known as the euro area. At present, Lithuania is in the process of accession to the Organisation for Economic Co-operation and Development (OECD), following an official invitation by the OECD Council. Already the process of accession and a fortiori membership to the European Union had a profound impact on Lithuania's economy, the institutional setup and framework conditions under which it operates. It also triggered profound changes in the Lithuanian innovation system, including in the modes of steering and funding of science, technology and innovation (STI). The process of accession to the OECD offers another important opportunity for Lithuania to strengthen its position in, and integration in, the global economy, and to benefit from the OECD experience and peer review in various areas, including STI.

Lithuania is located at the border of the European Union and has a very small domestic market. However, the Lithuanian economy is integrated into the European Single Market and the world economy, which mitigates the disadvantages of small domestic market size and the adverse effects of recent geopolitical events. Continued investment in an effective and up-to-date transport and communications infrastructure is essential for reaping the benefits of trade openness by facilitating access to major markets.

2.1. Macroeconomic developments

Macroeconomic performance before and after the crisis

Lithuania's macroeconomic performance after independence has been favourable overall. Lithuania's gross domestic product (GDP) per capita stands at USD 28 809 (USD, 2015, current prices and purchasing power parity [PPP]), compared to an OECD average of USD 40 144.[1] The country has made much progress in catching up, thereby rapidly narrowing the gap between Lithuania and the advanced economies in the OECD and the European Union. While in 1995 Lithuania's GDP per capita (USD 8 920) stood at approximately one-third of the OECD average (USD 27 396), it exceeded two-thirds of this benchmark (69%) in 2015 (USD, constant prices and 2010 PPP).

Following the deep transition crisis in the early 1990s, Lithuania entered a phase of growth which was only briefly interrupted by the economic downturn in the wake of the 1998 Russian financial crisis. Following a period of high growth up to 2007, Lithuania, like other countries in Europe and around the world, was hit hard by the global financial and economic crisis that began in 2008 and this led to a deep recession of 2009. Together with Estonia and Latvia, Lithuania recorded one of the sharpest contractions of economic output in Europe (close to 15% of GDP in 2009). Thanks to the relatively high degree of flexibility of the economy, underpinned by a generally favourable regulatory framework, the Lithuanian economy rebounded quickly, however. It performed better than its Baltic neighbours and stagnating central and eastern European (CEE) comparators, as well as the EU28 as an entity. Lithuania's economy was the first among the comparator group of countries to reach the peak pre-crisis level of GDP (Figure 2.1). The first *OECD Economic Survey: Lithuania* (OECD, 2016a) observes that the post-independence Lithuanian economy has been "volatile but also resilient to shocks".

Lithuania's current macroeconomic situation is favourable in a number of respects. In particular, Lithuania's fiscal position is strong, with a comparatively small fiscal deficit (-0.7% of GDP in 2014) and comparatively low public debt (41% of GDP) despite a significant increase in relation to pre-crisis levels. In addition, the current account has been close to balance, and turned into surplus in some years recently.

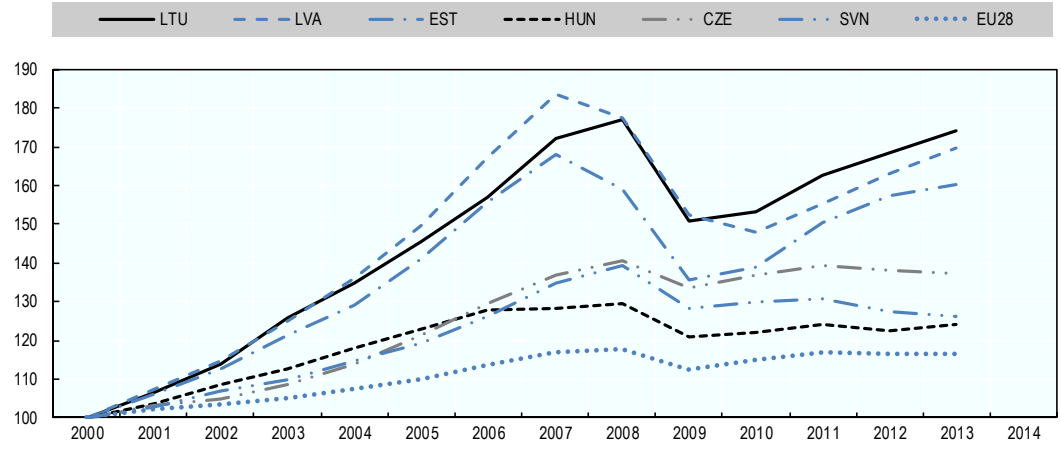
In other respects, Lithuania's economic performance is mixed. Business investment, for instance, has been slow to recover from the collapse during the crisis. Business gross fixed capital formation peaked at 20% of GDP during the boom in 2007 to drop sharply to a low of about 9% in 2010. In 2014, the ratio of business investment to GDP barely reached the EU28 average, which was still significantly below what might be expected from a catching-up economy. Together with a decline in the population, sluggish investment could reduce Lithuania's growth potential (European Commission, 2016).

GDP growth is projected to accelerate from a temporary low of 1.6% in 2015 to 2.8% in 2016 and 3.4% in 2017 as export growth recovers, and investment is projected to rebound as EU Structural Funds disbursement related to the new programming period picks up and business enterprises start increasing investment in production capacities.

In the wake of the crisis, Lithuania's unemployment rate peaked at approximately 18% in 2010. Since then it has declined steadily to about 9% in 2015 which is still above the OECD average. At 28.6%, the unemployment rate for the low-skilled was more than twice the OECD average of 13.7% in 2014 (OECD, 2016a).[2] This – together with underlying skills mismatches – poses challenges to policy for education and training.

Figure 2.1. **GDP growth performance before and after the crisis**

Index 2000 = 100



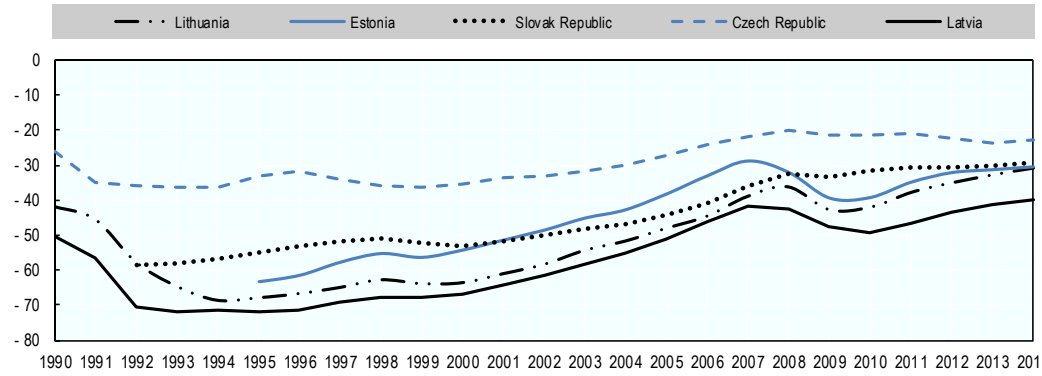
Source: OECD (2015e), *National Accounts Statistics* (database), http://dx.doi10.1787/na-data-en.

Although Lithuania has weathered the crisis well and recovered rapidly, economic growth did not return to pre-crisis levels (Figure 2.1). The speed of convergence to the OECD average level of per capita income has slowed somewhat in recent years, especially when compared to the high-growth years preceding the crisis, perhaps unsurprisingly given the sluggish economic environment, especially in Europe. Lithuania's growth performance has, however, been stronger than in a number of CEE comparator countries with higher initial levels of GDP per capita, such as the Czech Republic and the Slovak

Republic (Figure 2.2). Lithuania's GDP per capita gap with the OECD is in the range of 30%, similar to that of Estonia and the Slovak Republic, whereas Latvia's gap is ten percentage points larger. The Czech Republic's gap was just 20% at the onset of the crisis but widened by some percentage points in the following years, which was characterised by a sluggish international environment, notably in the euro area, to which it is closely connected through value chains.

Figure 2.2. **Gap in GDP per capita relative to OECD countries**

Constant 2011 PPP

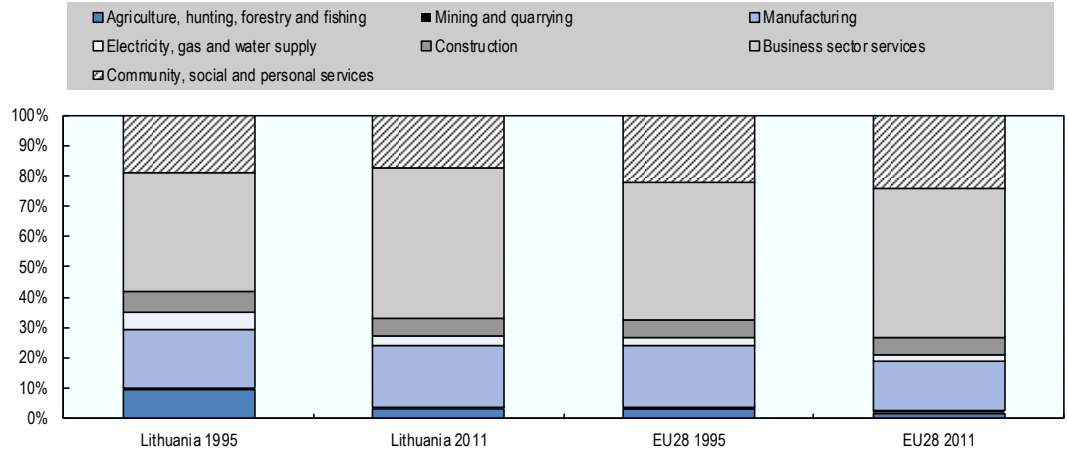


Sources: OECD (2016a), *OECD Economic Surveys: Lithuania. Economic Assessment*, http://dx.doi.org/10.1787/eco_surveys-ltu-2016-en and http://dx.doi.org/10.1787/888933338536, based on World Bank, *WDI Database*, and OECD *Economic Outlook 98 Database*.

Compared to the 1990s, the structure of the Lithuanian economy has changed, moving away from traditional sectors such as agriculture and mining to service industries. As in other European economies, the contribution of the business services sector to aggregate value-added has been expanding while that of agriculture, hunting, forestry and fishing have been shrinking (Figure 2.3). The share of the manufacturing sector has also increased slightly (from 19% to 20%), in contrast to the trend observed in the EU28.

Figure 2.3. **Evolution of the economic structure**

Distribution of value-added, 1995 and 2011



Source: OECD (2016b), *Trade in Value Added,* (TiVA database), https://stats.oecd.org/index.aspx?queryid=66237.

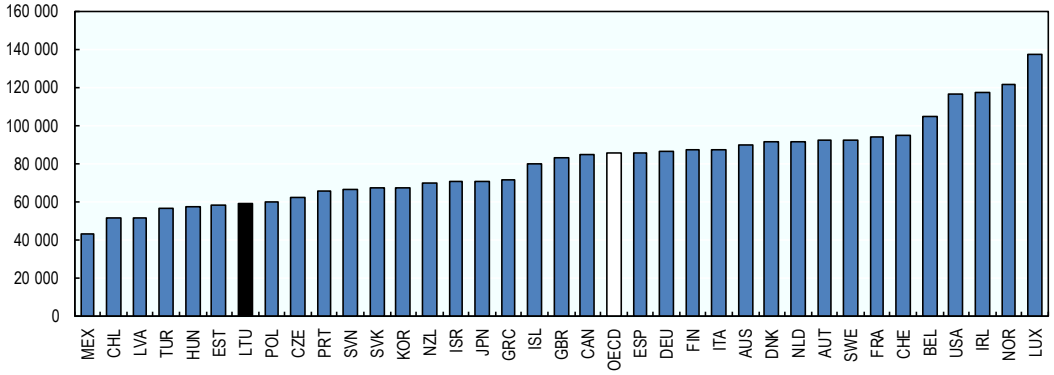
While Lithuania's post-transition economic performance has been favourable overall, the gaps between GDP per capita in Lithuania and the OECD average, and especially with its technologically and economically advanced Nordic neighbours, are still large. Aggregate labour productivity is at a level similar to Poland, just ahead of the six countries at the lower end of the OECD, that is, Estonia, Hungary, Turkey, Latvia, Chile and Mexico (Figure 2.4, Panel A). Boosting productivity is therefore critical for catching up and narrowing the remaining gap in GDP per capita.

Productivity and innovation

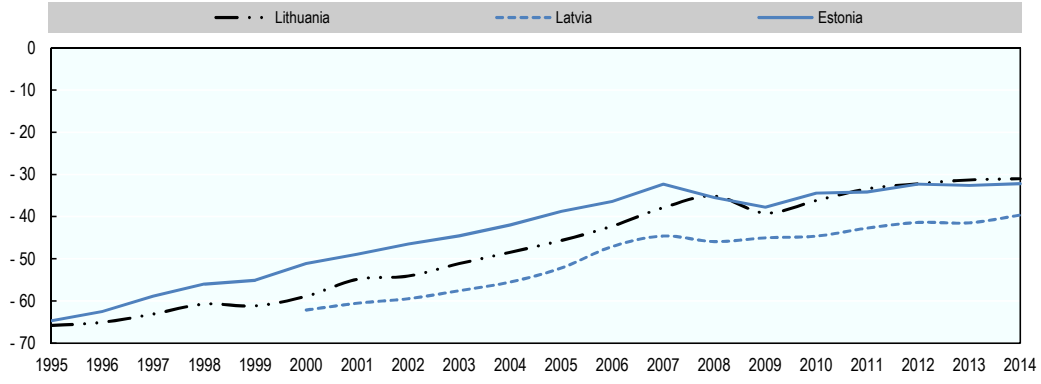
While productivity has converged steadily, and at a fast pace, from the mid-1990s to 2007 it lost some of its dynamism (Figure 2.4, Panel B).

Figure 2.4. **Lithuania's productivity gap with the OECD**

A. GDP per person employed (2014, current prices, current PPPs)



B. Labour productivity gap with OECD



Note: Labour productivity is measured as GDP per person employed.

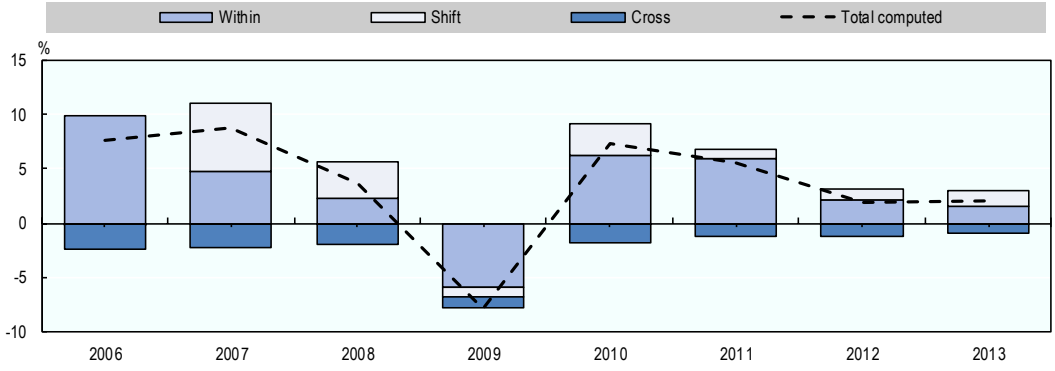
Source: OECD (2016a), *OECD Economic Surveys: Lithuania. Economic Assessment*, http://dx.doi.org/10.1787/eco_surveys-ltu-2016-en, based on OECD National Accounts Statistics.

Aggregate labour productivity growth of the Lithuanian economy has been strong over the past decade, but there have been sectoral disparities (OECD, 2016a). In particular, advances have been slow in a number of service industries. Since EU accession in the mid-2000s, Lithuania's labour productivity growth has averaged 5% per year. Between 2005 and 2013, there were particularly sizeable productivity gains in the

utilities (electricity, gas, steam and air conditioning supply), as well as in manufacturing, health and agricultural industries. This reflected a combination of government reforms (e.g. utilities and health), absorption of EU Structural Funds (e.g. agriculture) and strong foreign direct investment (FDI) inflows (e.g. manufacturing). In a number of these sectors growth has also reflected a reallocation of resources to more productive uses following the burst of the housing bubble (OECD, 2016a). In contrast, a number of professional and business service industries have experienced negligible growth.

Both the reallocation of resources between sectors and within-sector productivity growth has been important in driving Lithuania's productivity growth in recent years (OECD, 2016a). The within-sector effect – which is driven by reallocation between firms in the same sector as well as increases in within-firm productivity – has been particularly important in the return to growth after the crisis in 2009. Yet in more recent years (data are available for 2012 and 2013), the contribution of within-sector improvement to labour productivity growth has decreased (Figure 2.5.). This highlights difficulties in the undertaking of innovation activities and translating them into improved economic performance.

Figure 2.5. **Labour productivity growth and effect decomposition**



Note: "Within" measures the contribution to total labour productivity growth from productivity growth within sectors. "Shift" measures the contribution resulting from the movement of labour between sectors. "Cross" indicates whether the within-sector and between-sector effects are complementary. A negative value for the latter indicates that productivity growth is particularly strong in sectors that have a contracting labour share.

Source: OECD (2016a), *OECD Economic Surveys: Lithuania. Economic Assessment*, http://dx.doi.org/10.1787/eco_surveys-ltu-2016-en and http://dx.doi.org/10.1787/888933338632, based on data from Eurostat database.

Productivity is commonly recognised as a main driver of long-term economic growth and the major source of differences in GDP per capita across countries (OECD, 2013). Innovation, which thrives on the creation, absorption and implementation of new ideas and technologies, increases the value of production through quality increases and new product offers (product or service innovation) and renders production itself more efficient, for example through process and organisational innovation. Innovation can also benefit all firms in industries if new and more efficient technologies spread within sectors, in turn raising average productivity.

To close the income and productivity gap with the leading countries in the European Union and the OECD – which is largely accounted for by lagging productivity – Lithuania's innovation capability has to be improved substantially. In achieving and maintaining high firm productivity growth and ensuring synergies with improvements in resource reallocation, public policy to foster innovation (including policies to nurture

skills and their upgrade) has an important role to play. Raising the currently low innovation capabilities of Lithuanian business enterprises deserves priority attention. The untapped potential for Lithuania is high in this regard as innovation capabilities are currently low (see Chapter 3 and section 3.1), the modern, high-performing innovation system and its institutions are very young and in many respects still in the making, and innovation policy and governance can draw on a vast body of international evidence to derive benefits for Lithuania.

2.2. Framework conditions for innovation and entrepreneurship

This section considers broad features of entrepreneurial activity in Lithuania and key framework conditions in the areas of finance, infrastructure, taxation and product market competition. Overall, framework conditions for innovation and entrepreneurship in Lithuania are supportive and conducive to efficient resource allocation. Indeed, many such conditions are highly favourable. These include:

- One of the fastest recent rates of growth among European countries.
- A low corporate income tax rate of 15%.
- One of the most advanced IT infrastructures in Europe.
- Relatively few and low regulatory barriers.
- A prized investment location, which by one estimate was the second most attractive investment environment in Europe in 2014 (Foreign Policy Baseline Profitability Index).[3] [4]
- Increasingly streamlined administrative procedures for starting and running a business. Indeed, Lithuania occupied 20th place in the World Bank's 2016 Ease of Doing Business Index.

However, besides these conducive framework conditions, there are a number of problematic areas. In particular, while entrepreneurial dynamism appears satisfactory overall, the presence of high-growth enterprises is relatively weak. Support for entrepreneurship is quite well-developed at the early school level, but could be strengthened at secondary and vocational levels and is nearly absent in higher education (outside of business schools). World Bank data from the *Doing Business* study show that in a number of regulatory and administrative processes Lithuania outperforms many OECD countries. However, further reforms may be needed, for instance with respect to insolvency. Furthermore, in 2015, around 14% of Lithuanian firms considered access to finance to be their most serious problem (as compared with 10% of firms in the EU28). And there is evidence that firms which consider access to finance as particularly problematic tend to be those with higher levels of labour productivity. The venture capital industry is also relatively young, although growing. Businesses in Lithuania likewise consider infrastructure supply to be below OECD average standards, while limits on the compatibility of the transport, electricity and gas networks with those in the rest of Europe may hinder competition and raise costs for Lithuanian firms. A range of reform initiatives and public investments are under way which will help to mitigate some of the above problems. But monitoring of these conditions should be ongoing.

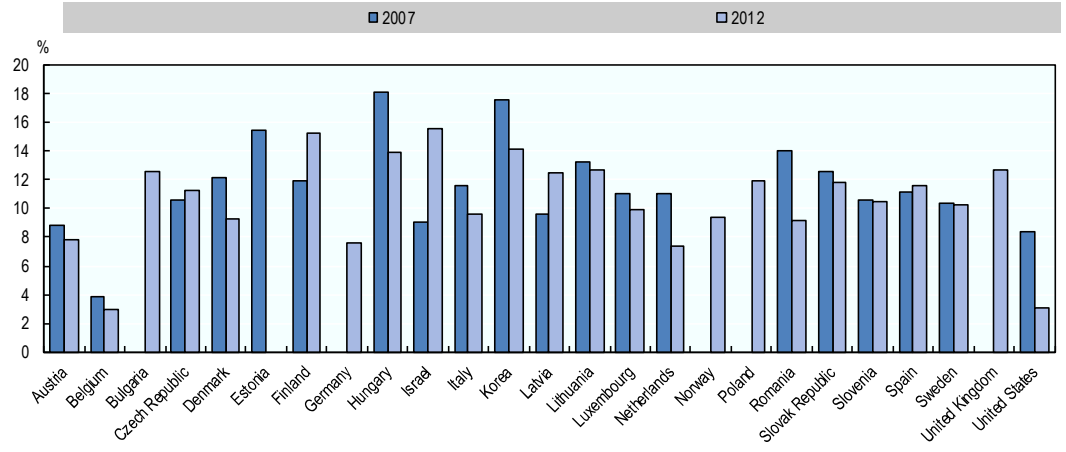
Stylised features of entrepreneurship in Lithuania

Research shows that firm turnover can be an important source of growth of multifactor productivity (MFP). The overall process of business birth, growth and exit is a critical carrier of innovation and structural change.

Interpretation of data on firm births must recognise that start-up can occur because individuals are pursuing need rather than opportunity: their employment opportunities in alternative occupations may be limited. Accordingly, the data presented here refer to employer enterprise births (i.e. the creation of an enterprise to which at least one employee was recruited in the year of birth). Aside from creating jobs, such firms are more likely to be opportunity driven. Figure 2.6 depicts employer enterprise birth rates across countries. For Lithuania it is apparent that the birth rate is not low. Indeed, at 12.7% Lithuania's rate of employer enterprise births is the same as that in the United Kingdom and is exceeded only by Finland, Hungary, Israel and Korea in this sample of countries.

Figure 2.6. **Employer enterprise birth rate, total economy**

Percentage of active enterprises with at least one employee

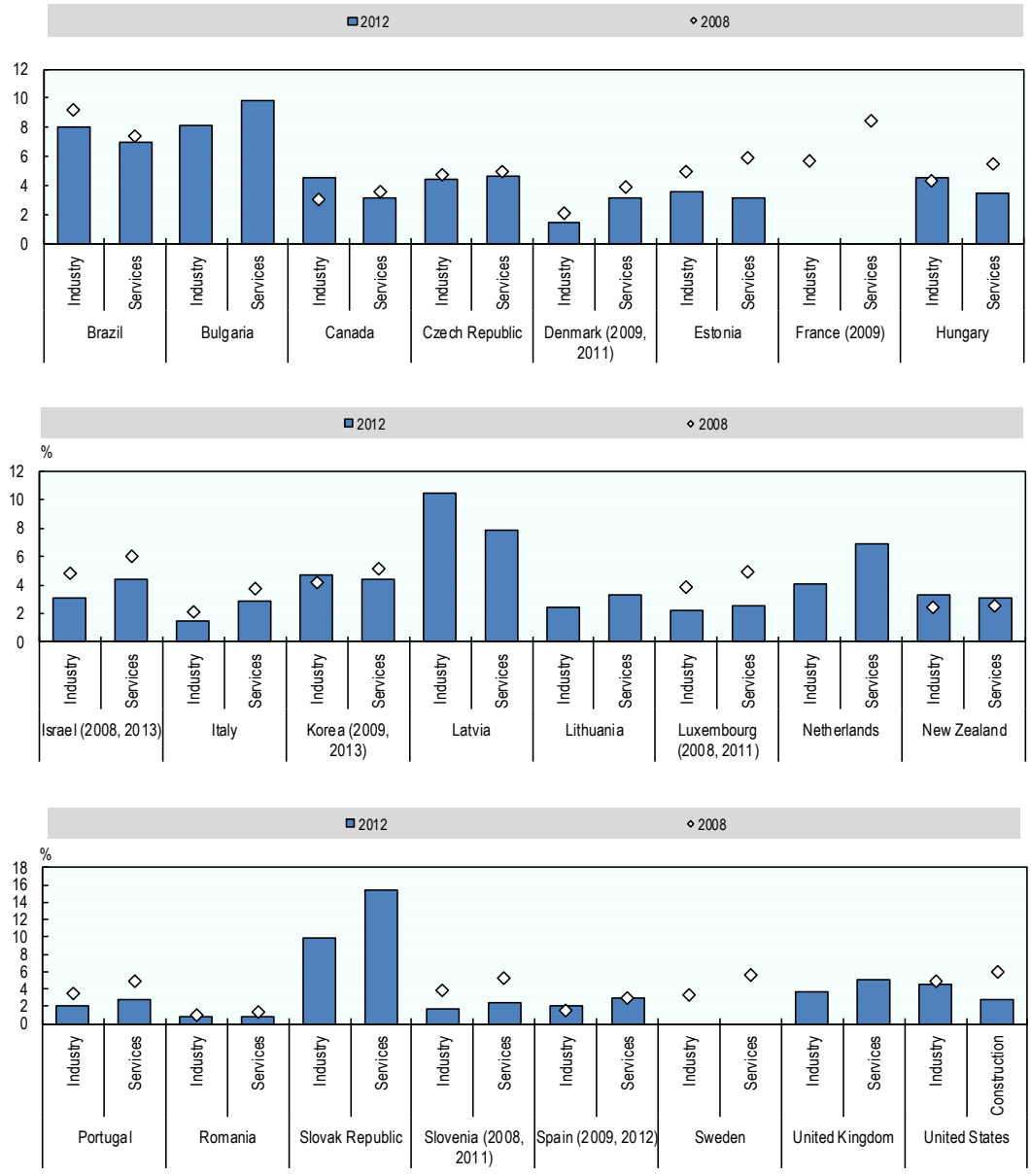


Source: OECD (2015d), *Entrepreneurship at a Glance*, http://dx.doi.org/10.1787/888933230667.

Another feature of entrepreneurial dynamism relates to the presence of high-growth enterprises. Here Lithuania is seen to be lagging. In the data shown in Figure 2.7, high-growth enterprises are those with average annualised growth in employees (or in turnover) greater than 20% a year, over a three-year period, and with ten or more employees at the beginning of the observation period. Measured by employment growth, high-growth enterprises typically represent a small share of the total population of firms, usually between 2% and 6% (the proportion of enterprises that show high growth in turnover is higher). In most countries, high-growth firms (by employment) are more frequent in services. Among the countries in Figure 2.7 high-growth enterprises in industry represent 4.1% of all firms, on average. For Lithuania the corresponding figure is 2.45%. In the services sector, among the countries covered in Figure 2.7 the average share of high-growth enterprises is 4.58%. The figure for Lithuania is 3.34%.

Figure 2.7. **High-growth enterprises as a share of all enterprises**

Measured by employment growth



Note: Years in parentheses indicate latest available, if different from 2008 and 2012.

Source: OECD (2015d), *Entrepreneurship at a Glance*, http://dx.doi.org/10.1787/888933230667.

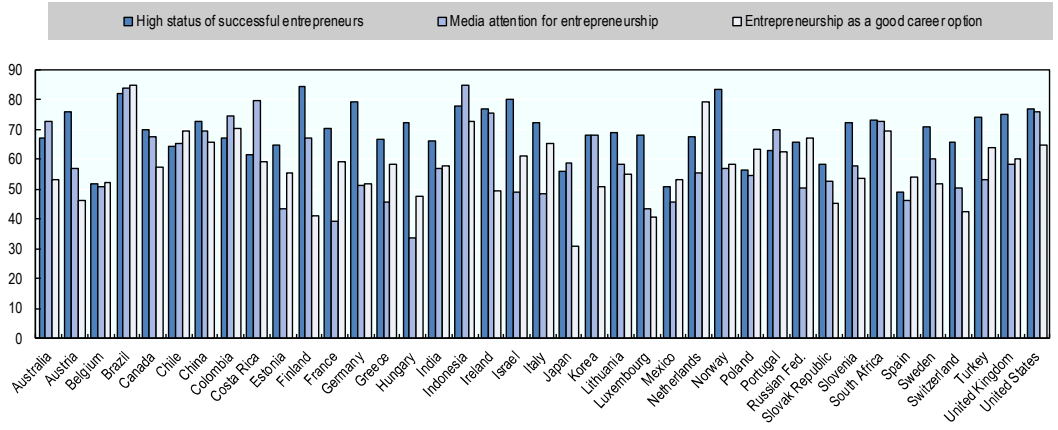
Attitudes towards entrepreneurship – a mixed picture in Lithuania

A country's entrepreneurial culture is likely to affect the attitude that individuals have towards entrepreneurs, the likelihood of choosing entrepreneurship as a career, the ambitions to succeed and start again after a failure, and the support provided to family and relatives planning to set up a business. While, in general, little is understood regarding the interplay between culture and entrepreneurial outcomes, it is probable that

societal attitudes play a role. Figure 2.8 presents indicators of certain aspects of society's view of the entrepreneur and entrepreneurship. These indicators show:

- the percentage of 18-64 year-olds who agree with the statement that most people in their country think that starting a business is a desirable career choice
- the percentage of 18-64 year olds who agree that in their country, successful entrepreneurs have a high social status
- the percentage of 18-64 year-olds who agree that in their country they often see stories in the public media about successful new businesses.

Figure 2.8. **Attitudes to entrepreneurship, 2014**



Source: OECD (2015d), *Entrepreneurship at a Glance*, http://dx.doi.org/10.1787/888933230667, based on data from the Global Entrepreneurship Monitor (GEM) project.

The combined results in Figure 2.8 do not suggest significantly negative attitudes towards entrepreneurship. Indeed, there is a slightly above-average ranking with respect to the perception of social prestige attached to successful entrepreneurs. And near-average rankings exist on the perception of entrepreneurship as a favourable career option and the frequency of media coverage of entrepreneurship. However, in another survey, 70% of respondents agreed that entrepreneurs take advantage of the work of others: some 57% of respondents held that view in the European Union overall (European Commission, 2012).

Entrepreneurship education – a solid foundation which could be built upon

Lithuania has worked to encourage entrepreneurship in ways that are likely to develop positive social perceptions. Lithuania was one of the first countries in the European Union to develop entrepreneurship education in schools. The government considers the teaching of entrepreneurship to be essential, throughout the education system (Eurydice Network, 2012). Entrepreneurship education is compulsory at lower secondary level. Specific strategies, such as the Strategy of Economic Literacy and Entrepreneurship Education (2004), the National Program of Youth Entrepreneurship Education and Encouragement for 2008-2012 and the broader National Education Strategy 2003-2012 have sought to strengthen the focus on entrepreneurship at all levels of schooling. Many of these initiatives aim to improve practical understanding of how to start and run a company (for instance with respect to financial management and business organisation).

However, while the promotion and support for entrepreneurship is quite well-developed at the early school level, it could be strengthened at secondary and vocational levels and is nearly absent in higher education (outside of business schools) (OECD, 2015a). Higher education institutions are autonomous in Lithuania. OECD (2015a) points to the consequent need to convince universities that there are benefits to promoting and supporting entrepreneurship. These benefits exist for students, professors (for example to seek research funding) and institutions (for instance to attract top researchers). Many countries have successfully created a change in the culture within higher education (possible approaches are set out in OECD [2015a]). The European Commission and the OECD have developed HEInnovate, a tool which could be used to frame a dialogue with higher education institutions.

Internationally, entrepreneurship education programmes are under-evaluated, especially outside of the United States. Too little assessment is available that takes account of selection effects (in particular the tendency of students with a prior interest in business to choose to follow courses on entrepreneurship). No evaluations were seen of the impacts of the entrepreneurship education programmes in Lithuania. At the same time, business representatives pointed to a need to improve the knowledge base about doing business, holding that too few entrepreneurship courses were available in universities.

Administrative burdens, regulation and entrepreneurship in Lithuania

Data suggest that establishing a company in Lithuania is straightforward and that regulatory barriers are low. Rules also appear to be clear. The 2015, and most recent wave of the survey on access to finance, conducted jointly by the European Commission and the European Central Bank, asked companies what was the most important problem they faced. Only 8% of Lithuanian companies referred to regulation, as compared with 13% of companies across the EU28. According to the World Bank's *Doing Business* study, starting a business in Lithuania requires just two procedures, takes 3.5 days, costs 0.6% of average income per capita and requires no paid-in minimum capital. Table 2.1 shows data on the costs and procedures required to start a business in Lithuania and comparator countries. No country requires fewer procedures than Lithuania, and in only two is the time required to create a business less than in Lithuania.

Figure 2.9 summarises information on all of the ten dimensions of creating and running a business captured in the World Bank's *Doing Business* 2016. For comparative purposes, Lithuania is reported alongside the average score for all OECD countries. Each of the vertical bars shows the ranking – among the 189 economies covered by the study – of Lithuania and the OECD average on the dimension in question (each dimension is made up of a variety of indicators). A low ranking on the index means that the regulatory and institutional environment is more conducive to starting and operating a firm. So, for example, with respect to the dimension "Enforcing contracts", Lithuania ranked 3rd among the economies in the study (a lower bar on the figure indicates superior performance).

Figure 2.9 suggests that on many dimensions Lithuania provides one of the best environments globally as regards the operation of a business. On a number of dimensions Lithuania significantly outperforms the OECD average ranking. The dimensions on which Lithuania has relatively less favourable rankings are "getting electricity" (ranked 54th, compared with the OECD average of 38), and "resolving insolvency" (70th, as against the OECD average of 26).[5]

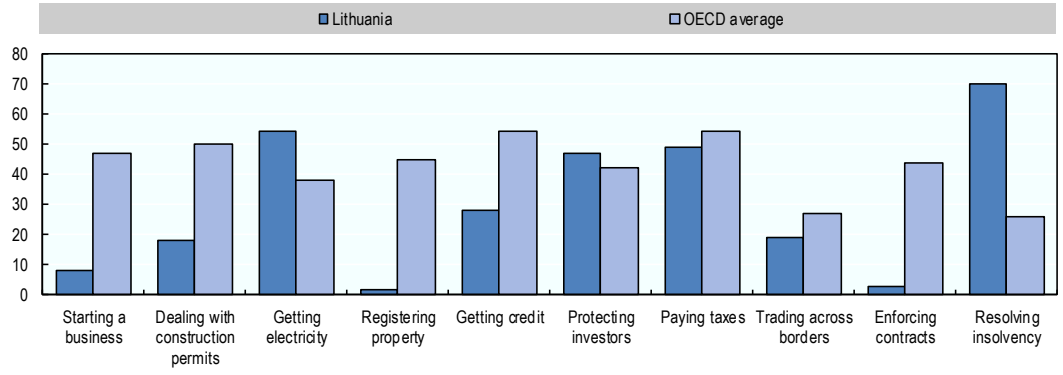
Table 2.1. **Ease of Starting a Business, Lithuania and comparator countries, 2016**

	Number of procedures	Time required (days)	Cost (% income per capita)	Paid-in minimum capital (% of income per capita)
Lithuania	**2**	**3.5**	**0.6**	**0.0**
Austria	8	22	0.3	13.1
Canada	2	1.5	0.4	0.0
Denmark	4	3	0.2	14.3
Finland	3	14	1.0	6.8
France	5	4	0.8	0.0
Germany	9	10.5	1.8	33.9
Israel	5	13	3.4	0.0
Italy	5	5.5	13.8	0.0
Japan	8	10.2	7.5	0.0
Korea	3	4	14.5	0.0
Norway	4	4	0.9	4.8
Switzerland	6	10	2.0	24.6
United Kingdom	4	4.5	0.1	0.0
United States	6	5.6	1.1	0.0

Source: World Bank (2016), *Doing Business* (database), www.doingbusiness.org.

Figure 2.9. **Ease of Doing Business – Lithuania and the OECD average scores**

By position in global rankings



Source: World Bank (2016), *Doing Business* (database), www.doingbusiness.org/.

Finance and entrepreneurship in Lithuania

The majority of small and medium-sized enterprises (SMEs) in Lithuania rely on commercial banks for external finance. The 2015 wave of the survey on access to finance, conducted jointly by the European Commission and the European Central Bank showed that around 14% of Lithuanian firms considered access to finance to be their most serious problem (as compared with 10% of firms in the EU28). Around 16% of Lithuanian firms responding to the Business Environment and Enterprise Performance Survey (BEEPS) held access to finance to be a major or very severe obstacle in 2013 (this compares to 5% of firms in Estonia and 15% in Latvia). Furthermore, the BEEPS survey results also suggest that, unlike in other Baltic countries, firms that considered access to finance to be particularly problematic tended to be those with higher levels of labour productivity.

These firms also tended to be smaller in terms of full-time employees, suggesting that problems of access to finance could be constraining resource reallocation to some small high-potential firms (OECD, 2016a).

Public support for business finance

The OECD mission was not in a position to undertake a detailed assessment of the different financial instruments and institutions described above. However, a number of general observations are in order.

Although the financial market is small, the national government has a well-developed microcredit programme operated by the public agency INVEGA (OECD, 2015a). INVEGA, a public loan guarantees institution, also operates the Entrepreneurship Promotion Fund (EPF), which provides microcredit and related training. In response to the global financial crisis the government established credit schemes to support SMEs and start-ups. The government has relied on the European Regional Development Fund (ERDF) and European Social Fund (ESF) to support enterprise promotion in the country.

The EPF supports the financing of key target groups in Lithuania: the unemployed, the disabled, young people (under 29) and older people (50 or older). The EPF offers soft loans with government guarantees for new ventures. A total of EUR 14.5 million in micro-credits was available during 2007-13 for smaller businesses. A particular feature of the EPF is that the micro-loans are part of a package of complementary support, which includes free training, advice and additional financial support (e.g. interest rate subsidies, partial employee subsidies). INVEGA also offers loan guarantees of up to 80% of the value of the loan for those start-up businesses that create jobs and employ staff. A strong point of the EPF programme is that potential entrepreneurs can easily register online, by phone or at a credit union (OECD, 2015a).

Bankruptcy procedures could be more efficient

OECD research shows that expensive and time consuming bankruptcy processes can hinder resource reallocation between lower and higher productivity firms (OECD, 2015c). Inefficient insolvency procedures can also deter entrepreneurship and experimentation by businesses with new technologies. Lithuania has simplified its insolvency laws and shortened the period for decisions on appeal. Nevertheless, the World Bank's Doing Business indicators show that finalising an insolvency procedure takes 2.3 years on average, compared to 1.8 years in the OECD (investors also recover only 43 cents per dollar in Lithuania, on average, compared with 71 cents in OECD countries [World Bank, 2015]). Bankruptcy processes could be made quicker and less costly (OECD, 2016a).

Venture capital

The venture capital industry in Lithuania is relatively young. Firms report greater availability of venture capital in the other Baltic countries (World Economic Forum, 2014). However, with important assistance from the European Union, the government is supporting the creation of new venture capital funds and investing in existing funds.

Since 2010 five venture capital funds financed from the EU Structural Funds resources have been implemented in Lithuania through the JEREMIE Holding Fund, managed by the European Investment Fund (EIF). These five funds are intended to fund all the main stages of firm development where equity finance is needed (i.e. seed, start-up, later-stage venture and growth) (Leichteris et al., 2015). Two venture capital funds which

aim to support longer-term investments in business growth and expansion were established in 2010 (Lithuania SME Fund [BaltCap] and LitCapital). In 2010 the Business Angels Fund was established in order to invest in innovative export-oriented Lithuanian firms together with business angels (private investors). Two separate seed and venture capital funds managed by one fund manager, Practica Capital, were established in 2011. The seed funds make investments up to EUR 200 000, while the venture capital fund makes seed, start-up and expansion capital investments up to EUR 2 million. Since March 2016 these funds have facilitated 92 investments in the Lithuanian SMEs. A European Venture Capital Association (EVCA, 2014) report cites Lithuania as among the top three countries in the CEE region in 2014 in terms of number of companies invested in. The number of investments has grown steadily since 2010 when the EU-backed equity funds were launched. A further positive development is the creation in 2014 of Nextury Ventures, a 100% privately owned venture capital fund.

In many countries, a preferred model of support for equity finance involves allocating public support through either "hybrid" venture capital programmes or through a so-called "fund-of-funds". Under a "fund-of-funds" approach, the government provides financial resources to a quasi-governmental body, which then invests these as a limited partner in privately managed venture capital funds. The advantages of information and expertise allow investment decisions be made by successful private venture funds. The year 2012 saw the creation of the Baltic Innovation Fund (BIF). The BIFis a fund-of-funds set up by Estonia, Latvia and Lithuania and the EIF. The EIF is investing EUR 52 million alongside investments of EUR 26 million from each country through national agencies in Estonia (KredEx), Latvia (Altum) and Lithuania (Invega). During 2013–16 the BIF will invest EUR 130 million in private equity and venture capital funds in the three Baltic countries, with co-investments from private investors and pension funds. The principal target group is Baltic companies with international development potential (OECD, 2016c).

If the government seeks to further enlarge the venture capital sector, it should be borne in mind that publicly owned and managed venture funds have had a consistently poor track record across OECD countries and non-member economies. Internationally, government-supported risk-finance instruments have often been designed to explicitly address social objectives. However, a commercial orientation in investment decision making often leads to better developmental and employment-generation outcomes.[6]

The Lithuanian Private Equity and Venture Capital Association (LTVCA) has 13 members engaged in various activities linked to venture capital, from fund management companies to lawyers. The LTVCA represents and promotes the industry to institutional investors and policy makers.

The market capitalisation of Nasdaq Vilnius is the largest among the Baltic country exchanges. Further development of the equity market could permit the creation of an alternative investment market similar to those operating in the United Kingdom and Italy tailored to the needs of smaller growing companies with lower listing values (OECD, 2016a).

The government is currently considering proposals to promote new forms of financing, such as crowd-funding platforms. At the time of writing Lithuania is in the process of adopting a draft law on crowd-funding. Some other countries, such as Austria and Germany, have recently modified regulations so as to promote equity-based crowd-funding. This involves many investors making small investments for specific projects through an online platform. Perhaps the best known platform is Kickstarter.[7] Some crowd-funding platforms do more than provide access to finance: they create an online community that monitors

projects as they develop (OECD, 2015a). However, this funding mechanism typically engages relatively small volumes of total investment, and must therefore be considered an adjunct to other financing channels.

Enterprise Lithuania organises events to help entrepreneurs build connections with and attract funding from Silicon Valley and European investors. Similarly, the "3-Stop Road Show" provides an opportunity to the 20 best Lithuanian start-ups to visit Stockholm, London and Tel Aviv where they present their companies to potential investors (OECD, 2015a).

Business angels

So-called "business angels" are private individuals who invest in and provide business know-how to unlisted companies. In many countries, business angels play a significant role in the early-stage financing of firms. Owing to its informal nature, the volume of equity provided by business angels is often uncertain. However, research indicates that the volumes involved may surpass those supplied by venture capital funds. Business angels are often successful entrepreneurs themselves and can therefore bring significant knowledge and experience to the investee. Non-financial resources provided by angel investors typically include assistance in such areas as business strategy, the search for additional finance, recruitment of key staff, and enterprise governance. The level of control of the enterprise is frequently lower than that demanded by venture capitalists, and the time horizons over which informal investments are allowed to mature are often longer. Furthermore, business angels are not averse to investing in technology-based firms.

