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Foreword

The OECD Review of Finland's Innovation Policy is part of a series of OECD country reviews of innovation policy (www.oecd.org/sti/innovation/reviews). It was requested by the authorities of Finland, represented by the Ministry of Employment and the Economy and supported jointly by the Minister of Economic Affairs and Employment, Dr. Olli Rehn, and the Minister of Education and Culture, Ms Sanni Grahn-Laasonen. The review was carried out by the OECD Directorate for Science, Technology and Innovation 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 Finland's 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 Finnish innovation system
- recommends where improvements can be made in the system
- formulates recommendations on how government policies can contribute to such improvements, drawing on the experience of OECD and non-OECD countries and evidence on innovation processes, systems and policies.

The review is relevant to a wide range of stakeholders in Finland, including government officials, entrepreneurs and researchers, as well as the general public. It aims to provide a comprehensive presentation of the Finnish innovation system and policy to a global audience through the OECD communication channels.

A draft version of the "Overall assessment and recommendations", containing key issues and recommendations, was presented for a peer review at the Workshop back-to-back to the Meeting of the Working Party on Innovation and Technology Policy (TIP) of the CSTP in December 2016. Adam Baden (Danish Agency for Science, Technology and Innovation, Denmark) and Eric Hauet (Ministry of National Education, Higher Education and Research, France) acted as peer reviewers.

Related to, but independent of, the review, the Finnish Ministry of Economic Affairs and Employment asked the OECD to carry out a survey of the macroeconomic literature on the role of research and development (R&D) in fostering economic performance. The report, drafted by Professor Pierre Mohnen (Maastricht University and UNU-MERIT), provided background and informed the review. A high-level workshop on "The Role of R&D in Fostering Economic Performance: Lessons from Research and Implications for Finland" was held in Helsinki in December 2016, bringing together international experts in the field from Finland, other parts of Europe and the United States to discuss findings of the forthcoming report and related complementary work. On this occasion, the Research Institute of the Finnish Economy (ETLA) presented a review of the microeconometric literature considering the impact of public subsidies on private R&D which was carried out in parallel to the OECD survey.

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 Pluvia Zuniga (STP, DSTI, OECD), who acted as the project manager of the review, and, at the final stage, Johannes Weber (STP, DSTI, OECD), with contributions from Erik Arnold (consultant to the OECD; Chair, Technopolis Group, United Kingdom, and Adjunct Professor in Research Policy, Royal Institute of Technology, Sweden), Sylvia Schwaag Serger (consultant to the OECD; Executive Director International Strategy and Networks, Vinnova, and Adjunct Professor in Research Policy, School of Economics, Lund University, Sweden), with valuable support from Yana Vaziakova (STP, DSTI, OECD) under the supervision of and with contributions from Gernot Hutschenreiter.

The review draws on the results of a series of interviews with a wide range of major stakeholders of the Finnish innovation system during a fact-finding mission to Finland in June 2016. A background report served as preparation for the OECD fact-finding mission. The background report was commissioned by the Finnish authorities and prepared by editing-authors Annu Kotiranta and Petri Rouvinen with the support of a team of other authors and contributors.[*] It contains a broad range of valuable information that is drawn upon in this report. ETLA supported the process.

This review has benefited from comments and additional information received from stakeholders in Finland, including during a stakeholder discussion in Helsinki, preceded by a meeting with the Research and Innovation Council (RIC) on 8 February 2017.

The authors owe much to the support and co-operation of the Finnish government officials, in particular Kai Husso (Ministry of Economic Affairs and Employment and Finnish delegate to the Working Party on Innovation and Technology Policy) and Kirsti Vilén (Ministry of Economic Affairs and Employment and delegate to the Committee for Scientific and Technological Policy and the Working Party on Innovation and Technology Policy). Many of the stakeholders the OECD met during the fact-finding mission and at the stakeholder discussion provided valuable information and data and were instrumental for the preparation of this report.

[*] Other authors: Heli Koski, Terttu Luukkonen, Mika Pajarinen, Ilkka Ylhäinen and Pekka Ylä-Anttila. Other contributors: Pia Björkbacka (SAK), Henri Grundsten (FII/Tesi), Ulla Hagman (Finnvera), Milla Halme (SAMOK), Riikka Heikinheimo (EK), Pauli Heikkilä (Finnvera), Erja Heikkinen (MEC/OKM), Jemi Heinilä (SAMOK), Raine Hermans (Tekes), Kai Husso (MEE/TEM), Jani Hyppänen (SAMOK), Jari Hyvärinen (Tekes), Marko Häikiö (FII/Tesi), Tiina Ingman (MEE/TEM), Tiina Jokela (Sitra), Seppo Kangaspunta (MEE/TEM), Mervi Karikorpi (Federation of Finnish Technology Industries), Hannu Kemppainen (Tekes), Jari Konttinen (EK), Heikki Koponen (SYL), Sixten Korkman (Aalto University), Mikko Kosonen (Sitra), Anne Kovalainen (University of Turku), Jonne Kuittinen (FVCA), Marko Niemi (UNIFI), Darius Ornston (University of Toronto), Tuomas Parkkari (MEC/OKM), Pekka Pesonen (Tekes), Mika Pikkarainen (MEE/TEM), Pentti Pulkkinen (Academy of Finland), Riitta Rissanen (ARENE), Jari Romanainen (Tekes), Anne Sarrivaara (MEE/TEM), Markku Sotarauta (University of Tampere), Ilkka Turunen (MEC/OKM), Antti Valle (MEE/TEM), Leena Wahlfors (UNIFI), Katri Vataja (Sitra), Juha Viitasaari (ARENE), Kirsti Vilen (MEE/TEM), Vesa Vuorenkoski (Akava).

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Acronyms and abbreviations

ATT	Open Science and Research Initiative
BERD	Business enterprise expenditure on research and development
CoE	Centre of excellence
EEA	European Economic Area
EPO	European Patent Office
ERDF	European Regional Development Fund
FDI	Foreign direct investment
FII	Finnish Industry Investment
FIOH	Finnish Institute of Occupational Health
FTE	Full-time equivalent
GDP	Gross domestic product
GERD	Gross domestic expenditure on research and expenditure
GOVERD	Government expenditure on research and development
GVA	Gross value added
GVC	Global value chain
HEI	Higher education institution
HERD	Higher education expenditure on research and development
ICT	Information and communication technology
LUKE	Natural Resources Institute
MNE	Multinational enterprise
NS&E	Natural sciences and engineering
OIP	Open Innovation partnership
P2P	public-to-public
PISA	Programme for International Student Assessment
PMR	Product Market Regulation
PPP	Public-private partnership
PRFS	Performance-based research funding system
PRI	Public research institute

R&D	Research and development
RCA	Revealed comparative advantage
RIC	Research and Innovation Council
SBRI	Small Business Research Initiative (United Kingdom)
SHOKs	Strategic centre for science, technology and innovation
Sitra	Finnish Innovation Fund
SME	Small and medium-sized enterprise
SRC	Strategic Research Council
STI	Science, technology and innovation
SYKE	Finnish Environment Institute
TFP	Total Factor Productivity
THL	National Institute for Health and Welfare
UAS	University of applied science
VC	Venture capital
VTT	Technical Research Centre of Finland

Executive summary

Finland's economic and social development has been one of the great successes of the second half of the 20th century. Supported by continued investment in education, research and innovation, Finland achieved a widely acclaimed transition from a largely resource-based to a leading knowledge-based economy shifting towards high-technology manufacturing and knowledge-based services.

Finland was hit hard by the global economic crisis in 2009, and disruptive technological change contributed to the decline of Nokia's handset business and a sharp drop in exports of ICT goods. In the years to follow Finland lost ground *vis-à-vis* its peers in terms of productivity and competitiveness. Industrial restructuring entailed a steep decline in business R&D expenditure. However, Finland has important assets, including a wide range of innovation capabilities and proven ability for transition.

Recognise the continued importance of R&D, innovation and skills

During the recession, the widely shared consensus on the role of science, technology and innovation (STI) epitomised by the renowned Research and Innovation Council (RIC) has weakened. Cuts in public spending on R&D, especially funding for applied research, have exacerbated the drop in business R&D. The innovation agency's budget has been cut severely. This, combined with cuts at VTT and other research institutes, has opened a gap in funding for technology development and innovation needed to reinvigorate industry.

Although there have been commendable initiatives (e.g. regarding start-ups and entrepreneurship), STI policy seems to have lacked coherence and orientation in recent years. Nevertheless, education, R&D and innovation remain paramount for Finland's future economic and broader social development and standards of living.

Develop a new vision for Finnish research and innovation policy

To regain its dynamism along a new path of high and sustainable growth, Finland needs a new vision for STI driven by economic needs and societal challenges (including energy efficiency, population ageing and climate change). Governance has to be reinvented to generate a whole-of-government policy for innovation-enabling system transitions, involving the co-ordination and co-operation of national and regional actors. The RIC needs to play an important role in creating this vision through a wide-ranging consultative process, advanced foresight and road mapping.

Implementing the vision entails using new instruments to link a wide range of actors (knowledge producers, users, intermediaries and others) for addressing industrial innovation and societal challenges. Finland already has some activities in place that foreshadow the proposed new approach, but further policy experimentation will be needed. A new model for public-private partnerships (PPPs) will be required.

Foster innovation, productivity and diversification in the business sector

Public support to business innovation is comparatively low and should be strengthened according to clear objectives. Priority should be given to more "radical" innovation projects. Small and medium-sized enterprises (SMEs) – whose share in business R&D and propensity to export is low overall – need different kinds of support, from innovation grants to the promotion of innovation linkages with large firms, and access to test sites, demonstration facilities and research infrastructure.

Industry and cross-sectoral challenges require improved co-operation and stakeholder co-ordination through support for innovation road mapping and innovation agendas, cross-sectoral collaboration involving users and a new type of PPP for research and innovation, drawing lessons from the history of the SHOK funding instrument which was discontinued like the INKA innovative cities programme. Moreover, opportunities can be enhanced through innovation networks around public markets and demand-side programmes.

Diversifying the economy remains a central issue. Finland has a narrow range of industries in which it enjoys comparative advantage and needs to build new export strengths, while established industries extend their capabilities to compete in high value-added segments on international markets.

Enhance research addressing industrial and societal challenges

Funding for applied research and "enabling technologies" (e.g. biotech, nanotech, advanced materials, advanced manufacturing) aimed at supporting innovation capacity to address both industrial and societal challenges needs to be enhanced. Funding and novel (joint) operating models for VTT and other research institutes also need to be reinforced to maintain their quality and industrial impact, and address the "strategic research" needs of industry and intermediary stages of the innovation process.

The Strategic Research Council, and the Prime Minister's Analysis Unit, represents an ambitious effort to strengthen knowledge-based decision making, particularly on societal challenges. To strengthen impact, Finland should consider encouraging close co-ordination with instruments and policies for the participation of innovation actors, including business enterprises, and more downstream innovation development. More attention should also be given to how research on societal challenges can be turned into concrete, viable and scalable solutions.

Complete the reform of higher education institutions and public research institutes

Governance reform and consolidation in both the research and education sector would help build a "critical mass" to create competitive research environments and efficient specialisation. Using different funding instruments, centres of excellence and other collaborative arrangements could encourage defragmentation and strengthen the research base. Better identifying the evolving skill needs would help align skills with demand.

Higher education institutions should be encouraged to develop strategies and to engage in knowledge transfer activities that contribute to economic and societal development. Reducing the performance-based share in institutional funding could improve higher education institutions' use of strategic resources, while assessing social and economic impact could strengthen the "third-mission" of the Finnish research system.

Improve internationalisation of business and research

Further internationalisation is critical for the performance of a small open economy and innovation system. The internationalisation of firms and access to global markets is paramount to enhance innovation activity and firm growth. There is a large gap between the ability of large firms and that of SMEs to access markets.

New export niches require appropriate channels for innovative Finnish products and services to reach global markets. Maintaining a high level of global value-chain integration and attracting more foreign direct investment is critical, all the more so as the decline of large domestic firms in core industries has made it more difficult for many Finnish firms to access global markets. Both domestic and foreign-owned companies can play an important role in this regard.

International linkages are also an effective way to increase the returns of research. Currently, few foreign researchers come to work in Finland, and there is scope for improvement with regard to the extent to which Finnish researchers co-operate with their peers abroad. Finland's attractiveness could be increased by strengthening specialisation and excellence in key areas of research and innovation, and better global marketing of the best local skills and technology assets. Reducing the fragmentation of the higher education and research sector and further improving governance would be beneficial.

Further improve framework conditions for innovation and entrepreneurship

Finland provides generally favourable framework conditions that could facilitate the economy's renewal based on innovation and entrepreneurship. Recent reforms promote employment, entrepreneurship and economic growth and aim at reducing regulatory burdens for businesses.

There is still scope for rendering business policies and product market regulation more competition-friendly by encouraging vigorous competition, firm entry and easing cumbersome regulations in certain sectors. Labour market flexibility could be enhanced.

Chapter 1

Overall assessment and recommendations

This chapter presents an overall assessment of Finland's innovation system and policy, reflecting key findings of the review. It identifies strengths and weaknesses of the innovation system and key tasks of the innovation policy, and develops specific policy recommendations.

Background

Finland has experienced an extraordinary period of industrialisation and economic and social development since World War II, transitioning from a resource-dependent economy to an industrial and knowledge-based one, retaining – like its peers in Northern Europe and North America – a strong resource base, and has achieved a high standard of living supported by a developed welfare system and culture. This period also saw heavy investment in education and research and development (R&D) and the establishment of a Nordic-style welfare state. During this transformation, Finland successfully aimed to become a leading knowledge-based economy and developed into one of the most research-intensive nations (as measured by investment in R&D), with a strong technology orientation. However, performance has deteriorated in recent years. The global crisis hit Finland severely in 2009. Gross domestic product (GDP) contracted by 8.3% (according to Statistics Finland) and recovery has been difficult ever since. National economic performance as reflected in productivity growth and international competitiveness deteriorated. Moreover, the Finnish economy was subject to shocks associated with Nokia's decline and downsizing in the forestry sector, which brought the issue of Finland's diversification into the limelight.

National confidence in the importance of research and innovation and Finland's widely shared and internationally recognised paradigm of R&D-driven growth and development has come to be contested. The role of national institutions that played an important role in Finland's rise – such as the Science and Technology Policy Council (now the Research and Innovation Council, RIC) and the Finnish Funding Agency for Innovation, Tekes – has diminished. Against this backdrop, and the urgent need to revive the economy and achieve high and sustainable economic growth, research and innovation remain critical for Finland's future success in economic and broader social development. The recent budget cuts for research and innovation have an impact on innovation activity and without corrective action will be felt for years to come in the form of dampened innovation activity and productivity growth.