Lithuania was reported to have one business angel network and some 80 active business angels in 2013 (EBAN, 2014). Business angel investments totalling EUR 2 million were reported to have been made in 2013 to 18 companies (just over EUR 25 000 per angel). This compares with Estonia, where there were fewer reported business angels, at 52, but combined investments totalled EUR 4.7 million (just under EUR 90 000 per angel).

Currently the Lithuanian government provides no tax incentives for private venture investors or business angels. However, the Lithuanian government is planning to implement six new venture capital instruments, financed from the 2014-20 EU Structural Funds and national resources (from which EUR 97.7 million will be allocated to these instruments). A new business angel fund and co-investment fund will be established which will enable business angels to invest in Lithuanian SMEs together with the state.

Demand-side support for equity finance

In many countries, much of the focus of policy support for early-stage equity financing is on expansion of the supply of funds. However, an array of demand-side considerations is also important in determining the level of venture investment. More attention might be required for these demand-side considerations, notably by improving investment readiness among Lithuanian start-ups, and possibly improving knowledge of intellectual property (IP) issues among entrepreneurs. A focus on the demand-side conditions also makes sense given the small size of the Lithuanian market for risk capital. The following paragraphs sketch the underlying rationale for a focus on demand-side considerations.

Innovative business activity usually occurs prior to the development of venture capital (Hirukawa and Ueda, 2003). And many entrepreneurs lack knowledge of external equity investment processes. Furthermore, venture capitalists often demand a significant equity stake in the investee firm, as well as board participation, to which entrepreneurs are often averse. Consequently, many businesses are under-capitalised. This adds to their risk,

which in turn can deter providers of debt. A greater willingness to accept external equity would facilitate growth and survival in many small firms. Furthermore, it is often observed that a lack of good projects can constrain venture capital activity. For instance, most investment proposals put to venture capital funds and business angels are rejected, often because of quality concerns. Consequently, policies that help to improve the quality and presentation, or "investment readiness" of projects might expand access to equity finance.

Investment readiness programmes can help new and fast-growth firms in a number of areas. They can assist, for example, in developing a business plan, explaining the sources of financing, understanding investors' requirements, ensuring that the right management skills are available, and improving the quality of presentations made to investors. Appropriate education, training and information might also help to reduce aversion to external equity among entrepreneurs. In this connection, it is noted that Lithuania's State Patent Bureau organises events and implements other measures providing information to the public, including SMEs, on the protection of IP rights (and from July 2016 a new industrial property information division will be established within the State Patent Bureau). However, as evidence of further systematic support for investment readiness was not seen in Lithuania, a number of observations are made in Box 2.1 on the design and operation of investment readiness schemes.

Box 2.1. **Programmes to enhance investment readiness: Stylised facts**

- Different models exist. Some schemes are publicly sponsored, as in Ireland and Spain. Others are privately run, as in France and Austria. In the United Kingdom, public and private programmes operate. It is unclear a particular model is optimal.
- The sources of advice used can be multiple, from retired entrepreneurs, as in Ireland, to recent business school graduates, as in France. However, a generic insight from the literature on business development services is that greatest value is typically attached to advice coming from others with business experience.
- Many schemes exclusively target young firms (Toschi and Murray, 2009). This focus could be enlarged, because fast-growth firms can also be relatively old. Indeed, as there is some randomness in which firms will grow fast, it is important not to define overly rigid eligibility criteria that could exclude potential beneficiaries.
- Among the services offered, attention should be given to the management and use of IP, as a source of competitiveness and as a means of raising finance.
- Broader business development advice, while often provided by different types of programme, is also relevant to investment readiness. The integration of such advice should be sought (Toschi and Murray, 2009).

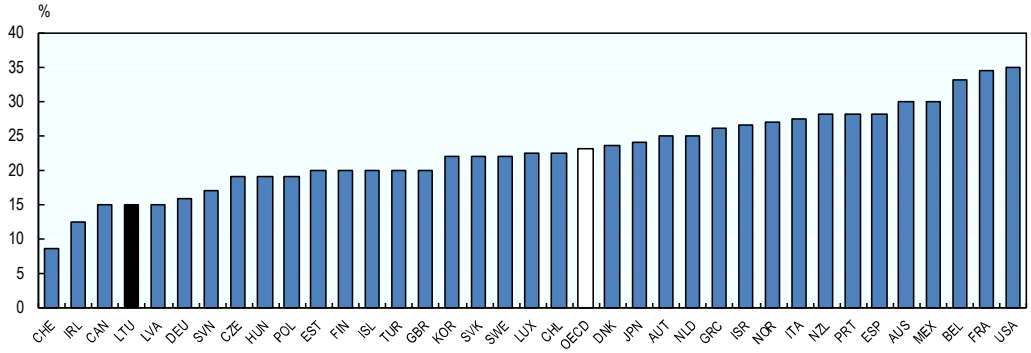
Tax

Tax policy strongly affects the returns to innovation and hence the incentive to innovate. Innovation in firms is associated with many aspects and levels of taxation. These include indirect taxes, such as value added tax (VAT) on innovative products, direct taxes such as income tax paid by researchers and scientists, and taxes on IP. Corporate income (CIT) and capital gains taxes are the most relevant taxes for business investments. Decreasing the rate of capital gains taxation has been shown to increase commitments to new venture capital funds and raise the share of high-tech and early-stage investments in overall venture capital activity (Da Rin, Nicodano and

Sembenelli, 2005). A lower rate of capital gains taxation may also raise the supply of investment opportunities by increasing the incentive for workers to become entrepreneurs (Poterba, 1989).[8]

Tax settings in Lithuania are favourable to entrepreneurship. In recent years corporate income tax in Lithuania has been lowered. At 15 %, Lithuania's corporate income tax rate is now below OECD and EU average rates (Figure 2.10.). Capital gains from the sale of shares/securities are also taxed at 15%, one of the lowest rates in Europe.

Figure 2.10. **Statutory corporate income tax in Lithuania and comparator countries, 2015**



Source: OECD (2016a), *OECD Economic Surveys: Lithuania. Economic Assessment*, http://dx.doi.org/10.1787/eco_surveys-ltu-2016-en and http://dx.doi.org/10.1787/888933338994, based on the *OECD Tax Database* and KPMG.

A number of additional tax conditions are relevant:

- The self-employed working in activities other than professional services (such as legal services, accounting, architectural and engineering services) pay income tax at 5%. The self-employed engaged in other activities are allowed deductions equivalent to 30% of taxable income, without the obligation to provide documentary proof of expenses.
- A company with investments of at least EUR 1 million and operating in a free economic zone is exempt from corporate income tax for the first six years, and pays only half of the standard rate for the next ten years.

A reduced rate of corporate income tax of 5% applies to micro companies with income lower than EUR 300 000 a year and ten or fewer employees. The OECD (2016a) notes that the rationale for this latter tax provision is unclear, especially as previous OECD analysis shows that investment choices in small firms are less sensitive to corporate tax rates than those in larger firms. In addition, tax treatment differentiated in terms of enterprise size can hinder the efficiency of resource allocation. This could happen if: (i) the lower tax rate causes resources to become trapped in small unproductive firms, rather than being reallocated to more productive small firms; and (ii) firms are discouraged from growing larger than the tax deduction threshold. Nevertheless, the OECD (2016a) concludes that evidence of such a threshold effect was not apparent in 2013 (there was no increase in the number of firms reporting for tax purposes just below the employment threshold of ten employees or less). But the OECD report recommends that the distribution of firms should continue to be closely monitored to ensure that the small business tax advantages do not distort the pattern of firm growth.

The administrative burden of tax compliance

The burden of administrative compliance with corporate taxation is relatively low in Lithuania. *Doing Business 2016* ranks Lithuania 49th, among 189 economies, in this connection, ahead of the positions of 17 OECD countries. On average, firms in Lithuania make 11 tax payments a year and spend 171 hours a year filing, preparing and paying taxes.

Competition

Research concurs that competition is central to innovation, even if discussion continues on the precise circumstances under which competition yields the greatest effect.[9] Competitive product markets force companies to increase labour and multi-factor productivity. Competition policy itself has its most direct impact on the innovation process in activities linked to organisational change in firms (i.e. competition policy plays a modest role in affecting basic research and invention, but has a more marked effect on the commercialisation of new science and technology, as well as on efforts to diffuse innovations throughout the economy [Shapiro, 2002]).

At the same time, enforced intellectual property rights (IPRs) afford a degree of monopoly power in order to induce entrepreneurs to assume the risks of innovation. OECD research shows that, for a given level of IPR protection, regulatory barriers to entry in product and labour markets undermine long-run productivity. Reducing anti-competitive regulation provides an incentive for increased business spending on R&D (Jaumotte and Pain, 2005).

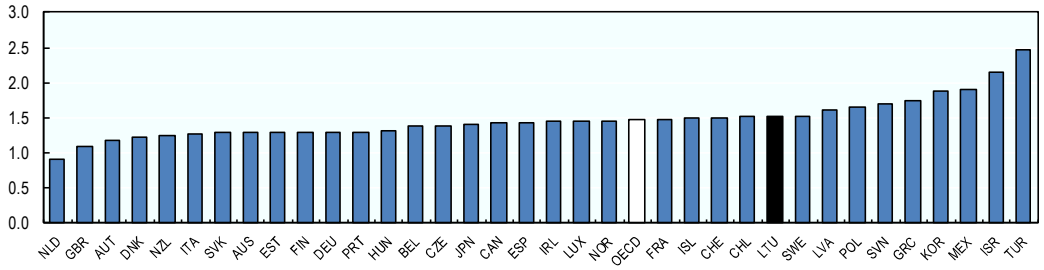
Lithuania's product-market policy settings are largely in line with settings across the OECD area. Figure 2.11 shows Lithuania's standing relative to the OECD average on a range of indicators of product market regulation (PMR). The OECD PMR indicators are a comprehensive and internationally-comparable set of measures of the degree to which policies promote or inhibit competition in product markets. The index scale of 0 to 6 runs from least to most restrictive. Lithuania is seen to perform particularly well on the index of restrictiveness of FDI rules (panel D).

The main indicator on which Lithuania scores significantly below the OECD average is in barriers to trade and investment (panel C). Openness to trade and FDI flows (both inward and outward) is a key driver of innovation: it reinforces competition and facilitates knowledge flows from abroad. In particular, regulation in Lithuania makes it time consuming to employ non-EU workers, with the need for a labour market test which is rare among OECD countries. Such a requirement could hinder growth in firms which are rapidly expanding, especially in areas where specialised skills are needed. Foreign firms considering establishing operations in Lithuania might also be hindered by such regulation. Such regulation is particularly problematic given evidence that the availability of qualified labour is insufficient and is a larger constraint to businesses in Lithuania than in other comparable countries (OECD, 2016a).

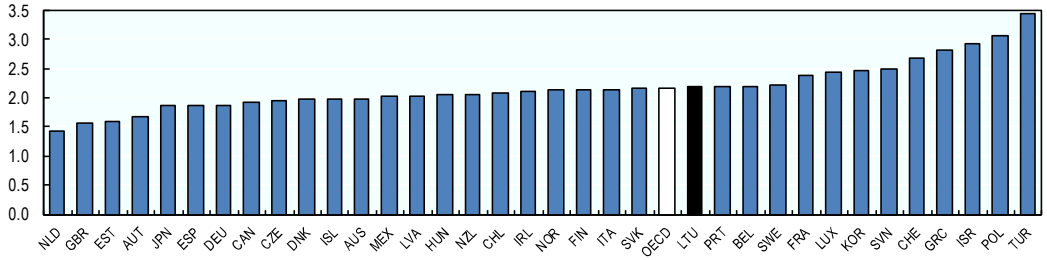
The PMR indicators also suggest a need for further reforms concerning state-owned enterprises (SOEs) (included in the indicators which make up panel B). Many of these institutions underperform and absorb resources that could be reallocated to more productive firms (OECD, 2016a).

Figure 2.11. **PMR and FDI regulatory restrictiveness index**

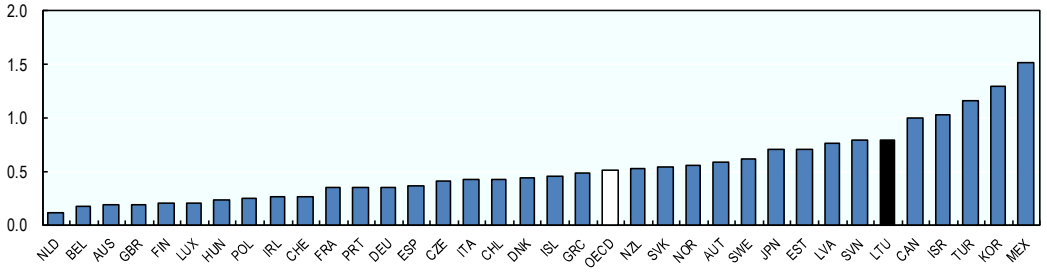
A. PMR, overall indicator (2013, index scale of 0-6 from least to most restrictive)



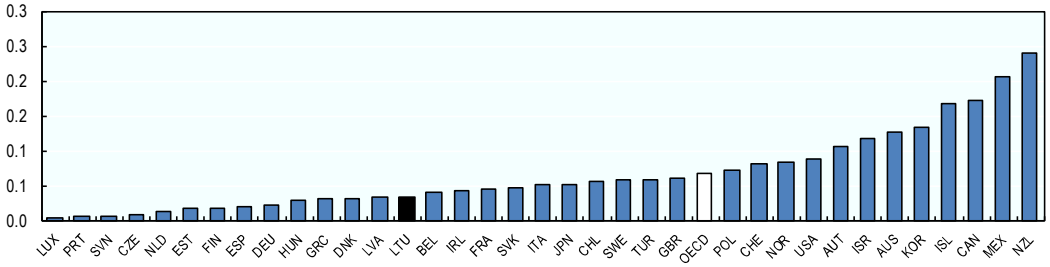
B. PMR, State control (2013, index scale of 0-6 from least to most restrictive)



C. PMR barriers to trade and investment (2013, index scale of 0-6 from least to most restrictive)



D. FDI Regulatory Restrictiveness Index (2014, index scale of 0-1 from open to closed)



Source: OECD (2016a), *OECD Economic Surveys: Lithuania. Economic Assessment*, http://dx.doi.org/10.1787/eco_surveys-ltu-2016-en, based on *OECD Product Market Regulation* (database), http://dx.doi.org/10.1787/888933338851 and OECD FDI Regulatory Restrictiveness Index, www.oecd.org/investment/index.

2.3. Infrastructures

Physical infrastructure is important to enterprise and innovation systems in a variety of ways. Road infrastructure, for instance, facilitates trade and competition, affording incentives for investment and innovation.[10] Cheap airline connections can affect interactions between, and the productivity of, scientists in connected cities. And transport

delays can affect just-in-time production processes. However, in high-income economies, concerns related to innovation-related infrastructure tend to focus on information and telecommunications (ICT).

ICT infrastructure – especially high bandwidth connectivity – affects innovation and broader business outcomes in a variety of ways. For instance, Internet usage is associated with superior performance in small firms. Data from France demonstrate that Internet-using firms report higher revenue per salaried person, higher value added, superior job creation, and a proportionately greater number of registered patents. Evidence from the United States also suggests that small firms that use the Internet have higher revenues than non-users.

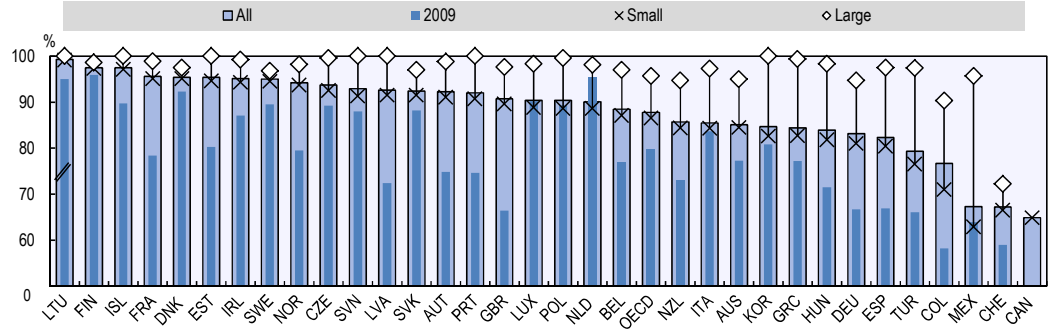
More generally, ICT infrastructures facilitate innovation by enabling the circulation of data and information, whether publicly or privately generated or funded. In many areas of science, research communities use powerful computing resources across grids to access large data sets for experimental purposes. And ICT infrastructures also facilitate the data-driven delivery of key public services: from the management of smart electricity grids and transport systems, to efficiency-enhancing patient data in health care.

As indicated in the European Digital Single Market scoreboard[11] fast broadband (over 30 megabytes per second) is available to 98% of homes in Lithuania. Fibre-to-the-premises coverage has already reached 95%, the highest coverage in the European Union. And an average EU consumer has to spend almost twice as much of their income on broadband as Lithuanian residents. Despite this, take-up of broadband services remains relatively low (58% of households).

Currently, across the OECD area, around 21% of businesses engage in sales via the Internet. The corresponding figure in Lithuania is 19.3% (OECD, 2015b). There is scope to convince more firms of the benefit of selling online to foreign markets. The share of Lithuanian companies which use the Internet to interact with public authorities is higher than in any OECD country (Figure 2.12). Having a fast and cheap Internet network has facilitated the development and use of the Point of Single Contact for Services and Products (PSC). The PSC aims to streamline applications for permits and licenses for service providers, as well as provide information on legal requirements (OECD, 2015a).

Figure 2.12. **Businesses using the Internet to interact with public authorities, by size, 2012**

As a percentage of businesses in each employment size class



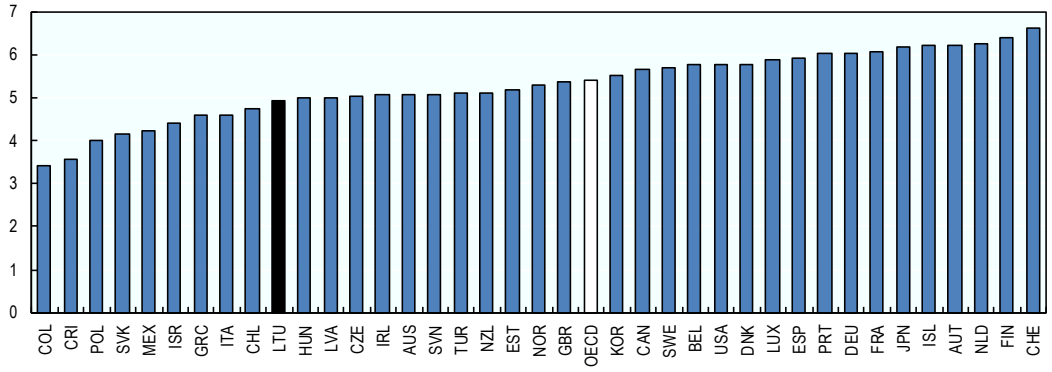
Sources: OECD (2016a), *OECD Economic Surveys: Lithuania. Economic Assessment*, http://dx.doi.org/10.1787/eco_surveys-ltu-2016-en and http://dx.doi.org/10.1787/888933274893, based on data from the *ICT Database*; Eurostat (2016), *Information Society Statistics Database*, http://ec.europa.eu/eurostat/web/information-society/data/database; national sources.

Businesses assess Lithuania's infrastructure supply as below the OECD average (OECD 2016a; Figure 2.13). Limits on the compatibility of the transport, electricity and gas networks with those in the rest of Europe may hinder competition and raise costs for Lithuanian firms. Nevertheless, Lithuania's infrastructure is being upgraded, partly with EU funding. Projects to further integration with the European rail, electricity and gas networks are a priority (OECD, 2016a).

As previously noted, the World Bank's *Doing Business* report ranks Lithuania 54th in terms of getting electricity (compared with the OECD average of 38). But progress is being made, with a legal time limit for completing connections now in force. The reported time to obtain electricity connection fell from 135 days in 2014 to 95 days in 2015.

Figure 2.13. **The quality of Lithuanian infrastructure could be improved**

Quality of overall infrastructure score, 2014-15



Note: The score is based on the assessment of business leaders operating in the country in response to the question: How would you assess general infrastructure (e.g. transport, telephony and energy) in your country? (1 = extremely underdeveloped – among the worst in the world; 7= extensive and efficient – among the best in the world).

Source: World Economic Forum (2016), *Global Competitiveness Index* (database), http://dx.doi.org/10.1787/888933338694.

Lithuania has been vulnerable to disruptions in electricity supply. Several recent infrastructure projects will diversify the sources of electricity supply (such as the NordBalt electricity transmission line between Klaipeda and Nybro in Sweden). Similarly, infrastructure investments are improving integration with the European gas market and should reduce potential disruptions to gas supply (OECD, 2016a).

Rail infrastructure in Lithuania suffers from limited interoperability with the European gauge network, a shortage of lines with double tracks, and a level of electrification significantly below the EU average. Rail infrastructure will be improved by the Rail Baltica project, which will pass through Kaunas and link Finland, Poland, Germany and the Baltic states. Water transport has benefited from recent port investments – for instance expanding capacity at the Klaipeda port – but there is scope to increase inland waterway transport: the proportion of total inland freight transport by water is less than 1%, compared to more than 5% on average across the European Union (OECD, 2016a).

Notes

1. USD 25 603 and USD 37 043, respectively, at 2010 prices and PPP.
2. Structural unemployment is estimated at 10-12% (Ebeke and Everaert, 2014).
3. See http://foreignpolicy.com/2014/05/29/where-to-invest-around-the-world-2014-edition. The BPI combines three factors into a summary statistic that conveys a country's basic attractiveness for investment: how much an asset's value grows, the preservation of that value while the asset is owned, and the ease of bringing home the proceeds from selling the asset.
4. The Mercer Cost of Living Index also places Vilnius as one of the least expensive European capitals for expatriates. https://www.imercer.com/uploads/GM/col2015/f123654/index.html.
5. The "getting electricity" dimension comprises an index of indicators of the procedures, time and cost to get connected to the electrical grid, the reliability of the electricity supply and the cost of electricity consumption. The "resolving insolvency" dimension is made up of indicators of the time, cost, outcome and recovery rate for a commercial insolvency and the strength of the legal framework for insolvency.
6. For instance, Murray (1998) assessed the European Seed Capital Fund Scheme and found that commercially-oriented venture funds recorded significantly lower failure rates among investees by comparison with developmentally-oriented regional funds. Employment growth per investee, and per fund, were superior in the commercial funds. The pursuit of non-commercial objectives, often involving the targeting of high-risk, low-potential-return and long-maturing investment opportunities, frequently undermines programme sustainability (Bates, 2002).
7. See https://www.kickstarter.com/.
8. Rather than reduce all forms of capital gains taxation, many countries have opted to introduce lower rates of capital gains taxation on certain types of business asset, such as qualifying small firms, held for specified periods.
9. Famously, Aghion et al. (2005) found that the degree of product market competition bears an inverted U-shaped relationship to innovation.
10. For example, illustrating the positive association with investment demand, Egeln, Licht and Steil. (1997) show that public traffic infrastructure has been important in determining the distribution of start-up activity across Germany's regions.
11. https://ec.europa.eu/digital-single-market/en/scoreboard/lithuania.

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Chapter 3.

Innovation performance in Lithuania

This chapter reviews Lithuania's aggregate innovation performance relative to OECD countries with comparable or advanced levels of innovation system development, similar size and geographical proximity. The chapter starts by examining expenditure across institutional sectors (business, higher education and government) and considers the availability of human resources for innovation. It then reviews indicators of innovation output (drawn from bibliometric, patent, trademark and design data) to highlight qualitative and quantitative characteristics of Lithuania's innovation system.

3.1. Innovation inputs

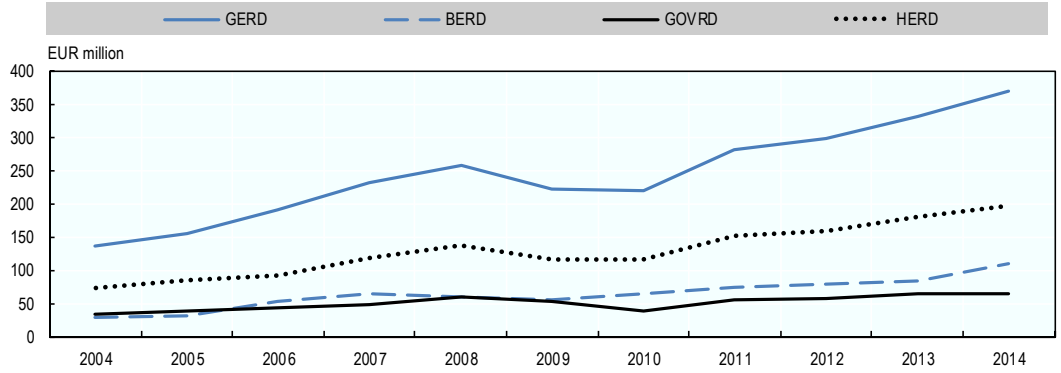
The ability to mobilise resources for science, technology and innovation (STI) differs markedly across countries. Innovation-intensive countries devote considerable financial resources and personnel to STI. An assessment of the amount and the characteristics of financial and human resources devoted to innovation should take into account a wide range of indicators related to R&D expenditure and skill characteristics across the population. These variables are described across industries and sectors – government, business and higher education – to show the relative weight of different actors in the innovation system.

Data on innovation inputs show that Lithuania is accelerating its innovation effort but lags significantly behind advanced innovation-intensive countries in the European Union (EU) and the OECD area. Investments in innovation in the business sector have considerably increased in the recent past, although their level remains low. International knowledge linkages, which are key for small-sized countries, are underdeveloped and need to be strengthened. Investments in higher education are high, which translates into a high share of the population with tertiary education. However, skill mismatch is reportedly high and this problem is exacerbated by the fact that many skilled Lithuanians leave the country to work abroad.

Innovation and R&D expenditure

Between 2004 and 2014 Lithuania's gross domestic expenditure on R&D (GERD) increased from EUR 137 million to EUR 370 million (Figure 3.1). This level of spending is higher than in the two other Baltic states, Estonia (EUR 287 million in 2014) and Latvia (EUR 163 million), but significantly lower than in Slovenia, another small OECD former transition economy (EUR 890 million in 2014). GERD decreased between 2008 and 2010 as a consequence of the economic crisis, but returned to growth afterwards, albeit at a somewhat slower pace. Over the same period (2004-14) business enterprise expenditure on R&D (BERD) more than tripled (from EUR 29 million to EUR 109 million), government expenditure on R&D (GOVERD) doubled (from EUR 34 million to EUR 64 million) and higher education expenditure on R&D (HERD) more than doubled (from EUR 74 million to EUR 196 million). Despite its expansion, BERD is below GOVERD, which is not typical in advanced innovation systems.

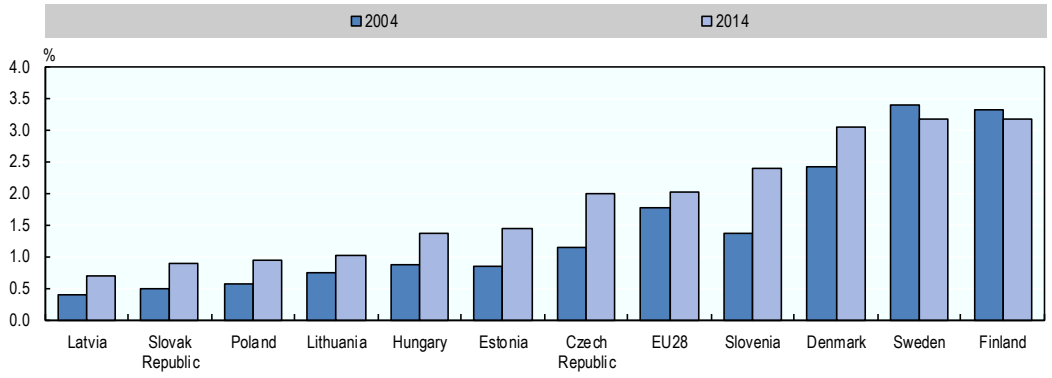
Figure 3.1. **Lithuania's GERD and its components**



Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

Lithuania's aggregate R&D spending increased from 0.75 to 1.01% of gross domestic product (GDP) between 2004 and 2014, to a level just half the European average (2.03%) and far below the OECD average (2.37%) (Figure 3.2). Less than one-third of GERD is financed by the business sector, considerably less than in EU countries on average, and much below the rate in innovation-intensive countries such as Sweden, Finland and Denmark where the share of GERD financed by business exceeds 50%. The share of GERD financed by industry peaked before the onset of the financial and economic crisis in 2007 (32.8%). It declined afterwards as a consequence of the unfolding crisis, but returned to previous levels in 2014 (Figure 3.3).

Figure 3.2. **GERD as a percentage of GDP in selected countries**



Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

In Lithuania, the share of business sector funding of higher education R&D and government expenditure on R&D (HERD and GOVERD, respectively) is comparatively high. The business sector's share in the funding of HERD was 13.9% (2013) (the OECD average was 6%), and its share in funding GOVERD was 12.3% (the OECD average was 4%) (OECD, 2016a). Lithuania's STI policy of recent years has supported stronger linkages between the business sector and research institutions.

However, the percentage of total GERD financed by business is low (Table 3.1). In Lithuania, this share increased somewhat up to 2007, and subsequently fluctuated around 30%. Among comparator countries, only Latvia has had a lower (and recently declining) share of business-funded GERD (Figure 3.3). A very high share of Lithuania's GERD (around 34%) is financed from abroad. This share nearly tripled over the last decade (Figure 3.4), largely owing to Lithuania's access to European research and innovation funding. Only Latvia had a higher share of international funding in 2013 (44.3%).

Although it has been increasing over the last decade, Lithuania's ratio of BERD to GERD remains very low at 0.3% (compared to the EU and OECD averages of 1.3% and 1.6% respectively) (Figure 3.5). Among the Baltic countries, only Latvia's BERD-to-GDP ratio is lower, while Estonia's is twice that of Lithuania. The ratios of GOVERD and HERD to GDP, however, show rather different patterns (Figures 3.6 and 3.7). Lithuania's ratio of HERD to GDP (0.54%), in particular, exceeds both the OECD (0.42%) and European (0.47%) average, as well as those of central and eastern European (CEE) comparator countries (with the exception of Estonia), but falls short of countries with advanced innovation systems such as Denmark, Sweden and Finland.

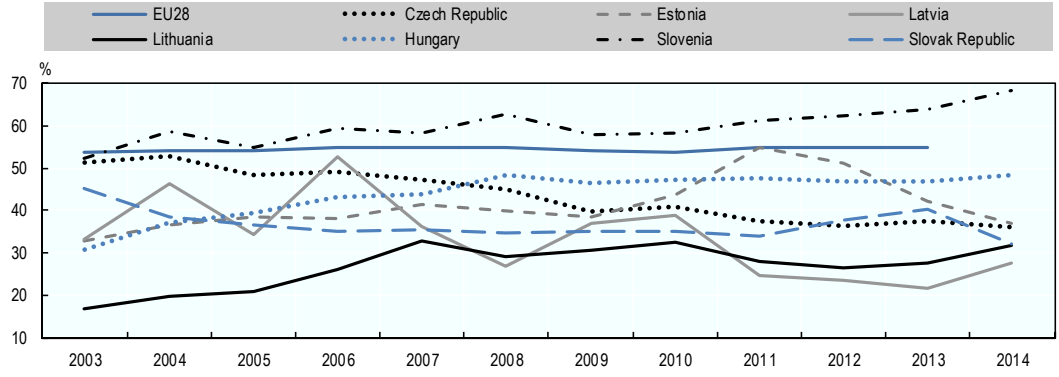
Table 3.1. **Lithuania's GERD by sector of performance and source of funds, 2013**

EUR million, percentages of performance in italics

Sector of performance / Source of funds	Business enterprise	Government	Higher education	Total (performance)
Business enterprise	82% (75%)	7.9 (12.3%)	27.3 (13.9%)	117.2 (31.7%)
Government	2 (1.8%)	33.4 (52.2%)	89.1 (45.4%)	124.6 (33.7%)
Higher education	0.2 (0.2%)	0.1 (0.2%)	0.4 (0.2%)	0.6 (0.2%)
Private non-profit	0.3 (0.3%)	0.1 (0.2%)	0.3 (0.2%)	0.7 (0.2%)
Funds from abroad	24.8 (22.7%)	22.5 (35.1%)	79.3 (40.4%)	126.7 (34.3%)
Total (funding sector)	109.3 (100%)	64.0 (100%)	196.4 (100%)	369.8 (100%)

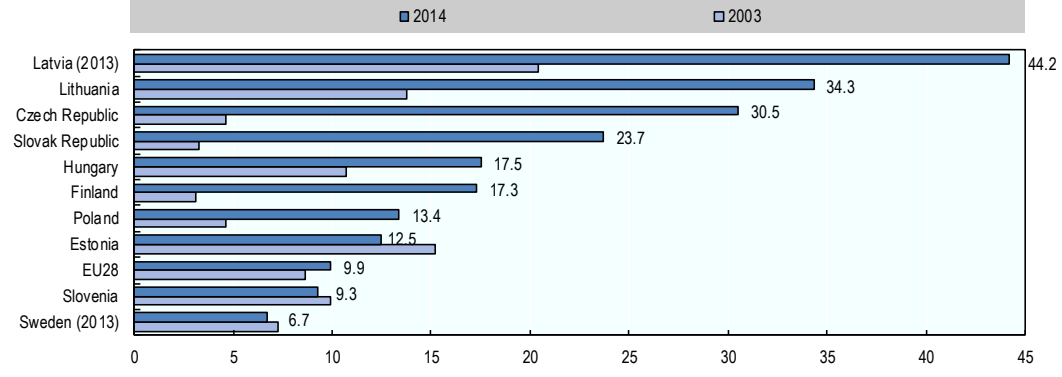
Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

Figure 3.3. **Percentage of GERD financed by industry in selected countries**



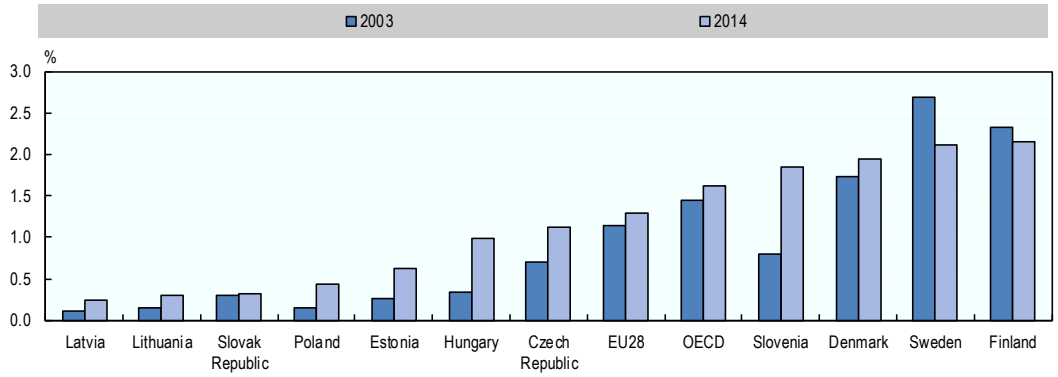
Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

Figure 3.4. **Share of GERD financed from abroad in selected countries**



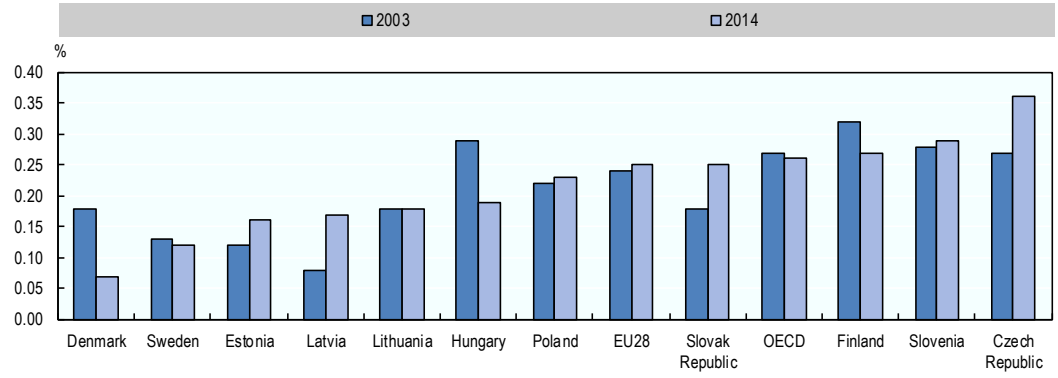
Source: Eurostat (2016), *STI statistics*, http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated (accessed in April 2016).

Figure 3.5. **BERD as a percentage of GDP in selected countries**



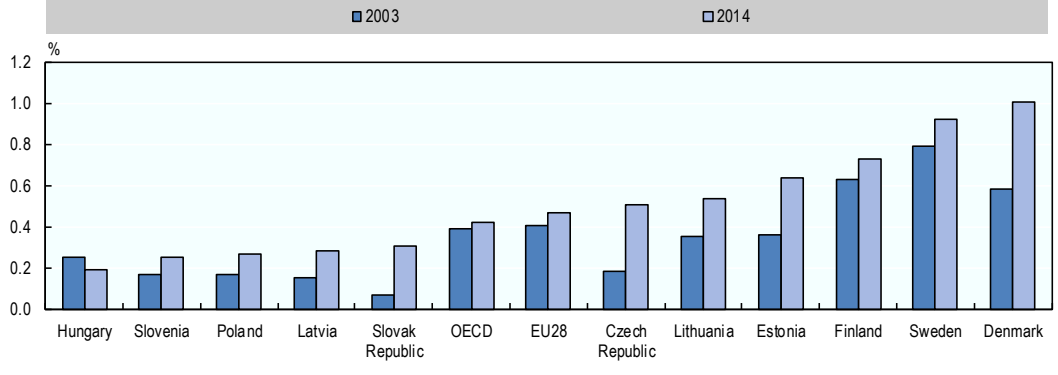
Sources: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated; OECD (2016a), *Main Science and Technology Indicators*, http://dx.doi.org/10.1787/msti-v2015-2-en.

Figure 3.6. **GOVERD as a percentage of GDP in selected countries**



Sources: Eurostat (2016), "STI statistics" http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated (accessed in April 2016); OECD (2016a), *Main Science and Technology Indicators*, http://dx.doi.org/10.1787/msti-v2015-2-en.

Figure 3.7. **HERD as a percentage of GDP in selected countries**



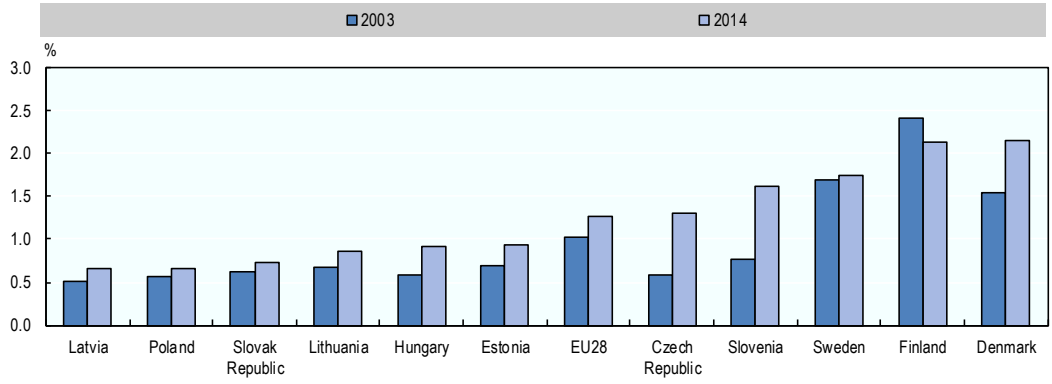
Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

R&D personnel

The category "R&D personnel" includes researchers and other support staff such as technicians. Analysing the evolution of R&D personnel numbers and their composition over time provides a perspective on the changing structure of R&D activities. As a large portion of R&D expenditure takes the form of salaries of research personnel, a headcount correlates strongly (albeit imperfectly) with the size of GERD. Divergence between GERD and R&D personnel may indicate a shift in policy focus, at times directed towards the improvement of human resource capabilities or, alternatively, towards the development of infrastructures (e.g. laboratories and research centres). While the total number of R&D personnel provides valuable information regarding the supply of human resources, it does not reflect the quality of their skills or how these are deployed. In Lithuania, the share of R&D personnel in total employment increased between 2003 and 2014 (from 0.67% to 0.86% of total employment) (Figure 3.8). However, this employment share remains below the EU average and considerably below countries such as Denmark and Finland, where it exceeds 2%.

Figure 3.8. **Share of R&D personnel**

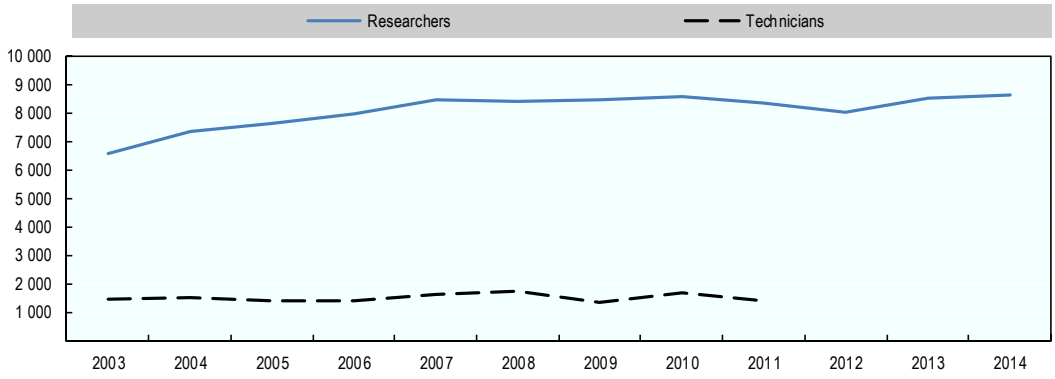
Percentage of total employment – numerator in full-time equivalent (FTE)



Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

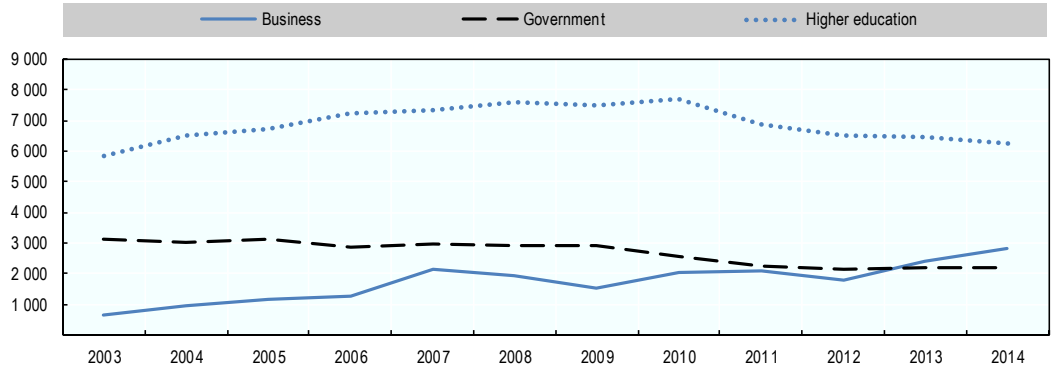
Between 2003 and 2011 the number of technicians remained stable. However, the number of researchers increased by approximately 25% between 2003 and 2014 (Figure 3.9). The higher education sector employs more than half of Lithuania's R&D personnel (Figure 3.10). This reflects the low volume of business R&D and, on the other hand, institutional features of the research system, notably the strength of universities relative to public research institutions. In countries with advanced innovation systems, like Finland or Denmark, the share of higher education R&D personnel accounts for approximately one-third of total R&D personnel, because a larger proportion of R&D personnel is employed by business. Business R&D personnel (per thousand in employment) increased considerably from 0.05 in 2003 to 0.21 in 2014. However, the share of R&D personnel in the business workforce is still very low when compared to innovation-intensive countries or the EU average (Figure 3.11). Government and higher education R&D personnel has decreased since 2010.