Overall, the numerous policy reforms undertaken since 2006 in the areas of education, research and innovation seem to have lacked coherence and a unified vision or strategy. Finland needs a new approach for innovation and renewed governance for science, technology and innovation (STI), lifting itself out of the period of uncertainty and lack of confidence that followed the 2009 recession to establish a new national vision for sustainable recovery. This recovery needs to be based on research, innovation, education and training in the framework of the strong international engagement which Finland needs in order to overcome disadvantages due to its small size and geographic location. This effort will entail addressing both short- and medium-term challenges in the economy to boost productivity growth and continuously developing long-term strategies and mechanisms to build new competitive advantages at global scale. Both are fundamental for maintaining the high level of well-being and living standards of the Finnish population in the future which are threatened by persistent economic weaknesses.

Finland can draw on its high level of social capital to build a national consensus on how to mobilise and further strengthen its domestic innovation capacity more effectively to boost productivity growth and social development more broadly. This will involve wide societal consultation and the development of new forms of governance to tackle major transitions through which societies will have to go in the coming years. The vision is that of a knowledge-based Finland with a proactive and innovative government

working in partnership with the business sector and wider society to support and identify opportunities for innovation and sustainable growth.

Achievements and challenges

Finland's long-term development has been impressive. It has enjoyed strong economic progress over the past decades, which is reflected in high living standards and well-being. The country stands out for high subjective well-being, education and skills, environmental quality and personal security. Inequality (as measured by the Gini coefficient of disposable income) is among the lowest in the OECD and has remained fairly constant since the turn of the millennium. Absolute poverty (as measured by material and housing deprivation) is among the lowest in the European Union.

Until the early 1900s, its strengths were the abundant endowments of wood and national resources such as minerals. Like other resource-based economies, Finland tended to import established technologies and to produce commodities containing little value added, and to which further value was then added in supply chains abroad. The subsequent period of industrialisation allowed Finland to develop its own technological competences and increased Finnish capacity in producing capital goods, especially heavy machinery and equipment that could also be sold on international markets and in some of which Finland gained leading positions. Finland built capacities in various kinds of manufacturing-related innovation. For example, paper-making technology and machinery supplemented the strong wood sector and ship-building became important, and is an area where Finland still has strong capabilities in certain high value-added segments.

During the 1970s and 1980s, Finland transitioned from a natural resource-intensive economy into a high-technology exporting country. In the 1970s, it started to expand higher education in engineering sciences, which would become an important element of the country's economic transformation. In the 1980s, Finland began to shift into entirely new areas of knowledge-based innovation and new sectors, such as information and communication technology (ICT), machinery, and chemicals. While the sector shifts were radical, there were also important links with previous developments. Developing a strong paper industry involved moving into pulp and papermaking machinery and developing capabilities in chemistry. A growing ship-building industry created a launch market for heavy marine diesel engines, and so on.

Around the end of the 1980s, Finland invested heavily in human resources. By the mid-1990s, it was investing more in education than any other country (relative to GDP). Important efforts were made to increase the quality and supply of human capital and a number of reforms were introduced along with expanded public investment in education and R&D. Finland was thus able to upgrade its human capital by transforming its education system from less-than-average to one of the best international performers, becoming a modern publicly funded system with a high degree of equity, good quality and wide participation.

In the early 1990s, Finland went through a deep recession caused by a combination of international and domestic factors (the global recession, the collapse of exports to the Soviet Union, and a highly overvalued Finnish mark and over-indebted business sectors, among others). Countercyclical policies compensated for the decline in business R&D expenditure during the crisis. Domestic investment in research and innovation started to expand rapidly in the second half of the 1990s. This was partly a result of policy decisions but even more so due to an expansion of business R&D spending in the wake of

a growth acceleration which entailed a virtuous cycle of productivity gains and improved international competitiveness, as manifested by the rapid expansion of Nokia. Productivity increased due to the growth of electronics and related industries, enhanced investments in machinery and equipment, technology (public and private investments in R&D), education and training. Overall, the economic crisis and the subsequent period of growth resulted in an increased specialisation of production, trade and R&D in the Finnish economy.

Policy that supported the upswing at that time reflected the great importance ascribed to innovation for Finland's long-term success and underlined the necessity of continuous investment in innovation, based on wide societal consensus, rather than short-term policy considerations related to the business cycle. Innovation policy and a long-term approach to building a strong national innovation system were already in place in the 1980s. Economic policy more broadly, deregulation and improvements in tertiary education also contributed to the rise of Finland. The expansion of R&D expenditure during the second half of the 1990s supported Finland's shift towards an increasingly knowledge-based and high-technology economy. Technologies driving the success of the ICT sector, forestry and the metal-mechanical industry were also supported by an ensemble of public research institutions whose quality was recognised internationally. Public investment in education was increased to match the demand for new skills and the structural change towards ICT-related activities. The emerging knowledge-based economy coincided with the opening of the economy. This period saw Nokia rising as a global corporation and becoming a world leader in mobile handsets. The economy developed robustly, underpinned by strong productivity growth and high social and economic performance.

Finland was hit harder than its Nordic neighbours by the crisis in the late 2000s. Its economy went through a deep recession in 2009, followed by a partial recovery in 2010. It became increasingly clear, however, that economic performance was falling significantly behind that of its peers, especially when Finland went into recession again in 2012. Finland found it hard to catch up with the pre-crisis level of GDP in real terms and industrial production has still not recovered to its pre-2008 level, owing mainly to the contraction of the electronics industry but also to the decline in the forestry sector triggered by shifts in demand and the success of lower cost competitors and machinery. The weight of Nokia in the Finnish economy meant that its difficulties contributed significantly to the downturn and weak post-recession economic performance. But Nokia is by no means the only factor. Other important factors include the fall of prices in global markets for electronics, shrinking global demands for durable investment goods and machinery in which Finland is specialised, and disruptive technological change affecting not only ICT but also traditional industries. Shrinking trade with the Russian Federation has also disproportionately touched Finland due to its historically strong trade ties with that country. Finland is finally pulling out of the long, double-dip recession, but output growth still remains weak.

In the aftermath of the "great recession", the need for mobilising new sources of growth has been moving up on the agenda in many countries. Finland's public R&D expenditure continued to increase during the recession in 2009 and in the partial recovery in 2010, but this policy was reversed as the economic difficulties lingered on. Since then both government and business investment in R&D have been declining. There has been a switch from an expansionary ("countercyclical") to a contractionary ("procyclical") policy in funding R&D and innovation. This is in contrast to OECD peer economies (Denmark, Germany) which have responded to the global economic crisis by adopting countercyclical policies. More recently, the Netherlands and Norway have also moved

from a contractionary to an expansionary R&D policy. The level of R&D intensity – gross expenditure for research and development (GERD) as a percentage of GDP – is still relatively high in international comparison. Yet, the trend is steeply decreasing, from 3.35% (of GDP) in 2007 (and 3.73% in 2010) to 2.90% in 2015. According to preliminary estimates by Statistics Finland, R&D intensity reached 2.81% of GDP in 2016. This trend poses a risk to Finland's ability to return to a path of high sustainable growth. While there has been a multitude of changes in innovation policy since 2006, a clear strategy to underpin these adjustments and reforms has been lacking.

Tackling productivity growth, diversification, internationalisation and broader societal needs

Before the crisis of 2008 productivity growth had already weakened in many OECD countries. In some countries, such as Japan, Korea and the United States, total factor productivity (TFP, a measure of efficiency in the use of production factors) continued to increase after the crisis but at a slower pace than before. In others, including Italy, the United Kingdom and all of the Nordic countries, TFP growth declined between 2008 and 2014. In Finland, labour productivity has stalled. The gap vis-à-vis Sweden, to some extent Denmark, and the OECD average has widened and is only slowly recovering. TFP growth contracted substantially over the period 2007-13, in contrast to the rapid expansion in the previous decade. Most of the decline in productivity occurred in manufacturing whereas the business services sector has shown a modest improvement, although at productivity levels lower than those of Norway, Sweden and other European countries. The sharp decline in the high-productivity, high value-added ICT sector meant that more traditional and less productive activities have increased their weight in aggregate economic activity and productivity.

Finland has also started to encounter difficulties and new challenges in the area of social development. While its level of income is still higher than the OECD average, recent economic performance has been reducing this lead. Unemployment rose to a peak of about 9.5% in 2012, and has started to fall only recently. An ageing population also means that high growth becomes more difficult to achieve – as more people retire from economic activity and demands for healthcare increase. To restore Finland's capacity for productivity growth and international competitiveness and safeguard the high living standards it has achieved over the past decades, it is critical for Finland to:

- Revive value added and enhance economic diversification. Finland needs to tap new sources of growth based on new and sustainable export strengths, as well as by revitalising traditional industries, e.g. the metal-machinery industry, forestry, chemicals and biopharma, fostering their capability to compete globally through new economic competences and value added. This transformation will require Finland to engage more in "radical innovation" and become more effective in utilising its valuable knowledge capabilities and transforming them into globally competitive innovation.
- Enhance firm-level productivity, especially in small and medium-sized enterprises (SMEs) and start-ups, and enable them to grow and compete globally. Raising productivity levels requires making innovation and commercialisation more effective, which entails rethinking the innovation strategy as well as the need for Finnish firms to maximise the benefits of new technologies (e.g. digitalisation). This also requires boosting innovative entrepreneurship – and new firms capable

to grow and compete globally – and new high-technology export sectors. New company formation and growth would be favoured by an ecosystem that is internationally linked, connecting new firms to sufficiently large markets that provide a base for scaling up.

These two objectives are closely intertwined and reinforce each other. Attaining them will require a policy mix that boosts radical innovation while at the same time recognises the need to build on established strengths and companies and diversify to new areas and new knowledge-based firms with high potential to grow. There are opportunities in both directions and policy needs to take account of this.

Finland, along with other countries, also faces the challenge of ensuring the future quality of life and well-being and addressing societal challenges such as energy efficiency, healthcare for an ageing population, and climate change, and developing new solutions in innovative ways and based on innovation. Addressing these challenges – many of which are global – is also an opportunity for business development and global market expansion.

The crisis and industrial decline has highlighted the lack of diversification in the export basket, with a rather narrow range of industries where Finland has comparative advantage. Finnish exports have declined by approximately one-fifth since 2008, which is more than in any other advanced economy. The share of high-technology goods in exports dropped from 23% in 2005 to 6% in early 2016. There is an acute need to build competitive advantages in new areas of business and to diversify Finland's pattern of trade. In this context, the following trend causes some concern: the number of Finnish R&D-intensive "frontier" companies in the EU area has declined from some 70 companies (in the top-1 000 list of the EU Industrial R&D Investment Scoreboard) in the mid-2000s to slightly over 40 in the mid-2010s. Other countries and their companies have overtaken Finland.

There are some industries that have been less affected by Finland's economic downturn and which have potential for future growth. The level of services exports has remained more or less unchanged since 2008. IT services have been a strong pillar in this development, reflecting the massive capability building through the preceding ICT boom period. The creation of large amounts of ICT-capable human capital provides a crucial platform for strengthening existing business, building new firms and diversifying the economy. Harnessing this expertise to develop new competences and addressing new technology challenges (e.g. related to current trends in digitalisation) is an important opportunity for productivity growth and societal development in the coming years. The huge increase in national ICT capabilities and the knowledge base that underpinned Nokia's boom has been the basis of Finnish success in a number of business areas, including gaming apps.

Although some progress has been made, the lack of diversification has not yet been compensated for by developments among new and small firms. There are promising new emerging economic areas such as clean and medical technologies, and new ICT niches (e.g. gaming). While having increased in recent years, start-up rates (new firm creation relative to firm population) still remain comparatively low, and young firms' contribution to job creation and employment is among the lowest in the OECD. In general, firms in this category do little disruptive innovation and are often locked into domestic supply chains and the declining fortunes of important large Finnish enterprises abroad has made it more difficult for small firms to access international markets as subcontractors. At the same time, a lively start-up and early-stage capital scene has been evolving, and social

attitudes to this kind of activity appear to have become much more positive over the past decade or so.

An important challenge for increasing innovation performance opportunities is the low participation of SMEs in R&D. Although aggregate investment by SMEs in R&D has been evolving favourably throughout the decade, the number and share of SMEs in business enterprise expenditure for research and development (BERD) is well below OECD standards, despite the government's efforts. SMEs account for less than a quarter of BERD (21.8% in 2013, far below the OECD average of 35%). In efforts to integrate SMEs, innovation partnerships with large companies and with the universities of applied science (UAS) can play a strategic role in the advancement of industries.

Internationalisation remains a persistent challenge for the entire innovation system, both in the public and the private sector. In addition to relatively high labour costs, language barriers and a peripheral geographic location limit to some extent Finland's capacity to attract talent and foreign investment in knowledge and production activities. As indicated, measures are needed to empower SMEs and new firms and help them grow. This could be part of broader innovation agendas linking such firms with large firms and the public sector and supporting their early integration in global markets. The need to cope with globalisation and the growing importance of new competitors through internationalisation affects much of the Finnish economy and society. In a number of respects, Finland is well prepared. English is commonly spoken and used, just as there has been high capacity in Swedish, Russian and German in the past. However, the level of foreign direct investment (FDI) remains low and – post-Nokia – the extent to which Finland has multinational enterprises (MNEs) performing R&D abroad is rather limited. This tends to make access of Finnish business to international supply chains and to global technological developments and international innovation networks more difficult, and deserves due attention from policy makers. A key challenge for Finland is to transform knowledge (and better utilise knowledge capabilities) and new ideas into new products and innovation in global markets.

Internationalisation is also a challenge for the research and higher education sector, as few foreign researchers come to work in Finland. There is also scope for improvement with regard to the extent to which Finnish researchers co-operate with their peers abroad. As mentioned, language barriers and geography may inhibit the inward flow of foreign talent – but these factors affect all Nordic countries to some degree. Probably the most effective way to make Finland more attractive is to strengthen capabilities in key areas of research and innovation, which means strengthening specialisation and excellence, and better marketing the best local skills and technology assets in global markets. Reducing the fragmentation of the higher education and research sector and further improving governance in important parts of it would be beneficial in this context. While there are strong points, links to industry are in many places poor. Specialisation and scale are keys to improving performance in the higher education sector, and these need to be supported by institutional reforms and by rebalancing state funding with present and likely future societal needs. In addition, Finland could further promote other country-specific endowments, such as the business environment, quality of life, and the country's nature and safe environment, which are also important factors in attracting talent and FDI in both production and research and innovation activities.