Figure 3.9. **R&D personnel (FTE)**



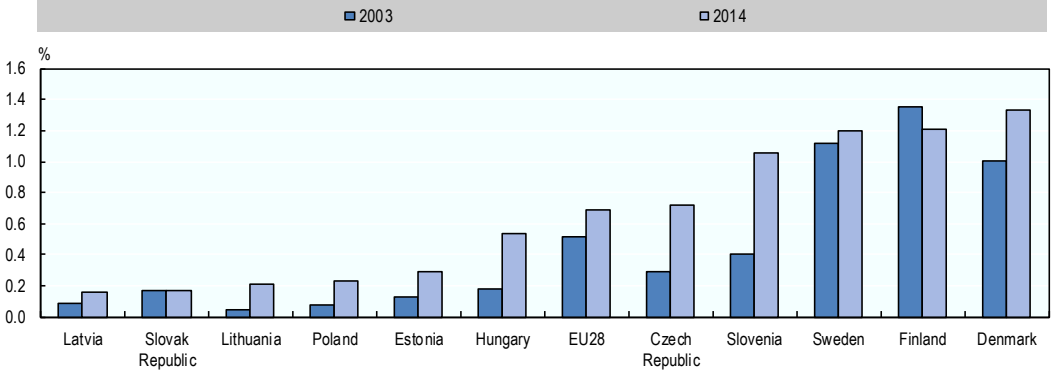
Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

Figure 3.10. **Trends in R&D personnel (FTE) by sector**



Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

Figure 3.11. **Business enterprise R&D personnel (FTE) per thousand employed in industry**



Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

The majority of higher education and government sector researchers are female (52.5% and 50.7%, respectively; Table 3.2). These figures are among the highest in the comparator group of countries. In the business sector, female researchers represent approximately one-third of researchers. Although the share has declined since 2003 this is still the second highest (after Latvia) among the comparator countries.

Table 3.2. **Female researchers by sector**

	Business enterprise		Government		Higher education	
	2003	2014	2003	2014	2003	2014
Czech Republic	16.0	14.7	33.8	36.9	32.7	32.1
Denmark	23.7	25.6	57.9	47.1	33.7	42.2
Estonia	23.8	29.4	57.9	59.3	42.7	45.6
Latvia	50.9	45.8	55.5	54.5	53.3	50.4
Lithuania	**38.0**	**34.0**	**50.9**	**50.7**	**48.5**	**52.5**
Hungary	23.0	18.1	36.0	39.7	36.0	37.9
Poland	22.0[1]	20.9	38.2	41.8	40.0	42.7
Slovenia	24.5	25.7	39.2	47.1	35.3	42.4
Slovak Republic	31.8	19.5	45.0	47.4	42.5	45.9
Sweden	24.8	22.5	35.3	42.6	37.9[1]	38.8

1. Data for 2006 instead of 2003.

Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

Human resources for science, technology and innovation (STI)

Innovation performance critically depends on highly-skilled human resources. In different contexts, generic skills – such as reading, writing and problem solving – as well as technical, managerial, design and interpersonal skills, such as multicultural openness and leadership, all affect innovation. Skilled people generate knowledge that can be used to generate and implement innovations (OECD 2015a). For instance, in American cities, a 10% increase in the share of the workforce with a college degree is associated with an increase in (quality adjusted) patenting per capita of about 10% (Carlino and Hunt, 2009). Locations with a high share of college graduates host more jobs that require new combinations of activities or techniques (Lin, 2009). And Jaumotte and Pain (2005) found, perhaps unsurprisingly, that the policy objective of increasing R&D intensity would generally fail unless supported by an increased supply of R&D-related skills.

Skills that aid the adoption and adaptation of technology are beneficial across the workforce, not just within R&D teams. Innovation in firms is particularly associated with the in-house development of skills, rather than their acquisition through hiring, as the former often has strong positive effects on the firm's capacity to absorb technological and other types of knowledge (Jones and Grimshaw, 2012). Educated workers also have a better foundation for further skills acquisition.

Skills and experience are crucial to enterprise growth and survival. For example, Cressy (1999) shows that after controlling for the effects of human capital, financial capital is a relatively unimportant determinant of business longevity. In addition, skilled users and consumers of products and services often provide suppliers with valuable ideas for improvement (Von Hippel, Ogawa and de Jong, 2011).

Education and training

Lithuania boasts a high level of tertiary education graduates. The percentage of adults who have attained tertiary education is above the OECD average for all age cohorts (25-64 years of age) (OECD, 2015b). Approximately 30% of the total population (15-74 years of age) has obtained a higher education degree and an above-EU-average share of those aged 20-29 has graduated in science, mathematics and computing, engineering and manufacturing and construction. The share of 20-24 year-olds enrolled in tertiary education (41.4% in 2014) is also among the highest in Europe.

There are concerns regarding recent trends, however. The number of students enrolling in universities and colleges has been declining, reflecting the demographic trend of decreasing birth rates since 1994, combined with an increased propensity of Lithuanian students to study abroad. Moreover, the share of science and engineering students is below the European average.

Science and engineering graduates at the doctoral level represented 41.7% of all doctoral level graduates in 2012. This share is slightly below the EU average (42.7%). However, the Lithuanian Research Assessment Exercise (MOSTA, 2014-15) highlighted the low turnout of new doctoral graduates in some promising areas of research. Another weakness is the small number of international doctoral graduates, of whom most are from less innovation-intensive neighbouring countries such as Belarus. Overall, the share of foreign students is among the lowest in Europe. The number of non-EU doctoral students is particularly low (in fact the share is close to 0%) against the EU average of 24%. However, Lithuania, together with Estonia, compares favourably with respect to the percentage of science and engineering doctorates awarded to women (45%).

There is scope for improvement of student performance in secondary education. The Programme for International Student Assessment (PISA) is a triennial international survey which aims to assess education systems by testing the generic skills and knowledge of 15-year-old students. In the OECD PISA survey 2012 Lithuanian students scored below the OECD average in all three surveyed areas (Table 3.3): mathematics (494 for the OECD on average, as compared to 479 for Lithuania), reading (496 compared to 477 for Lithuania), and science (501 compared to 496 for Lithuania). Students in the two other Baltic states performed better than Lithuanian students: 491 in mathematics, 489 in reading and 502 in science in Latvia and 521 in mathematics, 516 in reading and 541 in science in Estonia (OECD, 2014).

Despite the high share of the population with tertiary education, mismatches between the needs of the business sector and the qualifications offered by HEIs are regularly reported. The Lithuanian business community has expressed concerns about the quality gap between the skills provided by universities and the economy's requirements. According to MOSTA (2014), 44% of entrepreneurs find that specialist graduates are inadequately prepared for the job market (a third considered that graduates were suitably prepared). Entrepreneurs also note that many graduates fail to find jobs that match their qualifications or do not work in their areas of expertise. Furthermore, data gathered for the World Bank/EBRD Business Environment and Enterprise Performance Survey suggest that skill shortages are a larger constraint to businesses in Lithuania than in other comparable countries (OECD, 2016b). MOSTA (2015) also recently found that rates of return to education are higher for those completing vocational and college studies than for those completing university education. The skill mismatch can be partly explained by the fact that traditional industries dominate Lithuania's business sector both in terms of value-added and export specialisation. These industries generally have a large share of jobs without specific skill requirements.

Table 3.3. **PISA 2012 results in mathematics, reading, science**

Country mean score

Mathematics		Reading		Science	
Estonia	521	Finland	524	Finland	545
Finland	519	Poland	518	Estonia	541
Poland	518	Estonia	516	Poland	526
Slovenia	501	Denmark	496	Slovenia	514
Denmark	500	**OECD average**	**496**	Czech Republic	508
Czech Republic	499	Czech Republic	493	Latvia	502
OECD average	**494**	Latvia	489	**OECD average**	**501**
Latvia	491	Hungary	488	Denmark	498
Slovak Republic	482	Sweden	483	**Lithuania**	**496**
Lithuania	**479**	Slovenia	481	Hungary	494
Sweden	478	**Lithuania**	**477**	Sweden	485
Hungary	477	Slovak Republic	463	Slovak Republic	471

Source: OECD (2014), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science*, http://dx.doi.org/10.1787/9789264208780-en.

The problem of skill shortage and mismatch is exacerbated by the large outflows and limited inflows of skilled people from and to Lithuania. Lithuania's emigration rate is amongst the highest in the European Union and includes highly-skilled people leaving to work and study abroad. Most immigrants are Lithuanian citizens returning to the country from abroad (Leichteris et al., 2015). However, the number of returning Lithuanians has considerably increased since the beginning of the 2000s, particularly after the economic crisis. Attracting highly-skilled non-Lithuanians from abroad – including students and researchers – remains a challenge.

3.2. Innovation outputs

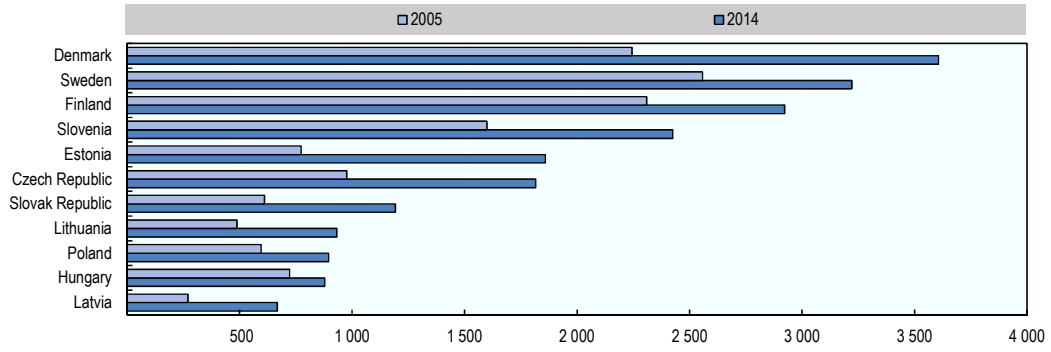
Available indicators of research and innovation output only partially cover all developments of interest. Examples of widely-used indicators include patents and scientific publications. While these measures of technological innovation and scientific output are readily available and often used, they only capture certain types of innovation activity: typically R&D-based, technological innovation. Such limitations mean that these types of indicators offer a partial picture of the innovation activity in a given country. Nevertheless, taken together, the various indicators help to map innovation output.

Scientific publications

Lithuania's production of scientific output expanded over the last decade, when scientific publications per thousand of the population almost doubled from 0.49 to 0.93 (Figure 3.12). However, the number of scientific publications remains significantly below the level of innovation-intensive countries: Finland, Denmark and Sweden record more than 2.5 scientific publications per thousand of the population. The number of times a scientific article is cited is often used to measure the impact of scientific research. Citation counts depend on the scientific field, as some scientific fields tend to cite more than others. As citations cumulate over time, it is preferable to look at citation counts of articles already published some years previously.

When scientific quality is taken into account, as measured by the number of publications receiving the top 10% of citations worldwide, Lithuania ranks higher than when only the absolute number of scientific productions is considered: Lithuania's share of the top 10% most cited publications doubled between 2002 and 2009 (from around 3% to 6%) (Figure 3.13). Lithuania shows the highest increase in the comparator group of countries in this respect. The analysis of the two indicators (scientific publications and top-cited publications) taken together shows that Lithuania's scientific production is low but its quality has progressed rapidly and is reaching levels closer to the European average (and above many eastern European countries).

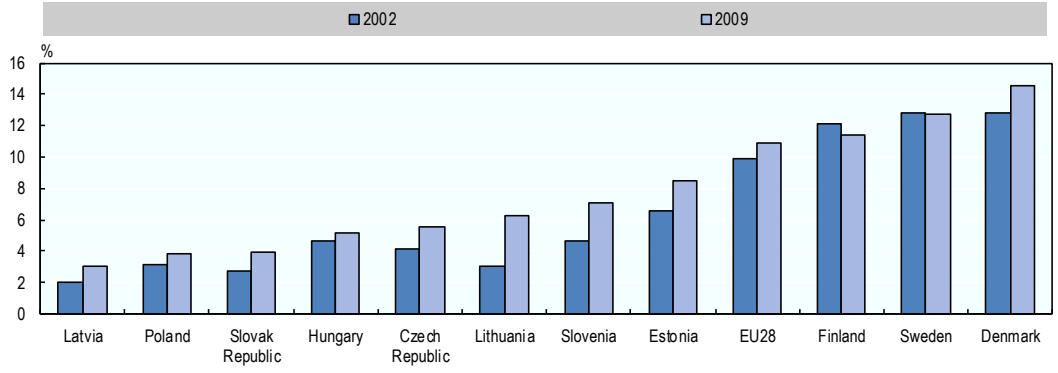
Figure 3.12. **Scientific publications per million population**



Source: Scimago Research Group (2016), online website, www.scimagojr.com/index.php.

Figure 3.13. **Scientific publications among the top 10% most cited publications worldwide**

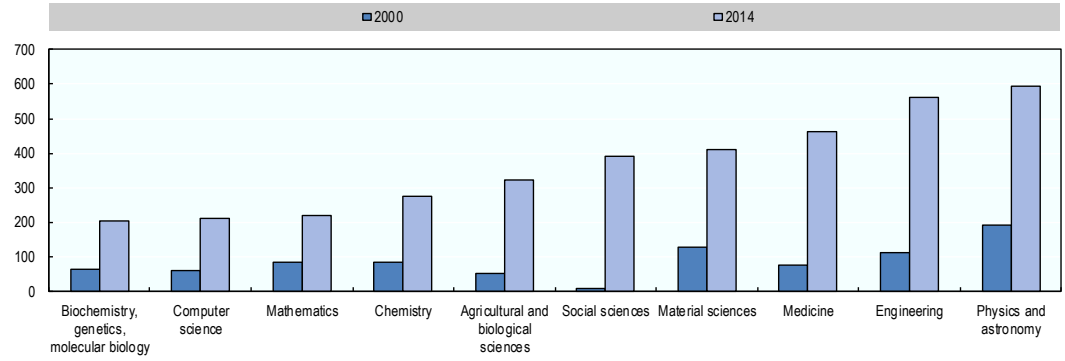
As a percentage of total scientific publications of the country



Source: Leichteris, E. et al. (2015), *Initial Assessment of Lithuanian Innovation Policy*.

The scientific fields where Lithuania produces the highest number of research publications are physics and astronomy, followed by engineering and medicine. The social sciences have witnessed a very strong expansion since 2000 (Figure 3.14).

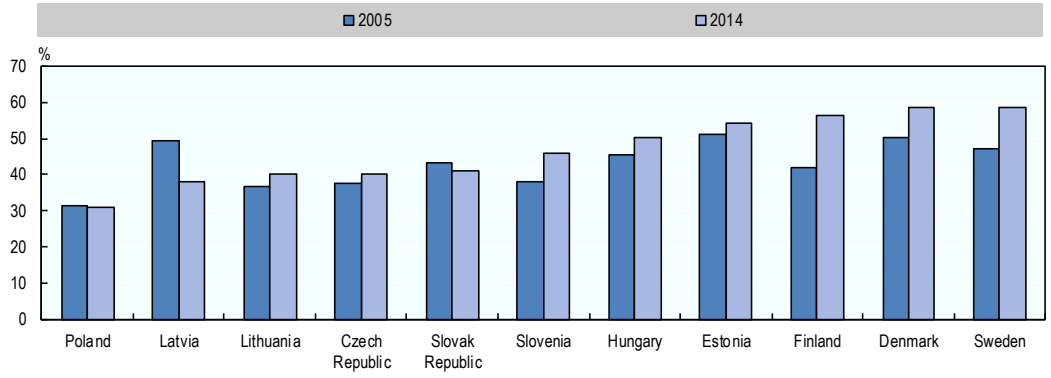
Figure 3.14. **Top scientific fields in terms of publication production**



Source: Scimago Research Group (2016), online website, www.scimagojr.com/index.php.

International collaborations in science are critical for achieving excellence in research. International linkages are even more important for small economies such as Lithuania as they need to tap into global science and innovation networks and maximise knowledge sharing to leverage their own capacities and achieve critical mass. While the internationalisation of Lithuania's STI activities has advanced in recent years, it remains weak in a number of respects. One measure of the degree of internationalisation of scientific research in a country is the number of scientific co-publications with researchers affiliated to foreign organisations. Like scientific production in general, the share of publications with foreign co-authors has increased over the last decade (from 36.5% to 40.0%). There is still a large gap relative to small advanced economies such as Finland, Denmark and Sweden, but also in relation to economies such as Hungary and Estonia where at least half of all publications are the result of collaboration with foreign researchers (Figure 3.15). Lithuania's main scientific partners are large European countries such as Germany, France and the United Kingdom, as well as the Nordic countries.

Figure 3.15. **International scientific co-publications, share of total scientific publications**

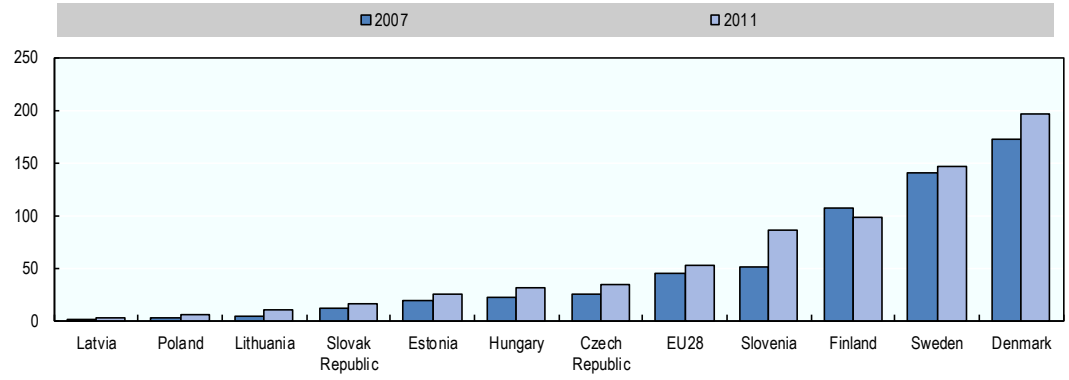


Source: Scimago Research Group (2016), online website, www.scimagojr.com/index.php.

The number of public-private co-publications, a proxy for the collaboration between public research actors and the business sector, almost tripled between 2007 and 2011 (from 3.5 to 9.6 co-publications per million of the population) (Figure 3.16). Public-private co-publications were considerably below the European average of 53 in 2011. The low

number of public-private co-publications reflects weak industry-academia collaboration, as is also illustrated by the low share of GERD financed by business, which was highlighted earlier.

Figure 3.16. **Public-private co-publications per million population**



Source: Leichteris, E. et al. (2015), *Initial Assessment of Lithuanian Innovation Policy*.

Patents, trademarks and design

International patenting is commonly used as an indicator of economically valuable technological inventions. Patent counts are a good indicator of innovation activity, notably in advanced innovation systems with a strong manufacturing sector. Patent data are, in many cases, ill-suited to capturing innovation in less R&D-intensive sectors, such as services, which rely more on non-R&D types of innovation, including process innovations and non-technological innovations such as marketing and business model innovation. Even in the manufacturing sector, the propensity to patent and use other means to secure intellectual assets varies across industries. Industrial structure therefore affects countries' position in international comparisons of patenting activity. Firms' patenting behaviour in a given country may also be strongly affected by national intellectual property frameworks and other national regulations.

One measure of international patenting that is particularly relevant to European countries is the number of patent applications filed under the European Patent Office (EPO). In Lithuania, the number of patent applications to the EPO per million inhabitants has almost tripled over the last decade (Table 3.4). However, Lithuania exhibits the lowest number of EPO patent applications per head in the comparator group of countries. International co-patenting involving Lithuanian inventors is extremely low and has not progressed much over the last decade. The situation is similar in neighbouring Baltic countries.

Trademarks protect distinctive signs (like words, symbols or images) used to identify the goods or services of a firm from those of its competitors and they are closely linked to the brand strategies of firms (OECD, 2015c). The number of European Union trade mark (EUTM) registrations from Lithuanian firms – those trademarks protected in the entire European Union market – has expanded considerably over the past decade (Table 3.5). This is a sign of the increasing propensity of Lithuanian firms to protect their brands in the European market rather in the domestic market only. The number of EUTM registrations is, however, lower than in most small-sized European countries.

Table 3.4. **EPO patent applications per million inhabitants**

	Average 2004-06	Average 2011-13
Lithuania	**2.94**	**8.64**
Slovak Republic	5.73	11.24
Poland	3.42	11.38
Estonia	8.88	16.19
Latvia	6.53	17.01
Czech Republic	12.15	21.96
Hungary	14.96	23.65
Slovenia	53.32	49.93
EU28	115.16	113.18
Finland	260.80	252.27
Denmark	211.88	272.75
Sweden	270.40	298.89

Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

Industrial designs are intellectual property rights that protect the ornamental or aesthetic aspects of an article or its parts against copyright or the independent development of similar designs (OECD, 2015c). Registered industrial design data can be used to proxy firms' creative activities. The European Office for Harmonisation in the Internal Market (OHIM) registers industrial designs that are protected in the EU market. Such records, therefore, may capture the export ambition of creative firms: firms competing only in the domestic market are more likely to register design rights in national offices only. As in the case of trademarks, over the last decade Lithuanian firms have increased the number of registered industrial designs at European level (from 29 in 2005 to 82 in 2014). This is an additional indication of the fact that Lithuanian creative firms increasingly look to do business across the European market.

Table 3.5. **EUTM registrations**

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Czech Republic	184	285	385	474	581	604	702	693	776	606
Denmark	814	923	1 040	1 149	1 299	1 170	1 182	1 268	1 249	1 131
Estonia	27	48	91	97	133	169	183	193	245	217
Latvia	24	23	48	61	73	107	86	102	128	107
Lithuania	**29**	**36**	**77**	**82**	**133**	**106**	**145**	**183**	**198**	**180**
Hungary	138	108	160	248	316	317	279	339	410	362
Slovenia	53	44	106	172	201	181	162	183	275	234
Slovak Republic	31	59	94	104	214	179	220	215	271	217
Finland	442	606	763	745	985	896	943	1 000	997	856

Source: Eurostat (2016), *STI statistics* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated.

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Chapter 4.

Innovation actors in Lithuania

This chapter describes the main actors in the Lithuanian innovation system – business enterprises, higher education institutions and public research organisations – and highlights their respective roles in the development of innovation activities in recent years. It reviews competences for innovation, and related strengths and weaknesses.

4.1. Business sector

The moderate innovation performance found at the macro level (see Chapter 3) is largely caused by the limited innovation activities in Lithuania's business sector. Although investments in innovation are increasing, innovation activity by small and medium-sized enterprises (SMEs) remains weak and collaborative links between the business and public research sector are lagging in the area of research and development (R&D). This situation results from a combination of factors including: a weak demand for knowledge and innovation (both technological and non-technological) that somewhat mirrors the structure of the economy, prevailing productivity gaps, and little awareness of firms about the role of innovation in driving firm economic performance and competitiveness.

Innovation efforts by Lithuanian firms mostly focus on incremental innovation and adoption of technology reflecting firms' dependence on external technology in the process of catching up with the technological frontier. The preponderance of low and medium-high-tech industries explains to some extent firms' preference for embodied technology acquisition (machinery and equipment) and non-R&D-based innovation outcomes such as organisational and marketing innovation. Yet propensity rates to adopt international managerial practices and engage in more disembodied forms of technology acquisition are lower than peer economies and other central and eastern European (CEE) countries. This means that even in basic forms of innovation (e.g. non-technological innovation such as new management methods), Lithuanian firms are lagging behind on average compared to firms from peer economies and advanced countries. This situation makes the case for addressing the need for such forms of technology diffusion, which are particularly relevant to catching up with innovation and productivity in the services sectors.

Although the interest of firms in R&D is improving – following the introduction of new funding mechanisms – the Lithuanian business sector still invests insufficiently in R&D compared to the average in EU countries and peer countries. Important constraints exist in the innovation system inhibiting firms' demand for knowledge and their investment in innovation activities (particularly in R&D) on a more formal and continuous basis. Lithuanian firms perceive competition (in prices and quality) as a very important factor in dissuading innovation activities, as in other CEE countries. Lack of finance and scarcity of skills are the second and third most important factors hindering business innovation activity (as shown in Chapter 3). The latter is exacerbated by brain drain, particularly of highly- skilled people looking for higher living standards abroad. This situation explains in large part the difficulties in making R&D a relevant option for firms.

The growing levels of global economic integration raise opportunities for value chain integration and knowledge acquisition – which are key to domestic firms' productivity. Firm innovation would benefit from greater international spillovers from foreign direct investment (FDI) and improvements in firm's absorption capacity (including strengthening internal R&D). Improving absorption capacity would help firms better identify and absorb knowledge (and technology) opportunities, and boost participation of Lithuanian firms in global value chains (GVCs) (OECD, 2014). There is a high potential for technological learning and knowledge transfer through enhanced productive interactions with multinational enterprises (MNEs).

The industrial tissue – types of firms and sectors

The (non-financial) business sector of Lithuania is mostly composed of SMEs – 99.8% of the total firm population: a figure in line with the EU28 average (Table 4.1).

SMEs play a fundamental role in the Lithuanian economy. They are the main producer of value-added and the main source of employment in the non-financial business sector: they account for 69% of value-added versus the EU average of 58% (European Commission, 2015). Micro companies play a relatively minor role. In terms of employment, SMEs account for 76.7% of people employed in the non-financial sector, with large firms accounting for the reminder (33%). As discussed in the 2015 Small Business Act Fact Sheet (European Commission, 2015), SMEs have largely recovered from the crisis. Their value-added increased by 8% between 2008 and 2014, and has increased by almost two-thirds since 2009. The wholesale and retail trade and transportation and storage sectors are the industries with the greatest SME contribution to value-added, at 31% and 13% of value-added, respectively (the corresponding figures for the EU28 are 22% and 6%).

Medium-sized firms in Lithuania generate a higher share of industrial value-added than their peers in Slovenia, the Slovak Republic or Finland where less than 23% of industrial value-added comes from this type of company. As in many European countries, these trends highlight the need to address innovation needs for future competitiveness in the SME sector, particularly in those firms with potential to grow. Overall, SMEs account for more than three-quarters of all employment in Lithuania, compared with the EU average of just over two-thirds (European Commission, 2015).

Table 4.1. **SMEs – basic figures, Lithuania and EU28**

	Number of enterprises			Number of persons employed			Value-added		
	Lithuania		EU28	Lithuania		EU28	Lithuania		EU28
	Number	Share	Share	Number	Share	Share	EUR billion	Share	Share
Micro	132 276	91%	92.7%	231 678	26.6%	29.2%	2	15.3%	21.1%
Small	10 752	7.4%	6.1%	223 531	25.7%	20.4%	3	24.1%	18.2%
Medium-sized	2 057	1.4%	1%	211 326	24.3%	17.3%	4	29.2%	18.5%
SMEs	**145 085**	**99.8%**	**99.8%**	**666 544**	**76.7%**	**66.9%**	**9**	**68.5%**	**57.8%**
Large	280	0.2%	0.2%	202 851	23.3%	33.1%	4	31.5%	42.2%
Total	**145 365**	**100%**	**100%**	**869 395**	**100%**	**100%**	**13**	**100%**	**100%**

Note: These are estimates for 2014 produced by DIW Econ, based on 2008-12 figures from the *Structural Business Statistics Database* (Eurostat). The data cover the non-financial business economy, which includes industry, construction, trade and services (NACE Rev. 2 sections B to J, L, M and N), but not enterprises in agriculture, forestry and fisheries and the largely non-market service sectors such as education and health. The advantage of using Eurostat data is that the statistics are harmonised and comparable across countries. The disadvantage is that for some countries the data may be different from those published by national authorities.

Source: European Commission (2015), "2015 SBA Fact Sheet - Lithuania", http://ec.europa.eu/growth/smes/business-friendly-environment/performance-review/index_en.htm.

Lithuanian manufacturing is mostly dominated by low and medium-low technology industries. These industries represented 58% and 24% of total manufacturing value-added in 2013 (Figure 4.1). These sectors combined account for 95% of the total population of firms in manufacturing. In comparison, the average in the EU28 is 86% (Eurostat, 2016a).

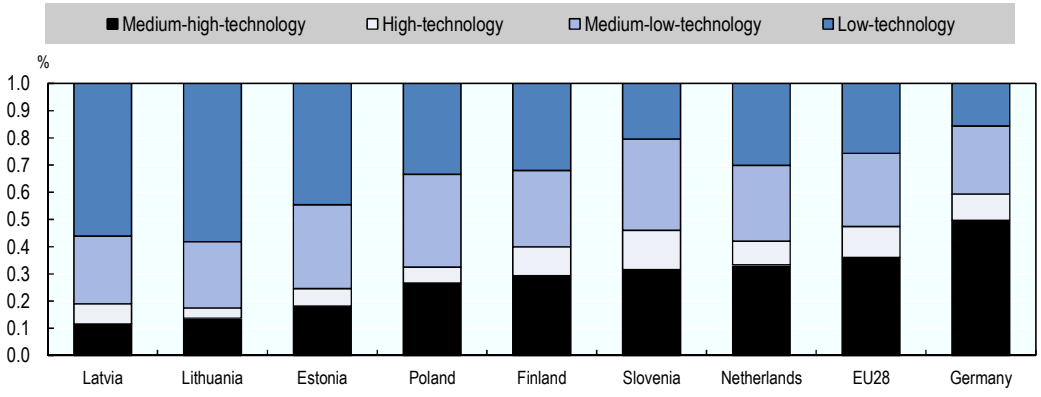
The high-technology sector remains small, contributing just 4% of manufacturing value-added, compared to the European average of 11.4% (EU28). There are few medium-high and high-technology firms in Lithuania: only 4.6% and 0.99% of all manufacturing firms fall under these categories. High-technology industries suffered most from the economic downturn between 2010 and 2014 but are now on an upward growth trend. Chemicals, refined petroleum products, apparel, textiles and furniture are the most

important sectors within manufacturing. The manufacture of refined petroleum products and food products represented 35% and 16% of manufacturing turnover, respectively, in 2012.

Knowledge-based activities are expanding but are mostly confined to a few industries within manufacturing and services. These include: biotechnology industries (industrial and diagnostics), laser manufacturing, mechatronics and information technology (IT). Together these industries are considered strategic for the future development of Lithuania's economy. R&D-intensive manufacturing industries absorb 33% of total employment (similar to the Czech Republic and Slovak Republic), which falls short of the EU28 average of 40% (Figure 4.2). Knowledge-intensive services, although growing, still account for a minor part of total employment: just 1.9% compared to the average in Europe which is approximately three times this figure (5.7%).

Figure 4.1. **Technology intensity of the Lithuanian manufacturing sector, 2013**

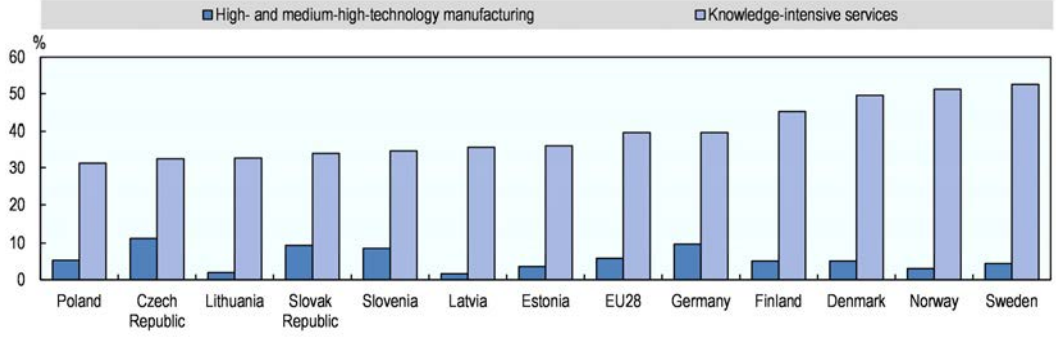
Share in total value-added at factor cost



Source: Eurostat (2016a), *Annual enterprise statistics for special aggregates of activities* (database), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sbs_sc_sca_r2&lang=en.

Figure 4.2. **The importance of knowledge-intensive sectors, 2014**

Percentage in total employment



Source: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

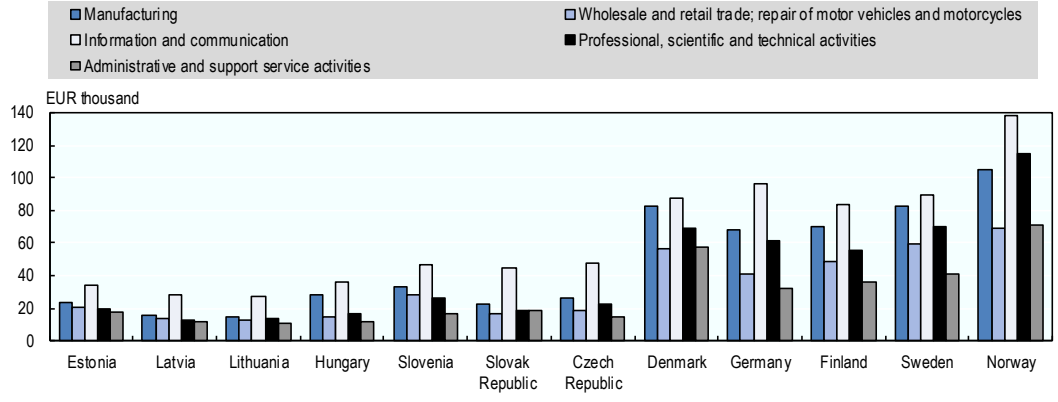
Productivity trends and uneven growth across industries

In spite of consistent productivity growth in recent years, productivity in Lithuanian industry, and all other sectors of the economy, lags substantially behind EU averages (Figure 4.3). For instance, in manufacturing, labour productivity is approximately one-sixth and one-seventh the productivity of Sweden and Finland, respectively.

An important challenge remains the high level of heterogeneity in productivity across Lithuanian industries. Information and communication (IC) industries are the leading sector in terms of labour productivity (and productivity growth rates), followed by manufacturing. Services show the weakest performance both in levels of labour productivity and growth rates, in spite of their growing importance in the economy in employment terms. Over the period 2006-13, there was negligible productivity growth in a number of professional and business services (especially in the wholesale and retail trade sectors). An efficient services sector is especially important given that services are intermediate inputs for other firms and can be integral to successful participation in GVCs (Adalet McGowan and Andrews, 2015).

The high dispersion in productivity levels across industries raises the possibility of more-targeted policy interventions and strengthened industry-level approaches in innovation policy. Examples of targeted approaches (vertical innovation policies) include: sectoral funds for innovation, (industry-focused) innovation networks, technology/industry clusters, industry-focused innovation or technology transfer centres, among others (OECD, 2015b). An efficient services sector is especially important given that services are intermediate inputs for other firms in all sectors of the economy.

Figure 4.3. **Apparent labour productivity in economic sectors, 2013**



Note: Apparent labour productivity is defined as value-added at factor costs divided by the number of persons employed.

Source: Eurostat (2016c), *Structural Business Statistics* (database), http://ec.europa.eu/eurostat/en/web/products-datasets/-/TIN00152.

Innovation activity

Business sector investments in innovation have considerably increased in the recent past (see Chapter 3 for R&D trends and Deloitte, 2016), but they remain low compared to international standards. Innovation investment, collaborative linkages and international integration – which are key to strengthening innovation capacity in small countries – are particularly underdeveloped and need to be strengthened.

As discussed in the previous chapter, R&D investment by the business sector has been growing but remains low compared to EU standards. Less than one-third of gross expenditure for R&D (GERD) is financed by the business sector (compared with some 60% in innovation-intensive countries within the OECD area). In 2014, business expenditure on R&D (BERD) was 0.24% of gross domestic product (GDP) – far below the EU28 average of 1.29%. This is also far from the national target for BERD, which is hoped to be met by 2020, of 0.9% of GDP.

In 2012, the share of researchers working in the business enterprise sector in Lithuania was 12%. This was lower than in the other Baltic countries and markedly lower than in some OECD countries such as France (60%) and the Netherlands (68%). Overall business R&D has been well below the EU average but some improvements in R&D capabilities have been made. In terms of R&D personnel, their number has increased considerably over the last decade, from 0.04% of the total labour force in 2003 to 0.19% in 2014. More generally, the number of employees involved in R&D activities has increased steadily over the last few years (Deloitte, 2016). However, the presence of R&D personnel in the labour force remains low compared to the EU average of 0.62% (Table 4.2).

According to the Community Innovation Survey (CIS) 2012, Lithuanian companies invest 0.79% of their sales in innovation activities (Figure 4.4). This figure is significantly lower than leading innovative European countries such as Sweden (3.6%), Denmark (3.2%), Finland (2.3%) and Estonia (1.4%) or Latvia (0.63%), and exceeds the investment ratio seen in other small CEE economies. However, the innovation investments of Lithuanian companies have increased considerably in the recent past. According to recent data from Statistics Lithuania, expenditure on innovation accounted for 3.5% of turnover in the group of technologically innovating enterprises in 2014.

Table 4.2. **R&D personnel in the business sector**

Full-time equivalent as a percentage of total labour force

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EU28	0.48	0.48	0.48	0.5	0.52	0.54	0.53	0.55	0.57	0.59	0.6	0.62
Lithuania	0.04	0.06	0.08	0.08	0.14	0.13	0.1	0.14	0.14	0.12	0.16	0.19

Source: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

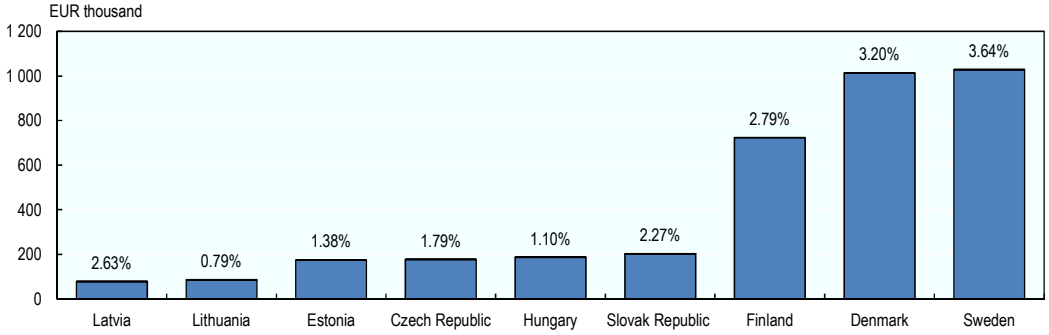
The innovations of Lithuanian firms are not primarily driven by R&D. As is typical for economies in a catch-up phase of development, a large part of Lithuania's innovation expenditure (around 70%) is used for the acquisition of machinery and equipment (Figure 4.5), followed by extramural R&D (19%). Intramural R&D only represents 3.31% of total innovation expenditures. This indicates that the majority of innovative companies are catching up by transferring ("embodied") technology from abroad. More advanced economies typically invest less in machinery and equipment for innovation. Instead, the majority of their innovation expenditure is related to R&D and other intangible assets (as in the case for instance of Sweden, Finland or Denmark). As the innovation system matures and evolves, Lithuania may follow a similar trajectory.

There are indications that firm managerial and organisational competencies – which are fundamental to productivity growth and complementary to technological change (e.g. adoption of information and communications technologies [ICT]), might be underdeveloped in Lithuanian firms. Data from the World Bank Enterprise Survey suggest

that Lithuanian companies in the manufacturing sector are lagging behind peers in other Baltic countries (Figure 4.6) in terms of their propensity to invest in international quality certifications (ISO 9000, 9002 or 14000). These and other types of international certification are often essential to exporting and integration in GVCs. Other requirements for firm upgrading and exporting include the adoption of product quality and safety standards, and/or the adoption of new production models (e.g. just-in-time, lean manufacturing, etc.).

Figure 4.4. **Average innovation expenditure per innovating firm, 2012**

In EUR thousand and percentage of turnover

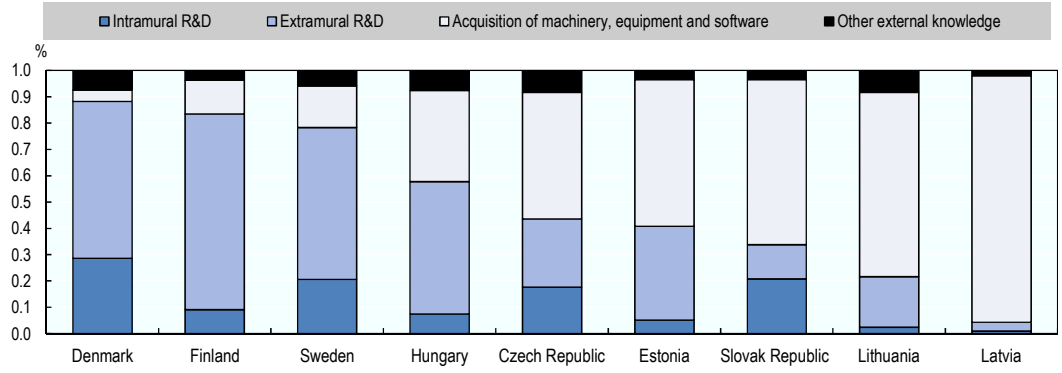


Note: Innovative firms are firms that introduced product and/or process innovation, regardless of organisational or marketing innovation (including enterprises with abandoned/suspended or ongoing innovation activities).

Source: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

Figure 4.5. **Innovation expenditure by type (by innovative firms), 2012**

Share in total expenditure



Note: Innovative firms are firms that introduced product and/or process innovation, regardless of organisational or marketing innovation (including enterprises with abandoned/suspended or ongoing innovation activities).

Source: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

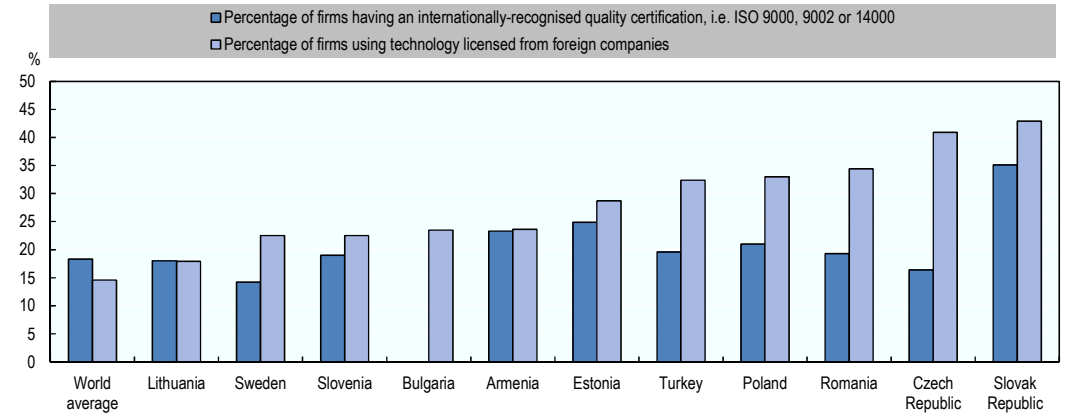
Information from the same survey also indicates that while the importance of technology acquisition through machinery and equipment is high, few firms in Lithuania are engaged in "disembodied" technology acquisition, for instance through technology licensing agreements with foreign firms (Figure 4.6). In this indicator, Lithuania ranks well below its peers. In 2013, for example, 18% of manufacturing companies were

involved in technology licensing from overseas firms while in Poland this figure was 33% and in the Czech Republic and Slovak Republic the rate was above 40%.

Foreign technology licensing can bring important benefits to firms through learning and know-how acquisition. These benefits are also larger when firms have an internal R&D capacity. Technology purchasing is not neutral with regard to its impact on firm innovation and the type of innovation that firms produce. The evidence shows that technology licensing is closely related to process innovation (Goedhuys and Veugelers (2012) and Arvanitis et al. [2013]).[1] But maximising the benefits of external technology depends greatly on internal absorption capacity, that is, in-house R&D activity and investment (Griffith et al., 2004). Innovation policies in Lithuania should aim to support both forms of innovation capacity (and their financing) and ensure that they interact in complementary ways (by supporting the building up of in-house R&D in parallel to technology acquisition to achieve more efficient productivity gains).