Main strengths and weaknesses of the national innovation system

Table 1.1 provides a SWOT analysis of the Finnish innovation system. Finland has built strengths through the process of industrialisation. Over the past decades human capital and skills were reinforced, and the country embraced global market integration. Finland also has important "know-how" and experience in articulating innovation policy and governance mechanisms (e.g. through building broad-based consensus) to tackle structural change and economic transformation. Internationally, Finland has been a pathfinder in establishing good governance of the national innovation system and in building technological capabilities and advantages that sustained development and growth.

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

Strengths	Opportunities
• Political stability with clear rule of law, high levels of trust and a culture of Nordic-style "flexicurity" • Strong base in resource-based and certain manufacturing industries as well as ICT and related services • Strong, skilled, innovative and experienced ICT and new media communities able to diversify into new businesses and provide digitalisation expertise to existing businesses • High-skilled professionals (ICT, health tech, mechanical engineering) • An education system that is excellent at the school level and good at higher level • Strong culture of co-operation and a willingness to unite behind policy when people are "all in one boat" • Greater willingness and determination to drive and implement change than in other Nordic countries • Most skilled adult population in the OECD (according to the Programme for the International Assessment of Adult Competencies) • Still relatively high levels of both public and private investment in R&D	• Restructure production in new high value-added segments, based on existing strengths in manufacturing, services and digitalisation • Revival of the Research and Innovation Council offers a new option to reinvigorate innovation policy, dialogue and governance • Use the Finnish Innovation Fund's (Sitra)ability to carry out policy experiments "outside the box" of normal procedures • Leverage ICT expertise for digitalisation as a new competence and for boosting productivity in industries • Foster recent cultural change – young talent and professionals embracing entrepreneurship (start-up boom) • Growing attraction of foreign investors (venture capital/business angels) and start-up networks (accelerators, etc.) • University profiling and reforms provide basis for stronger research performance and better links to societal needs • Better integration of demand and tackling societal challenges into government innovation policy • Ambition to improve cohesive, knowledge- and evidence-based policy making
Weaknesses	**Threats**
• Few exporting sectors and firms; a narrow export base; difficulties to diversify the economy • Advanced but small, peripheral market; companies need to export early on to secure growth • Few leading industries and companies; size distribution that is thin on "Mittelstand" • Small and medium-sized enterprises (SMEs) play a very small albeit growing role in R&D and innovation • Low overall rate of entrepreneurship, despite a small and growing start-up scene • Low rate of radical innovation; business innovations mostly focus on minor improvements and operational efficiency; even if "new to the world", little ability to capitalise on it • Talents leaving due to reduced research budgets • More strengths in knowledge than in its deployment	• Declining competitiveness and loss of export markets • Reduced R&D expenditures in both the private and public sectors • Declining knowledge and human capital generation and competitiveness in the longer term as a result of reduced policy priority for research and innovation • Loss of confidence in research as a basis for innovation and growth, as well as with the institutions and policies associated with this • Underutilisation of skilled ICT experts • Weakened consistency in innovation policy making; uncertain business and innovation environment • "Peripheralisation" in industry and research if internationalisation challenges are not adequately tackled • Continuously reduced ability to adjust to globalisation-led changes

Table 1.1. **SWOT analysis of the Finnish innovation system** (*cont.*)

Weaknesses	Threats
• Imbalanced funding pattern, under-emphasising applied research and enabling technologies • Fragmented, under-internationalised university system with decreasing industry links • Lack of university "excellence" in education or research (with some exceptions; e.g. University of Helsinki) • Limited foreign direct investment; domestic business R&D poorly integrated with business R&D internationally • Lack of vision, ambition and holistic approach to develop new forms of public-private partnerships and innovation programmes to tackle societal challenges and driving industrial renewal	• Ageing population, reducing the societal surplus available for investment • Absence of solid/large-scale platforms for strategic (cross-disciplinary) research and innovation

The rise of the ICT sector demonstrated the ability of Finland's innovation policy to nurture new economic competencies with high value added. Finland has thus a well-known track record in pursuing structural change and aligning public policies for national objectives. This legacy provides an important foundation for future development and overcoming recent setbacks and current challenges, but new lessons need to be taken into account.

Scope for improving and further developing innovation policy

It is widely acknowledged that the very success of Nokia combined with the pre-existing structure of industry has entailed a rather narrow base for industrial and economic development and that this constituted a risk. The policy lesson is that efforts to revitalise the economy need to involve a wider range of sectors and technologies that together will allow Finland to build on its advantages and to diversify. It has also been stressed that success in dominating industries was mostly achieved by relentlessly refining core technologies in their respective domains, and introducing them into successful products with the help of supply chains and competitive marketing organisations. It seems that this model based on incremental innovation – where firms tend to improve upon existing technologies and original products – prevails today. For continued success, however, advanced countries' firms in existing industries increasingly have to innovate radically, transforming their products from articles valued for themselves into "platforms" or networks that afford users a wide range of new and evolving possibilities. Sectors should be open to new technology adoption and new industrial applications, widening their market portfolio and even reorienting their business strategy while harnessing or building on existing assets.

Overall, Finland continues to have a range of favourable conditions for innovation-driven growth. Nevertheless, its innovation system has shown some difficulties in ensuring smooth connections between innovation actors, sectors and disciplines and in transforming new ideas and knowledge into globally competitive commercial products and services. This indicates structural weaknesses, weak incentives and downstream competences (such as weaknesses in technology transfer mechanisms, export competences and strategy in business, as well as shortfalls in intellectual property and value-chain management, etc.) complementing Finland's substantial R&D effort in the interactive processes of innovation and diffusion. There is significant scope to improve

linkages between the research sector, innovation intermediaries (e.g. the Technical Research Centre of Finland [VTT] and other technology transfer agents/institutions), industry and government (exerting demand for innovation) in order to better serve existing or create new markets.

The spectacular success of electronics, especially in mobile telephony, and the impressive growth achieved during the latter part of the 1990s and until the early 2000s, might have, paradoxically, rendered innovation efforts targeting new competence development sluggish and might have lessened the pressure to undertake some important reforms (such as university modernisation and regulatory reform affecting innovation). Moving forward also requires continued improvement of framework conditions for innovation and business activity, such as excellent regulatory frameworks enabling fair market competition and entrepreneurship-enabling policy frameworks (e.g. insolvency laws enabling quick firm exit, tax regimes conducive for new firms).

In relation to the innovation system itself, it is critical that policy takes a proactive stance. This means moving from policies that have increasingly become reactive (and unpredictable) towards policies which are set to continuously transform and improve the effectiveness of the entire innovation system. In addition, a better balance between curiosity-driven and applied-oriented research is required to address the needs of diversification and disruption in technology regimes, and focus more scientific and technological effort onto areas of social and economic priority. Public funding for applied R&D and innovation (e.g. the steep decline in Tekes' budget) has been more severely affected than other types of research, contrary to what might be needed to reinvigorate industry in the short and medium term. In addition, cuts at VTT have further exacerbated the gap in funding for technology development and innovation. A better balance is needed between research with a short-term and that with a long-term horizon, which are both important for innovation. With the discontinuation of some of the collaborative programmes (importantly the SHOKs programme funding), the need for more systemic innovation efforts has become more pertinent.

Improving the transfer of knowledge to economic use and all that this process entails (e.g. translational research, technology testing/prototyping, and diffusion/adoption in firms as well as new firm creation) remains a priority and needs to be further opened up to SMEs and new firms. This also means mobilising innovation for a wider set of users in the economy and society, in government, among final users, and abroad. This should be based on a forward-looking strategy and vision which should be promoted by the RIC, but needs the backing of government as a whole.

In a nutshell, innovation policy making should adopt functional mechanisms enabling system transition and adaptability, moving towards:

- A more responsive system with enhanced flexibility and which allows rapid decision making to address disruptions and challenges related to evolving global contexts. This requires having working groups or platforms in priority policy areas with the capacity to mobilise consultation and information from lower levels.
- Stronger interactions and permanent bridges within the innovation ecosystem. Currently, the private and public sectors have to figure out forward developments on their own. Public-private collaboration programmes should be relaunched, but require more diverse stakeholder participation and improved governance mechanisms.

- Addressing societal challenges (e.g. energy efficiency, water constraints, health, environment and green growth, including for example the circular economy) and the needs for more inclusive growth, which entails adaptation to technological change (especially of the least skilled segments of the population), should become a permanent feature of a renewed innovation policy.

The "societal challenges" pose to varying degrees existential threats to mankind. They also provide massive opportunities for knowledge-based innovations and new kinds of business. Their systems-changing nature means that they require a new style of innovation system governance, which is more participatory and more inclusive of a wider set of stakeholders, and which is more open to societal input to the process of innovation. These elements are also pertinent for addressing economic challenges in more effective ways through innovation policy than in the past.

Fostering innovation for economic and social development requires the co-ordination of a broad range of public policies (and their mix), including productivity-enhancing and social policies. Public policy has a leading role in fostering innovation, for instance through demand-enhancing regulatory development (e.g. environmental policy and standards, as well as public procurement legislation that specifically supports environmental aspects spurring innovative products and services), other framework conditions (e.g. fostering competition and easing entry of firms), or co-ordination of policies fostering innovation and internationalisation (e.g. by fostering international trade and FDI).

It is important for Finland to move towards a more integrated and systemic approach to STI policy. This entails conceiving new policy mechanisms to support innovation ecosystems (and communities), challenging traditional roles for both businesses and the higher education sector (and scientific communities). New interactions and more open modes of innovation are needed, which include a broad range of communities of knowledge and practice.

Key issues and recommendations

Some key issues have been identified based on the foregoing analysis. These are summarised below, together with recommendations on how they could be addressed.

Develop a new national vision for STI and reinvent governance to generate a whole-of-government policy for innovation-enabling system transitions

Finding ways to meet the economic and societal challenges will provide a way to reunite and reinvigorate key actors in research and innovation in Finland. Two lines of action are needed. First, with the authority of government, the Research and Innovation Council should lead the generation and co-ordination of the new national vision for research, innovation and economic renewal that addresses the need for boosting productivity growth and diversification as well as societal challenges. It should also decide which are priorities for Finland. It should then establish itself as the central co-ordination mechanism for implementing the vision and linking this implementation to broader research and innovation policy. This will require gathering and aligning relevant innovation stakeholders (not only research actors) around shared economic and societal challenges and innovation agendas. Hence, second, this vision should be supported by creating new instruments for establishing networks and programmes able to lead and manage the transitions in individual socio-technical systems that will be needed to address the selected challenges. Since the practices needed are still evolving, there will be

a need for policy experimentation. Implementing the vision will also depend on using more established research and innovation policies in parallel while carefully co-ordinating them so that there is consistency at the systemic level.

Develop a new national vision for research and innovation policy, driven by societal and economic needs

In view of recent developments, there is a strong need for a unifying national vision that establishes a consensus about how to reinvigorate the economy and enhance societal development by harnessing research and innovation. This should counteract the lack of co-ordinated action across different parts of government, business and the wider society. Tackling productivity and societal challenges requires going beyond more traditional models of research and technological development to more broader and inclusive partnerships. A higher-level strategy is needed that determines which challenges Finland should prioritise and invest in based on the available opportunities and the assets that it brings to the table.

For this reason, a high-visibility, national effort is needed to create and generate support for a new vision and all-of-government strategy for using knowledge to drive economic performance by tackling the societal challenges. This would involve mobilising knowledge and experiences from recent years on how to manage "transitions" or "system innovations". Key elements of such a strategy would be:

- Define a vision for Finland's future development through a wide-ranging consultative process. Advanced foresight, should be reinforced in many areas and extend to road mapping, in order to establish a consensus about implementation and reduce the perceived risk of innovation.
- In addition to technology experts, industry and sector representatives, such foresight exercises should include a wide range of stakeholders and experts – such as various categories of consumer, regulators, "users" such as healthcare and transport providers, social scientists, philosophers, artists, students, immigrants, regions and cities – to ensure a broad, ambitious and socially relevant perspective. This effort should not only seek to define a set of priorities but also be deliberately public and inclusive, in order to establish a social consensus and boost expectations.
- Establish a co-ordination mechanism that can oversee the implementation of the vision, but that spans both the vision and more established research and innovation policy. It will be important to maintain a systemic perspective on the whole innovation system and its associated policies, in order to ensure coherence.

Over the years, the RIC has functioned as an "arena" in which alternative policies and priorities are debated and a strategic consensus formed. This function has been closely coupled with monitoring the health of the innovation system as a whole. The need for such functions has not disappeared. However, addressing the prioritised challenges is inherently a decentralised process. Economic and societal challenges are too big to all be addressed by one central body; they must involve numerous stakeholders. Each will require its own arena or co-ordinating mechanism to be effective. Given the number of stakeholders involved, each challenge will have its own decentralised "arena". The revival of the RIC should be used as an opportunity to redefine its role to encompass the wider mission of defining and co-ordinating the implementation of the national vision. In

addition to its traditional function, the RIC would become an "arena of arenas" to co-ordinate the implementation effort and keep the vision up to date.

The revival of the RIC in 2016 has entailed a number of changes. It is now smaller; its independent secretariat was abolished and preparatory work is now carried out by a group consisting of civil servants from the Ministry of Education and Culture, the Ministry of Economic Affairs and Employment, the Prime Minister's Office, Tekes, and the Academy of Finland. It is envisaged that the group will involve stakeholders in the preparations. The RIC's membership could usefully be extended to include one or two foreign members, in order to expose it to more international ideas.

The RIC still appears to be best placed to lead these processes because it encompasses the highest level of government and is in principle capable of reaching across multiple ministries, agencies, and sectors of society and stakeholder groups. But generating and co-ordinating the needed vision is a very demanding task because it extends far beyond research and innovation policy. It would require sufficient budgetary resources to support analysis and monitoring as well as the various supportive mechanisms (consultative processes, foresight exercises, etc.) for developing and launching the new vision.

There is also a need for co-ordination at the government level, to ensure that the ministries are aligned and involved with the policy and to get an overview that identifies synergies and opportunities, for example to boost the generation of knowledge and skills to support (selected) transitions (e.g. regarding digitalisation or the bio-economy). Due to its membership, the RIC is best placed to engage with government policy.

Create new networks and partnerships to co-ordinate individual system transitions

Implementing the vision entails using new instruments to link a wide range of actors (knowledge producers, users, intermediaries and others) for addressing industrial innovation and societal challenges. A new model for public-private partnerships (PPPs) will be needed.

Finland already has some activities in place that foreshadow the proposed new approach to addressing economic and societal challenges, notably in the form of the cross-ministry Health Sector Growth Strategy and the Bioeconomy Strategy. Each involves a number of ministries as well as research, industry and users, among other stakeholders. The transition literature implies that even wider coalitions may be necessary. The fact that Finland is already working in this direction implies that it is at the forefront in developing these kinds of policies and instruments. Finland should exploit this advantage, which should also make it easier to take the next step towards more holistic strategies with yet wider stakeholder participation as it already has experience moving in this direction. Another advantage that Finland enjoys is a strong national tradition of foresight activity, although it has not been so widely in the recent past. This means that skills needed for the visioning process are already available locally. The Strategic Research Council (SRC) provides a further opportunity to support such a new approach. Its activities could be more explicitly integrated into wider social policy, and research and innovation more generally.

Other countries are also beginning to use public-to-public (P2P) partnerships and PPPs to cope with broad industry-wide (or economy-wide issues such as skills or infrastructure) and societal challenges. These typically involve the creation of a platform for relevant stakeholders, which generates a strategic research agenda approved by the

government or one of its agencies. The partnership is then left to manage certain aspects of implementation. Policy instruments can then be matched and utilised by the consortiums to address their innovation needs. In some cases, new instruments are launched to support implementation. In some instances this can involve the partnership issuing calls for proposals, evaluating and funding research using money provided by the state. The power of wide partnerships is their ability to move beyond the confines of research and innovation policy to deal with the broader, systemic issues involved in addressing the societal challenges and the transitions among socio-technical system that they require.

The Swedish Strategic Innovation Projects (SIP) programme provides an interesting example of such partnerships and their governance. The cross-ministry "21" strategies in Norway provide another. Like the Finnish Health Sector Growth Strategy and the Bioeconomy Strategy, these represent a step towards the kind of P2Ps and PPPs (stronger industry-government collaboration in innovation) needed but so far under-emphasise the non-R&D related aspects of networking, road mapping and policy development.

In deploying these efforts, there is need for policy experimentation and innovation in order to find models that correspond as much as possible to Finnish specificities. An important element of new programmes and initiatives are facilities for policy experimentation and learning. It should be acknowledged that learning by doing and rigorous testing will define in the end what the best modalities are for Finland, hence flexibility and recognition of the need for continuous improvement and adjustment will be needed. In order for experimentation to have an impact, it needs to be matched by a willingness to implement and scale up successful solutions and to tackle regulatory or other obstacles.

In rethinking governance, it is also necessary to examine the key public innovation actors (such as Tekes) to see whether their current missions, organisations, operations and competencies are appropriate for ensuring the kind of reflexive governance, new instruments and collaborations and experimentation that will be required to tackle societal challenges and turn them into opportunities, and to contribute to strengthening Finland's long-term resilience and innovative strength.

Recommendations

- Develop a new vision for STI and reinvent governance to generate whole-of-government policy for innovation enabling system transitions. To succeed in this effort the RIC needs to take on a key role.
  - Work at the highest level of government to initiate the creation of a new unifying national vision about how to reinvigorate the economy and society by harnessing research, innovation and education. This vision needs to be broadly accepted across government and in and beyond industry, including the research and higher education sector, in particular by encompassing national action on societal challenges.
  - Adopt a forward-looking strategy making use of various types of foresight (technology, global markets/demand, socio-economic prospects) to nourish strategic planning and the definition of innovation roadmaps to address industry-specific and cross-cutting (e.g. digitalisation, green growth) and societal challenges.

  - Extend the role of the RIC beyond its current mission of co-ordinating research and innovation policy to become an "arena of arenas" to co-ordinate the implementation of the vision across the necessary decentralised networks and to keep the vision up to date. In doing so, provide the RIC with the capacity and financial means to fulfil its commitments based on a clear mandate and agenda.

- Improve the steering and impact of research and innovation policy by supporting stakeholder co-ordination to address societal and economic challenges.
  - Use new instruments to link a wide range of actors (knowledge producers, users, intermediaries and others) in addressing innovation and societal challenges.
  - Launch a programme for PPPs for societal challenges that will enable co-ordination not only for research and innovation via jointly agreed strategic research and innovation agendas but also for involving the other stakeholders whose engagement is needed in order to achieve systems transitions.
  - Ensure that PPPs not only tackle research but also pursue broader innovation goals by including downstream areas – translational research, product testing, and technology diffusion and commercialisation of innovation – and a wider set of national- and regional-level stakeholders, such as innovation users and regulatory agencies.
- Strengthen policy learning and design through experimentation.
  - Embed policy experimentation into the mainstream of implementation of the vision so that it becomes a routine way to evolve policy and instruments towards better performance.
  - As an option, foster experimentation by encouraging Sitra to experiment with network-based governance models for socio-technical transitions.

Foster productivity and innovation in the business sector

Part of the policy response to Finland's protracted economic difficulties has been a reduction of public funding of business R&D and innovation. Tekes, the main funding agency for applied R&D and business sector innovation, has seen its R&D budget shrinking steadily since 2010. Over the period 2011-17, its budget has been cut by 51% (in real terms). Furthermore, research institutes – in particular VTT, which could play an important role in more long-term and strategic R&D for the business sector – have been hit particularly hard by the combination of cuts in basic funding for public research institutes (PRIs), a hard reduction in funding from Nokia (which added to the cuts in funding to Tekes, which has lowered both the direct funding the institutes receive from Tekes and revenue from large companies who often used Tekes funding to procure projects).

Business R&D intensity (BERD relative to GDP) is still well above the OECD median and at a level similar to that of Sweden. However, there has been a rapid contraction in the wake of the ongoing industrial restructuring, from 2.3% in 2013 to 2.12% in 2015. At the same time, Finland shows one of the lowest shares of government funding of BERD in the OECD. Finland's BERD is primarily performed by the high-technology manufacturing sector and strongly concentrated in large firms. Nokia

alone performed about half of BERD in 2010. In 2015, the firm represented 20% of BERD whereas Microsoft Mobile accounted for 10%. Nokia's reduction of investment in R&D is the main cause of the decline of Finnish BERD in recent years. In the aggregate, the remainder of the firms – including in the services sector – have shown a more stable pattern of development and their BERD (in real terms) has actually slightly increased since 2010.

A three-pronged approach is needed to foster productivity and innovation in businesses:

- Investment in research and innovation should be increased but with a new approach that is aimed more at the development and adoption of radical innovation and new technological solutions for building new competitive advantages in both existing and new industries. This should also include the pursuit of technologies and business models that enable companies to upgrade business and shift from existing activities to new, related ones.
- Closely related to the previous objective, larger scale initiatives for research and innovation needs in industries should be launched, allowing for greater involvement of innovation actors and facilitating a more ambitious medium- to long-term innovation agenda co-ordinated within networks. The purpose is to revitalise industries through radical innovation and wider strategic (economic challenge-driven) innovation agendas. A new type of strategic (challenge-driven) PPPs should be established based on new models of governance and operation.
- Encourage new and existing SMEs to innovate and enter markets. This includes embedding them into innovation ecosystems, improving access to business services that facilitate the development of management skills necessary for the internationalisation of SMEs and better integrating them into global value chains (GVCs). All three elements need to be combined to make both new and existing industries more dynamic. Finally, efforts should be geared towards providing better growth opportunities for firms through value creation networks and internationalisation.

There is a clear role for government to foster renewal through education, research and innovation and to help businesses manage risks and invest in strategic areas of research and innovation. Finland has done this successfully before and should consider doing it again, based on new evidence. In particular, it should identify strategic areas in need of public investment, rather than indiscriminately cutting public funding across the board.

Boost radical innovation for diversification and new competitive advantages

Diversification is critical for future economic performance. Finland's opportunity for restructuring existing industries towards high value-added and high-productivity activities can take the form of strengthening capabilities in existing areas of business strengths and extending from those areas into related ones that provide innovation opportunities. Yet, as international experience shows, the adoption of new and radically new technologies (which may be developed by third parties, e.g. PRIs or new technology-based firms) can revolutionise existing industries and enable them move to new industrial applications and higher value-added products. Certainly, general purpose technologies such as biotechnology and clean technologies are of high relevance to Finnish traditional industries.

However, while Finland has a high share of industry-funded R&D, survey evidence shows that Finnish businesses invest little in radical innovation, with the likely implication that they become overly locked into existing products and markets and that they then fail to replace them with new ones in sufficient number. As individual product cycles mature, there is an increasing need for firms to break out into successor cycles. Finnish companies are less likely to do so than those in countries more committed to radical innovation. Incentives for "radical" innovation development and adoption should be strengthened, not only through public funding programmes but also through stronger and more systemic (and inclusive) cross-sectoral collaboration and better aligned industry-science co-operation for research and innovation.

Enhance research and innovation partnerships – the need for large-scale collaborative initiatives

Firm collaboration in innovation is also an area that deserves attention. In principle, aggregate figures place Finnish firms among the best performing of OECD countries in terms of co-operation (co-operating with others in innovation, all types of partners combined). A closer look shows that co-operation activity by SMEs seems to have suffered dramatically since the crisis and has not recovered to its 2008 levels. In terms of innovation outputs, Finnish firms mostly generate product improvements rather than "new-to-the-world" innovation. They seem to have encountered some difficulties in generating intellectual property rights (patents, trademarks, etc.) which can be partly related to under-performance in reaching global markets, in particular by SMEs, as previously discussed.

Cuts in Tekes' budget have entailed a reduction in funding for collaborative research and innovation. Earmarked Tekes funding for strategic centres for science, technology and innovation (SHOKs) – PPPs for collaborative research led by industry clusters – was discontinued in 2016, although the SHOKs, as private limited liability companies, are still operating independently under business law. SHOK companies are still eligible for normal Tekes funding and may apply for other types of funding. The aim of the SHOKs was to reinforce global market relevance of publicly funded R&D and innovation by enhancing the joint involvement of industry (or public R&D institutions).

According to an evaluation and certain experts, the SHOKs showed mixed performance and weak governance mechanisms, in addition to difficulties in aligning academia and the business sector in the setting of common research interests. They were considered as being used mostly by large firms (incumbents) with limited participation by other firms (SMEs and new firms), and functioning under a rather closed regime and with a bias towards existing technologies and products. There are, however, interesting cases of practice still under operation (such as DIMECC Ltd and CLIC Innovation Ltd), whose features and evolution should be examined and better understood. Active and promising innovation networks could be further mobilised and better utilised to address innovation challenges in high-priority areas such as bioeconomy/cleantech, the circular economy and digitalisation. PRIs need to work and interact closely with business enterprises in order to deliver commercial success of high significance.

The INKA Innovative Cities programme, involving PPPs using a bottom-up approach, will be suspended in 2017. Hence, incentives for public-private collaboration for research and innovation are currently limited, which restricts the business sector's possibilities for innovation and productivity recovery. While new forms of policy are needed, it will be crucial to restore the level of resources and effort previously devoted to

these policies in order to enable recovery and growth. The government does recognise the importance of cities and regions as drivers and test beds for innovation. Effective use of them requires focused effort and a formal framework so that interventions happen at a scale that can be effective. More interaction and closer co-operation will be needed to link national strategies and policies to regional and local strengths and development effort. Open co-operation platforms involving local actors, national and international networks can be mobilised to leverage the dynamism and strength of innovation ecosystems in the regions.

Like many other countries, Finland needs to move forward, draw lessons from the SHOK experience and engage in a new generation of PPPs for research and innovation. These PPPs should be more open, flexible, allow for a wider set of stakeholders to co-operate and could also extend to broader innovation agendas, not only research but also complementary resource development (e.g. training and human capital formation) and downstream stages of innovation (e.g. commercialisation). They should be based on enhanced governance and a clear definition of common goals agreed through a joint research or innovation agenda (for the medium to long term), based on road-mapping and joint stakeholder engagement.

The renewed PPPs could mobilise complementary support mechanisms for innovation competence development and commercialisation and better link to new innovative firms and value chains. Hence, a better mix of top-down and bottom-up approaches is key to launching a new revitalised model of PPPs. Finland currently lacks programme-based national-level mechanisms to support industry-science collaboration to address urgent industry needs for innovation and productivity growth. The only available policy tool for cross-sectoral collaboration is the SRC project funding, but this addresses policy concerns in priority societal challenges.

Increase innovation opportunities for SMEs through networks and internationalisation

The share of SMEs in BERD in Finland is below the OECD average and less than in Norway and Denmark. SMEs account for less than a quarter of BERD (21.8% in 2013), well below the OECD average (35%). Norway and the Netherlands display shares of 50% and 41%, respectively. According to Statistics Finland's last R&D survey, large firms with more than 500 employees represented about 76% of BERD in 2014. Finnish policy has provided comparatively little economic support to in-company innovation in SMEs in an OECD comparison. This means that the state mitigates the risks of innovation to a lesser extent than in other countries, making it more difficult for companies to undertake more radical or risky forms of innovation.

One way to strengthen the participation of SMEs in innovation is through the promotion of innovation linkages between large firms and SMEs. Tekes already goes some way to promote such linkages. One funding criterion for large companies is research co-operation with other innovation actors: SMEs, research organisations and universities. Almost 90% of Tekes funding to large companies is channelled through subcontracting to SMEs or research service purchases to higher education institutions (HEIs) and research organisations.

Looking to innovation beyond R&D, several indicators suggest that Finnish firms invest less in non-R&D innovation activities (relative to total sales) and intangibles (e.g. ICT investment and intellectual property) than some of their European peers and less than the European business average. Moreover, between 2008 and 2012, Finnish firms'

non-R&D innovation expenditures fell from 0.57% to 0.37% of GDP while EU firms overall devoted as much as 0.69% of turnover to such activities in 2012. This suggests a low rate of non-technical innovation and may well indicate difficulties in valorising the R&D already performed. This could result from companies' difficulties in national and international markets and may also suggest that the mix of types of R&D – especially that funded by the state – is not well adapted to industrial structure and needs.

ICT investment (relative to GDP or value added) is an area where Finland clearly lags compared to comparator countries. For instance, computer software investment represented about 1.1% of GDP in 2013 whereas this share was twice as high in Sweden and Denmark (2.25% and 2.2%, respectively). Finnish firms could also improve their use of ICT, and digital technologies more generally.