In terms of percentage of innovating firms, in 2013 Lithuania performed below the EU28 average (Figure 4.7): 32.9% of Lithuanian enterprises introduced some type of innovation (technological or non-technological) in the 2010-12 period, compared with 48.9% on average across the EU28 (Eurostat, 2016b). Firms' innovative activities mostly concern process and marketing innovations. According to more recent surveys by Statistics Lithuania, the share of innovating firms increased by almost 11% between 2010-12 and 2012-14, reaching 40% of total enterprises.

Figure 4.6. **Disembodied forms of technology acquisition in manufacturing firms, 2013**



Note: Data refer only to manufacturing.

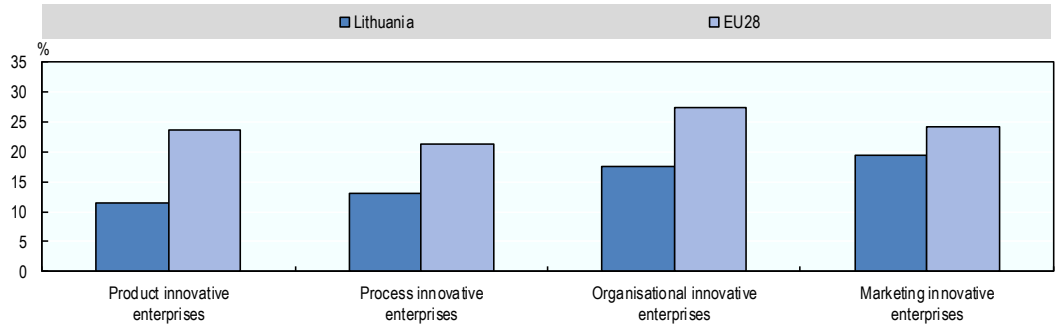
Source: World Bank Enterprise Survey (2013), available at: www.enterprisesurveys.org.

Part of the reason for low levels of firm innovation is firms' weak capacity to absorb foreign ideas and technologies (Angelis, Antanavicius and Martinaitis, 2014), as reflected in the limited importance of R&D in innovation strategies. A recent survey suggests that over 80% of Lithuanian SMEs can be classified as having "low absorptive capacity": that is, they underperform in knowledge and technology transfer activities (Leichteris et al., 2015). This is in line with the previously cited figures reporting limited international technology transfer activity.

Only 16.1% of SMEs introduced product or process innovations, which is half the EU28 average (32%). Some 25.2% of Lithuanian SMEs introduced marketing or organisational innovations, a figure near to the EU28 average (34%) (Figure 4.8). Only

14% of SMEs innovate in-house while the EU28 average is twice as high (29%). Lithuanian SMEs rely mostly on external sources of knowledge to innovate.

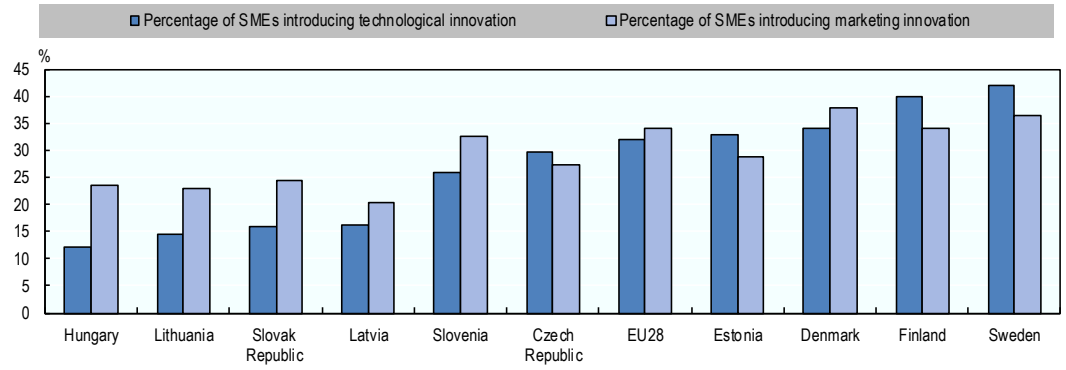
Figure 4.7. **Share of innovators in total firms, 2010-12**



Note: A process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. An organisational innovation is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations. A marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

Source: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

Figure 4.8. **Percentage of SMEs introducing innovation (from 10 to 49 employees), 2012**



Source: European Commission (2014), *Innovation Union Scoreboard 2014* (database), http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards/index_en.htm.

The weak innovation capacity of the Lithuanian business sector is also reflected in other performance indicators, such as intellectual property rights (IPRs). Over the last decade, Lithuania registered a small number of industrial designs (with the exception of furniture and household goods) (Table 4.3).[2] Industrial designs have IPRs protecting the ornamental or aesthetic aspects of an article or its parts against copyright or the independent development of similar designs.

Unlike the general trend in OECD countries, there is no striking difference in innovation rates between the manufacturing and services sector in Lithuania. Around 36% of firms in manufacturing undertake innovation activities while the figure for services is 31%. Yet both values are considerably below the European averages of 58% (in manufacturing, EU15) and 47% (in services, EU28).

Table 4.3. **Lithuania's OHIM[1] registered community designs (RCD) by economic class**

Based on the Locarno classification

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Health, pharma and cosmetics	0	0	0	0	0	0	0	1	3	2	6
Agricultural products and food preparation	1	0	0	2	1	0	4	0	0	0	8
Transport	0	0	0	0	2	0	4	6	1	2	15
Advertising	0	0	0	3	2	1	7	2	5	1	21
Tools and machines	1	0	0	0	0	10	2	2	8	0	23
Electricity and lighting	0	4	0	4	0	9	2	4	0	4	27
Construction	0	0	0	0	5	2	8	1	9	5	30
ICT and audio-visual	0	0	0	0	6	3	7	6	8	5	35
Leisure and education	0	4	2	0	0	11	0	3	17	6	43
Clothes, textiles and accessories	0	0	5	9	6	0	2	14	13	1	50
Packaging	1	1	26	2	4	9	3	6	6	17	75
Furniture and household goods	22	0	14	0	3	1	12	7	24	15	98

1. Office for Harmonisation of the Internal Market.

Source: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

Constraints to business innovation

According to the innovation survey, the four most important factors discouraging innovation in Lithuanian firms are (Figure 4.9): (strong) price competition (53% of innovative companies consider these obstacles as highly important), product quality (37% of innovative companies consider this factor as highly important); a lack of adequate finance and dominant market share (28% consider this highly important). These are closely followed by "high costs of accessing new markets" (23.9%) and lack of qualified personnel (22.4%).

Data from the CIS suggest that these perceived difficulties are somewhat similar to those in peer economies (for instance price competition often ranks uppermost among the reported difficulties). More striking differences appear when comparing to Sweden, where percentages of firms reporting barriers to innovation are approximately half or one-third of the Lithuanian figures.

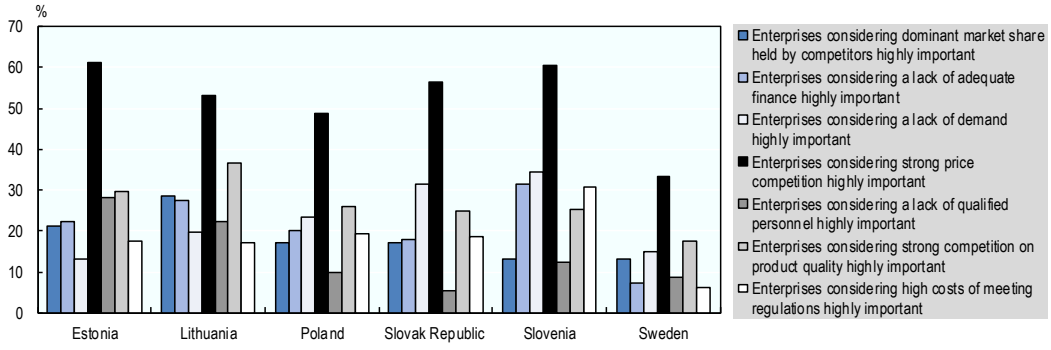
Obstacles such as lack of finance and qualified human capital (probably in terms of science and engineering graduates) are also much more important in Lithuania than in Sweden: while only 7.3% of innovative firms in Sweden consider access to finance a problem (highly important), in Lithuania 27.5% of innovative firms consider access to finance a serious handicap to innovation. The difficulties in accessing finance overall is a major issue for competitiveness, as discussed in Chapter 2. In terms of lack of qualified personnel, only 9% of innovative Swedish firms suffer from this issue whereas in Lithuania this handicap affects more than one firm in five (22.4% of innovative firms). Increasing business R&D in Lithuanian firms is challenging given that firms already report a shortage of researchers (Angelis, Antanavicius and Martinaitis, 2014), due in part to Lithuania's elevated rate of emigration of highly-skilled people and the significant administrative burden associated with hiring foreign specialists.

Co-operation in innovation activities

According to CIS statistics, Lithuanian firms co-operate with each other more often than the average firm in the EU28. For instance, 32% of innovative Lithuanian companies co-operate with suppliers (of materials, equipment, etc.) while the average in European countries is 18.3% (Figure 4.10). The most important form of co-operation is collaboration with suppliers, followed by co-operation with universities and higher education institutes. The least developed form of co-operation is co-operation with competitors and other firms from the same sector.

Figure 4.9. **Obstacles to innovation and their importance, 2012**

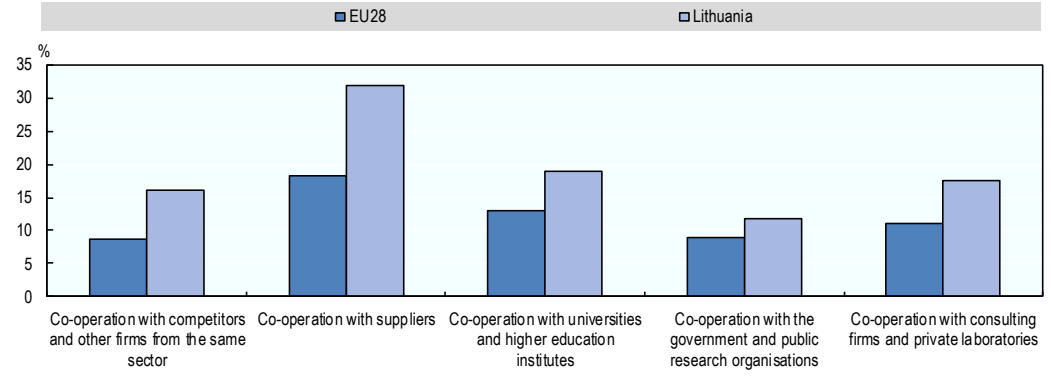
As a percentage of innovative firms, including firms with abandoned/suspended or ongoing innovation activities



Source: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

Figure 4.10. **Co-operation in innovation and its importance, 2012**

As a percentage of innovative firms, including firms with abandoned/suspended or ongoing innovation activities



Source: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database/.

However, indicators of collaborative activity by SMEs are less encouraging. Compared to the European SME average, Lithuanian SMEs are involved less frequently in collaboration for innovation: 7.5% of innovative Lithuanian SMEs co-operate with other organisations, whereas the average for innovative SMEs in Europe (EU28) is

10.5%. This lack of co-operation hinders Lithuanian SMEs' ability to increase innovation capacity and learning. This situation puts SMEs at a further disadvantage when compared with large firms (and average European SMEs) in approaching the knowledge frontier. Public policy for innovation could pay further attention to ways to approach and involve SMEs in collaborative activities, starting by understanding what their priority needs are (in terms of technology and markets) and facilitating their links with national knowledge and technology institutions, and inter-firm collaboration.

Enhancing innovation and technological change for SMEs also requires supporting co-ordination and associative activity to address common (or industry-level) innovation or technology bottlenecks and jointly accelerate SMEs' technological learning and innovation capacity. Examples of such mechanisms include technology extension centres and innovation centres involving public-private collaboration (for example the Manufacturing Extension Partnership Program of the United States, and the Catapult Programme of the United Kingdom). These approaches can be adapted to innovation agendas addressing SMEs' integration in value chains and broader SME upgrading on the basis of partnerships with large and multinational firms.

Trade performance

Trade is a major channel of global economic integration. Exporting is an important way to maximise economies of scale and specialisation, and is also a source of technological learning through interaction with global customers ("learning by exporting", Crespi, Criscuolo and Haskel, 2008). In addition, export-oriented firms are often required to undertake further efforts to innovate because of the competition effect from trade. Imports also facilitate learning by domestic firms and help firms to access frontier technologies.

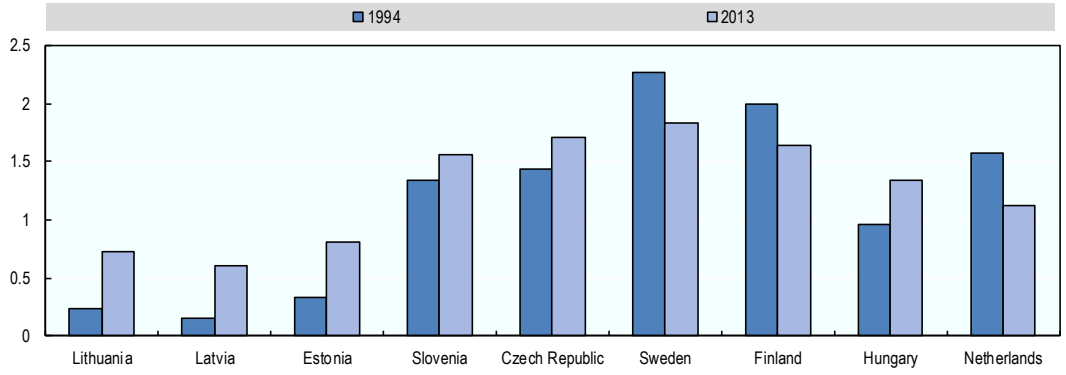
In terms of trade performance, Lithuania has significant achievements. Lithuania is the 65th largest export economy in the world and the 33rd most complex economy according to the economic complexity index (ECI).[3] However, most of its export activity concerns traditional industries, with the exception of a few high-technology products. Statistics on exports show the predominance of low- and medium-high-technology industries in Lithuanian exports. The country's top exports are refined petroleum (USD 4.81 billion; 16% of exports), furniture (USD 1.21 billion; 4% of exports), polyacetals (USD 700 million; 2.3% of exports), wheat (USD 686 million; 2.3% of exports) and nitrogenous fertilisers (USD 647 million; 1.4%). Lithuania's main imports are crude petroleum (USD 5.14 billion), refined petroleum (USD 1.68 billion), petroleum gas (USD 1.14 billion), cars (USD 1.12 billion) and packaged medicaments (USD 877 million).[4]

The level of economic complexity of Lithuanian exports has increased over time (Figure 4.11) but remains very low. The ECI in Lithuanian exports is approximately half of that in Slovenia, Finland, the Czech Republic and Sweden. The complexity of an economy, which is closely related to national innovation performance, reflects the multiplicity of knowledge pieces embedded in the export basket (number of goods/pieces that combined can lead to different products, see Box 4.1) (Hidalgo and Hausmann, 2009).

Trade integration with the European Union has expanded opportunities for knowledge and technology acquisition. After Lithuania became a member, the structure of trade flows started to shift and volumes to expand. The export specialisation index[5] (Table 4.4) indicates that over the period 2007-13 Lithuania achieved comparative advantages in trade with the European Union in the following industries: food, drink and tobacco products, raw materials, mineral fuels and related materials, and other manufactured goods. The leading sector is food, drink and tobacco. This configuration has been influenced by

different factors, the most important of which is the abolition of tariffs and customs taxes for food and alcoholic drinks from EU countries, which resulted in lower prices and increased imports.

Figure 4.11. **Evolution of the ECI**



Source: The Observatory of Economic Complexity (2016), *Economic Index Atlas* (database), http://atlas.media.mit.edu.

Industries in which Lithuania shows competitive disadvantages are: chemicals and related products, and machinery and transport equipment. The index of these two industries has improved in recent years but still remains below one. The comparison of export specialisation patterns indicates that the trade structure of Lithuania is rather similar to the EU average trade.[6] In this context, opportunities for technology learning via exports can be enhanced through quality upgrading and innovation resulting from closer relationships with customers abroad.

Box 4.1. **The Economic Complexity Index (ECI)**

The complexity of an economy is related to the amount of useful knowledge embedded in it. Because individuals are limited in what they know, the only way societies can expand their knowledge base is by facilitating the interaction of individuals in increasingly complex networks in order to make products. According to Hidalgo and Hausmann (2009), the economic complexity of a country can be measured by the mix of these products that countries are able to make.

Some products, like medical imaging devices or jet engines, embed large amounts of knowledge and are the result of very large networks of people and organisations. These products cannot be made in simpler economies that are missing parts of the network's capability set. Economic complexity, therefore, is expressed in the composition of a country's productive output and reflects the structures that emerge to hold and combine knowledge. To generate a more accurate measure of the number of capabilities available in a country, or required by a product, it is necessary to correct the information that diversity and ubiquity carry by using each one to correct the other. For a country, this requires calculation of the average ubiquity of the products that it exports, the average diversity of the countries that make those products and so forth. For products, this requires calculation of the average diversity of the countries that make them and the average ubiquity of the other products that the country makes.

Source: Hidalgo and Hausmann (2009), Methodology and index calculation, available at: http://atlas.media.mit.edu.

Table 4.4. **Export specialisation indexes (RCA) of Lithuanian trade with the European Union, 2008-13**

	2008	2009	2010	2011	2012	2013
Food, drink and tobacco	3.31	3.23	3.43	3.41	3.42	3.44
Raw materials	2.02	1.99	2.01	2.02	2.14	2.16
Mineral fuels, lubricants and related materials	2.64	2.6	2.62	2.67	2.69	2.7
Chemicals and related products	0.83	0.85	0.86	0.88	0.89	0.89
Machinery and transport equipment	0.55	0.54	0.55	0.65	0.67	0.69
Other manufactured goods	1.16	1.16	1.18	1.19	1.23	1.26

Note: The revealed comparative advantage (RCA) measures the intensity of trade specialisation of a country within a region or the world. It is the export share of an industry of the total exports (of goods) of a country divided by the export share of this industry of the region (European Union) or the world. If the RCA takes a value less than one this implies that the country is not specialised in exports of this industry. Similarly, if the index exceeds one this implies that the country is specialised in this domain.

Source: Bernatonyte (2015), "Estimation of export specialization: Lithuanian case equilibrium", http://dx.doi.org/10.12775, based on Eurostat (2016d), *International Trade* (database), http://ec.europa.eu/eurostat/web/euro-indicators/international-trade.

Foreign direct investment (FDI) and global value chain (GVC) integration

Innovation in domestic firms can potentially benefit from international knowledge spillovers through global interactions such as international trade and FDI. The extent of spillovers and the capacity to learn from trade and multinational activity, however, are determined by domestic absorption capacity and the existence (and quality) of productive linkages with global firms (Cohen and Levinthal, 1990; Griffith, Redding and Van Reenen, 2004).

Foreign firms have an important weight in the Lithuanian economy and as such they can have an important role in the process of innovation and technology learning by domestic firms. The participation of MNEs in generating value added is important in Lithuania, reaching 30%[7] in 2013 (three times the EU27 average). Furthermore, the amount of FDI has been increasing, reaching EUR 13.2 billion in 2015 (Central Bank of the Republic of Lithuania, 2016).

Inward FDI stocks represented 25% GDP on average over the period 2009-12, and reached 38% I 2014. In 2013 and 2014 FDI stocks were lower than in Estonia but higher than in Latvia and exceeded the EU28 average by a considerable margin. This multinational activity could be a potential source of knowledge transfer to domestic firms and a key mechanism for integrating GVCs through supply linkages.

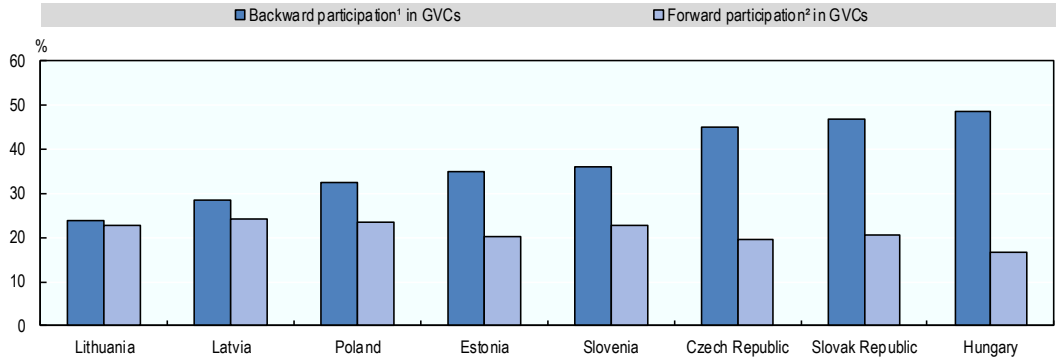
Yet, in spite of strong MNE activity in the economy, Lithuania has not yet fully benefited from FDI, as reflected in the low levels of value chain integration (Figure 4.12). This situation (as of 2011) limits opportunities for global exposure by domestic firms, and limiting technology learning through GVCs. Lithuania shows a low "backward participation" in GVCs as at 2011 (i.e. it has a relatively low share of foreign value-added embodied in Lithuanian exports). The level of domestic value-added embodied in exports (as of total gross exports) is also low but similar to levels in peer economies.

Innovation would benefit from greater international spillovers from FDI and improvements in firms' absorption capacity, as both can reinforce each other. Reinforcing domestic firms' absorption capacity through R&D and upgrading would help boost the participation of Lithuanian firms in GVCs and make Lithuania more attractive to FDI (OECD, 2016). Furthermore, FDI in Lithuania is characterised by a relatively large share

of green-field investment, which may be more beneficial than other types of FDI for job creation and knowledge transfer to domestic business. While Lithuania's inward FDI stock in 2012 was below that of other Baltic countries, there are signs of relatively strong growth since then (Invest Lithuania, 2014).

Figure 4.12. **Participation in global value chains (GVCs), 2011**

Percentage of gross exports



1. Foreign value-added embodied in exports, as % of total gross exports.

2. Domestic value-added embodied in foreign exports, as % of total gross exports.

Source: OECD-WTO (2016) *Statistics on Trade in Value Added* (*TiVA*) (database), https://stats.oecd.org/index.aspx?queryid=66237.

The country has become increasingly attractive to technology companies and international services companies. Google has recently established a sales office in the Lithuanian capital Vilnius, while Nasdaq has opened a centre of excellence in the same city. International companies in services have recently set up regional support centres. In 2011, Western Union officially opened their new European Regional Operating Centre in Vilnius. In 2009, Barclays established its Technology Centre Lithuania, one of four strategic engineering centres supporting Barclays' retail banking businesses across the globe.

4.2. Higher education institutions (HEIs) and public research institutes

Types of research systems: a characterisation

The share of BERD in GERD varies widely across OECD countries (Figure 4.13). The most advanced countries tend to have high shares of BERD in GERD while developing countries and emerging economies with low business innovation capability are placed at the other end of the spectrum, where R&D expenditure is typically low and concentrated in the public research sector (universities or government research institutes). This is where another important difference can be observed: national innovation systems show large variations with respect to the relative weight of universities (as measured by the share of higher education expenditure for research and development [HERD] in total publicly performed R&D) on the one hand and the public research institutes (measured by the share of governmental intramural expenditure for research and development [GOVERD] in total publicly performed R&D) on the other. Some countries rely on a large public research institute (PRI) sector, as is the case in a number of former transition economies, such as the Czech Republic, Hungary and Slovenia, which have retained

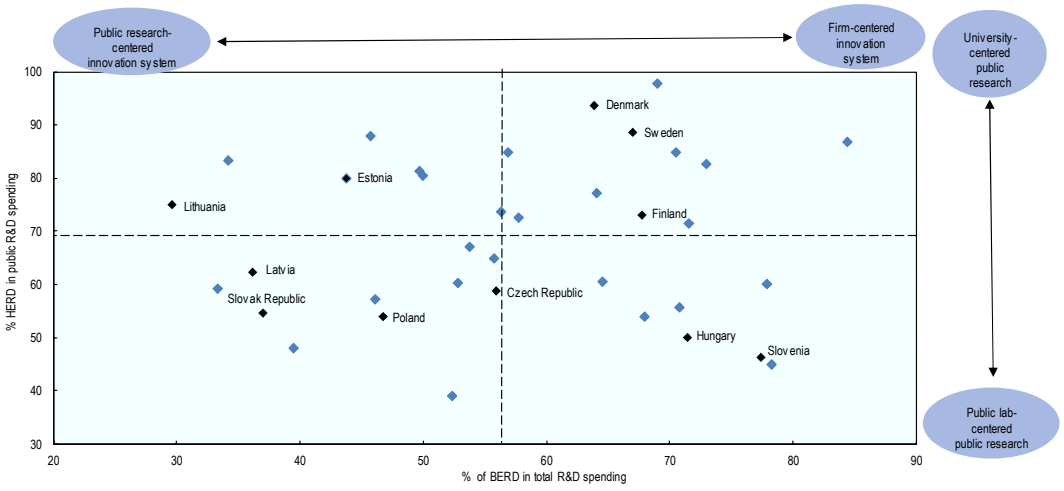
important parts of their historical public research institutes (following reforms). But other countries with a history like France and, to a lesser extent, Italy and Spain also have a strong PRI sector. In contrast, other national research and innovation systems are clearly university-based, characterised by a high share of HERD in total publicly performed research. These countries include, for instance, Austria, Ireland, Sweden, Switzerland, and – reinforced by the merger of PRIs with universities – Denmark as a prominent case.

A number of arguably the best performing small OECD countries are located in the upper right quadrant (which means that they are at the same time firm-centred and university-centred systems) of Figure 4.13. Among the Baltic countries, Estonia, which undertook a radical reform of its public research system after gaining independence, performs R&D mainly in the higher education sector. While Lithuania, which, with a share of public sector R&D performed by universities is above the OECD median, is among the more university-centred public research systems, albeit to a lesser extent than the three countries mentioned above, it has a long way to go to become a firm-centred innovation system. The share of R&D performed by the business sector in GERD is at the bottom end of OECD economies.

Some emerging economies, especially those whose catching up has not been driven by raw materials, have increased the BERD share in GERD rapidly. In the case of former planned economies which have drawn on the Soviet model of organising their research system, this shift towards BERD has often gone hand in hand with sometimes radical, in other cases more gradual restructuring of the research system and privatisation. The People's Republic of China is a prominent example for this type of trajectory but there are also examples among small CEE economies (such as Slovenia and Hungary).

Figure 4.13. **Share of R&D expenditure in firms, HEIs and PRIs**

Lithuania and comparator countries



Note: Data for Australia and Mexico refer to 2011; data for Ireland and Switzerland refer to 2012. The dashed lines correspond to the OECD mean values.

Sources: Eurostat (2016b), *Science and Technology* (database), http://ec.europa.eu/eurostat/web/science-technology-innovation/statistics-illustrated; OECD (2016c), *Main Science and Technology Indicators* (database), http://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

HEIs

The current Lithuanian higher education sector is a binary system consisting of two types of institutions:

- universities (i.e. universities, academies and seminaries) representing the university sector of higher education
- colleges.[8]

The current higher education system is the result of a sequence of recent institutional reforms. Until 2000, the Lithuanian higher education system was a unitary one. The binary system of higher education seen today was introduced in 2000, in compliance with European higher education standards. This reform was aimed at phasing out what was known as advanced vocational education (provided by advanced vocational education and training schools) and developing a non-university segment of the higher education system in its place. Institutions which were sufficiently qualified to provide non-university higher education were transformed into higher education colleges or departments of such colleges (SKVC, 2015).

The study programmes in the Lithuanian tertiary education system are designed in accordance with the Lithuanian National Qualification Framework which was approved in 2010 and is aligned with the European Qualification Framework.

The 2009 reform

Another major reform of the higher education system took place in 2009. In April 2009, after a long period of political consultation, the parliament of Lithuania passed the Law on Higher Education and Research. This law has strengthened the autonomy of universities and, at the same time, introduced new competitive mechanisms for funding education activities. Moreover, it has strengthened the role of colleges in the country, enabled competitive research funding (Table 4.5). To strengthen competitive funding mechanisms, the Lithuanian Science Council has been transformed into the Lithuanian Research Council and is responsible for distributing competitive research funding. The 2009 law also introduced the requirement of external evaluations of HEIs on the basis of their higher education and research activities. The external evaluation takes place every six years and is managed by an institution authorised by the Ministry of Higher Education and Science (the Centre for Quality Assessment in Higher Education). The results of this external evaluation are used for accreditation of HEI. In case of a negative evaluation, a second evaluation has to be arranged within two years. After a second negative evaluation the Ministry of Education and Science takes a decision to withdraw the licence to provide education studies.

The law has also redefined the regime for sharing the commercial revenues arising from IPRs. Researchers involved in the activity resulting in the intellectual property (IP) now benefit from at least one-third of the commercial exploitation of the IPRs. As a consequence of this change, technology transfer offices have been established in most universities.

An important change in the system since the reform of 2009 has been the funding of universities through student vouchers (tuition fees) which the students bring with them to the institution of their choice. The value of their vouchers depend on their secondary education results. Each year two quotas for vouchers are established: one for colleges and one for universities. In addition to the establishment of student vouchers, the 2009 reform has also increased the budget for loans to students in tertiary education (from

EUR 5.7 million to EUR 43 million in 2010) to cover additional expenses, such as living costs, part-time studies abroad and tuition fees for private universities.

The 2009 reform also introduced a new governance model for the universities which previously had solely senates composed of academic staff members and dealing with academic and management decisions. By the end of 2011 the management of all state universities had professional boards, composed of university staff and individuals from non-academic public or private organisations, to consider and approve strategic decisions and appoint rectors. Now councils and rectors decide on strategic and management issues while the senate deals with issues related to academic standards and education matters.

Table 4.5. **Main changes after the 2009 higher education reform**

Before the reform	After the reform
Higher education and students	
– Funding distributed to institutions according to the number of new students	– Funding tied to each student through a voucher allocated to the HEI of the student's choice
– State financing restricted to state universities and colleges only	– State funding targeting the institution chosen by the student, whether private or public
– State funding limited to full-time students	– State funding available to full-time and part-time students
Governance of HEIs	
– Senates composed of members of a university's academic community, in charge of the management of HEIs	– HEIs managed by boards that include, in addition to the university staff, individuals from other institutions outside of the academia. The board approve strategic decisions and appoints rectors
– HEIs had the legal status of budgetary entities receiving block funding from the state each year	– All HEIs, including colleges, have become public entities with more freedom in decision making and have the right to own and manage assets
Funding of HEIs	
– Funding based on a year-to-year allocation, only 20% based on performance	– The share of competitive funding increased to 30% in 2009, 40% in 2010 and has been 50% since 2011
IPRs	
– It was not possible to transfer IP developed through research to other persons or to businesses (but it was possible to license intellectual property)	– IPRs arising from intellectual activities belong to the HEIs. No less than one-third of the profit gained by the exploitation of the IPRs must be allocated to the author of the IP, employed by the HEIs

Source: Ministry of Higher Education (2011), *Higher Education and Research Reform in Lithuania, Resetting the System Towards Competitive Future*.

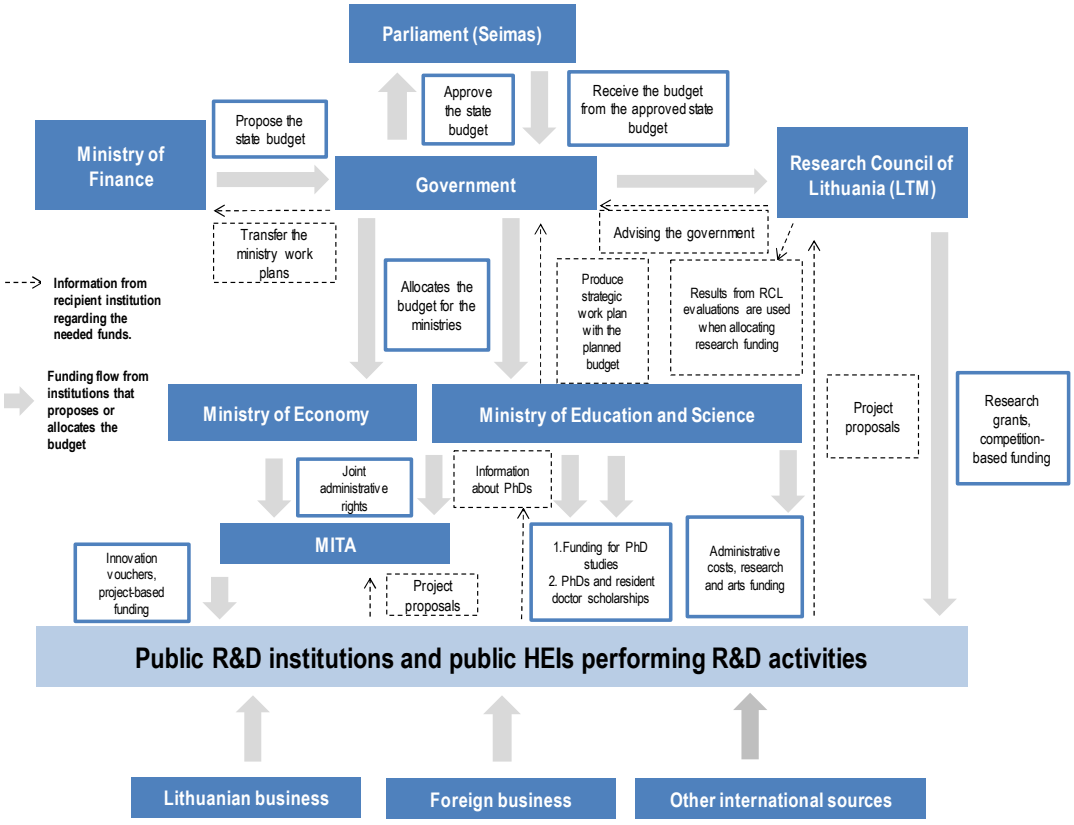
Institutional and third-party funding for research

Since the 2009 reform, the Lithuanian government has increased the share of performance-based funding for research (from 30% in 2009 to 50% since 2011). The remaining 50% of research funding is allocated on the basis of previous overall research funding, expressed in terms of "the standard number of research staff". The latter is approved by decree of the Minister of Education and Science for each organisation every three years.

The performance-based half of institutional funding is reallocated every three years on the basis of an assessment of R&D activities. According to a ministerial decree adopted in February 2015 the assessment of R&D activities is based on the following criteria:

- participation in international research programmes
- amount of contractual and collaborative research commissioned by the business sector
- publication and patent indicators according to an evaluation carried out annually by the Lithuanian Research Council.

Figure 4.14. **Overview of mechanisms of research funding**



Source: Arnold, E., J. Angelis and R. Nausėdaitė (2016), *A Review of the R&D and Higher Education Funding in Lithuania and Recommendations for Further Actions*.

The three criteria are weighted differently according to different fields of science. In 2016, institutional (including performance-based) funding for research in HEIs and PRIs amounted to approximately EUR 75.4 million, of which 62% were allocated to R&D activities and 38% to cover maintenance and administrative costs.

Additional sources of funding for public research institutions are grants awarded by the Lithuanian Research Council (LMT). The Lithuanian Agency for Science, Innovation and Technology (MITA), provides funding for innovation vouchers and other types of project-based funding to support industrial and social applied research. Some concerns have been raised about the practice of relying excessively on national experts for the evaluation of research project proposals (Paliokaitė, 2015; Arnold and Angelis, 2015). These studies suggest that a more systematic involvement of international experts would reduce the risk of potential conflicts of interest, which tends to be higher in small countries with a relatively small research and academic community.

This shift towards performance-based and competitive funding reflects a trend observed in OECD countries over recent decades (Arnold, Angelis and Nausėdaitė, 2016). There is no "ideal" balance between institutional and competitive/performance-based funding (see OECD, 2016b). It has to be noted, however, that institutional funding provides a basis for strategic planning of long-term and possibly risky research activities and for the development of large-scale research infrastructure that typically cannot be financed through short-term grants. Instead, too much performance-based funding may in

practice steer researchers towards short-term research output and less risky research activities in order to maximise those research output indicators taken into account in the performance evaluation mechanism. On the other hand, too little or no performance-based funding may discourage HEIs from supporting excellence in research and innovation.

Assessment of Lithuania's research output

External assessments of the Lithuanian research system have been performed twice in the past (Arnold and Angelis, 2014). The first of these assessments was performed by the Research Council of Norway, from 1995 to 1996, with the second done by the World Bank in 2007. These evaluations made recommendations to improve the system and placed particular emphasis on international co-operation, doctoral training and research co-operation within Lithuania. Numerous observations and recommendations were also given in relation to the size and overall structure of the research system. Since the mid-1990s many changes have been introduced. Universities are now more involved in research. Increasingly research articles are published in English; grants to support researchers in doctoral programmes and the participation of researchers in international conferences have been created; workshops and seminars take place regularly; universities have more freedom to increase the salaries of their staff; and knowledge transfer and the creation of spin-offs have been supported with the creation of technology transfer offices and science and technology parks (STP) around the main universities and research institutes. However some of the problems highlighted in these past evaluations still remain: institutional fragmentation is still high, the co-operation within and between universities is still problematic, and linkages with the business sector are still weak. In addition, regular evaluation cycles of the public research system still need to be fully implemented.

Partly to address this issue, during 2014 to 2015, a Research Assessment Exercise concentrating on Lithuanian research was conducted by the Research and Higher Education Monitoring and Analysis Centre (MOSTA) in consultation with the Research Council of Lithuania And the Ministry of Education and Science. Nine panels of international experts assessed Lithuanian research covering the following thematic areas: agriculture, biomedicine, biological sciences, social sciences and technological sciences. The panel assessed the groups based on five dimensions:

- scientific/research quality and impact
- economic and social impact in Lithuania
- infrastructure
- research management
- development potential.

Research in Lithuania was assessed from average to good (Arnold and Angelis, 2015) according to international standards on a scale ranging from 1 (lowest score) to 5 (highest score). Biological and physical sciences obtained the highest score (Table 4.6). However, the social sciences show lower quality if compared to international counterparts. These results appear to be related to the fact that these disciplines were neglected before independence and they over-focus on nationally specific topics and publications. The research infrastructure has received relatively good ratings. This is not surprising, as during the 2007-14 EU Structural Funds programming period Lithuania invested considerably in order to improve the research infrastructure of universities and research centres. However, the assessment highlighted how the issue of the maintenance and

renewal of this infrastructure has not been addressed yet. Additional concerns are related to the need for training researchers and students to use the newly developed research infrastructure in the most effective way.

Table 4.6. **Mean score of the Research Assessment Exercise by discipline (scale from 1 to 5)**

	Agriculture	Biological sciences	Medical sciences	Humanities	Physical sciences	Social sciences	Technological sciences
Overall score	2.6	3.2	2.9	2.9	3.0	2.2	2.6
Quality	2.6	3.0	3.3	3.0	3.0	2.2	2.5
Economic and social impact	3.1	3.5	3.0	3.1	3.1	2.7	2.9
Infrastructure	3.3	3.5	2.9	3.2	3.2	2.7	2.8
Research management	2.6	2.7	2.9	2.7	2.8	2.2	2.6
Development potential	3.0	3.2	3.3	2.9	3.3	2.4	2.7

Source: Arnold, E. and J. Angelis (2015), *Research Assessment in Lithuania: Lessons for the National Research System*.

In addition to scoring individual research fields, the Research Assessment Exercise made a number of overarching conclusions on the Lithuanian research system. The experts noted that there is a general lack of strategic approach to set research priorities in research institutions: researchers do not appear to be bound to national research strategies and often are not able to identify their comparative strengths. The lack of a strategic approach in research institutions has repercussions on the ability of Lithuanian researchers to establish collaboration with companies as the latter are often unable to identify areas of strength in research institutions and as a consequence do not establish collaboration (Arnold, Angelis and Nausėdaitė, 2016).

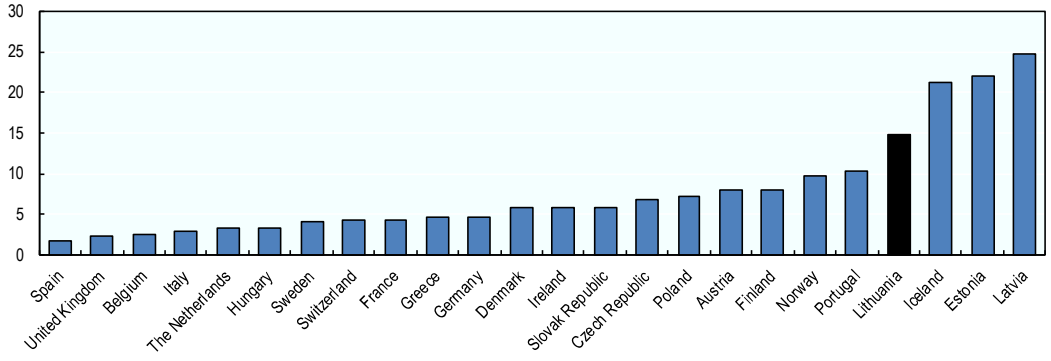
The international experts highlighted the insufficient resources allocated to research activities: Lithuania relies too much on European funding that will inevitably decrease over the years, as opposed to national resources. Another weakness is related to the insufficient degree of international openness of Lithuanian research. Connecting domestic researchers to global science and research networks is crucial to increasing the quality of research, even more so for countries lacking critical mass, like Lithuania. Encouraging internationalisation and research periods abroad, promoting publications in international high-quality journals and in English are all means to strengthen international linkages in science and research. Another crucial aspect highlighted by the assessment is the need to attract more foreign researchers (and students) to Lithuania. The 2015 annual review of the science system (MOSTA, 2015) arrived at similar conclusions and recommended the Lithuanian government to:

- improve and increase the system of competitive research funding moving towards EU standards
- improve the training and careers of researchers
- create stronger science and technology (S&T) links with foreign institutions
- improve management and strategic planning skills in universities and research centres.

The experts also highlighted the high degree of fragmentation of the Lithuanian research system: they reported a too large number of research institutions relative to the

small size of the country. In fact, Lithuania has a higher number of HEIs than larger research-intensive countries, such as Sweden, Switzerland or Denmark and a higher number of HEIs per million inhabitants than in most European countries, with the exception of the two other Baltic countries, Latvia and Estonia, and the geographically exceptional Iceland (Figure 4.15). As a consequence of this fragmentation of actors, the experts reported relatively small investments in research, resulting in small research units, duplication of research themes and little co-operation among research institutions as a result of increasing competition for funding at national level. They suggested to merge or to promote closer co-operation between some of the research units. The complexity of the HEI system is not a new issue and has been previously highlighted by an evaluation committee of the European Science Foundation in its 2014 institutional evaluation of the Research Council Lithuania (LMT), not only in terms of number of actors but also of complexity of funding streams (European Science Foundation [ESF], 2014). In addition, Arnold and Angelis (2016) point out that the current funding system for education (through vouchers) and research, by promoting competition, does not provide sufficient incentives for the consolidation of, or even collaboration between, institutions or research teams.

Figure 4.15. **Number of HEIs per million inhabitants in selected European countries**



Universities

In 2015 there were a total of 22 universities operating in Lithuania: 14 public universities and eight private universities (Table 4.7). As highlighted in the previous section, for a country of 2.9 million inhabitants that is a very large number of universities, compared to other small EU countries with a similar or larger number of inhabitants. In 2009 a total of 1 200 degree programmes were offered by Lithuanian colleges and universities for a total of 200 000 students.[9] In 2014-15 the number of students dropped to 140 000 while the number of study programmes increased to 1 800. Both numbers illustrate the fragmentation of the HEI sector.