The propensity to export among Finnish SMEs is generally low. While there is scope for improvement across the board, the barriers facing smaller firms are especially severe. Efforts should be made to increase growth opportunities for firms through value creation networks and internationalisation. The former means facilitating technology and production markets through platforms and inter-linked procurement, innovation and commercialisation systems. The latter entails enhancing innovation support mechanisms for rapidly reaching export markets and GVC integration and upgrading. Finally, complementary and synergistic to all these priorities is the need to address the development of non-R&D competences in Finnish firms (e.g. ICT investment, technology licensing/adoption, training related to innovation, and marketing/new organisational models, etc.) and non-technological innovation in SMEs and new firms. These two aspects are fundamental for all sectors for productivity catch-up and competitiveness, especially in the services sector.

Recommendations

- Strengthen public support to business R&D and innovation to address the current needs for economic renewal and productivity growth.
  - Prioritise more radical innovation projects which have the potential to lead to new high value-added products and services and increased export potential. This entails addressing gaps in the innovation cycle, including knowledge transfer, technology testing and commercialisation.
  - Strengthen the participation of SMEs in innovation activities and consider improved measures to help new firms enter R&D and innovation activities. Examples of programmes include the Engage Grants programme in Canada, KMU-innovativ in Germany and InnovationAgent in Denmark.
  - Promote R&D and innovation linkages between SMEs and large firms through capacity-building projects and encourage joint research and co-development, e.g. by creating common spaces that give SMEs access to large firms' research infrastructure and expertise (an example is Synerleap in Västerås Sweden, where ABB houses a number of SMEs in a common innovation space and gives them access to their research facilities and experts).
  - Enable SME innovation by supporting test sites and demonstration facilities (in areas of new technologies and applications) that are accessible to SMEs; examine ways of making research infrastructure (e.g. laboratories) more

accessible to companies (e.g. the ongoing efforts in Sweden to maximise companies' access to the MAXIV – one of the brightest X-ray sources in the world).

- Address sectoral and cross-sectoral challenges by promoting co-operation and stakeholder co-ordination via jointly agreed strategic research and innovation agendas and their implementation.
  - Support co-ordination for innovation and strategy setting (innovation road mapping and innovation agendas). While there are some networks or clusters (SHOKs), (cross-) sectoral innovation strategies and road mapping are currently lacking. Innovation road mapping consists of the identification of both technology and non-technology bottlenecks (e.g. regulation; skills) and innovation priorities and value-chain development needs.
  - Launch a new PPP model for research and innovation. In doing so, move towards a new, more open and inclusive programme, with reinforced governance and stronger participation of the state in governance, and based on an innovation agenda with broader scope, including different stages of the innovation process (according to the network needs), including start-up participation, demonstration and commercialisation stages. Examples are the Strategic Innovation Programmes in Sweden, Strategic Platforms for Innovation and Research in Denmark, and Leading Edge Clusters in Germany.
  - Encourage and facilitate new cross-sectoral collaboration involving users, including the public sector. One example is the Challenge-driven Innovation Programme carried out by Vinnova in Sweden which has resulted in new, strategic, collaborations, e.g. between the mining industry and ICT companies.
- Expand growth opportunities through innovation networks around public markets and demand-side programmes.
  - Enhance support for and co-ordination between innovation and internationalisation programmes (export, GVC integration, and FDI and business linkages with foreign firms) and assist firms in identifying which innovation and commercialisation capabilities are needed for successful exporting and globalisation of Finnish firms.
  - Consider launching an innovation support programme for international value-chain integration and exporting.
  - Enhance public procurement of innovation and work towards a more integral innovation model that is scaled up across government agencies and regions. This will entail expanding current initiatives for matched funding schemes for innovative businesses (start-ups and SMEs) participating in procurement processes. The adequacy of procurement laws should be ensured to prevent the implementation of new initiatives from being blocked or constrained.
  - Consider introducing a programme to support small companies in commercialising knowledge from the government laboratories. This could be modelled on the SBIR scheme pioneered in the United States, which requires

government labs to reserve a small part of their budget for innovation contracts with SMEs.

- Continue and strengthen efforts to involve the regional level, especially cities, in innovative procurement, acting as test beds and linking up with international activities – for example, in Smart Cities – that will help keep Finnish initiatives up to date and allow this work on the Finnish demand side to be leveraged in international markets. All this requires intense interaction between national- and regional-level organisations and their joint action in implementing policy measures and pooling resources for jointly selected priorities.

Research policy and the gap in "strategic technology" development

The need for public investment in key enabling technologies and applied research

In recent years, the development of public research funding in Finland has, in relative terms, moved away from the earlier pattern of focusing on applied research and technology through Tekes towards more basic research which is mostly conducted at universities. This has different causes.

First, between 2011 and 2017 institutional university research funding slightly decreased in real terms while the total funding of the Academy of Finland increased by 16%, due to the introduction of the SRC and the transfer of funding from the budget line for universities to the academy for supporting university "profiling". Second, Tekes has been instructed by successive governments to focus increasingly on start-ups and entrepreneurship, responding to the correct perception that these need to be fostered in Finland. However, the result has been a significant reduction in Tekes' spending on technology programmes and innovation. Third, the government announced the withdrawal of the SHOK programme in 2015. The overall effect is that the level of applied industrial research funding is dropping below that of the academy's bottom-up research funding. The SHOK programme, launched in 2008 and providing up to EUR 100 million per year to enable science-industry consortia in R&D for business innovation needs, certainly had shortcomings. While the intention was – like in similar "competence centre" programmes abroad – both to induce industry to engage with more fundamental research so as to enable more radical innovation and to encourage academia to carry out research and PhD education in industrially relevant areas. However, the governance of the SHOKs was dominated by the companies in a way that there was little voice for the interests of more fundamental research. As a result, the work funded through the SHOKs was of a highly applied, short-term nature, and the desired convergence between industry and academia did not take place.

The reductions in Tekes funding for technology means that less effort is being made towards developing and absorbing new and enabling technologies. This trend has affected research and societal impact of more applied R&D, conducted in various institutions, including in the universities of applied sciences. While the Academy of Finland continues to play a rather traditional research council role, funding investigator-initiated research and research infrastructure, it has broadened its activities to providing "profile" funding to encourage restructuring in the higher education sector and provided a home for the SRC, which funds research to address policy and the societal challenges. Nonetheless, a gap has opened in the funding of industrially strategic, "key" and "enabling" technologies. This is the opposite of what is needed to support innovation in existing

industries, diversification into related areas and tackling the societal challenges – the three elements identified above as necessary to combat Finland's recent decline in competitiveness, exports and productivity and to set Finland back on a sustainable growth trajectory.

Strategic research funding – implications and trade-offs

Another recent reform involved the reallocation of core funding from the government to new strategic tools. According to the Government Resolution of September 2013, during 2014-17, a total of EUR 65 million was to be transferred from the government R&D institutes to the SRC (EUR 52.5 million) and the government's analysis, assessment and research activities, the so-called TEAS projects (EUR 12.5 million). Almost one-third of the total sum (nearly EUR 21 million) was transferred from VTT. An additional EUR 10 million were moved from Tekes, EUR 7.5 million from the Academy of Finland and the remainder from other research institutions.

This reallocation may represent a loss of ability to pursue enabling, strategic research and technology in the PRI sector and appears unlikely to address the "strategic research" gap identified above. Furthermore, VTT's capacity in facilitating technology transfer towards industry is also weakened, which is also likely to constrain innovation opportunities for industry. Quite distinct in its purposes and goals from other public labs, VTT has traditionally played a major role in supporting innovation in the business sector. As a research and technology organisation, its role is to equip itself with technological capabilities that are in advance of those in industry and then work with companies to transfer and exploit those capabilities in innovation. This often means that VTT works with "key", "enabling" of "strategic" technologies that correspond to the strategic research gap identified here. Reducing VTT's core funding undermines this logic and is likely to make VTT's capacity building less ambitious and reduce its ability to help industry take significant steps in new technology development and adoption. The reforms of the government institute sector are very recent, so little can be said about their effects.

With the SRC, Finland has launched an ambitious attempt to strengthen research on real-world problems and, in particular, on societal challenges. The SRC was originally intended to address "strategic" research in the sense of "strategic basic" or "enabling" research to address real-world problems, in particular major societal challenges. SRC – and the Prime Minister's Analysis Unit, currently rather represent ambitious efforts to strengthen knowledge-based decision making particularly on complex policy issues such as societal challenges. They do so by promoting policy-relevant, cross-cutting and multidisciplinary research and analysis on themes selected and prioritised by the government. They also put a strong emphasis on continuous interaction with potential users and beneficiaries of the knowledge produced as an integral part of the projects, particularly the SRC.

The SRC is a very ambitious instrument for generating primarily evidence-based policy recommendations, since research or analytical work related to identifying regulatory, institutional or other bottlenecks that might hamper the upscaling or development of solutions is of a different nature (and time horizon) than engaging in breakthrough research for developing new solutions to address societal challenges. However, the SRC appears to focus more on policy than on promoting the development of technical aspects of concrete, scalable solutions and innovations for societal challenges that could also become business opportunities. Implementing its work will require links to significant scientific and technological programmes investing in research and innovation.

In contrast, with Vinnova's Challenge-driven Innovation and Strategic Innovation programmes, Sweden has put in place innovation programmes aimed at addressing societal challenges and driving system renewal for future competitiveness that are stronger in the applied, problem-solving dimension of developing concrete, scalable solutions for societal challenges. However, these initiatives have not yet been matched by concrete changes, such as the SRC in Finland or the Prime Minister's Analysis Unit, to strengthen knowledge-based policy making and a systemic "whole-of-government" approach to addressing societal challenges (e.g. identifying regulatory, institutional or other bottlenecks that might hamper the upscaling of solutions that address societal challenges). It seems that both Finland and Sweden could learn from each other and each country's policy effectiveness could be strengthened by combining the two approaches.

These efforts to strengthen research on complex policy issues should now be complemented with changes in education as well as efforts to strengthen the ability to translate research and knowledge into concrete and scalable products and services that can address societal challenges as well as create business opportunities. The latter requires collaboration between industry, academia and institutes, but also experimentation and demonstration. The current efforts seem quite research-heavy but light on the innovation end. So far, about three-quarters of the funding awarded – which is allocated competitively – has gone to the university sector. Furthermore, the international dimension should be strengthened, since many issues can only be addressed in international co-operation and the market opportunities for successful solutions are global.

Recommendations

- Enhance funding for applied research and "enabling technologies" (e.g. biotech, nanotech, advanced materials, advanced manufacturing), aimed at supporting innovation capacity to address both industrial and societal challenges, e.g. the United Kingdom's Emerging and Enabling Technologies programme (E&E).
  - This will involve a combination of traditional Tekes-style technology programmes and wider programmes linked to the agendas for resolving the societal challenges. Some of these may be run by PPPs, provided due care is taken in designing their governance and in keeping them accountable to the government and society. Special care must be taken to close the "strategic research" gap.
- Enhance funding for VTT and other relevant PRIs to maintain their quality and industrial impact, and address the "strategic research" needs of industry and intermediary stages of the innovation process.
- Consider adjusting the funding and operational model of the SRC programme ("societal challenges") to encourage better co-ordination with instruments and policies for the participation of innovation actors, including business enterprises, and more downstream innovation development. More attention should be given to how research on societal challenges can be turned into concrete, viable and scalable solutions. Research or analysis related to identifying regulatory, institutional or other bottlenecks that might hamper the upscaling or development of solutions is of a different nature and time horizon than engaging in new breakthrough research for developing new solutions that could address societal challenges.

Complete the modernisation of the research and higher education sector

The performance of the higher education sector is constrained by governance shortcomings, which call for continued reform. The national performance-based research funding system cannot compensate for this institutional deficiency and involves such a high degree of contestability in institutional funding that it risks causing unfavourable side effects. While reformed universities would have greater freedom to reallocate internal resources and reduce the fragmentation of the Finnish research system, the profiling funding provided by the Academy of Finland is welcome but may not be sufficient to encourage specialisation and the creation of larger research groups where needed.

A second major issue hindering the contribution of universities and the public research sector to innovation is the high fragmentation of research and education that prevails. Progress has been made in terms of education or departmental consolidation at HEIs. Strengthening the quality of research remains an important challenge. Some progress notwithstanding, e.g. in the number of international staff, the science and education systems still need to become more international and better connected to international networks of research and education. The Ministry of Education and Culture is preparing a new international policy for higher education and research which aims at addressing these issues.

Facilitating the contribution of universities and PRIs to innovation and improving the quality of research has also been addressed through the Open Science and Research Initiative (ATT). This initiative attempts to improve the visibility of open and collaborative science to relevant innovation system actors and has already had some success in engaging stakeholders in the open science strategy, although it still needs to strengthen its impact on the operational level. Further development of the ATT in 2017 is expected to improve the initiative's reach.

Complete governance reforms and optimise the structure of the research and higher education sector

The Universities Bill of 2009 provided universities with autonomy, giving them legal entity status and control over recruitment and finance. It mandated that a minimum of 40% of the governing board comprise people external to the university. Rectors were already appointed by the university boards rather than being elected, but leaving a majority of internal members on the boards (Finnish universities differ in this regard) imposes some of the constraints that apply to elected rectors, especially the need not to "rock the boat" within the university. This may explain the slow pace at which Finnish universities are reacting to the need for consolidation and specialisation and for making changes in course content. Other factors, like regional policy and political decision making, may also play a role.

HEIs' contribution to innovation could be enhanced in different ways. In general, the technology transfer function within Finnish universities is not strong and the broader links to industry are weaker than those in many other countries. Degree programmes are specialised and university rules could make it easier to move from one programme to another. The type of broader programme or degree sought by employers may help to lower the high rate of graduate unemployment.

In addition, moving course credits from one system to the other should be facilitated, enhancing the kind of institutional and social mobility this engenders. An evaluation of the reforms indicated that they had strengthened university management, but in combination with the recent cuts in university funding led to some reduction in the level of enthusiasm among faculty members.

There is room for improvement in terms of skills both at the higher education and post-graduate levels. There are indications that the skill sets which are being produced, especially in doctoral education, are not sufficiently aligned with those required by society, and this might be one of the reasons why the Finnish industry has not been employing doctoral degree holders as widely as some other countries.

Overall, the process of optimisation through mergers has been rather slow. While the Academy of Finland provides "profile" funding to help universities define clearer strategies and patterns of specialisation, the number of institutions is declining slowly from a very high level. There were 48 institutions defined either as universities or polytechnics (UAS) in 2009 and 37 in 2017. This will still leave Finland with about twice as many institutions per student as in other countries, so there continues to be significant scope for rationalising the system. It is now possible for universities and UAS to form consortia, which may help reduce the fragmentation.