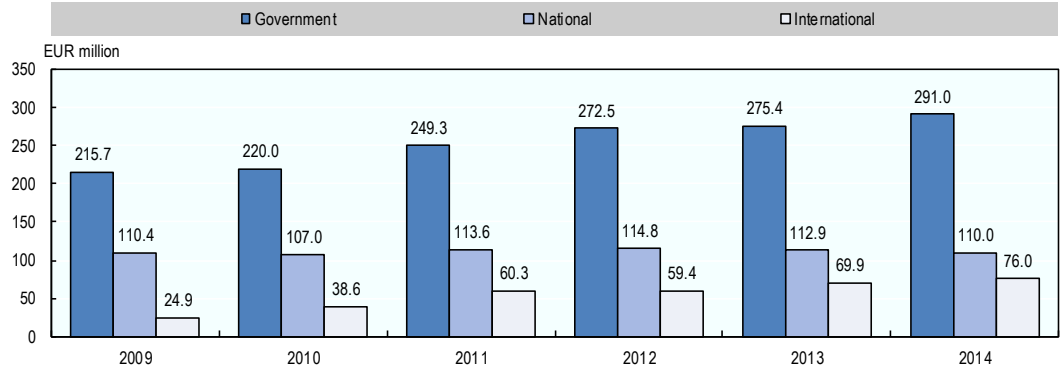
Universities are primarily funded by the Ministry of Education and Science, which receives funds from the government as part of the annual budget allocation. The funding of universities has been growing over time (see Figure 4.16 and Table 4.8 for the evolution of budgets and other key figures for the main universities in the country). In 2013, approximately 60% of the university funding came from the government, 25% from other domestic sources (such as private non-profit organisations and the business sector) and 15% from international sources (such as European programmes, foreign companies or non-profit organisations). The funding from international sources almost tripled between 2009 and 2013, thanks, primarily, to the increasing reliance on European funding.

Table 4.7. **Lithuanian universities**

Name	Type	Location
Aleksandras Stulginskis University	Public	Kaunas
European Humanities University	Private	Vilnius
ISM University of Management and Economics	Private	Vilnius
Kaunas University of Technology	Public	Kaunas
Kazimieras Simonavicius University	Private	Vilnius
Klaipeda University	Public	Klaipeda
LCC International University	Private	Klaipeda
Lithuanian Music and Theatre Academy	Public	Vilnius
Lithuanian Sports University	Public	Kaunas
Lithuanian University of Educational Sciences	Public	Vilnius
Lithuanian University of Health Sciences	Public	Kaunas
Mykolas Romeris University	Public	Vilnius
Šiauliai University	Public	Šiauliai
Telšiai Bishop Vincentas Borisevicius Priest Seminary	Private	Telšiai
The Faculty of Economics-Informatics of the University of Bialystok in Vilnius	Private	Vilnius
The General Jonas Zemaitis Military Academy of Lithuania	Public	Vilnius
Vilnius Academy of Arts	Public	Vilnius
Vilnius Gediminas Technical University	Public	Vilnius
Vilnius St. Joseph Seminary	Private	Vilnius
Vilnius University	Public	Vilnius
Vilnius University International Business School	Private	Vilnius
Vytautas Magnus University	Public	Kaunas

Source: Ministry of Education and Science.

Figure 4.16. **Funding allocated to universities, trends over time**



Source: MOSTA (2014), *Lietuvos švietimas skaičiais 2014. Studijos*, www.mosta.lt/images/leidiniai/Lietuvos_svietimas_skaiciais_2014_Studijos.pdf.

Many universities, including the largest university in the country, Vilnius University (Box 4.2), provide study programmes in several different study areas. Other universities are more specialised, such as Kaunas University of Technology (KTU) (Box 4.3) and the Vilnius Gediminas Technical University, in the field of physical and technological sciences, or the Lithuanian University of Health Sciences in the biomedical field.

Box 4.2. **Vilnius University**

Vilnius University is the oldest and currently the largest Lithuanian higher education institution. The university's importance to the Lithuanian higher education system is highlighted by the fact that it attracts the largest number of students (18 900, 23% of them at postgraduate level) and receives the highest amount of government funding for its activities (EUR 243 million). During the academic year 2015-16 Vilnius University had approximately 3 670 staff.

Vilnius University has 12 faculties, seven institutes, two university hospitals and four interfaculty centres of study and research. Each of the faculties focuses on different fields of education: sciences, medicine, humanities and social sciences. Its faculties and other academic units offer more than 70 bachelor and 115 master study programmes. While the faculties fulfil their role of education, research institutes and research centres focus on the university's research activities. The total budget for research is growing continuously: between 2009 and 2014 it increased from EUR 29.2 to EUR 78.5 million.

The university's Technology Transfer Office was created in 2013 and as of 2015 had a budget of EUR 160 000, 70% of which were financed by the ESF. Since its creation it has concluded 24 licensing agreements and as of 2015 had three permanent staff members.

Vilnius University has signed more than 130 bilateral co-operation agreements with universities in 41 countries, a third of which are with European universities. In addition, over 800 agreements have been signed with 430 universities in Europe and 55 agreements with universities in partner countries concerning academic mobility within the framework of the Erasmus+ programme (approximately 900 foreign students from more than 70 countries come to study at Vilnius University every year). In 2015 over 500 courses were taught in a foreign language.

Vilnius University participates in numerous national and international research projects and organisations such as the EU Seventh Framework Programme, Horizon 2020, COST, EUREKA and CERN. To enhance the interrelations between science and business, Vilnius University has established four open access centres aimed at providing access to research and laboratory equipment not only to students and researchers but also to representatives of business or to personnel of other institutions of science and research.

Institutes of Vilnius University

- The Institute of Applied Research is responsible for fundamental and applied research works in the fields of semiconductor materials and optoelectronics. The institute also focuses on training highly qualified specialists in the field of physics.
- The Institute of Biochemistry focuses on research of the biochemical and genetic principles of cell functioning (biocatalysis and cell regulation), designing and developing biosensors and synthesis of biologically active compounds.
- The Institute of Biotechnology focuses on the field of molecular biotechnology that includes nucleic acid and protein technologies, bioinformatics, molecular diagnostics, drug design, and next generation epigenomic and gene editing technologies.
- The Institute of Mathematics and Informatics is pursuing long-term research related to the economy of Lithuania and international co-operation.
- The Institute of Theoretical Physics and Astronomy investigates atoms, subatomic particles, molecules and their structures and plasma spectroscopy in their application in nanophysics and astrophysics. The institute also carries out research on the structure and evolution of the galaxy, stars and interstellar matter.

Box 4.2. **Vilnius University** (*continued*)

Study and research centres of Vilnius University

- The Centre of Oriental Studies focuses on providing knowledge about Asia and the Middle East within Vilnius University and at national level.
- The Religious Studies and Research Centre focuses on research about the situation of religion both in the national and international context.
- The Centre for Gender Studies conducts interdisciplinary academic research on women and gender.

Sources: www.vu.lt/en (accessed in June 2016); data provided to the OECD Secretariat by the Ministry of Education and Science of Lithuania.

Of the state universities three institutions emerge as the recipients of the highest amount of public funding. Vilnius University – the largest and oldest university in Lithuania – ranks first in terms of R&D funding, receiving nearly the same amount as the second and third recipient universities combined (Table 4.8). These two universities are the Lithuanian University of Health Sciences and Kaunas University of Technology. The Lithuanian University of Health Sciences is one of the few institutions which train doctors in Lithuania. KTU is an important university in terms of its R&D activities. The same holds true for the university ranked 4th on the list, Vilnius Gediminas Technical University. The government of Lithuania has placed great emphasis on the Lithuanian Valleys initiative and the funding for the universities reflects this. All the HEIs which are ranked among the top recipients of government funding are involved in the Lithuanian Valleys initiative and are either among the main academic partners or host the centre for the initiative's activities.

The main universities are also the main recipients of the competitive project-based funding for research allocated by the Research Council of Lithuania: in 2015 the University of Vilnius received approximately EUR 5.8 million, followed by the Kaunas University of Technology (EUR 2.1 million), the Lithuanian University of Health Sciences (EUR 1.2 million), and Vytautas Magnus University (EUR 1.24 million) (data provided by the Research Council, Lithuania). Vilnius University is also the institution attracting the highest amount of European Framework grants, followed by Kaunas University of Technology, Vilnius Gediminas Technical University and the Lithuanian University of Health Sciences (Leichteris et al., 2015).

In general, universities in Lithuania require higher entering scores than colleges. Also, the average entering scores for state-funded and non-state-funded study programmes vary significantly depending on the type of HEI. In 2014, biomedical sciences, arts and physical sciences in universities attracted students with the highest entering scores (Technopolis, 2015).

Box 4.3. **Kaunas University of Technology (KTU)**

KTU is one the largest universities of its kind in the Baltic region, with a total budget of more than EUR 62 million in 2015. KTU engages in all three cycles of higher education studies and awards bachelor's, master's, and doctoral degrees. In the academic year 2015-16 approximately 10 000 students were enrolled at KTU, 27% of whom were master's and PhD students. The primary domains at KTU are technological sciences, physical sciences, social sciences, humanities, biomedical sciences and arts.

R&D is an important part of KTU's activities. The total budget for research was almost EUR 46 million in 2014 and was largely financed by the government. Approximately 44% of funding was received on a competitive basis. In 2013 KTU's senate approved a resolution that outlined the five priority research areas of the university. These research areas seek to contribute to the solution of important challenges for the business sector, the R&D sector and the state. The research priorities of KTU are:

- diagnostic and measurement technologies
- new materials for high-technology
- smart environments and IT
- sustainable growth and socio-cultural development
- technologies for sustainable development and energy.

KTU is known for its increasing co-operation with business. In recent years it has adopted a flexible interdisciplinary approach to developing and adapting its study programmes to better meet the needs of its business partners and the university's increasing focus on R&D activities, which are strongly promoted among students.

In 2015 the Technology Transfer Office, created in 2012, consisted of 16 people and had a total budget of approximately EUR 640 000 (at least 50% of which is financed by European funding). Since 2012 it has concluded 19 licensing agreements (four in 2015) and had 422 contracts between business and researches in 2015.

KTU is involved in important national and international projects. A major part of current R&D activities are related to Santaka Valley, which was established on KTU campus in 2014. Santaka Valley was founded by Kaunas University of Technology in collaboration with academic partners (the Lithuanian University of Health Science and the Lithuanian Energy Institute), business partners (Achema Group, UAB MG Baltic Investment and AB Kauno tiltai) and other S&T institutions (KTU Regional Science Park, Technopolis and Kaunas High-Tech and Information Technology Park).

Sources: http://ktu.edu/en; data provided to the OECD Secretariat by the Ministry of Education and Science of Lithuania.

There is no long-standing tradition of benchmarking universities in Lithuania in terms of research and innovation outputs. For this reason it is difficult to assess individual universities' output performance over time. University rankings offer one possibility for international comparison. These rankings differ according to the specific indicators and weights they apply, in most cases for measuring education and research activities, and they vary accordingly. In many cases they tend to look at average indicators for the whole university and are therefore ill-suited to identify high-performing research teams or laboratories within a single institution. Nevertheless, they can provide some indications on the relative performance of universities. Comparing several published international

university rankings it clearly emerges that Vilnius University is the strongest performing university in the country, which may also be due to its larger size (Table 4.8). However, it is at best a moderate performer in the overall European context.

Table 4.8. **Leading universities in Lithuania – key data**

	2010	2011	2012	2013	2014	2015
Vilnius University						
Total budget (EUR million)	107.10	131.22	163.03	168.91	199.14	242. 92
Budget for research (EUR million)	37.10	55.10	70.30	60.20	78.50	..
Total number of students	20 211	19 561	19 368	18 974	18 937	18 903
Total number of researchers	2 070.56	2 084.76	2 030.38	2 113.82	2 094.53	..
Number of national patents	1	2	12	3	7	11
Number of publications	1 230	1 308	1 104	1 110	1 176	..
Number of publications with foreign co-author	230	249	288	272	317	..
Kaunas University of Technology						
Total budget (EUR million)	53.60	57.10	78.30	60.00	65.60	62.30
Budget for research (EUR million)	35.38	37.74	43.82	56.85	45.89	..
Total number of students	13 843	13 204	12 006	10 916	10 848	10 490
Total number of researchers	1 169	1 202	1 197	1 176	1 117	..
Number of national patents	5	7	5	8	9	12
Number of publications	569	634	346	457	433	..
Number of publications with foreign co-author	31	58	65	69	79	..
Lithuanian University of Health Sciences						
Total budget (EUR million)	40.37	48.49	52.95	57.35	67.42	65.75
Budget for research (EUR million)	25.89	29.80	33.63	37.00	42.45	..
Total number of students	6 936	7 290	7 628	7 753	7 856	7 983
Total number of researchers	925	879	1 342	1 306	1 348	..
Number of national patents	0	0	0	0	0	0
Number of publications	99	123	174	193	268	..
Number of publications with foreign co-author	59	71	66	93	121	..
Vilnius Gediminas Technical University						
Total budget (EUR million)	Approx. 40	Approx. 40	Approx. 40	Approx. 40	Approx. 40	Approx. 40
Budget for research (EUR million)	11.23	17.73	18.41	17.64	17.05	..
Total number of students	13 758	12 603	11 628	10 577	10 440	10 209
Total number of researchers	827	826	787	748	699	..
Number of national patents	11	13	9	7	9	11
Number of publications	446	444	177	299	274	..
Number of publications with foreign co-author	7	15	26	64	54	..
Klaipeda University						
Total budget (EUR million)	14.52	20.83	22.62	23.91	27.19	26.98
Budget for research (EUR million)	4.48	10.48	11.97	13.65	17.16	..
Total number of students	7 412	6 894	6 294	5 417	4 897	4 370
Total number of researchers	546	555	548	441	470	..
Number of national patents	0	0	0	0	1	0
Number of publications	499	578	331	319	368	..
Number of publications with foreign co-author	13	25	29	20	39	..

Note: .. = data not available.

Source: Data provided to the OECD Secretariat by the Ministry of Education and Science of Lithuania.

In the Webometrics Ranking of World Universities[10] Vilnius University emerges as the first Lithuanian university, ranking 305th out of a total of 6 050 European HEIs. The second Lithuanian university in this ranking is Vilnius Gediminas Technical University,

ranking 490th in Europe, followed by Vytautas Magnus University in Kaunas (704th), Mykolas Romeris University in Vilnius (790th), Kaunas University of Technology (823rd), the Lithuanian University of Health Sciences, also located in Kaunas (830th), Klaipeda University (858th) and finally Šiauliai University (992nd). The other universities do not appear among the top 1 000 European universities. Vilnius University is the only Lithuanian university on the list of 995 European top universities of the Centre for World University Rankings,[11] and it is also the only Lithuanian university appearing in the Times Higher Education World University Ranking (in the 600-800 bracket) receiving its best scores for international outlook and income from industry rather than research.[12] The CWTS Leiden Ranking 2015, which looks at scientific performance of major universities, does not include any Lithuanian universities.[13] In the European U-multirank platform Vilnius University is positioned considerably below the median of universities included in the ranking in terms of citation rates or top-cited articles.[14]

The picture emerging from these ranking is consistent with a recent benchmark of HEIs (Technopolis 2015) which notes the moderate research activity of Lithuanian universities. This study identify Vilnius University, Vytautas Magnus University and Kaunas University of Technology as the only universities in the country performing extensive research activities in many different fields. Vilnius Gediminas Technical University, the Lithuanian University of Health Sciences and Mykolas Romeris University, instead, perform research activities in specific areas: technological sciences, biomedical sciences and social science respectively.

Colleges

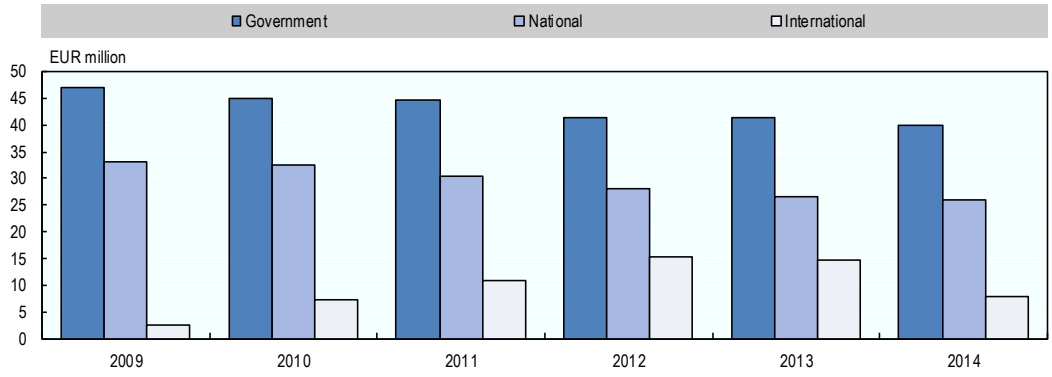
The other channel for tertiary education in Lithuania is colleges, which were established by a reform in 2000. Colleges offer more practical and professional education and are mainly oriented to teaching based on professional practice. Colleges specialise in applied tertiary education and knowledge transfer activities and in most cases do not perform research activities (see Box 4.4 for an example). Lectures remain a major part of the tertiary education programmes of colleges. However, as Lithuanian colleges often have closer ties with businesses than universities, college students generally have many options for internships. As of 2015 Lithuania had 24 colleges of which 13 were public HEIs and 11 were private.

The main source of funding for colleges is institutional funding by the government (Figure 4.17). National funding for colleges has slowly but steadily decreased since 2009, while international (largely European) funding has grown steadily. The evolution of the structure of funding is similar to that for universities. This highlights the importance of European funding for the Lithuanian higher education and research system.

PRIs

After the adoption of the 2009 Law on Higher Education and Research, the research institute landscape was restructured. Until 2010, Lithuania had 18 university research institutes, 17 state research institutes, and 11 other research institutions. As a result of the restructuring, 13 state research institutes were created. In addition there are nine non-state research institutes.[15] The research institutes cover a broad range of research fields and play a role in various national research strategies and policies. Table 4.9 presents an overview of the main PRIs in Lithuania.

Figure 4.17. **Funding sources of colleges in Lithuania**



Source: MOSTA (2014), *Lietuvos švietimas skaičiais 2014. Studijos*, www.mosta.lt/images/leidiniai/Lietuvos_svietimas_skaiciais_2014_Studijos.pdf.

Box 4.4. **Klaipeda State College (KSU)**

KSU is the third largest university of applied sciences in Lithuania, with a strong academic reputation. KSU is mainly focused on study programmes leading to a professional bachelor degree. The studies are practice-oriented which means that students are trained to successfully apply their knowledge in a real working environment.

KSU consists of three faculties: the Faculty of Social Sciences, the Faculty of Technologies and the Faculty of Health Sciences with approximately 4 000 students and 270 teachers and lecturers.

KSU has four "business practical learning enterprises" (BPLE) where students can simulate the activities of real business companies. This helps students to gain valuable experience for solving problems and applying their knowledge in real working condition by using "real" financial documents, agreements, tax tariffs, applying legal acts and foreign currency exchange rates. BPLE departments include human resources, purchase, sales and marketing, and finance and accounting.

KSU also collaborates with a number of educational institutions in different countries. It has an Erasmus University Charter (EUC) and is an active participant in the Erasmus+ programme.

Sources: www.studyinlithuania.lt/en/institutions/klaipedastatecollege (accessed in June 2016); data provided to the OECD Secretariat by the Ministry of Education and Science of Lithuania.

Another source of funding is funds awarded through calls for tender by the Research Council of Lithuania (LMT) for research programmes administered by LMT and by MITA. According to data from LMT the research institutes which attracted the largest amount of funding from LMT in 2015 were the Centre for Physical Sciences and Technology (EUR 1.2 million) and the Nature Research Centre (EUR 0.7 million). The Centre for Physical Sciences and Technology and the Lithuanian Energy Institute were the largest recipients of European grants during the 7th Framework Programme.

The number of PhDs awarded by Lithuanian PRIs has been fluctuating over time. The field of science in which they have awarded most PhDs are physical sciences, agrarian sciences, biomedical sciences and humanities (Figure 4.18).

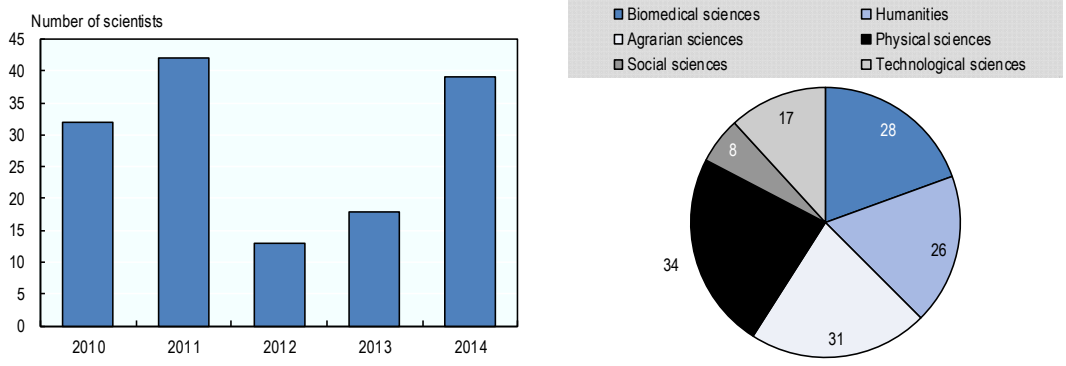
Table 4.9. **Leading PRIs in Lithuania – key data**

	2010	2011	2012	2013	2014	2015
Centre for Physical Sciences and Technology						
Total budget (EUR million)	8.04	9.72	14.03	18.06	18.60	17.40
Budget for research (EUR million)	6.38	15.5	13.7	17.8	12.1	..
Total number of students	44	53	51	58	65	70
Total number of researchers	323	389	431	471	475	..
Number of national patents	5	7	5	8	10	2
Number of publications	112	108	152	157	147	..
Number of publications with foreign co-author	64	51	67	62	59	..
Lithuanian Energy Institute						
Total budget (EUR million)	6.59	7.38	6.75	6.48	4.88	5.30
Budget for research (EUR million)	5.13	6.66	5.21	5.61	3.71	..
Total number of students	27	28	23	20	25	30
Total number of researchers	214	215	207	204	197	..
Number of national patents	0	1	0	0	2	1
Number of publications	36	45	48	45	63	..
Number of publications with foreign co-author	5	2	6	3	10	..
Lithuanian Research Centre for Agriculture and Forestry						
Total budget (EUR million)	6.97	9.60	10.10	10.00	9.70	10.50
Budget for research (EUR million)	4.16	6.16	6.24	5.45	5.81	..
Total number of students	35	39	48	56	56	52
Total number of researchers	362	354	326	347.61	334	..
Number of national patents	0	0	0	0	0	..
Number of publications	12	34	56	60	59	..
Number of publications with foreign co-author	4	11	38	21	13	..

Note: .. = data not available.

Source: Data provided to the OECD Secretariat by the Ministry of Education and Science of Lithuania.

Figure 4.18. **Number of scientists that gained their PhD degrees in Lithuanian PRIs by year and by field**



Source: Statistics Lithuania (2015), *The database for statistics indicators: number of doctoral awards in research institutes* (database), www.stat.gov.lt/en.

In many OECD countries, applied PRIs – especially research and technology organisations (RTOs) which play an important role as "connectors" in value chains and innovation eco systems (EARTO, 2014) – have a clear mission to work for industry or

societal actors. They are typically obliged to generate a considerable share of their research income from business sector partners. Lithuanian research centres largely rely on public funding. The Centre for Physical Sciences and Technology (Box 4.5), one of the country's leading research institutes, together with the Lithuanian Energy Institute (Box 4.6), has established strong international links and works with business partners. Yet only 16% of its 2015 income comes from private sector contracts. The Lithuanian Energy Institute shows a similar pattern, with 16% of its 2014 income coming from Lithuanian industry and 3% from foreign companies. Both institutes are very dependent on contributions from Structural Funds and need to prepare for a reduction of that source of income in the medium term. Lithuania is taking the appropriate steps.

Box 4.5. **The Centre for Physical Sciences and Technology (FTMC)**

The FTMC in Lithuanian is one of the largest scientific research institutes in Lithuania. The centre operates in the fields of laser technology, optoelectronics, nuclear physics, organic chemistry, bio and nanotechnologies, electrochemical material science, functional materials and electronics. It is equally focused on science innovation and high technologies and also responds to the needs of businesses and society through research.

The FTMC was established in 2010 through the merging of the institutes of chemistry, physics and semiconductor physics in Vilnius. In 2012, following a government resolution the Lithuanian Textile Institute in Kaunas was affiliated with FTMC. In recent years through the combination of different strands of science the FTMC has become one of the leading scientific institutions in the country and carries out fundamental, applied and experimental research. According to its 2015 annual report, in 2015 FTMC had a total budget of EUR 23.5 million, of which 34% were from Structural Funds, 26% from the Lithuanian government, 17% from international projects which include FP7 projects and projects funded through bilateral S&T programmes (particularly with the Swiss government), and 16% from contracts with companies.

FTMC unites leading Lithuanian researchers and is equipped with modern laboratory facilities. The results of FTMC's scientific research and the technologies that are developed at the FTMC are shared at international level. The centre hosts PhD studies and post-doctoral fellowships and trains researchers to carry out independent research. In 2015, 38 habilitated doctors of science, 246 doctors of science, more than 500 researchers and 60 PhD students were working at FTMC. The total budget for research in 2014 was EUR 12.1 million, including 90% in government institutional funding. The total number of publications produced at FTMC exceeded 200 in 2015 and approximately 50% of these were published in top-quartile journals.

In the development of new technologies and innovative devices FTMC has co-operates with scientists from many countries, among which are France, Germany, Great Britain, Scotland, Poland, Chinese Taipei, the United Kingdom and the United States on joint research projects. FTMC and its researchers are members of various international organisations: the European Photonics Industry Association (EPIC), the Optical Society of America (OSA) and e Laser Institute of America (LIA).

The FTMC has a number of open access centres and S&T parks which actively contribute to the commercialisation of research results: the open access centre of electronic microscopy, X-ray diffractometry and spectrometry; the open access centre of processing technologies (BALTFAB); the S&T park of the Institute of Physics and the Park of S&T. The Technology Transfer Office was established in March 2015, has nine permanent staff members and is 100% financed by FTMC.

Sources: FTMC (2015), *Centre for Physical Sciences and Technology, Annual Report 2015*, www.ftmc.lt/en/science/FTMC_Annual_Report_2015.pdf; data provided to the OECD Secretariat by the Ministry of Education and Science of Lithuania.

The commercialisation of public research is high on Lithuania's science, technology and innovation (STI) agenda. Where there is a need (mainly in the areas of physics and technology), most higher education and research institutes have recently established technology transfer offices. In addition, public research laboratories and infrastructure are "open access" centres available to companies and citizens on demand. However, to promote collaboration with the business sector and society more broadly, there is a need for a customised approach. This is because opportunities to work with business and particular societal stakeholders differ depending on the scientific domain and the sector concerned. As with business innovation support programmes, a more demand-driven approach requires thorough analysis of the demand side and of the propensity of specific stakeholders to engage with PRIs at various stages, including in co-development.

A change in direction would require a clear restatement of the mission of these institutes with a strategy and an incentive system that gradually moves them towards achieving greater socio-economic impact. The experience from other countries also shows that this process takes many years to establish and cannot be expected to happen quickly.

Box 4.6. **The Lithuanian Energy Institute (LEI)**

The LEI is one of the oldest scientific institutes operating in Lithuania. In 1948 the Lithuanian Academy of Sciences established the Institute of Technical Sciences, which analysed issues of rational water energy and fuel consumption, metal industry rationalisation and automation of production processes. After a number of reorganisations, the institute was established as the LEI in 1992. The mission of the LEI is the leading institute in Lithuania in the areas of engineering, hydrology, metrology, nuclear safety, environmental protection and economy related to Lithuanian energy.

The LEI has three strategic objectives:

- to perform fundamental and applied research in the fields of thermal physics, hydrodynamics, metrology, safety and reliability of energy objects, materials engineering, hydrology, and processes management
- to develop energy sector planning on a conceptual and methodological basis
- to train specialists for energy and energy-related scientific research.

The number of staff employed in the 11 laboratories of the Institute was 283 in 2014, a slight decline since 2010 when the centre employed 305 staff. The 2014 budget was EUR 4.9 million of which 48% were accounted for by state funding, 8% by structural funds, 13% by competitive government resources, 12% by international projects, 16% by Lithuanian companies and 3% by foreign companies. The budget devoted to research in 2014 was EUR 3.7 million, mainly consisting of government funding.

The Technology Transfer Office was established in 2012 and is fully financed by the government. In 2015, the office signed approximately 70 contracts for services and works of various sizes and three general agreements for co-operation. The LEI participates in various international research projects including those financed through FP7, Horizon 2020, Intelligent Energy Europe and COST.

Sources: www.lei.lt; LEI (2014), *Lithuanian Energy Institute Annual Report 2014*, www.lei.lt/_img/_up/File/atvir/2015/leidiniai/LEI_Annual_Report-2014.pdf; data provided to the OECD Secretariat by the Ministry of Education and Science of Lithuania.

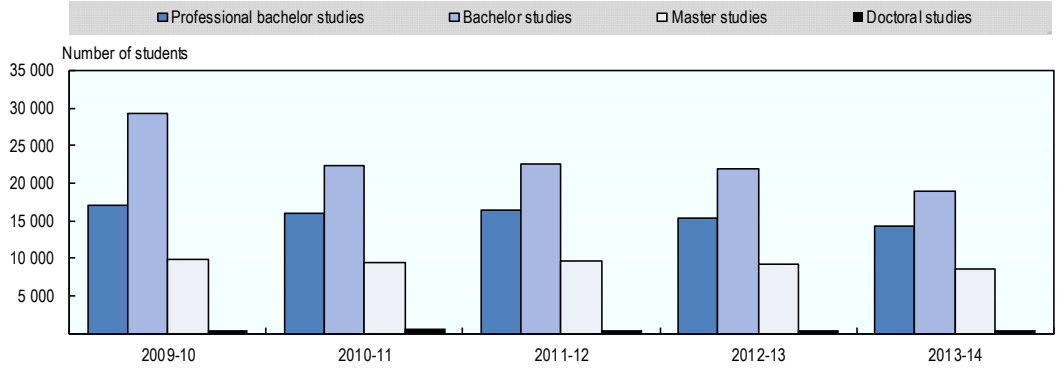
Human resources for STI

Lithuania has an above OECD average number of tertiary education graduates and high levels of students in science, technology, engineering and mathematics (STEM) disciplines. While the number of researchers is on the rise, Lithuania still has to catch up to reach the European average and narrow the gap with innovation-intensive countries. However, Lithuania is performing well on gender parity in tertiary education attainment and in R&D personnel.

Overall, the availability of skilled human capital for innovation remains an important concern. The number of students in Lithuanian HEIs has dropped considerably since 2009 at all levels of study programmes, and in all fields of study (Figure 4.19 and 4.20). The largest decrease in enrolled students has been recorded for the bachelor degree level at universities. Between 2009 and 2014 the number of students entering bachelor courses dropped by one-third. Professional bachelor studies and master's degree studies show a smaller decrease. The (low) number of PhD students has remained more or less stable over time. In 2013, the share of PhD students per thousand population aged 25 to 34 in Lithuania was approximately 1.2%, which is almost two times less than the EU average.

Both at universities and colleges the number of students in the humanities, arts, social sciences and physical sciences has declined, with the social sciences suffering the sharpest drop. The only exception is the biomedical sciences, which has recorded some growth in student numbers. Despite the decline in the number of students, the social sciences are leading in terms of student enrolments. Their popularity among young Lithuanians has encouraged HEIs to focus on programmes in social sciences to attract a larger number of students and, as a consequence, higher levels of funding.

Figure 4.19. **The evolution of students enrolling for higher education**

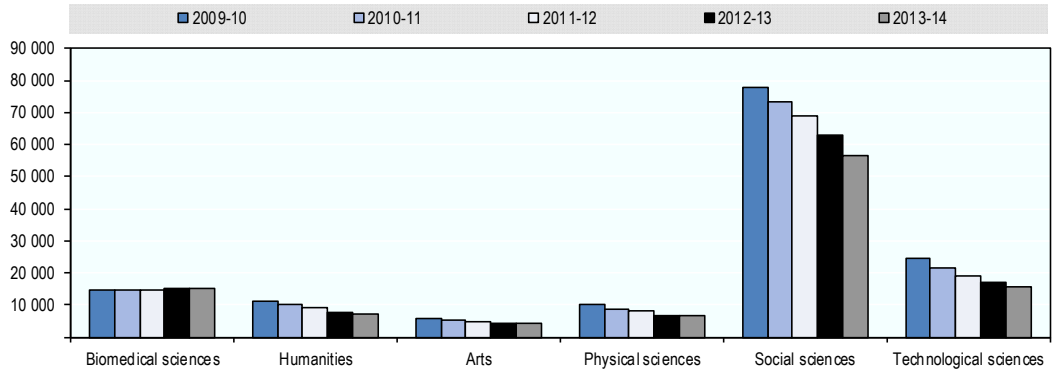


Source: MOSTA (2014), *Lietuvos švietimas skaičiais 2014. Studijos*, www.mosta.lt/images/leidiniai/Lietuvos_svietimas_skaiciais_2014_Studijos.pdf.

The declining number of students reflects demographic trends, exacerbated by the decision of many young and skilled Lithuanians to study and work abroad. On the other hand, only few skilled foreigners decide to come to Lithuania for their studies or work. According to the European Migration Network (2015), Lithuania's emigration rate is one of the highest in the European Union. Around 788 000 people (one-quarter of the population) have left the country since independence in 1990. The share of high-skilled emigrants from Lithuania is higher than from comparable eastern European countries (Figure 4.21). According to MOSTA (2015), the number of Lithuanian students in

European countries more than doubled between 2004 and 2011. The ratio of Lithuanians completing a PhD abroad to foreign PhD students in Lithuania is 10 to 1 (MOSTA, 2014).

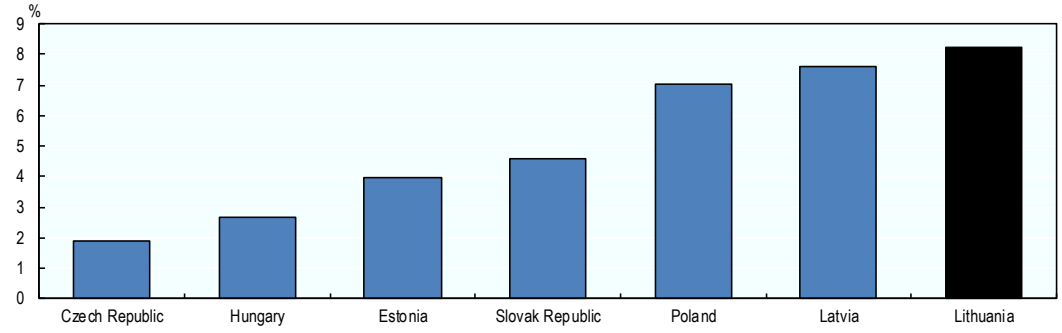
Figure 4.20. **The number of students per study field in Lithuania**



Source: MOSTA (2014), *Lietuvos švietimas skaičiais 2014. Studijos*, www.mosta.lt/images/leidiniai/Lietuvos_svietimas_skaiciais_2014_Studijos.pdf.

Figure 4.21. **Highly-skilled emigrants to OECD countries that have moved in the past ten years (2010-11)**

Percentage of domestic highly-skilled 15+ population



Note: Highly-skilled workers are defined as those with tertiary education.

Source: OECD (2016a), *OECD Economic Surveys: Lithuania 2016. Economic Assessment*, http://dx.doi.org/10.1787/eco_surveys-ltu-2016-en.

Most immigrants to Lithuania are returning Lithuanians. In 2013, Lithuanian nationals accounted for 86% of all arrivals. The increase in returns was due to the improved economic situation in Lithuania. At the same time, the immigration of foreigners to Lithuania remains very low, on average 2 000 to 2 500 people per year (European Migration Network, 2015).

Salaries of early-career researchers are low by international standards, which make Lithuanian public research institutions less attractive for both foreigners and Lithuanians (Technopolis, 2015, Paliokaitė, 2015). According to a survey by Idea Consult et al. (2013), only 30% of researchers are satisfied with their salaries. In addition, low early career salaries have increased the length of time PhD students take to complete their programmes (on average approximately six years): they often teach to augment their

income and devote less time to research activities. The 2009 reform of the higher education system gave public research organisations more flexibility in allocating salaries to researchers. This may have a positive effect on the domestic labour market for researchers in the future.

Given the current trends in human resources for science, technology and innovation (STI), it is not surprising that businesses increasingly report skill mismatches in specific technology fields. For instance, a survey of manufacturing companies (Visionary Analytics, 2014) reported that one-third of the survey respondents lacked engineers, technology designers and project managers needed to carry out innovation activities. Furthermore, cross-country surveys suggest that skill shortages are a more serious constraint to businesses in Lithuania than in other comparable countries (OECD, 2016a). To address this problem, in 2014, the Ministry of Education and Science increased funding for higher education in technology fields, with the aim of encouraging students to choose this path of studies (Paliokaitė, 2015).

Recent studies (e.g. Arnold and Angelis, 2015) highlight the need to increase both domestic and international mobility of Lithuanian researchers, particularly younger researchers. International post-doctoral studies are not very common among Lithuanian researchers, who instead tend to stay in the same institution where they complete their PhD. In this way they miss the opportunity to acquire new skills that mobility programmes provide. Another way to support researchers to develop skills and build international networks would be to encourage sabbatical leave abroad, which is currently uncommon for Lithuanian researchers. Sabbatical leave abroad could be a way of connecting senior researchers with their international peers and strengthening collaboration with research institutions abroad.

Notes

1. Technology purchasing, especially of new machinery and equipment, tends to be mostly related to process innovation, the most frequent type of innovation in firms in developing countries (see Goedhuys and Veugelers (2012) and Arvanitis et al. (2013).
2. Registered industrial design data can be used to proxy firms' creative activities. In Europe, the European Office for Harmonisation in the Internal Market (OHIM) registers industrial designs that are protected in all the EU market. Such records, therefore, may capture the export ambition of creative firms: firms competing only in the domestic market are more likely to register design rights in national offices only.
3. In 2014, Lithuania exported USD 30.3 billion and imported USD 34.5 billion, resulting in a negative trade balance of USD 4.22 billion.
4. The top export destinations of Lithuania are Russia (USD 4.58 billion), Belarus (USD 3.02 billion), Latvia (USD 2.69 billion), Germany (USD 2.07 billion) and Poland (USD 1.61 billion). The top import origins are Russia (USD 7.16 billion), Germany (USD 3.56 billion), Poland (USD 3.09 billion), Latvia (USD 2.31 billion) and the Netherlands (USD 1.64 billion).

5. The revealed comparative advantage (RCA) measures the intensity of trade specialisation of a country within a region or the world. It is the export share of a particular type of industry of the total exports (of goods) of a country divided by the export share of this industry of the region (European Union) or the world. If the RCA takes a value less than 1 this implies that the country is not specialised in exports of this industry. Similarly if the index exceeds 1 this implies that the country is specialised in this industry's exports.

6. According to Bernatonyte (2015) the Lithuanian export basket shows a low level of trade dissimilarity index compared to the EU average. Her study examined trade data from 2007 to 2013.

7. However, structural business statistics (SBS) do not capture the whole economy. SBS cover all activities of the business economy with the exception of agricultural activities and personal services. Taking the whole economy into equation, MNEs would most likely represent lower shares both for Lithuania and for other EU member countries.

8. In some countries referred to as universities of applied sciences.

9. See Ministry of Education and Science (2011).

10. www.webometrics.info/en/Europe, January 2016 edition.

11. cwur.org/2014/europe.html.

12. https://www.timeshighereducation.com/world-university-rankings, 2016.

13. www.leidenranking.com/.

14. www.umultirank.org/#!/home?trackType=home&sightMode=undefined&section=entrance, 2016 update.

15. These PRIs are the following: Lithuanian Research Centre for Agriculture and Forestry; Lithuanian Energy Institute; Nature Research Centre; Institute of the Lithuanian Language; Institute of Lithuanian Literature and Folklore; Lithuanian Institute of Agrarian Economics; Lithuanian Institute of History; Institute of Lithuanian Culture Research; Lithuanian Social Research Centre; Centre for Physical Sciences and Technology; Centre of Innovative Medicine; Institute of Lithuanian Textile; Law Institute of Lithuania; Public Policy and Management Institute; Space Science and Technology Institute.

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Chapter 5.

Innovation policy and governance in Lithuania

This chapter examines public innovation policy and governance in Lithuania. It begins with an overview of the historical evolution of science, technology and innovation policy in Lithuania. It then examines the main policy actors and governance arrangements under the light of observations made in earlier chapters and outlines areas in need of dedicated policy attention.

5.1. The evolution of science, technology and innovation (STI) policy in Lithuania[1]

The first phase (2002-07)

During 2002-07, Lithuania's innovation policy was characterised by ambitious plans to foster high-technology-oriented strategies. At the same time, the plans lacked sufficient commitment and financial investment for implementation. The underlying rationale for the strategies during this period was to achieve cohesion with Europe. The strategies took account of the national context, and recognised critical weaknesses of the innovation system. However, the institutional capacity to build up the evidence base for strategy development was weak at the time. Policies were developed top-down, involving little stakeholder consultation. This may have been one of the reasons why the resulting strategies lacked clear focus, priorities and selectivity, and some of them were not implemented. All this indicated significant weaknesses related to policy governance. Ambitious, sometimes unrealistic objectives and a lack of prioritisation met with a scarcity of resources. Scarce resources were spread across a number of initiatives which tended to be too small to have significant impact. Major research and innovation strategies and policies during 2002-07 are summarised in Box 5.1.

Box 5.1. **Research and innovation strategies and policies during 2002-07**

The **Long-term Strategy on Development of Lithuania** in 2002 was one of the first documents recognising the importance of innovation policy. The strategy highlighted societal goals and three main pillars: knowledge society, secure society and competitive economy. Several measures were planned to target research and innovation, including science and education, administrative capacity, information and communication technologies (ICT) infrastructures and science-industry collaboration.

The **Long-term Strategy of Economic Development by 2015,** prepared in 2002, was foreseen to complement the Long-term Strategy on Development of Lithuania. However, the strategy was never actively implemented. The Ministry of Economy took action in 2007 to revise this strategy with the help of external assistance, but the revised strategy was never approved.

The **Lithuanian Science and Technology White Paper,** prepared in 2001, was the first integrated strategy and vision for research and development (R&D). It recognised that Lithuania already possessed some of the pre-requisites for developing its R&D system (such as pockets of high-level research, potential for industry-relevant applied research, some high-technology products and research-intensive services).

In 2003, the white paper was used as the basis for the **Long-term Research and Development Strategy**. The strategy identified the need to take action in supporting R&D and competitiveness of industry, agriculture, construction and services, to improve the environment for private investments into research; to enable the scientific and business partnerships, high-tech start-ups, use of tax policies, venture capital and European Union (EU) funds; improve the quality of research focusing on the European Research Area, support joint projects with other countries; to establish an effective national innovation system, which guarantees favourable conditions for new technologies and methods of operation, development and diffusion; create a database of statistics on R&D policy. Reaching European innovation practice for science-industry collaboration, increasing gross expenditure for R&D (GERD) to 3% and business expenditures for R&D (BERD) to 2% and increasing high-tech share of gross domestic product (GDP) to 20% by 2010 (in seven years) were the ambitious, yet in retrospective highly unrealistic objectives set in the strategy.

Box 5.1. **Research and innovation strategies and policies during 2002-07** (*continued*)

Lithuanian R&D priorities for 2002-06 were selected in a top-down process. They included:

- research on human quality of life (genomics and biotechnology for health and agriculture; food quality, safe and ecologically clean food technologies, ecosystems and climate change
- research for the knowledge society: information society technologies; citizens and governance in a knowledge society; national identity in the context of globalisation
- research to develop nanotechnology (nanoscience, nanotechnology, multifunctional nanostructured materials
- research and experimental development for nuclear safety in the operation of the Ignalina nuclear power plant operation and decommissioning, radioactive waste management challenges (nuclear safety; radioactive waste management technologies)
- research and experimental development of Lithuanian industry to increase international competitiveness (biotechnology, mechatronics, laser, information and other high technologies).

The World Bank report **"Lithuania Aiming for a Knowledge Economy"** (World Bank, 2003) dealt with reforms and bottlenecks Lithuania was facing. The report's key recommendations were to improve collaboration between business, academia and the public sector, reform public institutions related to the knowledge economy, provide incentives for innovation, learning and networking, support labour market development to address future skill gaps, and strengthen the regulatory framework.

Major programmes during the period 2002-07 included:

The **High-technology Development Programme 2003-06** aimed to support already existing high-tech industry. It focused on:

- biotechnology
- mechatronics
- laser technologies
- information technology (IT)
- nanotechnology and electronics.

There was also a biotechnologies development programme.

The **Innovation in Business Sector Programme 2003-06** sought to promote innovation, increase public awareness of innovation, promote scientific and business community co-operation, improve the environment and support the development of infrastructure

The second phase (2007-13)

Since 2007, R&D and innovation policies have followed EU Structural Funds planning periods as these were the source of a large part of R&D and innovation funding. The period 2007-13 was marked by the EU Lisbon Strategy, which was reflected in the content and objectives of relevant national strategies. Overall, 2007-13 was a period of learning to design policy initiatives and instruments and transparency in policy design (stakeholder consultation), and innovation policy increased.

Science, technology and innovation (STI) policy was characterised by large investments in the research infrastructure. Other notable policy characteristics included efforts to attracting foreign direct investment, promoting exports and creating financial engineering instruments. While the basics of research and innovation policy did not change from the previous period, much more emphasis and resources were devoted to their implementation.

Attempts were made to address the gaps identified already during the earlier period. However, as a number of additional measures were launched, the policy mix became more complex and issues co-ordination increasingly pertinent. Administrative costs incurred by the support schemes were perceived as too high by businesses which led them to apply for less demanding schemes, which in some cases were less effective in reaching the overall policy objectives. Key research and innovation strategies introduced during 2007-13 are summarised in Box 5.2.

Box 5.2. **Key strategies introduced during 2007-13**

The **Economy Promotion Plan 2009-10** was developed by the Ministry of Economy as a response to the economic crisis. As a crisis measure its implementation was made top political priority with key indicators and assigned responsibilities. The plan focused on expanding business financing opportunities (especially with the aid of financial engineering), building energy efficiency (e.g. home renovation), quicker flow of financial resources in the EU Structural Funds national implementation system, better conditions for business environment, investments and export promotion. A public performance measurement system with a scoreboard approach and marketing campaign received positive feedback from the business community. However, many highly ambitious goals were set and were subsequently not reached. The plan was partly separated from the rest of the innovation policy, which created management problems and overlap between different measures, especially with other ongoing programmes implemented by the same ministry. Furthermore, the plan was drawn up quickly and lacked consistency and appropriate indicators. In 2010 the web page for monitoring the plan was closed, an analysis of factors of success and failure was not performed and lessons learned were not fed back into the policy cycle.

The **Lithuanian Innovation Strategy 2010-20** was a reflection of the government's goal to make innovation a top policy priority. Several measures were taken to address co-ordination problems in the national innovation system, and a new co-ordination instrument, the Agency for Science, Innovation and Technology (MITA) was established in 2010. The strategy presented a vision for 2020 highlighting that the Lithuanian economy would be based on high value-added products and services. The main goal was to build a creative society and conditions for the development of entrepreneurship and innovation. Goals were linked to Lithuania's integration into the global market, improving creative and innovative public education, the development of a variety of innovations, and the development of a systematic approach to innovation. The strategy emphasised priority sectors characterised by:

- high value-added and competitive in the international market (e.g. food products and drinks, wood and wood products, textiles, chemical products, transport and logistics)
- advanced and medium-advanced technology industry able to help traditional industry (e.g. biotechnologies, laser technologies, electrical and optical equipment, ICT)
- promising new areas in the economy (e.g. clean technologies and energy, the creative industry, pharmaceuticals, medical and wellness services, medical equipment, ecological food products).

An important focus was put on the development of mechanisms for co-ordination of fragmented innovation measures (mainly through concentrating efforts within MITA) and on the reform of research institutes. The strategy also emphasised the need for periodic evaluation of reforms and proposed to measure progress according to the results of the EU Innovation Scoreboard.

Overall, the lack of a systemic approach to research and innovation policy was evidenced by the prevailing policy mix. Innovation policy had a pronounced technology-push orientation which was driven mainly by scientific interests and ambitions in the area of high-technology. While this reflected the needs of a small number of typically R&D-intensive high-technology enterprises, it hardly addressed those of the majority of industry and the economy at large. Furthermore, several programmes targeted more or less the same target groups leading to overlapping or competing schemes which were likely to lead to inefficiencies.

There seemed to be an issue of intertemporal coherence. Long-term R&D investment requires predictability and is often put on hold or undone if uncertainties become too high. Managing the transition between programming periods is therefore an important issue and prolonged gaps are likely to reduce trust in the policy commitment of government. The launch of new measures for the new Structural Funds Operational Programme 2014-20 showed a similar gap in time. Key research and innovation policy programmes during 2007-13 are summarised in Box 5.3.

Box 5.3. **Key policy programmes during 2007-13**

The **"Valleys" programme 2007-13** started as a joint initiative between the Ministry of Education and Science and the Ministry of Economy. The attempt was to improve co-ordination between these ministries and to complement the previous top-down process with bottom-up stakeholder consultation. As the goal was to build the Valleys around strong centres of scientific excellence, universities were seen as the main stakeholders. Although the "Valley" concept foresaw mandatory consultations with other stakeholders, business showed little interest and was reluctant to engage in complex procedures. The programme eventually focused on the needs and interests of universities. The Valleys Programme, which led to the launch of five Valleys in 2007-08, had a pronounced technology-push orientation. It was complemented by the objective to develop a favourable environment for R&D-intensive businesses, which was reflected in eight national programmes focusing on R&D-intensive businesses, knowledge transfer, clusters, etc. Most of these other instruments included further infrastructure investment or focused on R&D-intensive businesses and science-industry knowledge transfer, thereby enhancing the technology-push approach rather than complementing it with an orientation towards industry or market needs. In 2009, the **Innovation in Business Programme 2009-13** was launched based on evaluation of its predecessor in 2003-06. It was prepared by the Ministry of Economy and aimed at the promotion of an innovation culture. The new programme aimed at encouraging innovative business, increasing innovative and high-tech and medium-high-tech enterprises in industrial and service sectors and promoting exports. Measures were aimed at increasing efficiency of innovation support institutions and capacity of human resources.

The **High-technology Development Programme 2007-2013** was launched to continue the previous programme from 2003-2006. Although it was partly overlapping with "Valleys" and other programmes, the priority areas remained the same: biotechnology, mechatronics, laser technologies, information technologies, nanotechnologies and electronics. The programme was complimented with **Industrial Biotechnology Programmes** during **2007-10** and **2011-13**. In 2014 Lithuania joined the European Space Agency as a co-operating state. Despite the community of dedicated companies and researchers, the **National Research, Technology and Innovation Programme for Space 2010-15** faced issues of implementation and funding.

While one of the original objectives of R&D and innovation policies during 2007-13 was to address the science-industry gap, the initiatives eventually launched largely failed to achieve this goal. However, as this period also saw the introduction of financial

support measures for business R&D and innovation, the seeds for a more balanced R&D and innovation policy were planted. Instruments such as small and medium-sized enterprises' (SME) innovation vouchers encouraged a larger number of companies to seek collaboration with public research organisations.

While the financial instruments introduced for business R&D and innovation during 2007-13 were not so much focused on science-industry collaboration, they were important in allowing a number of innovative and R&D-intensive companies to develop and grow. Measures targeting start-ups and early-stage companies were of particular importance. The number of high-growth innovative companies is still very small and contributes very little to the economy at large. However, a lively and active ecosystem for innovative start-ups is important in changing the entrepreneurial culture, attracting high value-added foreign direct investment (FDI), and facilitating the necessary renewal of industrial structures in the long term.

The third phase (since 2013)

In 2012, **Lithuania 2030**, a national strategy document which outlines the vision of Lithuania's future, was approved after having been prepared by a broad-based consultative process. The key objective of the strategy is to become one of the ten most advanced EU member countries by 2030 with intermediate objectives set for 2020. The implementation of the strategy is overseen by the State Progress Council with secretarial support from the prime minister's office. The Open Progress Forum "Lithuania 2030" was established to promote and maintain continuous dialogue within society.

Research and innovation-related issues recognised in the strategy include: the need for regulatory simplification and reducing restrictive regulations for businesses; enhancing the entrepreneurial culture; enhancing the production and protection of intellectual property; better international integration; attracting FDI; market-relevant innovations from research; and green procurement. Furthermore, the strategy calls for better stakeholder participation in policy design, evidence-based management, and enhanced analysis capabilities. It also highlights a one-stop shop approach in developing public services and customer satisfaction.

The implementation of the Lithuania 2030 strategy materialised in the **National Progress Programme for 2014-20**. The programme provided a basis for the EU Structural Funds (EU SF) support. The main priority was a "favourable environment for economic growth", which required 57% of the total funds reserved for programme implementation. These funds were envisaged to be invested in the development of transport, energy and IT infrastructures as well as in preserving nature, fostering entrepreneurship and creating an overall favourable economic framework for business creation and development. A share of 14% of total programme funds (comprising national funds and the EU SF support) were planned to be invested in education of society, science and culture, 13% into socially secure and active society, and almost 5% into building smart governance systems. Almost 12% of total funds were planned to be invested in the development of the networked economy, oriented towards higher value-added creation. The latter priority focused mainly on innovation networks and research collaboration, joining global networks and global markets as well as fostering innovation in business and demand for innovation.

As one of the outcomes of Lithuania 2030 and the National Progress Programme, the Lithuanian Innovation Strategy 2010-20 was replaced by the Lithuanian Innovation Programme 2014-20 which is a step towards more open, transparent and participative planning methodology.

The Lithuanian Innovation Development Programme 2014-20 (see MITA, 2014) has four main goals:

- develop an innovative society
- increase the innovative potential of the business
- promote the creation of value networks, their development and internationalisation
- improve the formulation and implementation of innovation policies as well as to promote innovations in public sector.

One of the new features of the programme was to create a legal model for joint activity of business and science/education institutions, which will provide for the implementation of common projects and foster the transition from mere provision of intellectual services to the creation of intellectual property and its commercial application. It is planned to expand the forms of partnerships and to improve patenting and licensing processes. The innovation programme also foresees the creation of new institutions and instruments: technological centres, which will help to accelerate "experimental development" before placing the products on the market. The programme also highlighted the need for a new legal act regulating R&D activities and a common system for implementation, co-ordination and monitoring of results.

The creation of value networks was related to facilitation of clusters and integration of innovation actors into international networks. The programme noted that financial engineering (guarantee, venture capital investment, loans and export credit insurance) is an important driving force. The subsequent Entrepreneurship Action Plan 2014-20 of the Ministry of Economy aimed to increase entrepreneurship, to support the creation of start-ups and to develop a supportive environment. In 2012 the European Investment Fund (EIF) and the three Baltic countries launched the Baltic Innovation Fund (BIF) – a fund-of-fund initiative to boost equity investments made into Baltic SMEs with high growth potential. The plan also highlights the importance of ensuring Investment and Business Guarantee Institutions (INVEGA), together with the Ministry of Social Security and Labour to administer the Entrepreneurship Promotion Fund (financial instruments). The programme aims to enable people to launch their own small businesses, to adopt new ways to promote innovation and to improve the regulatory environment for innovation policy making. It also emphasises the need to create demand for innovation and to address social, economic and environmental challenges. As a solution to such challenges various models of innovative procurement and pre-commercial procurement (PCP) are foreseen. The programme also changes the system of indicators used so far to monitor progress, which formerly relied only on the EU Innovation Scoreboard. A new system of indicators is based on the EU Innovation Scoreboard as well as on a mix of indicators provided by Eurostat, the Lithuanian Department of Statistics, and the World Innovation Index or collected by the Lithuanian authorities. The institution responsible for the annual monitoring based on this system of indicators is MITA while the Ministry for Economy is responsible for the co-ordination of the implementation of the programme.

The National Programme for the Development of Studies, Research and Experimental (social and cultural) Development 2013–20, approved in December 2014 is linked to the first main goal of the Lithuanian Innovation Development Programme and includes measures to promote knowledge and technology transfer, science and business co-operation.[2]

In April 2014, the government approved the programme of smart specialisation and ordered the Ministry of Education and Science and the Ministry of Economy to create the

co-ordination group and to prepare implementation plans. This group consisted of representatives of ministries, industry and science. It discussed roadmaps and prepared proposals for the implementation plans, which were approved by the ministries. Preliminary investments across all priorities were EUR 678 million.

The Smart Specialisation Strategy 2014-20 (RIS3) sets out the priorities of R&D and innovation development considering the business potential for excellence, the strengths in research, technological development and innovation, also a capacity to foster the collaboration among different stakeholders to respond to national, regional and global challenges. RIS3 was requested by the European Commission and closely linked to potential finance from EU Structural Funds 2014-20. The fact that the European Commission would review the strategy, in terms of the robustness of the analysis and the extent to which the priorities selected were fully discussed with a broad range of stakeholders, provided an additional incentive to build evidence, and make the process of setting up priorities transparent and clear. The Smart Specialisation Strategy development process was managed by the Ministry of Economy and the Ministry of Education and Science with the support of MOSTA, and ended in 2015 with approval of action plans for the implementation of the priorities shown in Box 5.4.

5.2. Main innovation policy actors in Lithuania

Main policy actors

At the highest decision-making level, the Lithuanian STI policy is set by the Lithuanian Seimas (parliament) and the government of Lithuania. At the strategic level, development of R&D and innovation (as well as the development of related priority areas) is in the hands of the Strategic Council for Research, Development and Innovation. The council is chaired by the prime minister and consists of the representatives of the ministries in charge of or engaged in R&D and innovation development, LMT), MITA, research institutions and HEIs, business, social and economic partners and independent experts. However, the potential of this body does not seem to have been fully used (Box 5.5).

The two ministries mainly responsible for the development of science and innovation policy are the Ministry of Education and Science and the Ministry of Economy: The Ministry of Education and Science is mainly responsible for policy development in the areas of research excellence in public science system, highly-skilled human resources, including for R&D, etc. The Ministry of Education and Science is in charge of a major part of financial and other resources for the implementation of national research policy. The ministry also proposes the establishment, reorganisation and closure of research institutions. The Ministry of Economy is the principal institution involved in designing policy for the promotion of innovation and business development. However, the Ministry of Economy has a limited mandate to participate in the process of R&D policy development which is led by the Ministry of Education and Science. The latter is also responsible for government funding of R&D. The Ministry of Economy co-ordinates the establishment and the operations of innovation support organisations such as science and technology parks (STPs) and business incubators. The recent establishment of the Innovation Department in the Ministry of Economy indicates the increased importance attached to research and innovation policy. Other ministries are active in sector-specific STI policies in their respective policy domains. So far, inter-ministerial co-ordination of STI-related policies remains weak.

Box 5.4. Proposed research, development and innovation (RDI) priorities in smart specialisation

Agro-innovation and food technologies:

- safer food and sustainable use of biomaterials
- functional food – innovative development, improvement and processing of biological raw materials (biorefinery).

Energy and sustainable environment:

- smart systems for energy efficiency, diagnostic, monitoring, metering and management of generators, grids and customers
- energy and fuel production using biomass/waste and waste treatment, storage and disposal
- technology for the development and use of smart low-energy buildings – digital construction
- solar energy installations and technologies for using them for power generation, heating and cooling.

Health technologies and biotechnology:

- molecular technologies for medicine and biopharmaceutics
- advanced applied technologies for individual and public health
- advanced medical engineering for early diagnostics and treatment for an inclusive and creative society
- modern self-development technologies and processes promoting formation of creative and productive individuals
- technologies and processes for the development and implementation of breakthrough innovations.

New production processes, materials and technologies:

- photonic and laser technologies
- functional materials and coatings
- structural and composite materials
- flexible technological systems for product development and fabrication.

Transport, logistics and ICT:

- advanced electronic content, content development technologies and information interoperability
- ICT infrastructure, cloud computing solutions and services
- smart transport systems and ICT
- technologies/models for international transport corridors management and integration of modes of transport.

Sources: www.mosta.lt/images/ss/Proposals_for_Smart_specialization_Lithuania.pdf; http://s3platform.jrc.ec.europa.eu/documents/20182/124683/151030_2_JP_LT_R%26I_Ecosystem.pdf/cdae05a2-767c-4baf-9689-8dfa779c2a47.

Box 5.5. The potential role of the Strategic Council for Research and Innovation

The full potential of the Strategic Council for Research and Innovation may not have been realised, and STI governance would benefit from a stronger co-ordination body. There is no unique blueprint for such a body that could be used as a model. According to Schwaag Serger, Wise and Arnold (2015) international comparison shows that a national council's influence or impact is not only determined by its mandate or its composition, for example the extent to which the council is composed of high-level decision makers as opposed to "merely" experts in their own right. Rather, there are many factors – acting in combination with one another – that contribute to councils' impact on innovation policy, including:

- **A mandate, composition and anchoring at top political level to give legitimacy**; in order to be able to have an impact on policy making, an innovation council must have a combination of relevant, recognised and sought after expertise and anchoring at top political level. The latter could mean that the council reports to or is chaired by the prime minister. However, it should be pointed out that the prime minister chairing the innovation council or the innovation council reporting to the prime minister are not sufficient determinants of its ability to have an impact.
- **A focus that is relevant and anchored in the national context – taking a broad perspective on innovation and a systemic approach** including aspects such as education, sustainability, etc. While it is not realistic to expect the council members to possess all the expertise necessary for a broad-based innovation policy, it is important that its composition does not lead to a limited or narrow perspective on innovation, and that the council's mandate and working practices allow it to access competence and examine issues that are outside "traditional" fields of innovation policy. One challenge is finding the right balance between being focused enough to be able to make meaningful policy recommendations and broad enough to address framework conditions and to secure societal relevance.
- **A mandate, governmental anchoring and composition that fosters receptiveness and willingness on behalf of government to receive and act upon suggestions put forward or decisions made in the council**.
- **Focus/approach and composition which acknowledge the increasing internationalisation of research and innovation in order to avoid the council (and innovation policy) becoming inward-looking**, for example through the inclusion of international experts in the council or the establishment of an advisory group consisting of foreign experts who are connected to the council.
- **Resources (budget and staff) that allow the council to produce and/or commission relevant analysis and engage in forward-looking activities, which are necessary in order to work proactively and promote broader visibility.**

Source: Schwaag Serger, Wise and Arnold (2015), "National research and innovation councils as an instrument of innovation governance, characteristics and challenges, Vinnova".

Major funding agencies and advisory bodies for research and innovation

The Research Council of Lithuania (LMT) – which is accountable to the Lithuanian parliament (Seimas) and government – is a counsellor of the Seimas and the Lithuanian government on issues of research and researcher training, implements programme-based competitive funding of research, administers the most important Lithuanian science development programmes, evaluates research performance and represents Lithuanian science in various European institutions and other international organisations. Legal

changes in 2008 provided LMT with the status of an agency with the mandate to fund competitive research programmes. It thus complements institutional research funding. LMT started administering the programme for competition-based R&D funding in 2009 with the overall focus on providing funding for high-level research projects. In accordance with its mandate LMT sees its main areas of activity in research policy and legislation, research funding and scientific advice. Examples for activities in the first area (research policy and legislation) are the roadmap for the development of Lithuanian research infrastructures (renewed in 2015), LMT's role in the Smart Specialisation Strategy formulation and as co-ordinator of open access to research in Lithuania. The third category (scientific advice) involves the evaluation of Lithuanian education and science institutions and doctoral studies (50 evaluations completed in 2014). LMT exerts influence at all three (decision making, strategic and implementation) levels of STI policy. This is a rather unique position which may carry some potential for conflict of interests. The European Social Fund Agency (ESFA) administers EU Social Fund aid and implements measures assigned to the Ministry of Education and Science in the development of human resources for science, technology and industry.

An important policy monitoring role is played by the Research and Higher Education Monitoring and Analysis Centre (MOSTA) which was established by the Ministry of Education and Science as an attempt to formulate the evidence-based approach in the field of studies and R&D. MOSTA provides recommendations on the development of the national research and higher education systems, performs monitoring, analyses the state of the Lithuanian research and higher education systems, and participates in the development and implementation of research and higher education policies. MOSTA played a central role in providing the evidence base for the Smart Specialisation Strategy by initiating studies and stakeholder consultations; it executed, in collaboration with LMT, the Research Assessment Exercise which was initiated by the Ministry of Education and Science and concluded in 2015; it was responsible for the co-ordination of the monitoring process of the Valleys Programme and the Joint Research programmes, including public procurement processes for international expertise and support of international experts; it has developed and implemented the Research and Higher Education Monitoring System which produces reports, foresight and analysis to support the strategic governance of higher education in Lithuania; it produces the annual Lithuanian Science Reviews; and reports to the Ministry of Education and Science.

The Lithuanian Academy of Science (LAS), an association of scientists, provides independent advice for the parliament, the government and its agencies on the topics of research and higher education, culture, social development, economy, environmental protection, health care and technology (LAS, 2015). The mission of LAS is to bring together Lithuanian and international scientists for meaningful collaboration, to act as an independent advisor in the areas of study, technology, economy, culture, social development and public health and to provide the best scientists needed for R&D. LAS also aims at encouraging the integration of Lithuania into the European Research Area and at helping to develop a knowledge society in Lithuania. LAS offers a number of scholarships and prizes.

Under the supervision of the Ministry of Economy the Lithuanian Business Support Agency (LVPA) administrates the EU funds allocated to business support programmes, including those for innovation and R&D in the business sector. Development and implementation of indirect public innovation support measures that are linked to export promotion and FDI are managed by Enterprise Lithuania and Invest Lithuania which are also supervised by the Ministry of Economy.

The Central Project Management Agency (CPVA) under the Ministry of Finance administers large-scale investments in the development of research infrastructure as well as international co-operation programmes (Lithuanian – the Swiss Co-operation Programme, EEA Grants and Norway Grants for Green Industry Innovation, etc.). The government of Lithuania gave this institution the mandate to provide methodological and advisory assistance on issues of public-private partnerships.

During recent years, INVEGA has played an increasing role in the implementation of STI policy. This institution implements and administers financial and other support measures for small and medium-sized businesses. In addition to traditional measures (very small loans, micro-loans) it started to implement STI-related financial engineering, entrepreneurship promotion and financial support measures as well as venture capital investment.

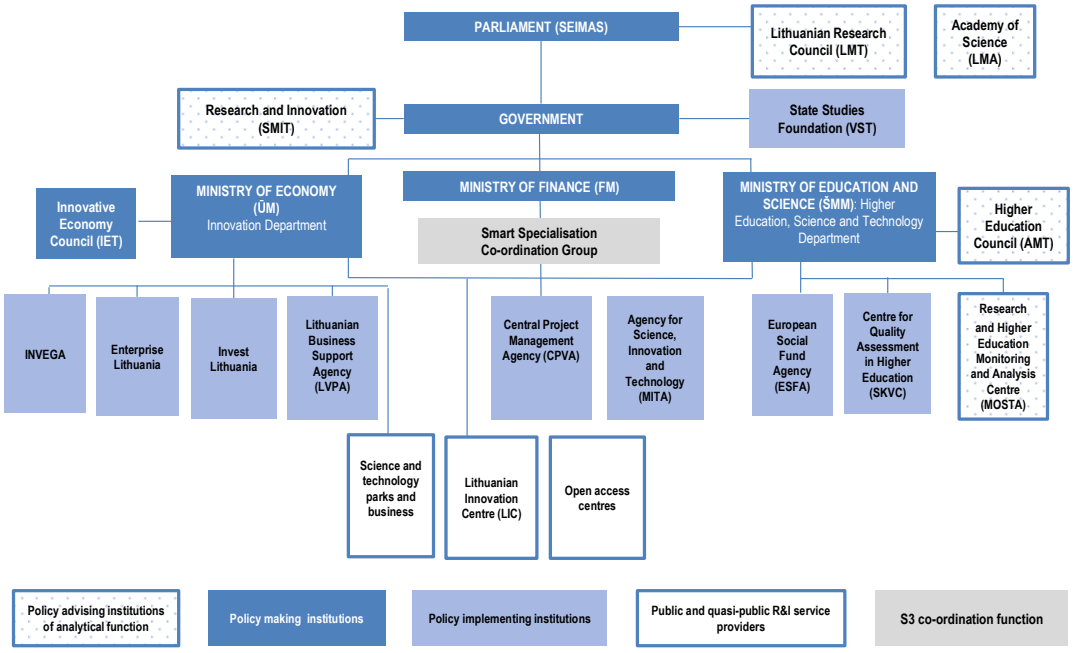
With the purpose of co-ordinating the development and implementation of STI policy the Agency for Science, Innovation and Technology (MITA) was established in 2010 as a result of an agreement between Ministry of Economy and Ministry of Education and Science. Its goal was to foster business and science co-operation and to create a friendly environment for business needs and innovation. These goals derived from the National Innovation Strategy 2010-20, approved by the Lithuanian government. The activities of MITA are jointly supported and funded by the two ministries. This institution administers a number of measures and programmes aimed at innovation and especially R&D collaboration, for instance the Industrial Biotechnologies Development Programme and the High-technology Development Programme, which have in the meantime come to an end. Both programmes were transferred to MITA from the LMT. MITA also administers the issuing of "innovation vouchers" for SMEs, which was piloted back in 2010 and then re-launched.

Enterprise Lithuania (VL) is an agency supervised by the Ministry of Economy with the mission to provide support for SME and encourage Lithuanian exports. Invest Lithuania is an agency supervised by the Ministry of Economy with a mission to attract foreign investment. This institution provides advice to global companies interested in doing business in Lithuania. The agency serves as a point of contact for foreign companies and guides international businesses through every step of the process of setting up operations in Lithuania.

Figure 5.1 provides an overview of the key actors in research and innovation policy.

Compared to many other countries, the number of agencies dealing with one part of business innovation or enterprise policy is high in Lithuania. In order to develop a coherent and enterprise-oriented policy (see for instance Di Anselmo and Saublens [2015]) and a good policy mix, close interaction and co-ordination between the support agencies is needed. Ireland, for example has strong co-ordination of enterprise policy between the key enterprise agency (Enterprise Ireland) and the agency responsible for FDI (IDA Ireland). They jointly implement programmes such as the technology centres. In Estonia, Enterprise Estonia manages the grants and support for innovation and internationalisation while Kredfex manages the financial instruments for start-ups. In this case, too, the co-ordination is in the hands of two organisations that use EU Structural Funds resources to manage their own programmes. In Lithuania, where separate agencies are dealing with EU Structural Funds project management, the organisation of enterprise support differs. This organisational model might create efficient project monitoring but it does not seem to fit the concept of being business-centric.

Figure 5.1. **Structure of the R&D and higher education (HE) policy institutions in Lithuania**



Source: Paliokaitė (2015b), "RIO country report Lithuania 2014", https://rio.jrc.ec.europa.eu/en/country-analysis/Lithuania/country-report.

As indicated earlier, the agencies for supporting business and innovation form a rather complex, fragmented and partially overlapping structure and there seems to be scope for improving information flows between these agencies. Also, there seem to be overlaps in funding between the Lithuanian Business Support Agency (LVPA), the Central Project Management Agency (CPVA) and MITA. While they have their own mandates, all these organisations manage funding for industrial R&D and innovation. Care should be taken that the division of labour in providing business support, in particular between LVPA and MITA, is clear and closely co-ordinated.

In many countries business R&D, and particularly innovation, are also financed using reimbursable forms of funding, especially soft loans. These can be rather effective close-to-market. Loans typically have a lower state aid intensity and cover a much higher share of the funding needed than e.g. grants. In Lithuania, all reimbursable support is centralised at INVEGA. This implies that projects that include, for example, industrial R&D combined with piloting and demonstration (where soft loans could be rather effective) may be difficult to support as the projects would most likely have to be divided into at least two different projects and funding from two different agencies would have to be applied for. One way to address this issue would be to combine grants and soft loans into unified support schemes. These could be operated by one agency alone, either by one agency acting as a "reseller" of the support from another agency or as a joint support scheme operated by the two agencies together (one application, one decision). In Finland, Tekes provides an example of the first model, whereas the Finnish Growth Track programme is a joint scheme of several agencies offering both funding and soft support.

As regards international trade and investment, outward and inward-oriented flows are often interlinked. A prominent example is inward FDI for export-oriented production. Multinational enterprises located in a country are often important (potential) customers for

local companies seeking access to international growth markets. Given these interlinkages between inward FDI and international market access, the promotion of inward and outward internationalisation has been put under one roof, for example in Finland and Estonia. In Finland, a cluster of agencies is linked to these activities through strategic intelligence and market observation under the "Team Finland" concept.

Observations on STI policy strategies and governance

There are still many indications that co-ordination between ministries is difficult. While the creation of a Strategic Council for Science and Innovation was a step in the right direction, its resources are limited and it does not seem to have played a very strong role within the system. The role of the Strategic Council should be made clearer[3] and it should adopt and lead a systemic policy and ensure that the national strategies, institutional structures and policy initiatives are consistent and coherent across ministries and agencies.

The RIS3 and the more transparent and evidence-based approach applied in its development has contributed to a more balanced R&D and innovation policy. The strategy results in a better balance between the objectives of developing research competences and addressing industry needs, and it introduces a more application-oriented approach, including by identifying societal challenges. The strategy also includes plans to introduce PCP as a new demand-side policy measure. The implementation of the strategy is shared between the Ministry of Economy and the Ministry of Education and Science. Attempts have also been made to introduce R&D and innovation into the agenda of other ministries.

Despite significantly increased transparency and stakeholder consultation, industry participation is still relatively weak. This can be partly attributed to the fact that policy implementation shows very little flexibility and the administrative burden is often high. Another reason might be uncertainty. While many of the industry-relevant schemes will continue during the new funding period, the transition from the previous to the new funding period has not been without friction. Delays in getting the RIS3 prepared and approved by the EU Commission and subsequent delays in launching new or re-designed schemes or continuing existing ones have created a period of uncertainty among companies. While this is understandable, given that the RIS3 process was entirely new and that all policies and policy measures needed to be re-evaluated and most also re-designed, it is equally understandable that this is detrimental to building trust and commitment in the business sector. Overly ambitious policy objectives are also ill-suited to fostering confidence and commitment. Policy objectives need to be ambitious, but at the same time realistic.[4]

Despite efforts to establish the necessary platforms, policy co-ordination is still rather weak. Policy processes lack coherence and systematic practices. Systematic, evidence-based, transparent and interactive policy processes can help to overcome this problem. Establishing such policy processes can build on experiences gathered during the smart specialisation process. It might also be useful to draw on the experiences of OECD countries in this regard. Several of them, for example Germany, Japan, the United Kingdom and the United States as well as smaller countries such as Estonia and Finland, have designed and implemented a national foresight process. A foresight process is typically less prone to confrontation as it takes a longer term view into the future and allows participants from all stakeholder groups to openly discuss what international scientific, technology, market and social trends might mean and what opportunities and threats are related to them. To attract business to participate, the timeframe should not exceed ten years. Alternatively, the foresight process could include two or three timeframes, for example 3-5 years, 5-10 years

and beyond 10 years. The methodological approach appropriate for small countries, and especially countries like Lithuania, where one key objective would be to enhance trust between industry, academia and policy makers should be interactive and based on a series of workshops supported by web-based tools for extending the participation to society at large. The Estonian Growth Vision 2018[5] project might act as a good example for this kind of a process implemented in a small country context. The processes related to evidence gathering, sense-making, monitoring and evaluation are discussed later in this chapter.

The resources for R&D and innovation are mainly based on EU Structural Funds. The monitoring and evaluation requirements related to the use of Structural Funds are mainly based on accountability, i.e. appropriate, acceptable and legally correct use of funds according to regulations, programme documents and project plans. Ensuring compliance with EU rules and regulations, monitoring by the European Union as well the legal enforcement of rules and regulations to combat misuse of public funds, economic crime and corruption, necessitates clear and strict rule setting. At the same time care should be taken to maintain the flexibility that is essential for effective R&D and innovation support systems and to avoid being more restrictive than necessary.

One way to address this issue is to increase the competences available for policy design (or redesign), or use external expertise for this purpose. Several European countries could be referred to as sources of inspiration and expertise in making R&D and innovation support measures more flexible. These include, for example, Tekes in Finland and EAS in Estonia for R&D and innovation project funding, the Ministry of Economic Affairs and Agriculture in the Netherlands and the Research Council of Norway for tax incentives, and the Ministry of Economic Affairs in the Netherlands and the Ministry of Employment and the Economy in Finland for start-up support.

A fragmented system with isolated small-scale agencies, operating on narrow mandates and a set of overlapping and competing schemes, is likely to result in reduced overall impact and efficiency. Transaction costs can be expected to be high in a fragmented system. All agencies need to have competences, for example on regulatory matters (such as state aid), on the specific needs of key industries and types of enterprises, and they need to have access to scientific resources and competences, etc. It is in general more efficient and effective to implement policies using a smaller number of multi-purpose agencies operating a portfolio of programmes and instruments. Examples of agencies with a relatively wide mandate in the area of R&D and innovation include for example Tekes in Finland, EAS in Estonia, FFG in Austria and RVO.nl in the Netherlands. EAS in particular manages innovation-related schemes as well as R&D funding for companies and industry-academia collaboration. It operates almost entirely with EU Structural Funds in a context which has many similarities with Lithuania.

Similarly, instead of a large number of single-purpose schemes it might be more promising to develop target group-oriented multi-purpose schemes. An example of a step in this direction is the new scheme to be implemented by MITA based on a merger of two earlier schemes (one focusing on R&D infrastructure and another on research activities). The new scheme will target growth companies with a combination of R&D and innovation activities and related investments. Good international examples of this type of scheme are, for example, the Growth Track scheme in Finland and the Enterprise Development Programme in Estonia, which are described below in this chapter.

5.3. Strategic intelligence, monitoring and evaluation

In Lithuania, the monitoring, evaluation and review functions are not systematically integrated into the R&D and innovation policy management cycle (Public Policy and Management Institute and Knowledge Economy Forum [2011]; Visionary Analytics [2014]). Over recent years the current system of strategic intelligence in Lithuania has improved in terms of monitoring, particularly in the science, research and HE sector where MOSTA systematically monitors developments and explores new ways of assessing performance (such as the Research Assessment Exercise and various foresight activities). Nevertheless, while understanding of the need for evidence as well as consultation with stakeholders is growing, and efforts to develop these have been made (e.g. in the context of smart specialisation), the systems and processes for strategic intelligence, monitoring and evaluation are still weak. Accordingly, this section first considers some general principles of policy evaluation, derived from experiences across the OECD area (OECD, 2015). The section then concludes with observations on developing a broader system of strategic intelligence, which would draw on policy and programme evaluations as one among a number of inputs.

The following principles reflect good practice in policy evaluation:

- *Make explicit, at the highest level, the commitment to policy evaluation.* There should be an explicit commitment to undertake ex post evaluation of significant innovation policies and strategies. For example, the Finnish Ministry of Employment and the Economy has a strategy to evaluate all agencies once every five years. Some evaluations cover several agencies simultaneously and provide a more holistic view on innovation policy and the innovation system. Overt recognition of the importance of evaluation, by senior policy makers and agency heads, is vital in securing the necessary human and financial resources for evaluation.
- *Consider mandating evaluations when public funding is provided.* Mandatory evaluation requirements are attached to the use of federal funds.
- *Insist on developing data and evaluation strategies as a pre-requisite for the start of programmes.* A clear programme evaluation strategy should be established from the outset, with an *ex ante* evaluation plan which, to the extent possible, articulates the theory of change and shows the main expected channels of impact (from inputs and activities to outputs and outcomes). A strategy should exist to ensure that the data necessary for evaluation are collected from the outset. Governments also have a duty to make more data available so that researchers and other interested parties can also assess policy effectiveness.
- *Choose the evaluation technique in the light of the size and nature of the programme concerned.* Studies of major programmes – especially pilot schemes that could be ramped up later – should use a variety of methods: random assignment, quasi-experimental assessments, interviews with beneficiaries and participatory approaches involving stakeholders. There should be a move to more use of randomised experiments as the basis of ex post impact assessment.
- *Use a mix of evaluation methods*. State-of-the-art econometric methods have a role in assessing components programmes that are part of an overall strategy, but are less likely to be useful for the policy package as a whole. Tracking of macro- or meso-level indicators, international benchmarking, subjective assessments gleaned via surveys, narrative reporting, case studies and other techniques all have a role to play.

- *Insist on full disclosure in evaluation reports. There should be a commitment to public diffusion of evaluation findings of publicly funded programmes.* The choice of methods and evaluation parameters used, methodological drawbacks and areas of subjective judgement should be described in full. There should be a commitment to transparency and early publication of evaluation findings and the data on which they are based. Published evaluation findings should be accompanied by meta-data that facilitate online searches.
- *Robust governance mechanisms are needed to ensure evaluation is objective.* Programmes should be evaluated by, or in collaboration with, genuinely independent experts, possibly from an audit office. Ideally, the body that implements the evaluation would work with programme managers but would not be dependent on continued contracts from the sponsor of the programme.

Developing a system of strategic intelligence

A system of strategic intelligence gathers, organises and assesses all form of policy-relevant data, information and analysis and feeds this into the policy making process. Innovation policies in Lithuania are fragmented into programmes run by different agencies, only some of which are evaluated (to satisfy EU Structural Funds rules, and mostly for reasons of financial accountability). This fragmentation may be one reason why there seems to be no attempt from any organisation in the system to conduct an overall evaluation of the effectiveness and impact of Lithuania's policy mix. An organisation which might commission and oversee such a broad evaluation would be the Strategic Council for Research, Development and Innovation.

Sufficient resources for evidence building and strategic intelligence should be ensured, both in terms of competences and funds. While there is no single best way to organise strategic intelligence, there are instructive international experiences (Box 5.6). However, the generic insights drawn from international experience do need to be adapted to Lithuania's specific policy and institutional environment.

In addition to monitoring and evaluation, it is important to gather wider evidence on such issues as the changing needs of innovation actors, the potential for innovation to address societal challenges, and specific barriers to innovation. This requires processes where topics to be studied are identified. It also requires processes for defining and launching studies to gather evidence. Such work can be co-ordinated by a dedicated government body, such as the prime minister's office or an agency directly under the parliament, or by a separate public-private platform facilitated by an external organisation such as a think-tank. Most OECD countries have either a government-organised think-tank type organisation (such as Sitra in Finland) or make use of NGO-type organisations (such as NESTA in the United Kingdom or Kennisland in the Netherlands).

The approach where evidence gathering is integrated into annual government planning processes relies more on competences within ministries and agencies. For example, in the United Kingdom, government departments allocate significant internal resources for strategic intelligence. While departments also use external research to gather evidence, having well developed internal resources also helps to make sense of the evidence and thus supports evidence-based policy making. In Finland, the prime minister's office (PMO) has been tasked to co-ordinate the gathering of research evidence for policy making. This office collects information on needs for evidence from all ministries and launches appropriate calls for research funding. In the past funding was allocated to each ministry separately. Now funds are managed under the PMO as one

single allocation. This makes it possible for the PMO to co-ordinate research needs between ministries and makes it possible to address more complex evidence needs and launch bigger projects (studies, analyses and research).

Box 5.6. Strategic intelligence: Establishing an evidence base for policy

There is no single best way to organise strategic intelligence. Countries have adopted different approaches to organising strategic intelligence as a recent comparative study of the United Kingdom, the Netherlands, Finland, Denmark and the European Union clearly shows (Technopolis, 2015). This study suggests a need to:

- use foresight techniques for thinking about the future to anticipate policy needs, and therefore the kinds of evidence required in future
- ensure that ministries have personnel who can specify research needs and make use of external research to generate evidence for policy making
- identify "evidence champions", such as chief scientific advisors, to promote and co-ordinate the generation and use of evidence for policy making
- create funded arrangements for generating and sharing evidence to address cross-ministry problems
- maintain long-term links with organisations like universities, including foreign organisations, which work at the boundary between research and policy, but do not allow any of these to monopolise relations
- publish evidence so that policy making is transparent and evidence can be quality assured and used by others
- be prepared to experiment and learn about new intervention designs and ways to develop evidence.

Sense-making – the interpretation of various types of research evidence – is at the core of strategic intelligence, linking evidence to policy design and implementation (Box 5.7). It is important to develop systematic sense-making activities. As with evidence gathering, sense-making can be a co-ordinated one-off national process or integrated into annual governmental processes. Being a part of an annual government planning exercise can increase the likelihood that results will be linked to resource allocations and other policy decisions.

Integrating systematic sense-making activities into annual government planning processes can be done by requesting ministries and agencies to prepare a mid- to long-term futures paper. A futures paper could analyse the current situation (strengths and weaknesses), identify key trends (opportunities and threats), outline rationales for potential changes in policies and policy measures, and provide options how these changes might be implemented and what their impact could be. Such an approach is used in several countries, including Finland and the United Kingdom.

Annual integrated sense-making should be complemented with more open, interactive sense-making processes from time to time. This allows wider stakeholder participation and can help to communicate policy changes and their rationales. Such processes can also be effective in developing shared understanding between stakeholders of the relevant challenges and opportunities, while building trust between politicians, policy makers and private and public R&D and innovation actors. Examples of interactive sense-making include:

- the smart specialisation process recently undertaken in Lithuania
- interactive national foresight processes such as BMBF Foresight in Germany[6] and the United Kingdom's Horizon Scanning process[7]
- research and innovation policy advisory bodies found in many countries (RIC in Finland or AWTI in the Netherlands)
- the activities of the Danish Board of Technology, which manages a wide range of participatory processes, engaging citizens, varied stakeholders and experts.[8]

Box 5.7. **Strategic intelligence 2 – Gathering evidence and sense-making**

Strategic intelligence can be divided into two types of processes: gathering the evidence and making sense of it.

Evidence gathering is a distributed function, in which all ministries and agencies should participate. Several countries also have research organisations, groups and/or think-tanks which focus on evidence gathering relevant to research and innovation policy. Some of these are government agencies with a specific task to collect evidence (such as Sitra in Finland and the former Forfás in Ireland), some are independent civic society organisations (such as NESTA in the United Kingdom), and some are partly or fully owned by research and innovation actors (such as ETLA in Finland). Often these organisations have a dual function: they collect and analyse the evidence, and they facilitate sense-making processes.

Sense-making should be organised as a shared participatory process among all relevant stakeholders. In some cases, this has been organised in the form of a high-level policy council. Such councils can be found in several countries, including Finland (RIC), the Netherlands (AWT) and Chile (National Innovation Council for Competitiveness). The main function of the council is to offer a permanent platform where stakeholders can engage in continuous interaction, where sense-making can take place and needs for new evidence can be identified.

For high-quality sense-making, it is important that policy makers have at their disposal a sufficiently independent body, or a process jointly owned by all key stakeholders. The most efficient way to establish this is to assign the responsibility for evidence gathering to a single independent organisation, which would also have a key role in facilitating sense-making processes. All of the evidence and the eventual policy recommendations would be discussed among all relevant stakeholders in a process facilitated by the same organisation responsible for gathering the evidence. This would create a strong link between the evidence and its use, ensuring that all new needs for evidence would immediately be recognised. Sitra has this kind of role in Finland.

Developing strategic intelligence on and monitoring of firms engaged in research and innovation schemes and other activities (such as the cluster policies) is essential to developing a well targeted portfolio of policies. It would for instance be important to know to what extent various schemes actually target the same companies and to what extent the needs of some companies might be partly or entirely unaddressed. This would be important given a general complaint from ministries and agencies in Lithuania that companies do not state their innovation activities in official statistical surveys. This could lead to an underestimation of private sector innovation.

Monitoring should be developed in an institutional collaboration, as monitoring needs to capture the funding and support provided through several agencies and programmes. Ideally there would be one point where all monitoring information is collected. This

could either be a single agency responsible for facilitating strategic intelligence processes, or another body, such as Statistics Lithuania.