Not only the number of institutions needs to be reduced but, more fundamentally, the number of small branches (ca. 120) of these institutions and a large number of comparatively small departments (in the same field of education/research) scattered across the country. Overall, it appears that the process of university reform in Finland is a work in progress. Many of the measures needed to affect the reform have been put in place but a significant amount continues to depend on the ability and mandate of university management to manage the reforms effectively. The balance of power probably needs to shift more towards the management if universities are to consolidate, focus and modernise in the way intended by policy.

The UAS suffer from many of the same rigidities as the universities but they are also confronted with other types of challenges given their different orientation and stronger connection to regions and localities. UAS are strongly engaged in research, innovation and entrepreneurship-related activities and one of their strengths is close interaction with the SME sector in regions as well as developing entrepreneurial competence as part of higher education curricula. According to the Polytechnics Act of 2003 (amended in 2009), a key mission of UAS is to carry out mainly applied research, development and innovation activities as well as artistic activities that serve UAS education, promote industry and commerce and regional development and regenerate the industrial structure of the region. Given the UAS' emphasis on applied R&D, an important challenge for their R&D funding is that there are few national tools and instruments for applied research and innovation. The Universities of Applied Science Act of 2015 promoted the role of research and innovation and for the first time takes it into account in the funding model.

Reconsider the balance between performance-based and block allocation of research funding to the higher education sector

The "levers" through which government can influence the quality of university research include:

- external, competitively allocated project funding

- the ratio between institutional and externally awarded funding
- using a performance-based research funding system (PRFS) to govern some of the institutional funding
- internationalisation, exposing domestic researchers to world-class quality norms
- the governance of the universities, including their ability to strategize and develop a quality culture
- overall investment in higher education research.

The policy choice in Finland has been primarily to focus on performance-based institutional funding, although there is also a significant effort in considering internationalisation among funding criteria.

The university reforms included changes to the funding model, which have made not only external but also institutional funding for research performance-based and dependent upon results.[1] However, major changes were made after the reform was introduced. In the current (2017) model, 39% of university core funding is allocated based on education metrics, 33% based on research performance and PhD education, and 28% on a mix of the university's strategic development intentions, its activities in specific fields and its performance of various national duties, such as professional education needed by the state.

While the universities and UAS receive the performance-based income as a lump sum and are in principle free to allocate it internally as they see fit, in practice it is hard to use these resources in a strategic way. This is partly because of the governance limitations in the university system that undermine rectors' ability to reallocate internal resources and partly because a performance-based incentive system empowers the good performers who have high value in the academic labour market and can easily move if they are not satisfied with the way their university treats them.

Depending on how much of the strategic funding can be treated as disposable resources by the universities, most or almost all institutional funding for research is conditional on performance, leaving little scope for strategic use of resources to invest in change. On average, half of the university research funding from the state is project-based, although this varies greatly across universities, so the level of contestability of university research funding is very high indeed. Finland and the United Kingdom are outliers in this sense: other countries tend to provide both a bigger proportion of research funding as institutional funding and where they use a PRFS to base a smaller proportion of it on past performance.

Convincing statistical evidence about the effects of performance-based funding systems on university performance is scarce. Most countries that have introduced such systems have done so in a context where performance (measured in bibliometric terms) was already improving, so the net effect of the PRFS is hard to determine. The behavioural effects of performance-based funding on university management, however, are easy to observe. There is a uniform picture in which university managers manage recruitment and careers to maximise faculty performance along whatever lines are encouraged by the national performance funding framework. Some frameworks (such as the Norwegian one) affect very little but nonetheless change behaviour significantly, so there is no evidence to suggest that awarding a very high proportion of institutional funding based on performance is better than awarding a somewhat lower one.

International experience suggests therefore that while there is probably a minimum amount of performance-based funding that is helpful to change behaviour and raise quality, allocating a very high proportion of institutional funding for research based on performance does harm in the longer term. Doing so, moreover, minimises universities' room for autonomous manoeuvre and is likely to lock relative university performance to existing levels. There are also indications that some performance criteria may lead to perverse effects on the research itself. These vary somewhat according to detailed aspects of PRFS design but may include making research more short term, avoiding high-risk or transformative research, discouraging interdisciplinarity, reducing career prospects for women and impeding inter-sectoral mobility.

A particularity of the Finnish PRFS is that the funding system does not give credit for "third mission" activities, thereby discouraging knowledge exchange and the generation of social and economic impacts from research. These negative effects are well documented in the case of the United Kingdom, illustrating the need for the Finnish research sector to better consider the societal relevance of research in funding decisions.

The cut in Tekes' funding and the decline of funding channelled through Nokia to universities are likely to have further affected universities' propensity to interact with surrounding society and engage in third-mission activities, by reducing the availability of funding for industry-academia collaboration and for industry-relevant research.

Use funding instruments to encourage defragmentation and strengthening of the research base, using centre-of-excellence or competence-centre arrangements in academia-initiated and industrially oriented research

Finnish HEIs are also internally fragmented. There are exceptions, but many institutions run in the old "one professor per specialisation" way and so fail to build larger, more sustainable research groups. Consolidation within the sector would ease this problem, which is partly driven by the need for small institutions to provide the full set of specialists needed to teach a degree, leaving little room to build bigger groups in selected specialisations. The funding system helps to tackle this problem, but in too limited a way. The Academy of Finland has increasingly started to use larger project awards that imply research should be done by groups rather than individuals, but continues to provide a large number of personal fellowships, which have the opposite effect. The declining role of Tekes in university funding has reduced the supply of large projects.

Since 1996, the Academy of Finland has run centres of excellence (CoE) programmes. This provides an incentive for defragmenting the academic structure. However, a precondition for the success of such centres is that the universities are willing and able to form larger research groups, often crossing departmental and disciplinary lines. This in turn depends on having a strategic management able to implement changes in university practice and culture. Today, there are 29 CoEs and some of these are of limited size. A critical issue – that should be subject to evaluation – is to what extent these CoEs are having an impact on knowledge transfer and generating industry or socially relevant research for innovation.

Strengthening the quality of research remains an important challenge. While significant resources are allocated to the science base, Finnish scientific performance measured by bibliometric and citation impact indicators has remained flat since 2000. Continuing to strengthen the quality of Finnish science is critical, as research is vital to world-class innovation activity. It is also a precondition for internationalisation of the university sector, and improvement of industry-science links and the relevance of

research for innovation. As discussed above, several measures have been taken to strengthen research excellence, including the reform of funding models and evaluations, and fostering conditions for improving research organisation and collaboration (e.g. CoEs).

Recommendations

- Complete governance reforms and consolidation in both the research and education sector to ensure critical mass and an efficient specialisation:
  - Use funding instruments to encourage defragmentation and strengthening of the research base, using CoEs (and other collaborative) arrangements in both academia-initiated and industrially oriented research (and collaborative schemes).
- Ensure skills are aligned with demand. Identify education needs for a changing world (skills, update programmes, allow transferability between programmes and universities).
- Encourage HEIs to develop their strategies to engage in knowledge transfer activities and contribute to economic and societal development.
- Improve the strategic use of resources at HEIs by considering reducing the proportion under performance-based criteria in institutional funding and minimise the unintended negative effects of performance-based funding.
  - Consider adding an "impact" dimension to the assessment, especially if the level of influence of the PRFS on funding is to remain high.
  - Better recognise "third-mission"/"societal interaction" activities (such as technology commercialisation) and advance a specific impact assessment and measurement agenda in this context.

Other measures rather concern the operational level of universities. For example, assessing the need to further professionalise university management and increase its internal power relative to the staff as a whole. A key measure would be to increase the proportion of external and international members on university boards to more than half, and putting the rector's authority beyond the reach of the collegiate. Secondly, review the content and structure of first degrees, with a view to broadening their scope and making them better adapted to the needs of the labour market. In doing so, also consider measures to increase the mobility of students across degree programmes and between institutions.

Pursue foreign direct investment and further internationalisation of R&D in both the research and business sectors

Integrate the business sector with global knowledge development and GVCs through FDI and innovation networks involving foreign companies

Finland has not been very successful in attracting FDI compared to its neighbours, especially Sweden and Denmark, and MNEs' participation in BERD is only a little more than half the share reported in Sweden, according to 2013 data. The ratio of FDI to GDP in Finland is lower than that in Denmark and Sweden. For many reasons (e.g. early industrialisation, a larger manufacturing base and a more favourable geographical location, etc.), Sweden has been more successful in attracting FDI, in recent decades

involving a wave of mergers and acquisitions starting in the mid-1990s. Finland's weak multinational activity not only limits the opportunities of domestic firms' integration in GVCs and global innovation networks but also the associated knowledge spill-overs. Finnish businesses also need to use the full range of opportunities to benefit from linking up to foreign-owned MNEs in and outside the country.

FDI can provide a link between Finland-based technological capabilities and the R&D performed by Finland-based MNEs outside the country. Experience elsewhere also suggests that inward investment by MNEs creates a kind of "training school" from which nationals often graduate to set up their own companies or to successfully manage existing domestic ones. Finland offers investors important advantages in terms of the capabilities of the labour force, but is less attractive because it is a small, geographically and linguistically peripheral market.

The need for measures to increase internationalisation is widely recognised in Finnish industry and policy circles. Measures are in place, but there is a need to make them more effective.

Further internationalise Finnish research through both inwards and outwards mobility and international collaboration

International mobility is an important driver and determinant of the globalisation of science, technology and innovation. Finland has a relatively small share of international students for a country with a relatively small population which, in addition, prior to the autumn of 2016, did not charge tuition fees for students from outside the European Economic Area ("third-country" students). From autumn 2017, these fees will be mandatory. Judging from the recent Swedish experience, the introduction of tuition fees for third-country students is likely to lead to a significant drop in the number of these students, perhaps close to the 80% decline in non-EEA students Sweden experienced after it introduced tuition fees. In 2014, only 19% of all doctoral students were international students, which is lower than in all the other Nordic countries (excluding Iceland for which data are not available) and 8 percentage points lower than the OECD average. The provision of English-language higher education programmes has been identified as a key enabler of internationalisation in higher education. Therefore universities and UAS should further increase the range of English-language degree programmes they offer.

Finnish researchers co-publish with international co-authors only a little less than their counterparts in the other Nordic countries. At the level of publications, the Finnish community appears to be as well integrated into global research as others. However, the small number of foreign-born researchers working in Finnish institutions suggests that these links may be shallow. In fact, much of co-publication activity has a regional bias (collaboration remains mostly within the Nordic area).

Researchers who move to another country take their networks with them, creating the basis for deeper relationships over time. Greater international mobility of students and researchers could contribute significantly to strengthening the linkages of Finnish firms to emerging and strategic markets and innovation hubs. Currently, however, given the limited degree of internationalisation of Finnish HEIs, this avenue is sorely underexplored.

The government has tried to promote internationalisation by including four internationalisation indicators in the budget formula according to which it allocates basic funding to universities. More widely, internationalisation was identified as a priority by

the predecessor to the RIC at about the turn of the millennium and again in 2004 and 2009 when separate internationalisation strategies were adopted, and project funding has become receptive to international participation. The Finland Distinguished Professor Programme (FiDiPro) aims to attract both international and expatriate researchers to work and team up with the "best of the best" in Finnish academic research. This programme was implemented in 2006 but discontinued in 2014. It would be helpful to identify lessons from this programme in the design of a new head-hunting strategy and policy programme to attract talents and globally competitive researchers to Finland. Funding agencies have made efforts to address the internationalisation challenge. The Academy of Finland has channelled a considerable amount of funding to international activities through the standard funding instruments. For example, all bottom-up instruments contain funding considerations for international collaboration. And there are ongoing programmes for international researchers and mobility.

More information may be needed on the reasons for the low level of internationalisation. A more ambitious and co-ordinated strategy for internationalisation of research and innovation might be needed. More capacity is needed to absorb and make the best use of EU funding. It is likely that, beyond language and geography and perhaps a lack of international schools and employment opportunities for spouses, the limited number of research groups recognised as internationally excellent is a factor. In addition, foreign researchers may also interpret the lack of established foreign-born academics as an indicator that there is a "glass ceiling" for foreigners.

Finland could benefit from strengthening the use of EU Framework Programmes for strategic networking as well as for excellence- and market-driven innovation activities. They provide a functional platform for more intense internationalisation and leveraging the impact of national R&D funding and innovation activities. Analysing the impact for different type of participants and of different kind of activities is important for developing adequate support and steering mechanisms.

Recommendations

- Enhance efforts to accelerate the integration of the Finnish innovation actors (both in business and public research) with global knowledge networks:
  - Attract foreign R&D activities and joint initiatives with foreign firms through the creation of joint CoEs in key areas for future competitiveness and/or societal challenges (e.g. digitalisation, big data, clean-tech and health-tech, etc.).
  - Foster inward and outward mobility, and strengthen incentives for talent attraction:
  - Establish a fund or some other specific instrument to head-hunt leading international researchers. This will involve competitive conditions to attract talent from abroad (both Finnish and foreign). Such a strategy could be part of the organisation of CoEs, thereby facilitating the placement of highly qualified scientists from abroad and their rapid integration in efforts to increase research excellence and critical mass in key areas of research and innovation.

- Ensure that immigration laws are conductive to attract talent, including timely and reasonable working permit conditions for foreign researchers and their spouses.
- Increase the proportion of higher education conducted in English. This will not only encourage foreigners to come to Finland, but also improve the linguistic capabilities of Finnish students.
- Further open faculty recruitment to global competition, based on scientific excellence.

Maintain and improve framework conditions supportive of innovation and entrepreneurship

General framework conditions are critical for a country's performance with regard to innovation and entrepreneurship. Finland's framework conditions are strong overall. Reforms have been implemented since 2015 to promote employment, entrepreneurship and economic growth. Structural reforms and government measures aim at reducing regulation and red tape to improve operating conditions for businesses. The government's tax policy aims to boost growth, entrepreneurship, work and employment. The total tax rate is not set to rise during the government term and labour taxes will be eased.

Despite a sluggish economic environment, credit remains relatively easy to obtain in Finland, although it has become more difficult for small firms in the very recent past. Although credit standards for SMEs have been tightened somewhat, access to finance has remained easy compared to most other European countries since the 2008 financial crisis. Finland ranks high on many key financial indicators compared to Europe, e.g. the percentage of firms with credit lines and loan application grant rates, and private equity investment (as a share of GDP) is one of the highest in Europe. Companies do not name access to finance as a significant problem, according to different business surveys. There is also econometric evidence that confirms that, on average, Finnish firms do not face financial constraints.