5.4. Nurturing innovation skills

Human capital shapes innovation in a number of ways. In particular, skilled people generate knowledge that can be used to create and implement innovations. Having more skills raises the capacity to absorb innovations. In this regard, innovation in firms is particularly associated with the in-house development of skills, rather than their acquisition through hiring, owing to the former's effects on absorptive capacity (Jones and Grimshaw, 2012). Skills interact synergistically with other inputs to the innovation process, including capital investment. Skills enable entrepreneurship. For example, Cressy (1999) shows that after controlling for the effects of human capital, financial capital is a relatively unimportant determinant of business longevity. And skilled users and consumers of products and services often provide suppliers with valuable ideas for improvement (Von Hippel, Ogawa and de Jong, 2011).

As already highlighted in the previous chapters, a number of points should be highlighted regarding skills and innovation in Lithuania, namely:

- the share of people graduating with a tertiary-level qualification is high compared to other EU countries
- large occupational mismatches exist. Some 31% of employees work in fields unrelated to their studies, compared with 23% on average in the European Union (OECD, 2016a). Several studies report a mismatch between the skills of university graduates and the needs of business
- student entry rates are dropping, particularly in applied engineering and other technical studies
- the phenomenon of international "brain drain" is significant.

The national programme entitled Lithuania's Progress Strategy: Lithuania 2030 (Lithuania 2010) focuses on strengthening the population's capacity to adapt to rapidly changing economic conditions, create new knowledge and support economic processes. Lithuania 2030 is intended to:

- promote lifelong learning by developing opportunities for the population to acquire skills that match labour market needs, via education services and/or diversification of adult learning opportunities
- encourage creativity, entrepreneurship and leadership, and the capacity for innovation among pupils, students and researchers
- promote better career development for researchers and better training of young researchers.

The Lithuanian innovation system has a strong focus on university graduates as a source of skills. The prominent engineering culture is also referred to in Lithuania's White Paper for Science, Technology and Innovation of 2002. These strengths are evidenced in data showing that the share of 20-29 year-old Lithuanian graduates in science and technology was 2.3%, exceeding the EU average of 1.7%.

The percentage of the Lithuanian population aged 30-34 having completed tertiary education is growing, and reached 48.7% in 2012, compared to the EU average of 35.8%.

The percentage of 20-24 year-olds with at least an upper-secondary-level education is increasing slightly, reaching 89.3% in 2012, which is also above the EU average. On the other hand, even though the share of new doctoral graduates has risen, to 0.9 per 1 000 of the population aged 25-34, this is well below the 2011 EU average of 1.7. This shortfall suggests a problem in ensuring the highest levels of qualification for R&D-driven and other forms of skill-intensive innovation.

Despite a number of positive developments, concerns remain about skills shortages in certain fields. Since 2004 the Ministry of Education and Science has launched various schemes to improve the quality of human resources for R&D and innovation. The main aim has been to improve the supply of skills in priority areas of science and technology (biotechnology, agriculture, forestry, mechatronics, laser and optical technologies) and in horizontal themes (such as innovation, entrepreneurship and languages). Schemes have also focused on developing master's and PhD level qualifications in selected fields.

In addition, efforts to upgrade workforce skills and competencies have sought to increase adaptability to change and align with the requirements of the modern economy (IT skills, for instance, have been among the core themes). Upgrading workforce skills is critical, among other things because only 6% of the working population is engaged in systematic learning activities, a share which has not changed in ten years.[9]

Lithuania's emigration rate is amongst the highest in the European Union. Around 788 000 people (one-quarter of the population) has left the country since independence in 1990. In 2013 over 38 000 people emigrated while 22 000 immigrated. Most immigrants are returning Lithuanian citizens. Immigration of foreigners to Lithuania is very low, with an annual average of 2 000-2 500 people.[10] The overall situation of brain drain contributes to skills shortages reported by the business sector.

Policy to encourage skills for innovation

Human capital spurs innovation through many channels (as described at the beginning of this section). In different contexts, generic skills, such as reading, writing and problem solving, as well as technical, managerial, design and interpersonal skills, such as multicultural openness and leadership, all affect innovation.

Jones and Grimshaw (2012) summarise the available assessments of how training and skills affect innovation in firms. In particular, the research shows that both tertiary and vocational education produce valuable skills; there is a positive innovation effect from intermediate technical skills (i.e. skills that are typically bound at the lower limit by unskilled labourers and at the upper limit by university or polytechnic graduates engaged in management, research, design or production); and that sectoral variation in how skills affect innovation suggests that institutions such as sector skills councils are important.

Innovation policy makers often emphasise science, technology, engineering and mathematics (STEM). However, the importance of different fields of study varies by type of innovation and sector of activity. For example, in manufacturing, over 50% of tertiary-educated employees involved in innovation have an engineering (42.9%) or science (7.8%) degree. But in finance, the proportions are 7% and 6.6% respectively (Avvisati, Jacotin and Vincent-Lancrin, 2013).

Because of the diversity of ways in which skills affect innovation, a broad approach to policy is needed. Policy must accomplish many objectives, such as ensuring the development of strong generic skills, so that specific skills can be more easily acquired later; creating arrangements which allow flexible demand-driven resource allocation

across providers of education and training services; developing curricula that are broad enough to expose students to different knowledge content and ways of thinking; using improved pedagogies in traditional subjects (such as metacognitive pedagogies that integrate an explicit reflection about students' learning and thinking); developing students' creativity, critical thinking and communication skills beyond subject-specific expertise; developing interdisciplinary and multi-disciplinary education (for example, the Biodesign programme of Stanford University has brought together students from engineering, management, genetics, biology, medicine and business since 2003 to train medical technology innovators); and establishing a migration regime which facilitates the movement of skilled workers.

Addressing skills mismatch

OECD research shows that potentially significant gains to labour productivity can be achieved by efficient matching of workers to jobs (Adalet McGowan and Andrews, 2015). The OECD (2016a) points to various measures which could help reduce mismatch in Lithuania. These include providing better information to students about the qualification requirements of different jobs; greater efforts to communicate to students the labour market outcomes of graduates by field of study (given recent high enrolment in programmes with low labour market returns); ensuring that the education system teaches skills needed by employers; more on-the-job training and apprenticeships in secondary and tertiary education that teaches practical skills, given the difficulties faced by firms in finding adequately-skilled workers; and measures that further encourage participation by businesses in training and education. Indeed, involving employers and other social partners in the design and delivery of skills policies is important. OECD (2016a) notes however that the Lithuanian government is taking important steps in many of these directions (for instance, the government aims to double the share of work-based learning in HE and in company-based training/apprenticeships that vocational education and training [VET] institutions provide by 2020).

Beyond the specific effects of education policies, Adalet McGowan and Andrews (2015) show that a wider range of policies can affect skill mismatch and its consequences. In particular, less stringent product and labour market regulations, more developed financial services, and bankruptcy legislation that does not excessively penalise business failure are all associated with lower skill mismatch. Reforming housing market policies that inhibit residential mobility may also reduce skill mismatch (such reforms can include lower transaction costs on buying property, less strict rent controls and less stringent building regulations).

The problem of brain drain

As described earlier, emigration is negatively affecting the supply of skills in Lithuania. In order to address the issue of brain drain, the Ministry of Education and Science has implemented the Programme of Brain Regain and Attraction. The main measures of the programme are to encourage researchers from abroad to participate in Lithuanian R&D, to co-operate with Lithuanian science and HEIs, organisations and researchers, and to monitor, collect and store information on the mobility of persons with high levels of skill.

Based on recent OECD analysis of the international mobility of highly-skilled individuals, a number of observations are offered here to help inform thinking on how emigration relates to innovation.

A first point is that a range of innovation activities cannot be conceived without taking into account the role played by mobile talent. This is particularly apparent in science, where progress relies on the circulation of knowledge, interaction between scientists, and the exchange of views and evidence (on average, the research impact of scientists who change university [or research centre] affiliation across national boundaries is 20% higher than those who never move abroad [Appelt et al., 2015]). Furthermore, businesses and academia often seek foreign staff for their specific knowledge and abilities.

The analysis of bilateral flows of scientists provides evidence of two mechanisms by which home countries can benefit from such mobility. First, greater mobility is closely related to scientific collaboration (OECD, 2013). Secondly, the mobility of scientists is strongly related to student flows in the opposite direction. These findings lend support to a "knowledge circulation" perspective on scientist mobility, rather than a more traditional zero-sum view in which some countries win talent at the expense of others. According to Visionary Analytics (2014),[11] Lithuania's rate of participation in international science and innovation programmes remains exceptionally low. This is a sign of the weakness of international knowledge linkages developed by Lithuanian STI organisations.

Some recruitment practices in publicly-controlled research systems can have adverse effects on mobility. If by moving abroad to acquire competences individuals find themselves in a worse position to take jobs in their home institutions, relative to those who stay, this may negatively affect mobility and research excellence. Some institutions address this problem, for instance by recruiting in international labour markets, and precluding the hiring of incumbent students, among other measures.

Financial assistance for mobility and support for the development of absorptive capacity are major policy approaches. Most OECD countries operate programmes to support the short-term outward mobility of students and researchers. These programmes differ with respect to the conditions and expectations placed on individuals upon their return. These types of programmes have also been developed in Lithuania (i.e. the Short Period Visits Programme administered by the Research Council of Lithuania). A major issue is to develop coherent approaches for creating value from investments in acquiring skills abroad. This need not involve the creation of academic positions. Promoting the development of absorptive capacity in the business sector is a complementary option. Several countries offer schemes to attract the return of nationals working abroad or encourage the inward mobility of foreign-born individuals, even to a point where such measures become a central part of science and innovation strategies (OECD, 2014). In this respect, the Ministry of Education and Science has established a competition leading to awards for scientists of Lithuanian origin working abroad.

Some countries also provide tax relief for key foreign employees, so as to help companies attract international expertise to their domestic operations. Such schemes have become increasingly popular in OECD countries. However, the schemes can become complex, imposing substantial compliance and administrative costs relative to the potential gains in employment or innovation (OECD, 2011a). Overall, an effective demand-driven labour migration regime is required. Among other things, such a regime should identify labour market needs, considering demographic and educational changes in the non-immigrant population; establish formal recruitment channels; issue sufficient visas and process them quickly; and, provide efficient ways to verify residence and immigration status (OECD, 2012).

Lastly, for host countries, enrolling international students can help raise revenues from higher education, and be part of a broader strategy to recruit highly skilled immigrants.

5.5. Supporting business R&D and innovation

Support measures for business R&D and innovation

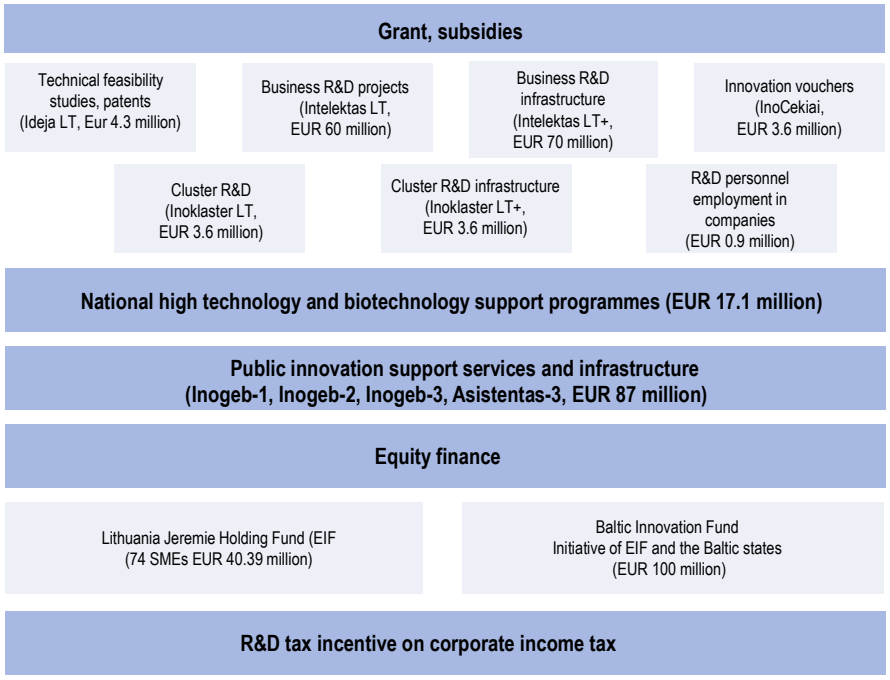
Lithuania offers a wide range of measures of direct and indirect public support for business R&D and technological innovation, aimed primarily at boosting private investment in R&D. Similar to other new EU member states, the main source of finance for the promotion of business R&D and technological innovation in Lithuania comes from EU Structural Funds. As stated above many of the policy schemes at the time of the OECD review stemmed from the previous EU Structural Funds cycle and were in the process of being terminated, altered or restarted.

Figure 5.2 represents a set of measures combining direct and indirect support for business R&D and innovation in Lithuania. The support includes grants and subsidies, financial engineering schemes, public innovation support services and R&D tax incentives on corporate income tax, but lacks measures to stimulate demand in innovation, which are as yet only in the planning stages.

In Lithuania, business R&D and innovation support schemes focus on funding R&D, buying R&D services and providing mainly soft support for innovation (Tables 5.1 and 5.2). Funding for innovation is rather limited and focuses mainly on start-ups and equity instruments.

The Economic Growth Operational Programme's 2007-13 priority number 1 is "R&D for economic development and competitiveness" aimed at increasing private investment in R&D through generic and direct support for business on a competitive basis. During the 2007-13 period of EU Structural Funds, most of the measures prioritised projects related to high- and medium-high-technology industries and high-tech knowledge-intensive services.

Figure 5.2. **A mix of support measures for business R&D and innovation in Lithuania during 2007-13**



Source: Leichteris et al. (2015), *Initial Assessment of Lithuanian Innovation Policy*.

Since 2012, MITA has implemented the Public Study, Research and Experimental Development Programme (2013-20) to support public R&D institutions implementing orders from businesses, while providing EUR 1.3 million in 2013. During 2011-15 MITA organised a national competition for EUR 1.7 million funding for 283 industrial property rights protection projects, resulting in a number of patent applications and registrations of community design. To promote business science co-operation, using national funds, MITA provided financial support (innovation vouchers) for private companies to buy R&D services from public R&D institutions. Innovation vouchers were funded from the national budget during 2010-12, with 222 SMEs receiving more than EUR 0.7 million. Since 2012, funding has been provided by EU Structural Funds (nearly EUR 3.3 million for 776 vouchers).

Table 5.1. **Direct support for business R&D and technological innovation (2007-13)**

Measure	Supported activities
Idėja LT (VP2-1.3-ŪM-01-K)	– Micro, small and medium-sized companies' development of R&D-related technical feasibility studies – Patenting
Intelektas LT (VP2-1.3-ŪM-02-K)	Business R&D activities (excluding R&D infrastructure and equipment, but including depreciation costs)
Intelektas LT + (VP2-1.3-ŪM-03-K)	– Co-financing investments into new or existing business – R&D infrastructure and equipment aimed at creation of new jobs for researchers and technicians
InoCekiai LT (VP2-1.3-ŪM-05-K)	Innovation vouchers to buy industrial or applied research, technological development, and technical feasibility study services from selected public research institutions
Inoklaster LT (VP2-1.4-ŪM-01-K)	Supported activities of cluster co-ordinator include: – Research to develop the cluster and improve its performance – Marketing to attract new cluster members – Management of cluster's open access R&D infrastructure – Implementation of training programmes, workshops and conferences – Promotion of internal and external co-operation
Inoklaster LT+ (VP2-1.4-ŪM-02-K)	Cluster co-ordinator's investment in cluster training, research centre infrastructure and open access R&D infrastructure (laboratories, test facilities, etc.)
Recruitment of highly-skilled workers in companies (VP1-3.2-ŠMM-01-K)	Employment of scientists and other researchers and technical personnel in knowledge-intensive SMEs

Source: www.esparama.lt.

Innovation service support measures aim to improve the dissemination of knowledge and the technology environment, and promote business and scientific co-operation in research and technological development to accelerate and increase business R&D and technological innovation. For instance, Inogeb-2 and Inogeb-1 provided the foundation for infrastructure and improved technology transfer services through technology incubators and technology transfer offices at STPs and universities.

Currently, Lithuania does not have a fully-fledged R&D and innovation policy monitoring system. Therefore, various institutions, including the Ministry of Finance, the Ministry of Economy, or other institutional players of the innovation system, undertake ad hoc policy impact assessments. The most recent impact assessment studies of STI policy measures undertaken during 2011-15 analysed different aspects or levels of policy implementation, especially those related to EU Structural Funds measures. The studies pointed to substantial efforts towards the promotion of public and private R&D but produced mixed results regarding their impact. All assessments used different methodologies with varying levels of inclusion of a number of stakeholders into the analysis, thereby making it difficult to provide an overall and balanced assessment.

Table 5.2. **Financing of innovation support service measures 2007-13**

Measure	Supported activities
Inogeb LT-1 (VP2-1.4-ŪM-03-K)	– Awareness raising about technology and innovation – Innovation support, increasing demand for innovation services (for example, the creation, production and dissemination of information materials, including audio and video) – Creation of information portals, and databases – Technology audits, technology reviews, market analysis and marketing of new products – Technology transfer and adoption – Partner search – Consultation on intellectual (industrial) property rights protection for R&D projects – Advice for entry of new products to the market (testing, certification, labelling, etc.) – Advice on access to finance for R&D and technology innovation – Advice on innovation management methods, and establishment of new innovation companies
Inogeb LT-2 (VP2-1.4-ŪM-04-V)	– Investments in education and/or technology parks infrastructure: – Technology business incubators, open access R&D laboratories and similar facilities – Development of the Integrated Science, Studies and Business Centres (Valleys)
Inogeb LT-3 (VP2-1.4-ŪM-05-V)	– Dissemination of information about R&D and innovation programmes and EU support for business development – Dissemination of information about successful innovation projects in Lithuania – Development and dissemination of information materials (including audio and video) – Creation and support of websites for information dissemination, databases – Innovation support services for SMEs, to foster business and scientific co-operation and innovation partnerships – Partner search services – Determination of corporate technology needs and partnership development – Consultation services in intellectual property protection, commercialisation of research results, and technology transfer issues – The initiation of innovative networking projects, advice on opportunities to participate in international R&D and innovation programmes
Asistentas-3 (VP2-2.2-ŪM-03-V)	Activities designed to encourage: – Entrepreneurship, the creation of new businesses – SME competitiveness – Foreign trade and exports, internationalisation of business – Attraction of good quality direct foreign and local investment – Positive representation of Lithuania 's economic image

Source: www.esparama.lt.

More than half the R&D and innovation initiatives managed by the Ministry of Economy and Ministry of Education and Science have been aimed at co-operation in R&D and innovation. However, the largest part of the funds (approximately 60% or about EUR 480 million) have been allocated to strengthen the knowledge base of the public sector, especially its infrastructure (Public Policy and Management Institute and Knowledge Economy Forum, 2011, Visionary Analytics, 2014). Incentives for business R&D and innovation received only 26%, while the remaining funds (approximately 14% or about EUR 115 million) were dedicated to direct co-operation between companies and research organisations (Public Policy and Management Institute and Knowledge Economy Forum, 2011). Therefore, it is expected that more resources will be allocated to R&D and innovation activities in the coming financial period, especially, for joint projects between research organisations and companies.

The support system for business R&D and innovation consists of isolated support measures based on top-down policy objectives. It is not obvious how companies could benefit from these support measures over time in order to develop their R&D and innovation competences. For example, what would be the logical next step to take after using a voucher? What support or supports would be relevant in developing a product and accessing international markets?

A better grasp of the relevant industrial target groups and their needs would allow the development of a more coherent and consistent support system, with clear tracks highlighting the relevant support schemes from which the companies could benefit. Systematic monitoring of the mix of schemes supporting business R&D and innovation and their participants would allow policy makers to monitor how companies move between schemes and how they develop R&D and innovation competences over time, and hence provide insight into the overall policy impact.

The overall policy mix has been developed towards supporting business R&D and innovation, especially towards the end of the last EU Structural Funds funding period 2007-13 and the preparation of the new period 2014-20. The main challenge is, however, the relatively small number of Lithuanian companies engaged in R&D and innovation. Except for the relatively small number of R&D and innovation-intensive companies, the absorptive capacity of the industry in general seems relatively low.

The policy mix supporting business R&D and innovation should reflect the fact that raising awareness of the importance of R&D and innovation as a source of competitiveness, facilitating competence building and absorptive capacities of companies, and other measures aimed at increasing the number of companies capable and willing to engage in R&D and innovation, are vital in increasing BERD. In this respect, the fit of the policy mix with the Lithuanian business R&D and innovation landscape still seems somewhat unbalanced. The policy mix consists of several measures targeting R&D and innovation-intensive companies. Fewer resources are allocated to identifying and attracting non-active companies to become R&D and innovation performers. For example, many efforts have been made to develop infrastructures supporting business R&D and innovation (Valleys, Open Access Centres, technology centres, STPs, etc.). However, the potential target group of companies seems very small compared to resources allocated to these infrastructures. There is a need to attract a much larger number of companies to engage in R&D and innovation to justify the existence and further development of the supporting infrastructures.

Moreover, the instruments are implemented in isolation from each other by separate agencies with different rules and regulations rather than offered as an integrated package. Even schemes that could benefit companies with lower absorption capacity are closely linked to research rather than more downstream innovation. The resulting policy mix is complex and administratively demanding. Hence, it seems that many companies that could benefit from support decide not to do so.

The bias in the policy mix towards companies already active in R&D and innovation limits the potential long-term impact of R&D and innovation policy. To reach the policy objectives related to the overall private R&D investment and innovation activity, the number of companies engaged in R&D and innovation must be significantly increased. This requires measures that are easy-to-access, easy-to-manage, and possible to tailor to the specific needs of companies. The mix of measures should also encourage and support the companies to systematically develop their internal R&D and innovation competences. Easy-to-access and easy-to-manage entry-level schemes should be followed by gradually more attractive yet more demanding programmes encouraging companies in this development.

One area where the policy mix seems more appropriate is in entrepreneurship and start-ups. Ample focus on access to funding operated by private venture funds, combined with private acceleration services is likely to provide high impact. This is further supported by the closeness of other similar and even stronger systems in the Scandinavian and Baltic regions. The sector in Lithuania is still very small, but it is growing fast. However, it will take a long time before it will have any noticeable impact on the national economy.

The progress in the start-up ecosystem and the related policies supporting it, the policy focus on companies already active in R&D and innovation, and strong investments in public research further highlights the structural mismatch between the policy mix for business R&D and innovation support and the Lithuanian industry needs. Policies mainly target new innovative start-ups, innovative growth companies and companies active in R&D and innovation. The share of these companies of the total company population is relatively small. Hence, the policy impact will inevitably remain small when measured by national level indicators such as BERD/GDP.

A better grasp of industry structures and the challenges and opportunities faced by Lithuanian companies should result in the identification of specific high-potential target groups. High potential may refer to growth in international markets, an increase in R&D and innovation performance or it may particularly refer to the potential to become engaged in R&D and innovation activities in the Lithuanian context. Policy measures should be clearly linked to these specific target groups. Focusing on high-potential target groups also facilitates the overview across policy measures. Instead of viewing each policy measure separately, the view from the side of the high-potential target group will easily reveal if and how different policy measures function in this particular target group, both as individual measures, but even more importantly as a dedicated policy mix.

The gap between R&D and innovation performers and the rest of the Lithuanian enterprise population seems relatively wide. This would further support adopting the target group approach in the design of policies and policy measures, and especially in designing and aligning policy mixes for the selected target groups. The resulting overall policy mix would then consist of:

- target group-specific policy mixes
- generic measures, such as framework conditions, education, etc.
- specific measures strengthening linkages between target groups, such as cluster-type initiatives, procurement-type initiatives, etc.

Several countries are developing business R&D and innovation schemes based on a more customer-oriented approach. The resulting policy mix is a combination of general purpose easy-to-access and easy-to-manage entry-level schemes, general R&D and innovation support and more selective and demanding stage-gate schemes targeting companies with high growth potential. The purpose of the easy-to-access and easy-to-manage schemes is to reach companies with the potential to develop R&D and innovation capacity and companies that have not previously been engaged in R&D. The most common of these types of schemes are R&D or innovation vouchers.

General R&D and innovation support targets the needs of R&D and innovation-intensive companies, but they can also offer a way to move forward from entry-level support schemes. R&D and innovation support schemes consist of bottom-up type schemes aimed at companies and top-down schemes aimed at industry-academia collaboration. While the latter focus more on the needs of R&D-intensive companies, collaborative research and commercialisation of public research, the former often offer support for companies' proprietary R&D and innovation projects.

In order to act as a step forward from the entry-level support schemes, the general R&D and innovation support measures should allow the full range of R&D and innovation activities. This means that R&D support schemes should also target companies with less scientifically demanding R&D: projects focusing on applied research, experimental

development, demonstration, piloting, and generally focusing more on applying existing knowledge rather than creating new knowledge. The focus should be more on how demanding and innovative the project is for the specific company than how demanding or innovative it is in general.

Schemes based on selective stage-gate approaches are gaining increasing interest in many countries. They are most commonly used in targeting high-growth start-ups, such as the Small Business Innovation Research (SBIR)[12] in the United States or YIC[13] in Finland. However, similar approaches are now being adopted to target high-potential SMEs. The main differences between these schemes and more traditional R&D and innovation support schemes include the following:

- The support is offered in stages ranging from feasibility to commercialisation.
- Specific milestones (key performance/success indicators) are set for each stage. Failure to meet the milestones set for a stage typically results in being dropped from the support scheme.
- The support is tailored for each specific company. This is done either by offering flexible funding not, or less limited to, specific costs, or by combining funding from several existing support schemes. Non-financial support is typically organised by securing a pool of potential service providers and allowing the company to choose from within this pool.
- The criteria for selecting companies to join the scheme is based on their ambition and potential for competitiveness, growth, internationalisation, etc., that is, the company's business objective. Instead of focusing on R&D and innovation activities as a proxy for future economic impact, the focus is directly on the expected economic impact, and R&D and innovation are merely part of the activities needed to realise the business ambition.

The benefit of selective stage-gate schemes is that they allow the company to focus and design their project based on their specific ambition and needs, instead of the often rather limited and strict requirements of a specific support scheme. This approach can typically be made administratively lighter for the companies as they can communicate all or most of their needs and manage administrative requirements with a single scheme/agency. Examples of these approaches include the Growth Track scheme in Finland and the Enterprise Development Programme in Estonia (see Box 5.8).

There are some signs of a better match between business R&D and innovation landscape and policy measures in the new EU Structural Funds funding period. Schemes such as vouchers, support for protecting intellectual property, innovation certification, and various other soft measures providing innovation and business support services are likely to reach potential future R&D and innovation performers. Cluster initiatives can also be effective in this respect, if they are industry driven.

The issues related to specific types of support instruments, schemes and target groups are discussed further in the following chapters.

Innovation vouchers

Voucher schemes such as the one in Lithuania are typically targeting the immediate needs of companies. They can be rather effective in raising awareness among companies of potential service providers such as universities. Learning to collaborate with service providers may later lead into extended collaboration once sufficient trust has been built

using the voucher. The challenge is that universities usually do not provide close-to-market services needed typically by companies and even if they did, there would be a risk of unfair competition with private service providers. Another potential problem with voucher schemes is that if service providers see them as a potential source of further funding, they might be tempted to start writing proposals on behalf of companies, and rather than addressing companies' needs, the focus would be on work that is more interesting for the service provider. This might be particularly the case if the vouchers cover 100% of the costs of the services provided.

Voucher-type schemes can be used for both R&D and innovation purposes, covering public and also private service providers. This requires that the operating agency set the necessary code of conduct and rules for the voucher scheme and organise a certification of service providers or some other form of validation, for example through a public tendering process. This allows agencies to focus on operating schemes rather than growing the public sector by hiring experts for providing services to companies. This approach is worth considering in areas where a sufficient supply of private services exists.

The main purpose of voucher schemes is to introduce companies to systematic R&D and innovation activities, and collaboration with R&D and innovation services provided typically by universities and public research institutes (PRIs). One of the key success indicators is the continuation of the relationship between companies and these research organisations. This can be in the form of return projects with additional vouchers or without them, or continuation of the relationship with more ambitious projects.

The key to ensuring success is in designing how the continuation or return projects can be supported. This can be done by allowing the company to apply for several vouchers over time. Another approach is to offer simplified small-scale R&D and innovation project funding for the companies.

EAS in Estonia has approached this by devising a voucher scheme with two types of vouchers.[14] An innovation voucher (maximum EUR 4 000) is available for companies who can use it only once. It is aimed at companies in need of external expertise to develop innovative solutions for their practical problems, carry out tests with new materials, gather knowledge on technologies, conduct studies in intellectual property databases, etc. A development voucher (maximum EUR 20 000) can be used for the next step and obtain external expertise to support the implementation of the identified solution in practice.

There is limited information available regarding the impact of the Lithuanian voucher scheme. A sufficient monitoring system should be put in place to allow further analysis, particularly as it is one of the few measures aimed at increasing the number of companies engaged in R&D and innovation. Evidence of more sustainable impact in the form of continued collaboration or return subscription, as well as entry of companies new to public support, would give the necessary insight into the impact and facilitate further development of the scheme.

Box 5.8. Customer-oriented approach in supporting business R&D and innovation – a way to cut across the fragmentation of public support agencies and schemes

Sensitive to the fragmentation of several support schemes and agencies, some agencies have started to adopt customer-oriented approaches in supporting business R&D and innovation. The rationale behind these approaches is to recognise the individual needs of companies and facilitate tailoring of the most relevant support measures accordingly. As a result, the awareness and access to relevant public support measures can be ensured, and the administrative burden of companies can be significantly reduced.

Growth Track was a service model for Finnish SMEs that strived for rapid growth and internationalisation. The service aimed to ensure that companies could efficiently utilise the best suited public expertise and financing services. Each company selected for Growth Track was given a Growth Pilot, a contact person who helped find the best suited services for the company and co-ordinated co-operation between the various agencies and public service providers.

Growth Track was offered jointly by Tekes, the Centres for Economic Development, Transport and the Environment, Finnvera, Finpro, Finnish Industry Investment Ltd and the National Board of Patents and Registration of Finland. The programme was part of the Enterprise Finland service network. Growth Track was a service model implemented between 2009 and 2014. As of the beginning of 2015, Growth Track became part of **Team Finland** network's services. Growth Track included a total of 135 companies. During Growth Track, their total turnover doubled (EUR 729 million), exports tripled (EUR 150 million) and the number of personnel doubled to almost 4 000.

Enterprise Estonia launched the Enterprise Development Programme in 2016. The target group of the programme is ambitious enterprises with the readiness to invest and the desire to grow, develop and launch new products and services. The total budget for the scheme is EUR 73 million over the current EU Structural Fund period.

Participation in the Enterprise Development Programme is open to industrial enterprises or companies of the smart specialisation fields that have been operating for at least three years (as of date of registration) with a minimum of eight employees have obtained first experiences in export or management of fast growth; these enterprises should also have clear ambitions and potential for growth and the ability to bring new or significantly improved products or services to the market. The Enterprise Development Programme supports the enterprise in making and carrying out planning and management decisions. Together with the enterprise participating in the development programme, EAS finds the best solutions for carrying out changes in the enterprise and making a significant stride in development. At the heart of the programme is the enterprise's multi-year development plan.

The Enterprise Development Programme consists of three stages:

- identifying the enterprise's ambition and readiness for change
- preparing the development plan
- implementing the development plan.

The common feature in these types of approaches and schemes is that the selection of the beneficiary companies is based on the company's ambition and potential to innovate and grow in international markets, not on detailed project plans or budgets. Once the company is accepted into the scheme, it has access to relevant services (e.g. diagnostics, mentoring and consultancy), events (e.g. international visits, fairs and trade shows), and funding (e.g. grants, loans and guarantees), all of which can be tailored to fit with the company's medium- to long-term development or growth plan. The company has easy access to all relevant public support with minimum bureaucracy.

Sources: http://team.finland.fi/en/services; www.eas.ee/service/enterprise-development-programme/?lang=en#articleblock-3stageimplementationofthedevelopmentplan.

Tax incentives for R&D

Since 2008 enterprises have been given the option to deduct 300% of their R&D expenditures from taxable income, this enhanced deduction scheme alongside an accelerated depreciation allowance for some R&D capital. Calculations based on the so-called B-Index show that this incentive is very generous compared to tax incentives in place in in OECD countries (see OECD, 2016b, Figure 1.18). However the utilisation of this support instrument for R&D appeared to be rather low. This is in line with the low R&D capacity of firms observed in previous chapters. However, data from the State Tax Inspectorate indicate that some expansion in terms of numbers of tax payers using the tax relief seems to have taken place recently (2014) although this was not accompanied by a commensurate increase in the volume of the tax relief.

As the recent OECD Economic Survey: Lithuania (OECD, 2016b) pointed out, a survey of Lithuanian businesses found that two-thirds of the respondents were unaware that a tax deduction for R&D expenditures existed (Deloitte, 2015). Of those that were aware, a commonly cited deterrent to applying for incentives was uncertainty relating to the definition of eligible R&D. Upon request by a firm MITA verifies whether activities can be classified as R&D. The Economic Survey recommended that along with the existence of R&D tax incentives, this service should be better communicated to firms.

While R&D tax incentives potentially encourage (additional) business R&D expenditures, it is also known that they may favour incumbents at the expense of young firms. An important reason for this is that the implicit subsidy rate of such measures increases with firm profitability and young firms are often in a loss position in the early years of an R&D project (Adalet McGowan and Andrews, 2015). The Lithuanian tax incentives should take due account of this issues in their design (for example by introducing suitable carry-forward provisions). After nearly one full decade of their existence, an evaluation of the impact of the tax incentives in place in Lithuania would be in order.

Access to debt and equity finance

Chapter 2 described key financial instruments and institutions relevant to finance for the business sector. A number of observations were made on policy, including that bankruptcy processes could be made more rapid and less costly; efforts to promote new forms of financing, such as crowd-funding platforms, could take stock of the recent revisions to related regulations in countries such as Austria and Germany, which aim at developing this form of finance, while recognising that this funding mechanism typically engages relatively small volumes of total investment; and support to improve investment readiness in firms – improving the quality and presentation of investment projects – can sometimes be the best course of action for policy makers seeking to enhance access to equity finance.

According to an evaluation report provided by PricewaterhouseCoopers, UAB and VšI ESTEP (2010), the financial engineering measures undertaken under the 2007-13 EU Structural Funds programming period covered all stages of company development. But the report suggests that more specific measures could be introduced, for example, dealing with export insurance.

Access to equity funding does not seem to be a particular problem in Lithuania. However, equity funding often targets high-growth companies. The wider SME population typically relies on bank-based non-equity finance. Access to non-equity funding might be a barrier for growth among SMEs. SMEs that are not willing to take on outside investors might find it particularly challenging to fund international growth. This could indicate that further public measures would be needed to support growth in the form of guarantees

or mezzanine funding. The evidence is too limited to warrant a clear recommendation here. However, it would be advisable to analyse SMEs' access to private non-equity funding and whether there are barriers which require remedial action, for instance through guarantee schemes. Such schemes are quite common and used successfully in most countries.

Chapter 2 also noted that the Lithuanian government currently provides no tax incentives for business angels or venture capital. As Chapter 2 described, while the venture capital sector in Lithuania is young, it is by some measures developing rapidly. The remaining comments in this section therefore focus on business angel investment.

In some countries, policies to encourage a greater number of angel investors seem to have played a positive role. These include supply-side measures such as tax incentives and the creation of co-investment funds. Countries such as the United Kingdom, with long-standing angel tax incentive programmes, cite the positive impact the programmes have had on increasing angel investment activity (OECD, 2011a). However, tax incentives can also be difficult to structure and target appropriately.

The level, sophistication and dynamics of angel investment often vary greatly across regions within a country. In a number of countries, such as Canada and the United States, policies on business angels are implemented at regional levels. At sub-national level, important benefits could come from supporting business angel networks. Such networks aim to match informal investors with ventures seeking small amounts of equity finance. Public policy towards business angel networks is justified, in principle, by obstacles to the efficient functioning of the informal equity market. An information barrier may exist in this market if business angels are reluctant to publicise their willingness to invest and entrepreneurs are reluctant to reveal innovative ideas. Furthermore, informal investors often rely on friends and business acquaintances for referrals of investment opportunities. This reliance on informal contacts reflects the time required to search for and appraise potential investments, as well as the fact that many business angels invest on a part-time basis. Such information and search-cost barriers, on both the supply and demand sides of this market, can be lowered through support for business angel networks. Angel networks can also create synergies by linking with mentor networks, chambers of commerce, clubs of entrepreneurs and other similar bodies.

Other areas in which policy makers have acted to develop the angel financing market include providing support directly to national angel associations or federations. National angel associations help raise awareness about angel investment, which is a critical step in building the market; also training angel investors can professionalise the sector and attract new angel investors. But such training is often overlooked by policy makers. Because angel investors are typically experienced entrepreneurs and business people it is assumed that they also know how to invest. However, the skills and experience needed to successfully invest in start-ups can differ greatly from those required to be a financial investor or build a company in a particular sector. Training and mentoring, in which new angel investors can learn from experienced angel investors, can be important to promote this form of equity investment.

Incubators, science and technology parks (STPs) and networks

An analysis of Lithuanian STPs revealed that the activity of parks is concentrated on establishing infrastructure, building connections with local businesses and the scientific community, developing administrative skills, identifying local demand for innovation, business and innovation enhancement services and exploring the potential commercial value of these (KEF, 2010).

About 34% of all enterprises established in the STPs were found to operate in the field of ICT; 23% offered financial, business and other consultative services; about 12% were active in engineering technologies, chemistry and the food industry, and 11% of enterprises were engaged in the energy and electronics sectors.

In 2015, seven of the nine STPs were operating in the Valleys and some of them included technology incubators. Some of the STPs are very active in start-ups promotion (for example the North Town STP) and regularly organise business plan competitions, among other entrepreneurship support activities. These are not exclusively focused on science-based entrepreneurship. To date the involvement of enterprises in STPs and open access centres has been limited. Most of these initiatives have focused on the modernisation of public research infrastructures rather than industry-science collaboration (European Commission, 2016).

Compared with other countries, the number of Lithuanian STPs is high and their size is relatively small. The small size of the STPs discourages a significant number of companies. The KEF study also suggests that the precise role of STPs and their engagement with universities is still not well defined.

Most STPs do not own land and buildings, but rent or use them on a contract basis. This may impede the development of parks' infrastructure when there is a disagreement about goals and amounts of infrastructure development with land owners (mostly the state). One potential outcome of this is the lack of commitment of the scientific institutions. Scientific institutions may see STPs as competitors for local, national and EU funding and funding from companies. They may also compete in attracting talented students and graduates. STPs should therefore work in close collaboration with the local (and other relevant) scientific institutions to avoid such potential problems.

The main goals pursued by Lithuanian STPs – incubation, enhanced networking and knowledge flows, promotion of a knowledge and innovation culture, restructuring of industry, and regional development – are common STP goals worldwide. However, an analysis of services provided by the parks showed that Lithuanian STPs have no specific orientation to services useful for institutions that add value to production. Rather, they provide a broad range of services suitable for a variety of companies (KEF, 2010).

The KEF (2010) analysis of STPs' plans to create added-value services shows a tendency to focus on consulting services, partnering services and searches for funding. Such plans for the development of new services were influenced by STPs' involvement in the Inogeb LT-1 programme. This suggests that the current or planned activity of the parks is directly connected with subsidised activities in specific programmes. Taking this fact into account, the programming of financial support from the EU Structural Funds 2014-20 is likely to be of great importance when further STP goals are set. Support from EU Structural Funds increases the possibility of extending the scope of STP's services.

STPs are starting to apply more precise criteria for tenant selection, but there is still a strong tendency towards keeping buildings filled to create revenue growth, with little account taken of the actual focus of the enterprises or their current innovation practices (KEF, 2010).

In summary, the effectiveness of existing STPs and business incubators may be rather limited. While policy makers have turned to business incubation to meet a wide range of policy goals – from raising enterprise birth rates, to commercialising university research, to expanding the supply of infrastructure – there are a number of general lessons from across the OECD area which might be helpful to take into consideration. These lessons are set out in Box 5.10.

Box 5.9. **Technology transfer and intellectual property functions in small countries**

Improving academia-industry collaboration is a key policy objective in Lithuania. STPs and incubators have been set up as a platform for such co-operation. However, to make these platforms more effective, universities need to establish well-functioning technology transfer offices (TTOs) that act as intermediaries between academia and the business sector. As Lithuania needs to expand the numbers of companies active in innovation, the pro-active business development functions of such TTOs would need to be adequately resourced. Evidence from studies of critical success factors for TTOs indicates that a TTO should have the full support of, and autonomy within, the university structure, and should also operate in an external context where legal frameworks support industry-science links. Debackere (2012) emphasises that operating a TTO requires considerable assets: "it is advisable for the TTO staff to have a thorough, in-depth understanding and experience with the academic environment, its *modus operandi*, its norms and values, its intricacies and behaviours. At the same time, a profound understanding of the needs of industry and business is an absolute necessity. As a consequence, an effective TTO operation requires experts able to 'see both sides', who are capable of translating the needs and objectives of the one side into the language understood by the other side." (Debackere, 2012).

People with sufficient knowledge and experience can be hard to find, particularly in a country such as Lithuania, which is small and has a relatively short history of industrial expansion. In terms of raising awareness of intellectual property in universities, TTOs need access to people with specific legal qualifications (Radauer, 2016). Again, these skills are scarce and in high demand. Given the small size of the Lithuanian innovation system and the relatively large number of universities, it would be advisable to consider:

- Pooling the TTO expertise and resources in the country and focusing on the two to three best-positioned universities and research organisations sharing the expertise of the TTO staff, rather than expecting each university to invest in a sub-critical TTO function (see, for instance, Debackere [2012]).
- Accompanying these activities with a capacity-building and awareness-building programme to support these TTOs in building up the pool of knowledge and expertise. It would be advisable to start with a focus on TTO staff with experience in a small number of priority sectors.

There are currently ongoing efforts to improve STP's efficiency and their business strategy. In February 2015, a new STPs Development Concept was approved by the Lithuanian government. This directive indicates that STPs should concentrate and optimise their infrastructure, and orientate to smart specialization strategies. Actions to restructure STPs have started. For instance, two STPs in Kaunas city were united in 2015. The new approach also defined a new responsibility for MITA to monitor and evaluate STPs as well as conduct analysis of STPs' business strategies.

The new Operational Programme 2014-20 plans to finance the operation of new TTOs in universities. Lessons for the setting up of TTOs are highlighted in Box 5.9. As Lithuania needs to expand the numbers of companies active in innovation and enhance industry-science collaboration for research and innovation activities, TTOs would help to build bridges between industry and universities. In deploying these new initiatives, attention should be given to the pooling of resources and provisioning TTOs with adequate resources and competences.

Policy towards enterprise clusters

A "cluster" is a geographical concentration of inter-related firms, often existing in close proximity to HE and research institutions and other public and private entities. In recent years, policies to foster enterprise clusters have been frequent in both OECD and developing countries, in wealthy and lagging sub-national regions, and in jurisdictions with *laissez-faire* and *dirigiste* approaches to economic development. Most OECD countries have some form of cluster or sector-based approach to support innovation.

A significant impetus for cluster development in Lithuania has been created by various public support measures. These have been financed from both national and EU Structural Funds, and include direct measures, such as "InoKlaster LT", and indirect measures, such as the National Cluster Support Network.

There are 52 cluster initiatives in Lithuania (see Box 5.11 for an example).[15] This activity has been the result of an intensive support during the period 2007-13 and great importance given to cluster policy and the creation of innovation value chains. In Lithuania, clusters have emerged in strongest cities economically speaking (Vilnius, Klaipeda, Kaunas and Alytus), which have the most dense concentration of operating economic entities and the highest employment rates. Cluster activity is accentuated more in the services sector than in manufacturing. Examples of industries with cluster activity are: information and communications technologies, creative industries, and health and medical tourism.

However, some of these initiatives are still embryonic, others comprise enterprises whose primary aim is to take advantage of EU Structural Funds, and only about a quarter are forming autonomously and are engaged in developing new products or services through long-term co-operation (Leichteris et al., 2015). Most of Lithuania's clusters participate in international projects, such as projects funded by the European Union's 7th Framework Programme for Research and other EU initiatives to create knowledge and innovation spaces and develop commercial co-operation with foreign partners.

There is anecdotal evidence that the rules for funding of cluster programmes are not always geared to the business sector's priorities. For instance, some firms would prefer not to have to involve a university in the consortium, and would instead wish to involve colleges or other types of organisations.

It is the case that clustered firms – those which are located near to each other – can experience positive economic spillovers from surrounding firms and institutions. These so-called "agglomeration economies" take many forms and are the subject of a vast multi-disciplinary literature dating as far back as Alfred Marshall's *Principles of Economics*. In the broadest terms, the agglomeration of firms and their suppliers permits the creation of locally concentrated and sometimes specialised labour markets. Clustering can encourage an enhanced division of labour among firms (offering greater scale economies for individual enterprises), and attract buyers and sellers. And clusters can facilitate flows of ideas and information that help underpin innovation. Such information flows occur formally and informally, for example when employees change employer, through contacts with common suppliers, and through social interaction. And by operating in close proximity firms can more easily subcontract to competitors those orders that exceed their own capacities, as proximity may allow greater knowledge of the capabilities of potential contractors, which can allow firms to retain valued customers. Similarly, cluster-based collaboration can also foster specialisation and the taking of higher risks, such as launching export activities, by offering peer support and complementary competences. As a consequence of benefits such as those outlined here, significant empirical evidence exists of the productivity- and competitiveness-enhancing potential of belonging to a cluster.

Box 5.10. Policy lessons on business incubators

A first point is that what makes incubation a potentially cost-effective policy tool is that information sharing and synergies can be realised among the firms that use the incubator – the tenants. Such information sharing is not expected to include proprietary knowledge, of course, but rather concerns day-to-day problems that typically affect small, fast-growth firms, such as the challenge of managing cash-flow (in many cases however, incubator managers fail to promote such information sharing). Incubation can also lower the unit cost of delivering services to co-located firms, as compared with providing services to firms that are geographically dispersed.

The services offered by incubators should match the particular goals they have. For instance, technology-oriented incubators typically possess features that differentiate them from mixed-use incubators. They are frequently affiliated with a university and often have selective entry criteria focusing on businesses with high-growth potential. They can also be more expensive to establish and run because of the need for specialised facilities and staff. Their service offering may also include a greater emphasis on services related to intellectual property.

In both mixed-use and technology-oriented incubators job creation is a frequent goal of publicly supported schemes. However, as an objective, business development should generally take primacy over job creation. In the context of incubation, job creation is best achieved through successful business outcomes (moreover, anecdotal evidence suggests that most job creation occurs after tenant firms graduate from their incubators). Incubator managers should therefore work with performance metrics and management incentives closely tied to measures of commercial and technological outcomes.

When it is given, public support should come at the initial stages business development, not through the long-term subsidy of operational costs. Without exposure to commercial disciplines the incubator is unlikely to provide competitive services.

Local authorities and incubator sponsors should encourage local business and community support. They should also seek to link incubator initiatives with wider business networks.

Achieving scale is important. Having a larger incubator opens possibilities for cost and risk reduction, as well as the leveraging of private finance. For small communities incubators should probably be treated with caution. If attempted, it may be advisable to embed the incubator in a larger umbrella organisation or network. So-called "virtual" incubators can be a cost-effective means of providing non-property-based services in areas with small numbers of potential tenant firms.

As the success of incubation programmes often depends on the quality of management, the development of professional training courses should be encouraged. Local and regional bodies that sponsor incubation programmes should ensure the establishment of a board of directors embodying a spectrum of skills and experience.

Incubation programmes should aim for high-quality accommodation to attract high-quality entrants.

Local and regional bodies should ensure that rigorous procedures for benchmarking and evaluation are integral to all publicly supported incubator schemes. There is a need to consider the outcome measures commonly used in evaluations of incubation schemes. As noted above, the focus of incubation should be on different dimensions of enterprise and technology development. This implies a need to record such things as the time that enterprises need to establish market niches or develop new products; the adoption of advanced management practices; the use of new or superior technologies; the number of patents registered; cost reduction resulting from technology developed through the incubator; the number of research projects transformed into business opportunities; the volume of royalties obtained by the incubator, university or research centre as a result of projects supported by the incubator, etc. Some incubators can also have long-run indirect effects that are difficult to measure. For example, technology-oriented incubators can provide concrete examples to university staff regarding the commercialisation of research.

In countries where incubators are numerous, the development of professional incubator associations should be encouraged in order to disseminate best practice, create benchmarks, and implement training. Associations can likewise be encouraged to create an accreditation programme.

Source: OECD/LEED-SOFIREM (2000), "Good practice in business incubation", www.oecd.org/cfe/leed/leed-publications.htm.

Box 5.11. **Photovoltaic Technology Cluster**

The Photovoltaic Technology Cluster is perhaps the most successful and ambitious of the cluster initiatives currently operating in Lithuania. Starting in 2008, this collaboration quickly initiated a new solar energy industry, which is continuing to gain momentum. At present, 19 companies are supported by three universities and the Science and Technology Park. The companies manufacture solar cells, modules and power plants as well as other high-tech products. The companies sell all over the world, and are constantly expanding their research and manufacturing capacities.

Although the cluster itself does not carry out any business activities (it is not a legal entity), it provides opportunities for fulfilling the research, production, and marketing potential of its members. Each enterprise in the cluster develops individually, but joint activities, such as research and prototype development, are co-ordinated inside the cluster. The joint work is facilitated by the Applied Research Institute for Prospective Technologies.

A new research centre of the Photovoltaic Technology Cluster in Vilnius started at the end of 2014.

However, in order to reflect on the possible policy actions to take with respect to clusters, it is essential to first make a number of conceptual distinctions. These distinctions are needed because terminology in this area of policy is sometimes imprecise, and a range of interventions are often subsumed under the same generic category of "cluster policy". For instance, policies that support competence/excellence centres or business networks are often referred to as cluster policies, without any differentiation. But distinctions between a cluster of firms and a business network are important. The two phenomena, or types of initiative, can entail different resource requirements, objectives and evaluation metrics. Business networks operate with varied forms and objectives. Some aim at general sharing of information, while others tackle more specific goals. Business network programmes can be easier to design and implement when firms are located near to each other, but they can also operate well beyond the geographical boundaries of a cluster.

In addition, in policy discussion there sometimes appears to be confusion between the economic benefits to firms of belonging to a cluster and the separate question of why governments need a policy on clusters. At least four observations are relevant in this connection:

- The available evidence suggests that while clustering can bring benefits to firms, the magnitude of these benefits is often modest (Rosenthal and Strange, 2004) and that firms are in any case able to appropriate some of the productivity gains from belonging to a cluster (Martin, Mayer and Mayneris, 2011). To the extent that firms capture such productivity gains, the need for a policy to alter firms' location decisions is lessened.
- The mere fact that firms in a cluster might be more productive than firms elsewhere is not an economic justification for policy support (as it is a state of affairs that could be consistent with efficient markets). Policy needs to start from the identification of market failure(s) that could merit correction.
- Many policies that are likely to have a major impact on clusters are almost never fully considered in programmes to support clusters. These include transport, land-use planning and labour market policies (Uyarra and Ramlogan, 2012). Evaluations also tend to focus on activities implemented as part of relatively short-term enterprise support initiatives, rather than the effects of these other policy variables, some of which operate over a longer period.

- Rigorous evaluations of cluster-related policies are also few (and show mixed results). One cause of this evaluation shortage may be that policy towards enterprise clusters often includes many different types of intervention, some with multiple and inter-related objectives. There also appears to be little evidence on how specific design and implementation features of cluster policy have contributed to policy outcomes. Various evaluations using statistical controls are cited in Warwick and Nolan (2014). A salient finding is that policy effects for the cluster programmes are often modest, and that assessments of long-term impacts are almost entirely lacking. Schemes focusing on business networks appear to give more positive outcomes.

The OECD has sought to distil the implications for policy of the above evidence and discussion (Warwick and Nolan, 2014). Accordingly, should Lithuanian policy makers seek to expand cluster-related activities or support, the following generic observations could provide a degree of orientation:

- *Caution in this area of policy development is prudent.* While cluster-type policies are popular, it remains to be proven which, if any, cluster policy measures are effective, and to what extent they might increase innovation or productivity. Indeed, many clusters have thrived in the absence of policy.
- *Policy should explicitly target market failures.* Several forms of market failure may be relevant. These include under-supply of public goods, particularly infrastructure.
- *The government should work with existing and emerging clusters rather than trying to create entirely new clusters*. A policy aimed at developing entirely new groups of firms in selected sectors can entail high costs and high risks, and give rise to destructive competition should many regions follow the same policies in pursuit of identical industries.
- *A policy on clusters should encourage dialogue and co-operation between firms and the public sector (particularly at local and regional levels of government).* This dialogue could identify and lead to the development of inter-firm networks and improved quality of government action (such as in co-locating complementary public investments, like research facilities).
- *Policy makers should also assess the wider determinants of cluster success, which may in fact be the best targets of policy*. Such determinants include transport, land-use planning, housing, the quality of public amenities and labour market policies.
- *Incentive structures should encourage local linkages between industry and universities.* Many institutional permutations are possible as regards the interaction of local firms, universities and training institutions. These can range from grants and fellowships to targeted research contracts, collaborative research and training programmes. Such arrangements will not always be the responsibility of central government, but if support for a cluster is provided, the programme managers can meet with the relevant local actors, encourage adaptability and assess the need, if any, for complementary actions by local, regional or central public authorities.
- *The government might justify a facilitating or co-ordinating role in developing business networks, owing to the fact that in some places and industries there may have been no, or limited, prior familiarity with the opportunities that networks afford.* However, if "demonstration" is the policy rationale, then this implies that the policy should have a short duration. Funding should be modest, and should be

phased out as participants start to engage more formally and obtain benefits. Precise market-oriented objectives for business networks should be set by, or in conjunction with, firms. Networks that only have loosely-defined goals tend to have limited impact.

In addition, clusters in Lithuania with already close collaboration structures, long-term vision and a focus on R&D and innovation could be developed further into competence centre-type structures. This could support patterns of collaboration which go beyond one-off projects and instead build strategic innovation agendas for the medium to long term. Examples of such centres can be found in several countries, such as Austria[16] and Estonia.[17] These centres often take the form of limited liability companies jointly owned by industry and research organisations, with a long-term objective to become financially self-sustaining.

Business services

The Enterprise Europe Network (EEN) started its activities in 2008 in Lithuania. This network brings together around 600 business support organisations from more than 50 countries with the goal of providing help for small companies to seize the unparalleled business opportunities in the EU Single Market and beyond. In Lithuania, this network is represented by four organisations – Kaunas Chamber of Commerce, Industry and Crafts (Kaunas CCIC), Klaipeda Chamber of Commerce, Industry and Crafts (Klaipeda CCIC), Vilnius Chamber of Commerce, Industry and Crafts (Vilnius CCIC) and Lithuanian Innovation Centre (LIC).

The Lithuanian EEN consortia offer European support services specifically designed to unlock the potential of Lithuanian businesses and researchers through:

- increasing the ability to innovate and create higher absorptive capacity
- improving performance in internationalisation as well as enhancing competitiveness in the EU Single Market
- enhancing management capacities and co-operation with clusters
- better access to new markets and networking opportunities at EU level and beyond
- improving understanding of EU legislation, standards, policies and programmes.

The Lithuanian EEN network plays a significant role in providing EU-level advisory and networking services to the Lithuanian business community, according to an analysis of business support demand (LIC, 2014). EEN services are the first choice of 68% of SMEs with regard to public innovation coaching services and the first choice of 77% of SMEs with regard to public advice on EU programmes and European funding opportunities.

The EEN network complements the Lithuanian business support environment by providing specific services to enable access the benefits of the EU Single Market and contribute to the competitiveness of SMEs:

- The new funding period (2015-20) in Lithuania and the European Union will bring many funding and partnering opportunities for the business and scientific communities. The main national funding agencies offer more than 25 national financial support measures for SMEs, to support internationalisation and R&D. In an analysis of business support demand (LIC, 2014), more than 80% of SMEs identify the need for support in understanding and selecting appropriate EU/national funding or partnering programmes. The Lithuanian EEN consortia reflect these

needs by enriching advisory services with detailed mapping of funding opportunities relevant to the individual SME's business strategies.

- EEN services such as technology audits, reviews of innovation capacity, access to large-scale technology markets and automated queries systems (AQS) are not only unique services to the Lithuanian public business support sector, but also highly valued by users (LIC, 2014).

The main targets for services delivered by the Lithuanian EEN consortia for the development of absorptive capabilities in Lithuanian firms include Lithuanian SMEs already engaged in innovation and/or having the potential to act internationally and adopt new technologies or non-technological innovations in the context of international partnerships, but facing internal barriers to these developments.

The barriers to business with regard to engaging in R&D and innovation relate to both funds and competences. Offering funding alone is therefore not sufficient. Business R&D and technological innovation also need to be supported by innovation support services.

In addition to the EEN network, there are also other business R&D and innovation services available in Lithuania, for example through MITA. However, the utility of these services is considered average (ESTEP, 2015). Visionary Analytics (2014) pointed to the fact that the existing innovation promotion system lacks sufficient "soft" measures, to increase companies' motivation to implement innovative activities and innovation capacity building. Despite the existence of the innovation support services, they lacked both R&D-related mentoring services and qualified staff to work with R&D equipment (Visionary Analytics, 2014, ESTEP, 2015). Evaluation draws attention to quality issues in innovation support service (promotion of networking, knowledge and technology transfer, technology and innovation audits, support for co-operation (business and education), partnerships and promotion of clustering (Public Policy and Management Institute and Knowledge Economy Forum, 2011). The report concludes that the lack of service quality is determined by two factors: a) the lack of expertise and experience; and b) the inefficiency of the performance measurement system (accounting for quantity rather than quality of results).

The typical way to organise R&D and innovation support services is to assign the provision of these to an existing or new network of various public sector organisations. The problem with this is that these public sector organisations are often not able to attract the necessary competences with hands-on experience in entrepreneurship and business development. People with entrepreneurial mind-sets and experience tend to stay in the private sector and work in or with companies, rather than seek employment in the public sector.

Therefore, these services have in some cases been organised in the form of vouchers or procurement contracts, where the services are provided by private sector service providers. These models may be based on the number of companies reached and services provided, but they may also include performance or success-based fees.

The benefit from using private sector service providers is that this approach addresses simultaneously both the demand and supply. The service made available enhances the demand for R&D and innovation support services and makes them visible. On the other hand, allowing the private sector to provide the services enhances the availability and quality of services. This will allow the public sector to gradually reduce its intervention as both the demand and supply develop over time.

However, services cannot be based on private service providers unless the private service market is developed enough. If the quality and availability of private business

R&D and innovation services is limited with high variations in quality, the public sector may have to organise the services itself. An alternative is to make use of certification and validation mechanisms or even selection based on public tendering. The rationale for these is that only those service providers that are able to show the necessary competences and experience, and thereby sufficient quality, are selected and/or certified to provide the service. These may include both private and public service providers. As the quality and availability of these services develop over time, the certification can be taken over and managed by the service providers themselves (self-regulation). This offers the mechanism for reducing public intervention over time.

Public business R&D and innovation services easily tend to become institutionalised, unless they are managed on business principles against clearly defined and monitored performance indicators.

The main challenge with the EEN network is related to its focus. It should provide services for companies regarding EU funding opportunities and other potential sources of funding as well as developing R&D and innovation competences. The relevant target group for these services consists mainly of SMEs with relatively high levels of R&D and innovation capacity. If the EEN network remains focused on these, the wider economic impact of its activities may prove to be relatively limited.

For wider impact, the EEN needs to reach companies with less R&D and innovation competences. However, these companies are typically not able to access EU funding or engage in challenging R&D and innovation projects. The services these companies need differ greatly from services needed by more competent SMEs.

It is therefore important that the EEN and other public innovation support programmes are clearly profiled to specific target groups and specific services. Unnecessary overlaps will inevitably merely confuse potential beneficiaries, and thus limit the impact of these services.

R&D and innovation support services should be made available to all SMEs with the capacity, or at least the potential to develop the capacity, for R&D and innovation. However, these services are often most effective when they are integrated into active development projects undertaken by companies. For example, offering training services in isolation is typically not as effective as those integrated into active projects with the possibility of an additional mentoring/coaching component.

Therefore, the design of R&D and innovation support services should be based on three main fundamentals:

- clearly identified and verified need experienced by targeted companies
- clearly definable and sustainable added value, that is, increase in targeted companies' R&D and innovation competences
- easy integration of the services into other support programmes, particularly R&D and innovation funding.

The supply of business R&D and innovation support services should be need-driven. The EEN network is a European construct based on the generic needs of SMEs with some bias towards companies capable of benefiting from EU support. It is important that the local implementation in Lithuania is strongly tailored to the Lithuanian context, otherwise it may end up focusing on a limited number of companies also targeted by several other measures, overlapping, and adding to the complexity and confusion rather than providing a clear added-value.

Awareness raising can also be viewed as a service. Instead of designing and implementing isolated campaigns, awareness raising can be integrated into services, such as reviews of international market trends and future opportunities, diagnostics and readiness analyses, coaching/mentoring, etc., raising awareness by bringing timely and relevant information to companies when they need it and/or can use it.

Public procurement for innovation

Innovation-oriented public procurement is not yet well developed in Lithuania, with lowest-price criteria still dominating public purchasing decisions. However, in 2014 the *Innovative Public Procurement Guidelines* were published to stimulate public procurement of better quality items more adapted to customer needs, and providing superior performance.

The ambition to develop innovative public procurement is set out in the Strategy of Development and Improvement of the Lithuanian Public Procurement System (2009-13). Despite the fact that current legal provisions provide possibilities for innovation-oriented public procurement, this happens in a rather limited way. The strategy set a goal where, by 2013, innovation-oriented procurement would account for 5% of all public procurement. This objective was not fully achieved.

- Recently, with support from the Ministry of Economy, MITA began an initiative on PCP called "Creation of a legal environment for pre-commercial procurement" (IPTAS) (PCP aims at purchasing R&D, design, prototyping and testing services for products or services that do not yet exist on the market. Such procurement requires innovative technological development work by companies or institutions responding to the tender (Edquist, Hommen and Tsipuri, 2000). Lithuania's IPTAS initiative developed a legal administrative structure as well as draft legal documents for the implementation of PCP.
- In 2015, the government established the "Basis of Pre-commercial Procurement", which enables the public sector to invest in new, innovative products. The Ministry of Economy – in co-operation with MITA, the co-ordinating agency for PCP – conducted a survey of public procurers (ministries, agencies, etc.) on the demand for PCPs (almost 50 at present). MITA is promoting them in different ways. In the framework of Inogeb, LT MITA – in co-operation with LIC – is launching a project aiming to provide advice on PCP to public procurers and business. In addition the European Structural Funds' instrument "Pre-commercial Procurement LT" provides favourable conditions for public procurers to use PCP more widely. Further dedicated activities, including seminars, a competence centre, the provision of methodologies and special guidance for public procurers on implementation of PCP, are foreseen for the future.

There are various rationales for using public procurement to promote innovation:

- because of their purchasing power, governments can shape innovation directly (because procurement can help firms recuperate the sunk costs of risky and sometimes large investments) as well as indirectly (because as a lead consumer government can influence the diffusion of an innovation)
- the delivery of some essential public services might become more cost-effective if relevant forms of innovation succeed
- particularly when procuring from small innovative firms, public sector demand may help to counter problems of access to finance that such firms sometimes face, because the public contracts provide a degree of security for third-party lenders.

For some time public procurement has been used to facilitate the emergence of a number of high-tech sectors in countries such as the United States, Japan and France (where procurement has helped to develop high-speed rail and nuclear energy technologies). However, in recent years countries such as Australia, Finland, Germany, the Netherlands, the United Kingdom and also the European Commission have given new emphasis to public procurement as a tool to promote innovation and meet societal goals (see Box 5.12 on the discussion of the use of PCPs in Europe). Nevertheless, despite the existence of national strategies, a recent survey of firms in six OECD countries (Austria, Belgium, Finland, Germany, Portugal and Sweden) indicates that innovation requirements are relatively rare in procurement contracts (Appelt and Galindo-Rueda, 2014). Making innovation-oriented procurement a reality appears to be challenging. What are these challenges and what might they imply for Lithuania?

Box 5.12. **Pre-commercial procurement (PCP) in Europe**

The use of public procurement in innovation policy is now widely discussed in Europe. A large number of initiatives, pilot projects or studies have been launched to experiment with and implement such procurement. The use of PCP has been inspired by the SBIR programme in the United States. Programmes that followed this example include the United Kingdom's SBRI programme. This programme, co-ordinated by the then Technology Strategy Board, involved public procurers from the Department of Health, the National Health Service and the Ministry of Defence. The Dutch SBIR, with a strong focus on public procurement to tackle societal issues, also involved procurers from ministries responsible for environmental, health, public transport and infrastructure-related fields. A lesson learned from early programmes is that it takes strong political leadership and training of procurement officers to adopt PCP. Agencies running these programmes have expended considerable effort in supporting and coaching procurers in other public authorities on how to launch PCP calls. In the Netherlands an expertise centre for public procurement was set up that also contributed to the dissemination of expertise on PCP (see https://www.pianoo.nl/public-procurement-in-the-netherlands). The European Commission has also invested in support and expertise platforms for public procurement for innovation (see https://www.innovation-procurement.org).

Key challenges in effectively implementing innovation-oriented procurement include the following (see OECD, 2011b):

- Procurement is often fragmented across local, regional and national governments. The fragmentation of public demand limits the benefits of larger scale that can be helpful to innovative procurement. For many investments in a potential innovation, having a larger public market will improve the risk-return profile for firms.
- Lack of skills for innovative purchasing has also been an important challenge. Specialised procurement agencies are mainly responsible for the efficiency of purchasing, and expertise in innovation is often lacking. When award criteria include considerations other than economic value, this introduces a level of subjectivity in the decisions of procurement officials. If, for instance, the innovative character of a good is to be considered in an award decision, procurement officials will need to be able to assess this. A study in the United Kingdom found that only 14% of surveyed firms strongly agreed with the statement that "public procurers are knowledgeable about the market in which our product and/or service operates." Just 18% of firms strongly agreed with the statement "public procurers are knowledgeable about the technical aspects of our product and/or service" (Edler et al., 2012). Procurement officials sometimes lack guidance on how to take innovation criteria into account in public procurement.

- Linked to shortages of skills is that smaller procurement units appear to perform less well in implementing innovation-oriented procurement. For example, a survey in 2013 of public procuring units in Finland suggested that the capacity of procuring units influences the incidence of innovation procurement. Procurement units with 1 000 or more employees were more likely than smaller units to make purchases in which the public sector is the first user. The larger procurement units were also more likely to award contracts that require delivery work (which may entail some level of innovation).
- Procuring innovation entails risks additional to those present in all procurement procedures. These risks include:
  - *technological risks*, i.e. risks of non-completion stemming from technical features of new goods or services
  - *organisational and societal risks*, i.e. risks arising within the procuring organisation and/or risks related to uptake of the good or service by users
  - *market risks*: the main market risk is that suppliers do not respond to the tender.
- Mitigation options exist for all of the risks (although all the mitigation options require experience and skills in the procurement agency). For instance:
  - One mitigation option for technological risk is to use cost-reimbursement contracts, in case the procured technologies underperform. As a part of the bid submission, vendors might also be asked to analyse risks associated with their proposals and assess how these could best be managed. Another mitigation strategy is to use framework agreements or multi-stage procurement processes. The latter effectively give opportunities to screen out more risky bids during early stages of the procurement.
  - Risks related to the uptake by users of the good or service can be mitigated through early user involvement in the procurement process, for instance through structured consultations and foresight exercises. Sweden's national innovation agency, Vinnova, has worked along these lines.
  - Market risks take various forms and can be addressed in different ways, for instance through user training schemes.

The generic policy lessons from OECD experience also apply in Lithuania, namely:

- It is essential that competition in the tender process be preserved. The particular threat to competition in innovation-oriented procurement comes from the greater interaction and information exchange that can occur between the procurer and suppliers, relative to purely arms-length procurement.
- General government procurement can be made more innovation friendly with little additional risk simply by specifying the goods and services to be procured in terms of their functionalities – what they will do when used – rather than pre-determined technical characteristics. This will provide opportunities for markets to propose new products or services to fulfil the specified functions.
- Skills and capacities need to be developed to implement innovation-orientation procurement successfully. Any funding for innovative procurement is also probably best complemented by support services for procurers. Support services can advise the procurers, or manage the procurement process entirely. The United Kingdom's

experience with PCP shows that once the benefits become clear, procurers can develop the necessary competences and take over the procurement processes (the SBRI programme has developed into a challenge competition scheme supporting and complementing procurement processes managed by different public sector organisations).[18] Improving risk management capabilities is essential.

- Since procurement of innovation represents a significant change in public sector culture, it may be advisable to pilot the respective schemes before launching them in full scale. Launching should take place in sectors which show highest potential for these types of measures. For example, in Estonia the first step was to implement a feasibility study[19] to identify which types of demand-side policy measures would show the greatest potential in which sectors. Based on this analysis and further insight into the readiness of potential procurers in specific areas of smart specialisation, a pilot call was launched in 2016. The plans are to learn from the pilot, develop and fine tune the necessary resources and eventually launch the full scheme in 2017.
- Every effort should be made to ensure that procurement processes do not disadvantage SMEs. Procurement processes often favour larger enterprises, which have greater capacity to respond to government tenders. Engaging as broad a range of the enterprise population as possible is good for equity and expands the range of ideas proposed.
- Procuring innovative goods and services can also require stakeholder involvement and co-ordination. Involving stakeholders – both users and potential suppliers – early in the procurement process may help to write better tender documents (i.e. documents that clearly guide innovative effort and solicit feasible innovation but do not preclude innovative solutions) and to forecast what the likely response from the market will be. A number of examples of early stakeholder engagement exist. For example, in the early 1990s, the Swedish National Board for Industrial and Technical Development (NUTEK) identified an opportunity to lower household energy consumption by developing more energy-efficient refrigerators. It was expected that public procurement of such refrigerators would have a catalytic effect. NUTEK created a purchaser group made up of an association of housing co-operatives, companies in insurance and real estate, the Swedish National Board for Consumer Policies and the Swedish National Energy Administration. This group convened seminars and visited factories to develop the specifications for the product to be procured (Vinnova, 2009). It is essential, however, that the closer engagement with potential suppliers be accompanied by practices which safeguard competition (for instance, any information provided about the process to one supplier should be made available to all, possibly through a website).

Developing challenge prizes

Challenge prizes appear not to have been used in a significant way in Lithuania. But challenge prizes can help to influence public perceptions, mobilise talent and capital, strengthen problem-solving communities and educate. Prizes are likely to be most effective in tackling problems which can be defined in an abstract, standardised way and which can be addressed by a relatively wide range of experts possessing tools with which to implement solutions. However, prizes are likely to be less effective and efficient than other incentive regimes when considerable effort is required to formulate the challenge and validate, test and implement possible solutions. International good practices can be used to give direction on how to introduce challenge prizes across different government bodies and agencies.

5.6. Investing in public research and related infrastructure

Increased competitive funding for research

With the introduction of competitive funding for research in 2009, LMT started to allocate competitive research grants in many different disciplines and with different characteristics. Currently, LMT runs about 20 programmes for research and scientific activities, funded through the national budget, EU Structural Funds and contractual arrangements with third parties. Around 40 calls for research funding are announced every year. The programmes can be broadly categorised as:

- programmes funding large-scale research projects
- programmes funding research in national priorities
- programmes to promote the integration of Lithuanian researchers in Europe
- bilateral programmes with selected countries
- programmes supporting young researchers
- funding schemes for specific research activities (European Science Foundation [ESF], 2014).

The main funding instruments of LMT are:

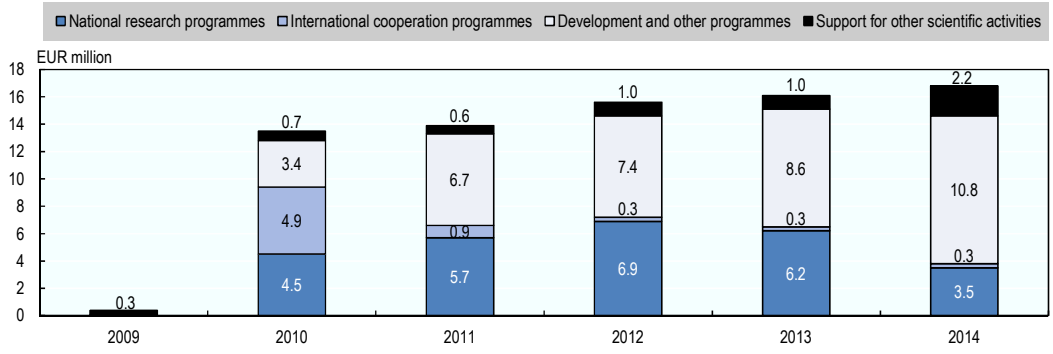
- The *Global Grant Programme*, supported by EU Structural Funds, with the aim to support world-class scientists and research projects. Each grant can be awarded for research projects from two to four years long. The Global Grant Programme does not prioritise any research field.
- The *National Research Programmes* with the aim of funding research projects to solve specific applied technological and societal challenges and to focus on national research potential.
- The *Researcher Teams Project* with the aim to develop world-class research in the following areas: humanities, social sciences, physical sciences, biomedicine, technological and agricultural sciences.
- The *National Lithuanian Studies Development Programme* (2009-15) funding academic research on Lithuanian studies, the promotion of interdisciplinary research and its digital dissemination.
- The newly-established *Open Partnership Programme* supporting Lithuanian researchers conducting research projects with researchers abroad. The duration of each research project can be two to three years.
- The *Breakthrough Idea Projects* to allow researchers to verify research ideas, undertake feasibility studies and support competition in national and international programmes.
- *Post-doctoral fellowships* funded on a competitive basis for up to two years.
- Other financing programmes supporting early-stage researchers through doctoral fellowships, academic associations, PhD students' academic trips, research visits, events, and the publication of scientific articles and books.

In addition to these programmes, LMT participates in and co-funds a number of international programmes, such as the Lithuanian-Swiss Co-operation Programme on Research and Development, bilateral partnerships with Belarus, France and Ukraine and a partnership with Latvia and Chinese Taipei.

A recent evaluation of LMT by the ESF (2014) recognised the well-managed transition to a more competitive funded system by LMT, but highlighted several weaknesses in the way some of the programmes are designed, funded or managed. The evaluation found that programmes funding larger research grants (such as the Global Grant and the Researcher Teams Projects) are more appealing for Lithuanian researchers with higher numbers of demands, and as a consequence a lower acceptance rate. These schemes allow researchers to develop the capacity to manage larger projects in an independent way. The evaluation highlighted the very high number of programmes and calls managed by the council every year, often distributing grants of smaller size, in a way that does not steer the research system towards excellence.

Another issue highlighted relates to the lack of, or very limited, funding for industrial research and academia-industry collaboration. Such programmes could be developed and managed jointly with MITA to avoid duplication of efforts and resources. However, it has to be noted that over time there has been a shift of attention towards more needs-driven research (with topics proposed by ministries) including technological development (EUR 495 000 allocated in 2015/16). Other weaknesses relate to the limited use of the English language in grant applications, which in turn limits the set of potential international reviewers essentially to Lithuanian speakers. Finally, the evaluation stressed the importance of increasing investments in programmes to support young, early-career researchers as well as the international mobility of scientists of all seniorities and in all research areas. To promote the internationalisation of the Lithuanian research system, LMT manages EU Structural Fund measures to attract distinguished researchers from abroad. LMT's funding portfolio is presented in Figure 5.3 and shows a decline in national programme funding and a growth in development and other programmes.

Figure 5.3. **Allocated funding by Research Council of Lithuania**



Note: For 2009, support for other scientific activities was negligible (EUR 0.1 million).

Source: Research Council of Lithuania.

The evaluation committee of the ESF (2014) evaluation of LMT (or RCL in English) also noted the high degree of complexity of the funding system for HE and research:

> The Evaluation Committee was struck by the complexity of the various national mechanisms for funding and setting policy for HE and research in Lithuania. We recognise that particular national circumstances govern the development of such systems, that international norms may not be appropriate within those circumstances (…) However, we also note that the complexity of the system is likely to hinder in certain respects the ability of the Lithuanian research system, and the RCL, to compete internationally, and constrains to a large extent the freedom of operation of the RCL (Evaluation Committee of the ESF, 2014).

The ESF evaluation recommended that there should be more formal and regular interaction between LMT and other agencies such as MITA. It found that LMT so far was hardly involved in the Ministry of Science and Education and the Ministry of Economy objectives to focus more on innovation. It also recommended that its National Research Programmes should be better linked to the development of the Valleys and the Smart Specialisation Strategy.

A review of the funding mechanisms of Lithuanian HEIs and research and technology organisations (RTOs) based on stakeholder consultation found that there is rather broad agreement on the fact that there are too many institutions and that most of them are too small (Arnold, Angelis and Nausėdaitė, 2016). Neither the HE nor the research funding system contain elements that militate against fragmentation. And the system as a whole suffers from insufficient research funding. Lithuanian research relies too greatly on European Structural Funds as opposed to national funding. These will diminish over the years. In addition, the presence of the dual voucher and fee system and the existence, therefore, of a quasi-market in degree courses as well as research has to some extent allowed the system to avoid a strategic decision about how much capacity to dedicate to academic, university-based HE and how much to the more professionally-oriented HE provided in the colleges. The report suggested that the student voucher system should be reviewed as well as the complex funding system which lacks the appropriate incentives to modernise and improve the public research sector. However, it concludes that without institutional change addressing bottlenecks, such as fragmentation and lack of strategic capacities, changes in the funding models alone are not sufficient to address the issues in the research system.

The Valleys Programme

The Integrated Science, Studies and Business Centres – commonly referred to as the "Valleys" in Lithuania – were one of the main public investments in STI during the 2007-13 programming period and were renewed in 2014. The Valleys Programme was started by the Ministry of Education and Science and the Ministry of Economy, and funded by EU Structural Funds (with more than EUR 200 million over 2007-13). The Ministry of Economy is supporting the development for R&D infrastructure by allocating about EUR 35 million of EU Structural Funds to the Valleys. The Ministry of Education and Science finances STPs, technology transfer centres, technological business incubators, open access laboratories, cluster laboratories, and similar infrastructure development projects within the Valleys.

The Valleys Programme created networks of research centres, linking universities and research institutes. As a major STI programme, the Valleys pursued multiple objectives: to promote the generation of a high-level research base, to encourage national and international collaboration among researchers, to promote the development of knowledge-intensive sectors of the economy, to upgrade research infrastructure and the

commercialisation of research results, to enable public researchers to effectively co-operate with the business sector, and to strengthen technology development and transfer.

While it was conceived as an initiative based on closer co-ordination between the Ministry of Education and Science and the Ministry of the Economy, it gradually moved into the domain of the Ministry of Education and Science although the Ministry of Economy participates in coordination and monitoring processes. As the Valleys were intended to develop around strong centres of scientific excellence, universities were leading actors in the programme and instead the business sector did not show strong interest in engaging in the consultation processes when the programme started.

Initially only two Valleys were planned, in Vilnius and Kaunas, but five Valleys were finally established. The Valleys are located in the three cities with the highest concentration of HEIs in Lithuania: Vilnius, Kaunas and Klaipeda. The Valleys are now seen as the foundation and an integral part of Lithuania's strategy for smart specialisation. The research focus and HEI participants of the five Valleys are presented in Table 5.3.

Table 5.3. **Integrated Science, Studies and Business Centres (Valleys) and participating universities in Lithuania**

Name	R&D focus	HEIs participating the Valley's activities
Saulėtekis Valley	– Laser and light technologies – Materials science and nanotechnologies – Semiconductor physics and electronics – Civil engineering	– Vilnius University – Vilnius Gediminas Technical University
Santara Valley	– Biotechnology – Innovative medical technologies molecular – medicine and biopharmacy – Ecosystems and sustainable development – Informatics and communication technologies	– Vilnius University – Vilnius Gediminas Technical University
Santaka Valley	– Sustainable chemistry (including biopharmacy) – Mechatronics and related electronic technologies – Future energy (including environmental engineering) – Information and telecommunication technologies	– Kaunas University of Technology – Lithuanian University of Health Sciences
Nemunas Valley	– Agrobiotechnology, bioenergy and forestry – Food technology, safety and health	– Lithuanian University of Agriculture – Aleksandras Stulginskis University – Lithuanian University of Health Sciences – Kaunas University of Technology
Marine Valley	– Marine environment – Marine technologies	– Klaipeda University – Lithuanian University of Health Sciences

Source: Ministry of Education and Science (2014), Integrated Science, Studies and Business centres (Valleys), www.smm.lt/web/en/science1/science_1.

Lithuania's Valleys eventually became development projects for the science infrastructure, deviating from the original idea of their being business and science co-operation centres. The limited public-private co-operation in the Valleys can be attributed to a number of factors: complicated procedures for the use of public R&D infrastructures, researchers' career regulations (high dependence on academic publications and low attention to collaboration), orientation towards "pure" research, the narrow definition of R&D (largely only research), lack of involvement by business players in the governing structures and decision-making processes of the Valleys (Visionary Analytics, 2014; Baltic Legal Solutions, 2015). On the other hand, it is difficult to assess the potential impact of the Valleys, due to the fact that they are just at the inception stage. For example, the annual progress assessment report on joint research programmes and interim report on joint performance monitoring prepared by Ernst & Young and the Technopolis Group in 2014

noticed initial positive effects of three Valleys-related projects with the expectation of positive impact in the future, if certain conditions are met. It should also not be forgotten that industry had little absorptive capacity and appetite to engage with the Valley initiative. As the history of successful high-tech Valleys shows, it takes a long time for these initiatives to develop into economic success stories. In addition, political endurance is needed to provides some form of policy support to enable the Valleys to become self-sustaining. See Box 5.13 for a description of success factors in public-private co-operation around STI in OECD countries.

Box 5.13. **Success factors for strategic public-private partnerships (P/PPs): Evidence from OECD countries**

Whilst there is no one-size-fits-all model for P/PPs, several factors recurrently appear as fundamental in the design and implementation of successful P/PPs schemes. In particular, good governance and public leadership are key factors ensuring the success of P/PPs. These include setting clear objectives and activities/responsibilities well defined for each participant; the existence of operational rules and implementing regular monitoring and evaluation; transparency; consultation with stakeholders; and the establishment of dispute settlement and exit strategies.

Other important factors are:

- a clear identification of failures
- long-term (open-ended) stable commitment by the government
- careful selection of participants and definition of their alignment/complementarity
- appropriate planning, task/responsibility definition, and information-sharing mechanisms
- inclusion of an education objective and equal emphasis on all four major objectives (research, collaboration, education and outcome application)
- a clear management structure
- a board of stakeholders chaired by an independent industry/research sector actor
- partnership scale and resources
- personnel stability, etc.

The success of P/PPs in many cases also depends on complementary regulatory frameworks shaping interactions between public organisations (e.g. academia) and industry. Examples of regulatory measures to incentivise P/PPs in innovation include tax incentives, performance-based funding (and metrics), rewards systems for researchers, and intellectual property legislation (e.g. Bayh-Dole Act). Recently, Belgium increased the wage-withholding tax credit for highly qualified researchers involved in industry-science research collaboration. In 2013, the Netherlands introduced the Rules of Play for Public-Private Collaboration jointly defined by a large number of STI actors. The code of practice seeks to make the connection between fundamental research and the top sectors more transparent, among other things. Starting in 2017, Norway will introduce a "third-party" indicator in funding metrics of HEIs. This indicator will help define performance-based components in block grant funding.

Source: www.innovationpolicyplatform.org.

As an attempt to increase public-private co-operation and shift the excessive focus on the development of research infrastructure for universities, the requirement to make all R&D resources located in the Valleys available to the public on the basis of open access

principles has been recently introduced. Universities and research institutes are obliged to provide non-academic actors access to their research infrastructure. Other entities not belonging to the Valleys are also eligible to become open access centres. However, the impact of open access centres so far has been rather limited, as very few companies use them.

5.7. International linkages

As illustrated in previous chapters, international linkages in STI are not well developed. For example, the share of foreign researchers and doctoral students in Lithuanian organisations, international co-publication (although increasing) and innovation-related linkages between Lithuanian companies and organisations abroad remain weak.

The success rate of Lithuanian organisations in applications to the 7th Framework Programme (FP7) was 20%, similar to the European average of 20.5%. The majority of Lithuanian participants in the FP7 project were public R&D institutions. However, SME participation has increased significantly compared to FP6 (Paliokaitė, 2015a). The FP7 Final Evaluation report (European Commission, 2015) shows that Lithuania receives only 0.15% of the FP7 budget (EC contribution). This means that Lithuania received the second-lowest contribution per researcher (after the Slovak Republic) and one of the lowest contributions per inhabitant. Compared to the other Baltic states, in terms of number of participants and amount of funding, Lithuania performs better than Latvia but lags behind Estonia. Lithuanian participants are most successful in ICT, energy, health, nanotechnologies, materials, new production technologies, food and biotechnology.

Internationalisation is critical for the development of Lithuanian business and clusters. Fostering business and cluster participation in networks, such as the BSR Stars Programme initiative "Innovation Express", EUREKA, Eurostars, participation in Horizon 2020 projects, organising dedicated business missions and providing favourable conditions for business participation in matchmaking events are among the actions taken to improve business internationalisation by the Ministry of Economy. It promotes international co-operation in innovation networks, especially in the Baltic Sea Region. For example, since 2012, the Green Industry Innovation Programme has been launched in co-operation with Norway (Paliokaitė, 2015b). Other programmes to promote international linkages of clusters and SMEs in the Baltic region have been developed, with particular emphasis on green innovations.

In 2012, MITA and MATIMOP, two national innovation agencies in Lithuania and Israel, responsible for promotion of R&D development, signed the agreement, which aims to promote bilateral co-operation in industrial research and technology fields, notably in lasers, IT, biotechnology, nanotechnology and other areas.

Lithuania is currently seeking to strengthen integration within international research networks. Lithuania established relations with the European Space Agency (ESA) in 2010 by entering into a co-operation agreement. As Lithuania seeks to become a member of ESA, dedicated calls have been announced which will increases Lithuanian business capabilities to participate in international tenders. Furthermore, agreements for co-operation have been developed with the United States in the field of science and technology and with NASA on student internships.

However, despite these initiatives, policy actions to support international co-operation in the area of STI remains fragmented and the financial commitment remains limited.

Notes

1. This section is mostly based on Leichteris et al. (2015).
2. For more information see www.smm.lt/web/en/science1/-programme-for-development-of-studies-and-rd-for-2013-2020.
3. For example, it is not clear what the council's role is with respect to the State Progress Council overseeing the implementation of the National Progress Programme and Lithuania 2030 strategy.
4. Examples are the objective to raise GERD to 1.9% (below 1%), or BERD to 0.9% (0.24%) by 2020. Given that very little progress has been made over recent years, this objective appears overly ambitious.
5. www.arengufond.ee/upload/Editor/English/publications/Estonian-growth-vision-policy-brief-eng.pdf.
6. https://www.bmbf.de/en/bmbf-foresight-1419.html.
7. https://www.gov.uk/government/groups/horizon-scanning-programme-team#role.
8. www.tekno.dk/ydelser/?lang=en.
9. Leichteris et al. (2015), p. 48, based on data from the European Commission (2014).
10. Statistics Lithuania, see http://123.emn.lt/en/general-trends/migration-10-years-overview.
11. Visionary Analytics (2014), Lithuanian high technologies development feasibility study. Contracted by the Ministry of Economy of the Republic of Lithuania. www.ukmin.lt/uploads/documents/AT%20studija_santrauka_EN.pdf.
12. https://www.sbir.gov/about/about-sbir.
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15. See www.mita.lt/en/general-information/innovations/clusters.
16. https://www.ffg.at/en/comet-competence-centers-excellent-technologies.
17. http://researchinestonia.eu/science-scene/competence-centers.
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