As regards early-stage financing, Finland's venture capital market ranks high among European countries in terms of size. Venture capital investment represented 0.05% of GDP in 2015, which is higher than in the other Nordic countries and well above the OECD average. Public funding for entrepreneurship, including venture capital, has been expanding in recent years. While early-stage funding seems more accessible to firms than in the past, young expanding companies still encounter difficulties to obtain growth financing. Funding of growth capital has not returned to 2010 levels when it reached EUR 253 million. The total venture capital flow has averaged less than EUR 130 million annually since. In 2014, venture capital came close to the level reached in 2007 in absolute terms. In addition, restrictions related to workforce availability (including highly skilled ICT personnel and managerial skills) and indirect labour costs have not eased significantly, despite the prolonged recession and comparatively high level of unemployment.

Finland's general business framework scores high in several indicators. In terms of the World Bank's aggregate Ease of Doing Business 2017 index, Finland ranks among the highest, at 13th position, just behind Sweden (9th) and Norway (6th), while Denmark comes out as the 3rd best country. Finland, however, has room to improve regulations regarding the protection of minority investors, contract enforcement and getting credit. Regulations remain cumbersome in some areas, notably in retail trade, network

industries, construction and land-use planning. Streamlining regulations is a key objective of the new government, which also plans to promote competition in the construction industry and public services.

Finland scores relatively well in terms of trade and FDI regulations. Finland's Service Trade Restrictiveness Index (STRI) scores are above the OECD average and scores of other Nordic countries in several sectors. A comparison with the OECD's best performers on these indicators suggests that there is room for lowering barriers further in a number of sectors, including transport and construction, consistent with the product market regulations indicators. Finland's product market regulations are less restrictive overall than the OECD average. Only the Netherlands and the United Kingdom have significantly leaner regulations. The 2011 Competition Act brought regulation in line with recommendations from the European Commission. It reinforced merger control and enhanced damage compensation as well as "whistle-blowing" instruments. It also expanded the investigation powers of the Finnish Competition Authority, whose resources have been increased. Competition is, however, limited by low population density in large parts of the country.

Recommendations

- Foster innovation through more competition-friendly business policies and product market regulation. Revisit the regulatory framework to encourage vigorous product competition, firm entry and ease cumbersome regulations in retail trade, rail network industries, construction and land-use planning, which helps increase the number of suppliers.
- Enhance flexibility in labour markets in various ways, including through employment protection legislation and labour market regulations.
- Continue improving business and regulatory conditions for business creation and growth and foster the entrepreneurship ecosystem through global linkages and investors.

Note

1. Although the model is mostly performance-based in principle, all of the funding is allocated to universities as a lump sum and they are free to decide internally how it is allocated. All metrics are calculated by using three-year averages to eliminate fluctuation in the institutional funding.

Annex 1.A1

The role of research and development in fostering macroeconomic performance

There is widespread agreement that research and development (R&D) for technological change and innovation is an important driver of growth, especially in the long run. However, the conceptual and empirical links between innovation and growth are complex. Innovation is not a simple linear process, with a chain of one-directional links between investments in R&D to economic or social outcomes. Moreover, metrics for certain aspects of innovation suffer from limitations, which have made it difficult to establish the role that innovation policies can play in shaping or strengthening innovation performance (OECD, 2015), in order to stimulate competitiveness, productivity and economic growth through entrepreneurial activities. Consequently, there has been an extensive discussion among academics and policy makers on the rationale for innovation policies. Neo-classical perspectives recognise only a limited set of market failures, such as externalities and information asymmetries, while other schools of thought point to a much wider range of factors and constraints that affect innovation and that provide a rationale for policy. These factors will vary from country to country and also depend on the particular area of innovation that is being considered, such as specific industrial sectors of the economy.

A significant body of econometric research on the impact of R&D on economic growth has been collected since the early work in the late 1950s, and generally confirmed the positive impact of R&D on productivity and economic growth. Most studies find that the social rates of return in R&D externalities exceed private rates by an order of magnitude greater than 50% (Mohnen, 2017). One important lesson to be drawn from the macro-econometric literature is that to positively impact economic growth, innovation requires not only investment in technology and R&D, but needs to be complemented and combined with other assets and embedded within a sound policy framework. As new knowledge-based assets, such as computerised information, intellectual property and economic competencies and business models grow in importance, so do the framework conditions facilitating their creation. The capacity to translate R&D investments into commercially viable product innovation is an important determinant of the efficiency of R&D inputs, and can be linked to the framework that motivates firms to innovate. Mohnen (2017) stresses a wide range of framework elements that affect the efficiency of R&D inputs in generating innovation. These include, among others, a high-quality education for the formation of human capital, pro-competitive market regulations, flexible and well-functioning labour markets, incentives to entrepreneurship, openness to trade and FDI that increase the diffusion of knowledge and new technologies, the accessibility of venture capital, pro-active government procurement that can support

scaling-up successful innovation, ease of starting new ventures, and industry-government collaborations in areas that present a comparative advantage to meet emerging demand. Tax incentives can also stimulate additional R&D, particularly if used simultaneously with direct support for R&D (Mohnen, 2017).

Finland is among the leading knowledge-based economies in the world, particularly due to its strength in education, technological readiness, financial market development and institutional capacity (Mohnen, 2017). Many of the framework elements underpinning the efficiency of R&D investments are thus well developed. Continued investments into R&D and Finland's innovation framework combined with an expansion of international collaboration in research and innovation and internationalising research and economic activity more broadly) are powerful tools to keep Finland in the proximity of the world technology frontier and at the forefront of technological progress, and which could generate additional returns from international R&D spill-overs (Mohnen, 2017).

Sources: Mohnen, P. (2017), "The role of Research and Development in fostering economic performance. A survey of the macro-level literature and policy implications for Finland", Survey prepared for the OECD and commissioned by the Finnish Ministry of Economic Affairs and Employment, (forthcoming); OECD (2015), *The Innovation Imperative: Contributing to Productivity, Growth and Well-Being*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264239814-en.

Chapter 2

Macroeconomic and framework conditions for innovation in Finland

This chapter discusses macroeconomic and framework conditions in Finland and their repercussions on innovation performance and future growth. It starts with a brief description of the recent macroeconomic context, with a special emphasis on the major economic challenges Finland is facing today, followed by an analysis of the strengths and weaknesses of the country's framework conditions for innovation and entrepreneurship.

Macroeconomic performance[1]

Moving from a dynamic to a sluggish economy

After a period of steady and fast growth – from recovery from the recession of the 1990s until 2007 – Finland's economic performance has since deteriorated significantly and has encountered great difficulties to return to its previous growth path. During the high-growth period, Finland's economy grew at the same rate as that of Sweden and faster than many European countries. As a result of the global financial and economic crisis, however, Finland's gross domestic product (GDP) experienced a deep recession in 2009, with GDP contracting by nearly 9%, reflecting the exposure of the country's economy to the international environment. Real GDP has since remained below the level achieved before the crisis.

Recently, the performance of the Finnish economy has been lagging significantly behind many of its peers. While Finland's economy initially rebounded from the crisis in 2010-11, it sank back into recession in 2012-14 and failed to make up for the losses in exports and investment, as external and domestic demand weakened. Since the onset of the global crisis, Finland's productivity has declined both in absolute terms and relative to the leading OECD countries, especially in the manufacturing sector.

Low growth seems to be mainly due to structural factors. Finland has been hit by a combination of adverse shocks. The electronics sector contracted significantly when Nokia's handset business failed to rise to the competitive challenge of smartphones and collapsed. In addition, the Finnish paper industry suffered from a secular decline in demand for paper products due to the rise of digital media. Downsizing of manufacturing industries, which traditionally recorded high levels of productivity, led to a lower aggregate level of productivity. Finnish labour productivity dropped by more than 5% in 2009, only partly recovering in 2010 and 2011, and has been stagnating since. In addition, since 2014, exports to the Russian Federation have almost halved due to the Russian recession and the imposed sanction regime. Sluggish global growth and contraction of global demand for products in which Finland specialises (e.g. durable investment goods) have also played a role. Finally, a rapidly ageing workforce results in an annual decline of the working-age population of 0.5%, which weighs on the growth potential in the long run.

Reviving growth remains the country's pre-eminent challenge, and this requires consolidating structural reforms and implementing prudent macroeconomic and fiscal policies. A turnaround of the economy might take time and concerted efforts.[2] Progress is currently being made in several of these areas, such as labour regulations, wage contention thanks to agreement with labour market partners, health and municipality reform, as well as the fiscal framework.

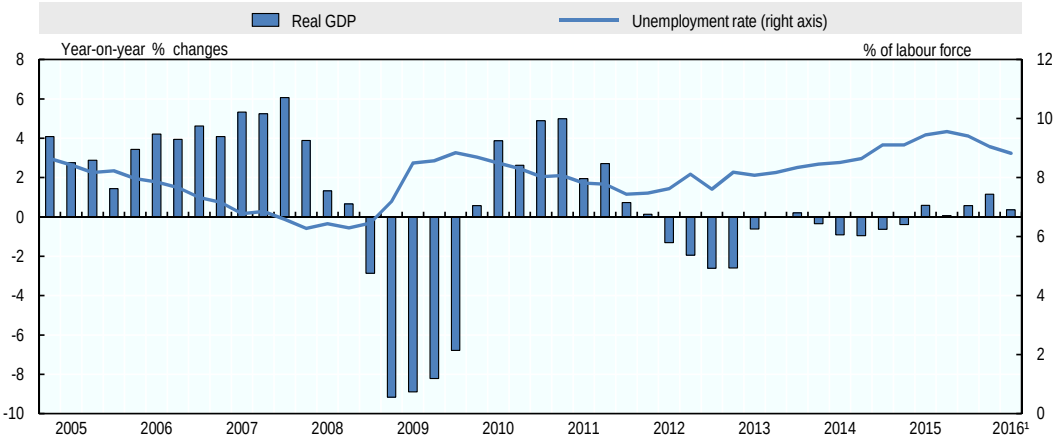
After four years of recession, a national plan for economic transformation aims to address cost competitiveness, an aging population and a decline in trade with major export markets. Government policies are currently focused on balancing public finances and reforms to address structural weaknesses. The government is implementing a fiscal consolidation agenda, intending to level off the GDP-to-debt ratio. Budget cuts also affect expenditure on R&D and innovation. The Strategic Government Programme of the Prime Minister launched in 2015 is based on five strategic priorities: 1) employment and competitiveness; 2) knowledge and education; 3) well-being and healthcare; 4) bio-economy and clean technologies; and 5) digitalisation, experimentation and deregulation.

The Finnish economy finally began to recover in 2015 (Figure 2.1) owing to rising private consumption, construction and investment, but growth prospects for the coming years remain modest.[3] Growth is set to remain slow at about 1.1% in 2017. According to the OECD (2016c), continued weak growth in the short run will mainly be supported by exports, as private consumption is constrained by low household income growth. Investment growth is broad-based, with residential and commercial real estate investment fuelled by low interest rates and high demand in the largest cities.

Closing the gap with the income level of the leading OECD countries has stalled

While Finland's level of income is still higher than the OECD average, recent economic performance (Figure 2.1) has been eroding this lead. The level of Finnish GDP per capita is above the OECD and EU average but lower than in all other Nordic countries. Finland's GDP per capita gap to the leading OECD countries has widened after shrinking by about 15 percentage points between the early 1990s and 2008 on the back of strong productivity growth (OECD, 2016a). A continued deterioration in the terms of trade, partly due to falling electronic products prices, has acted as a drag on income. According to OECD analysis (OECD, 2016a), the GDP per capita gap essentially results from lower productivity. Labour utilisation is close to the upper half of the average for OECD countries.

Figure 2.1. **Evolution of GDP and unemployment rate, Finland**



Note: Quarterly data; 1. 2016 data is for Q1 and Q2 only.

Source: OECD (2016b), *OECD Economic Outlook, Volume 2016, Issue 2*, OECD Publishing, Paris, http://dx.doi.org/10.1787/eco_outlook-v2016-2-en.

Unemployment has risen, peaking at about 9.5% in 2015, and has started to fall only recently (Figure 2.1). According to Statistics Finland's Labour Force Survey, the unemployment rate dropped slightly to 9.2% in January 2017, from 9.3% in the same month a year earlier (Official Statistics of Finland, 2017). Although the unemployment rate is poised to continue to shrink slowly, further policy reforms to enhance labour market flexibility will be needed to significantly increase the employment rate. An ageing population also means that high growth becomes more difficult to achieve – as more people retire from economic activity and demand for healthcare increases.

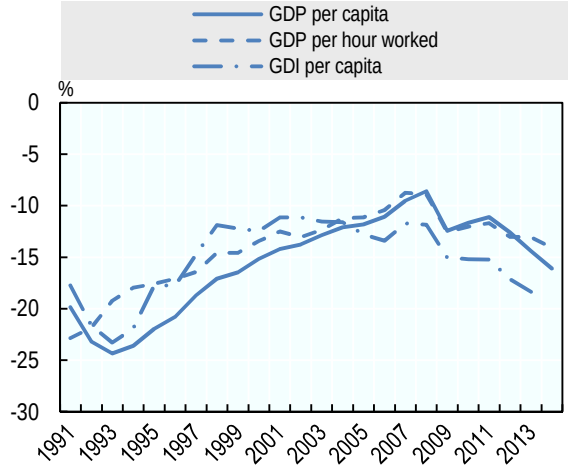
Public debt and fiscal imbalances

The prolonged economic weakness has contributed to a significant rise in debt. Total debt (excluding bank deposits) has increased by 95 percentage points of GDP since 2007, reaching about 355% of GDP in 2015 (IMF, 2016a). Most sectors have contributed to this increase in indebtedness, including the general government, households, non-financial corporations and banks. The fiscal deficit remains close to 3% of GDP as spending cuts and higher revenue are offset by increasing age-related costs. In 2015, a better-than-expected fiscal performance brought the deficit back under the 3% EU's Stability and Growth Pact limit. Nevertheless, fiscal space remains limited, as public debt reached 63.6% of GDP, which is above the Stability and Growth Pact threshold (IMF, 2016b). According to the same source, fiscal policy needs to strike a balance between safeguarding long-term sustainability and protecting the nascent economic recovery. After easing in 2016, the stance of fiscal policy is set to be broadly neutral in 2017-18.

Eroding trade performance

Manufacturing exports have plummeted, reflecting a loss in competitiveness of the Finnish economy. Since 2008, Finnish exports have declined by approximately one-fifth, which is more than in any other advanced economy. The share of high-technology goods in total exports dropped from 23% in 2005 to 6% in early 2016. Finnish enterprises' losses of global market shares were higher than those of any other European country. The current account balance moved from a surplus of nearly 4% of GDP in 2007 to a deficit close to 2% in 2011.[4] Exports of services have remained more or less unchanged since 2008. Information, communication and technology (ICT) services, in particular, have been evolving fairly well in terms of value-added growth and employment.

Figure 2.2. **Finland's GDP per capita and per hour worked relative to leading OECD countries**



Note: GDI: gross disposable income.

Source: OECD (2016), *OECD Economic Surveys: Finland 2016*, OECD Publishing, Paris, http://dx.doi.org/10.1787/eco_surveys-fin-2016-en, based on *OECD National Accounts and Productivity Databases*.

Figure 2.3. **Total factor productivity**

Source: OECD (2016), *OECD Productivity Database*, www.oecd.org/std/productivity-stats.

Finland has lost in competitiveness in global markets for reasons related to the deep structural adjustments in manufacturing (most prominently in the ICT manufacturing sector), high labour costs and global shocks (e.g. declining global demand for durable investment goods and shrinking trade with the Russian Federation). The fall in productivity primarily reflects a pronounced manufacturing, and especially ICT, cycle. Electronics and metal machinery have also suffered from low prices in global markets. The recession in the Russian Federation and the trade sanctions have further reduced Finnish exports and affected energy prices, which in turn pushed up production costs for Finnish firms. The value of exports of goods to the Russian Federation has fallen by roughly half over the past three years, detracting about 1.5% from Finnish GDP (OECD, 2016a).

Rising labour costs have contributed to the loss of competitiveness. In the wake of the 2008 global financial crisis wages have continued to progress steadily although productivity growth has slowed (OECD, 2016a). In effect, wages have been growing faster than productivity. Today, Finland has the seventh highest production costs in the European Union. In the last years, unit labour costs in Finland increased more than those of its main trading partners, by 25% between pre-crisis 2007 and 2014.

Productivity has lost ground vis-à-vis its peers

In contrast to the rapid expansion experienced in the late 1990s and early 2000s, total factor productivity (TFP) growth contracted substantially over the period 2008-14 (Figure 2.3). Much of this productivity contraction was due to manufacturing. As the electronics sector was highly productive, its decline led to a significant drop in overall productivity of the economy. As a result, aggregate productivity in 2015 was still below the 2007 level. Productivity growth has also been weak relative to that of Denmark and Sweden (as well as the OECD average), which experienced a smaller or no productivity drop during the recession and has achieved positive productivity growth over the subsequent years.[5]

Finland's post-2008 development is in stark contrast to the productivity performance achieved during the period 1997-2007 (Figure 2.3) when Finland outpaced its peers. The pre-crisis expansion was primarily driven by TFP growth, which encompassed technological innovations, new business models and more efficient allocation of resources. To a large extent, Finland's growth performance during that period reflected the rapid spread of ICT, shown in strong ICT investment, particularly in communication equipment where Finland outpaced all other OECD countries, and strong TFP gains allowed by digitalisation (Spezia, 2012).[6] Manufacturing was the main catalyst of this economic dynamism, contributing two-thirds of overall productivity growth between 1997 and 2007 and an even higher share of the decline since then.[7] After 2007, TFP performance collapsed. The reversal in TFP performance has been one of the most pronounced in the OECD.

Labour productivity has been particularly poor in manufacturing and – in contrast to Sweden – has not yet recovered from the 10% drop during the crisis. Productivity performance in services has also been weaker than in peer countries. One exception is the information and communication sector, whose productivity grew by almost 30% between 2007 and 2015. The sharp decline in the high-productivity, high value-added ICT sector meant that more traditional and less productive activities have increased their weight in aggregate economic activity and productivity.

Business services productivity growth has been sluggish, as in Denmark and Germany, contrasting with the strong performance of Norway, Sweden and the United Kingdom. Productivity in the business services sector has advanced only slowly in the past 15 years. Business services accounted for only about a fourth of productivity growth between 1997 and 2007, even though they represent about 40% of labour input. This suggests that there is room for raising business services productivity, which is all the more important as services and manufacturing are increasingly intertwined (Ministry of Employment and the Economy, 2015). Productivity in public services has also declined in Finland.[8]

Reviving productivity growth is crucial to restore Finland's competitiveness and stimulate output growth, while the contribution of labour input is shrinking due to population ageing. Reviving productivity growth is also important to maintain and further raise standards of living and well-being. As discussed in OECD (2016a), reviving productivity requires further improvements in framework conditions so that labour and capital can move more easily to the most dynamic sectors and firms, making the tax system more growth-friendly, supporting innovation and research, along with other measures.

The structure of the economy and the need for economic diversification

Manufacturing remains the largest contributor to gross value added (GVA) in Finland, accounting for 17% in 2015, which was still above the EU average (15.5%) in 2015 according to Eurostat. However, its share has significantly decreased in recent years, down from 23.3% in 2007 (for more detail see Chapter 3) Overall, the shares of sectors in GVA (at basic prices) in 2015 were as follows: primary production (agriculture, forestry, fishing: 5%, compared to 2.7% in 2012; secondary production (manufacturing and construction: 26.8%, compared to 27.0% in 2012); private services: 50.3%, compared to 49.6% in 2012; and public services: 20.3%, compared to 20.6% in 2012 (Statistics Finland, 2016).

Finland is the 43rd largest export economy in the world and the 7th most complex economy according to the Economic Complexity Index. Finland's top export destinations – according to export data for 2014 – are: Germany (USD 9.3 billion), Sweden (USD 7.9 billion), the Russian Federation (USD 5.7 billion), the United States (USD 5.2 billion) and the Netherlands (USD 4.5 billion). Understanding the sources of export performance variations and competitiveness is crucial for a small open economy such as Finland's, which is scarcely populated, with few sizable agglomerations and in a geographically peripheral location.

Finland's trade has not been highly diversified. In 2015, its top 10 exports accounted for 71% of the overall value of its global shipments and 26% of total Finnish economic output. These were: paper; wood; iron and steel; wood pulp; medical and technical equipment; machines, engines and pumps; ships and boats; copper and zinc; and gems. Ships and boats was the fastest growing of these export categories, up 95.8% over the period 2011-16.

The export product basket has traditionally been dominated by raw materials, production supplies and investment goods, making export performance heavily dependent on business demand, which has been subdued in almost all of Finland's major export markets since the global financial crisis. A more balanced basket composed of consumer-oriented goods and corporate-dependent exports would probably result in a higher degree of resilience of Finnish trade.

Overall, Finland has a narrow base of competitive advantages, e.g. measured as the number of sectors with high levels of specialisation according to the index of revealed comparative advantage (RCA). A recent study identified ten sectors with specialisation (RCA>1) (Holmström, Korkman and Pohjola, 2014).[9] These include traditional industries such as paper and wood and basic metals, but also IT services, business services and construction. Sweden has a broader base of industries with revealed competitive advantages, which includes these same areas of strength.

Finland needs to tap new sources of growth based on new and sustainable export strengths, as well as by revitalising traditional industries with new value-added products and services, e. g. the metal machinery industry, forestry and chemicals, fostering its capability to compete globally through new economic competences. This transformation will require Finland to engage in more radical innovation and become more effective in utilising its valuable knowledge capabilities.

The European Union remains the main destination of Finnish exports, with 57% of exports delivered to this region. Exports from Finland amounted to USD 59.7 billion in 2015, down by -24.3% since 2011 and by -20% from 2014-15, while 15.5% were exported to Asia. Finland shipped another 8.2% worth of goods to North America, and the reminder to other countries.

The economic impact of Nokia and its heritage

The economic impact of Nokia's restructuring has been profound. The restructuring of Nokia, which began as early as 2004 following the drop in global prices of electronic devices and notably the introduction of the iPhone and android phones, required the company to shut down the production of mobile phone devices and refocus its business strategy on hardware and network technologies, where it is still a major player.

The developments at Nokia had a strong impact on the Finnish economy, including labour markets, raising among others the important issue of how to best make use of the human resources formerly employed directly and indirectly and their skills and competences. According to a recent study (ETLA, 2015), Nokia's economic contraction directly accounts for one-third of the drop in GDP and one-fifth of the reduction of total employment between 2008 and 2014. In 2012, Nokia downsized its workforce in Finland by 40% (3 700 employees). Of the roughly 100 000 ICT professionals in the country, it is estimated that 14 000 (14%) have been affected by the closure or contraction of facilities owned by Nokia (Hallikas et al., 2013). In addition, knock-on effects of Nokia's contraction have led major Finnish software houses to cut investments, especially in the area of R&D. Major telecommunications companies (e.g. TeliaSonera) have restructured and concentrated product development activities at their Swedish sites. This combination of factors has weakened the Finnish ICT sector.

On the other hand, Nokia's former employees seem to be contributing to the rise of start-up activity. It is estimated that many former Nokia employees have contributed to the creation of new companies, either as founders or as employees, which means that Nokia's talents are utilised through entrepreneurship to the current and future benefit of the Finnish economy and society. This transition has not been easy for everyone as some frictions have prevailed regarding labour market integration and adaptation to new businesses and industries. The Bridge Programme, launched in the first half of 2011 and closed three years later, has contributed to the creation of some 400 companies in Finland concerning around 500 new entrepreneurs (Pesonen, 2013).

The reform agenda and recent actions

After easing in 2016, the stance of fiscal policy is set to be broadly neutral in 2017-18. The room offered by Finland's low government deficit and debt could be used to support the economy through the cuts in taxes and social contributions linked to the Competitiveness Pact and through investments in infrastructure (OECD, 2016b). There is room to spend more than what is currently planned on public support to R&D and innovation, both in the business and public sectors, including staff training.

Substantial progress has been made on implementing the government's reform programme. Social partners have agreed on a Competitiveness Pact, which lowers labour costs in 2017 (by about 4%), increases hours worked, and on wage moderation over the coming years (OECD, 2016b). It also aims to introduce more firm-level flexibility in the wage bargaining system. The pact also provides cuts in taxes and social contributions in 2017. A reduction in the maximum duration of unemployment benefits will also be implemented. The pact should help to contain unit labour costs, and thereby strengthen international competitiveness and export prospects. Draft bills on the reform of health and social services provisions are being discussed with stakeholders. Work is continuing on the macro-prudential policy framework and efforts to deepen regional co-operation are ongoing (IMF, 2016b).

Healthcare reform is also moving forward, with decisions to shift some responsibilities from municipalities to newly created regional institutions in 2019 and to reform funding mechanisms. This reform is expected to generate economies of scale, while enhancing user choice and equality in access to care across the country. Long-term fiscal sustainability is set to be strengthened by the healthcare reform.

A further boost to growth should come from product market reforms, particularly in the retail sector and in state-dominated sectors. This could increase competition and yield productivity gains. Employment could further be increased by strengthening active labour market programmes. Strengthening innovation should be addressed in order to revive productivity in both the medium and long run and further foster economic diversification.

Framework conditions for innovation and entrepreneurship

The quality of a country's general framework conditions is critical for its performance with regard to innovation and entrepreneurship. Finland's framework conditions are strong overall. Reforms have been implemented since 2015 to promote employment, entrepreneurship and economic growth. Ongoing structural reforms and government measures aim at reducing regulation and red tape to improve operating conditions for businesses. The World Economic Forum's Global Competitiveness Report 2016-17 ranked Finland as the tenth most competitive nation in the world. This can be explained by innovation and sophistication factors, which rank seventh in the world. It must be noted, however, that Finland's standing has been shrinking in the ranking compared to 2014-15, when it was the fourth most competitive country.

There is still scope for Finland to improve its competitiveness environment and business framework conditions for innovation and entrepreneurship, notably in the areas of competition and regulation, labour market flexibility, and tax policy. Among the most problematic factors for doing business in Finland are high tax rates and restrictive labour regulations, and competition conditions in a number of sectors (e.g. gas, retail and transport, among others).

As regards framework conditions for entrepreneurship, Finland has several strengths which are reflected in an increasingly vibrant and growing start-up environment. Finland provides an easy operating environment for businesses and firm creation, with minimal bureaucracy, and growing opportunities for start-up businesses through public sector initiatives (e.g. open data, procurement, health growth strategy, etc.). Finland's main weaknesses in this area are access to early-stage finance, especially growth funding, tax legislation and regulation frameworks for new firms.

Good access to traditional finance and early-stage finance

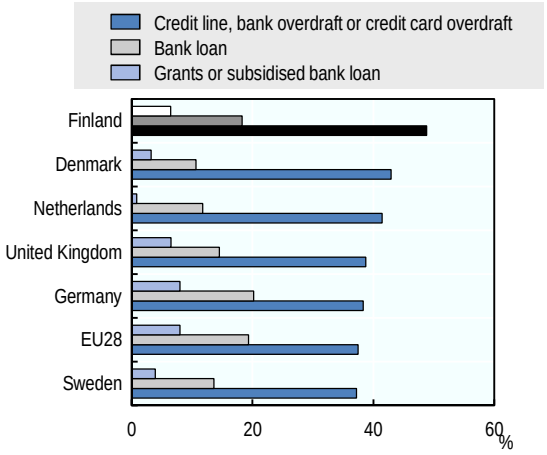
Despite a sluggish economic environment and credit standards for small and medium-sized enterprises (SMEs) being tightened somewhat, finance remains relatively accessible in Finland compared to other European countries. It ranks high on many key financial indicators compared to those of Europe, e.g. the percentage of firms with credit lines and loan application grant rates, and private equity investment (as a share of GDP) are one of the highest in Europe (Figure 2.4). Companies do not quote access to finance as a key problem, according to different business surveys (e.g. European Central Bank, 2015). However, it has become more difficult for small firms to be granted credit in recent years according to the World Bank's Doing Business 2017 (World Bank, 2017). The level of loans for SMEs in 2014 was lower compared to ten years earlier (EUR 6 697 million versus EUR 11 576 million), which is evidence that credit is more constrained than in the past.

Early-stage finance for young innovative firms is quite well developed given the size of the economy. Yet, access to growth funding is still an issue, in spite of the increase in public start-up financing seen in recent years. According to the most recent Entrepreneurship at a Glance report (OECD, 2016d), venture capital (VC) investment represented 0.05% of GDP in 2015, the largest proportion among Nordic countries and well above the OECD average, although it is far from the corresponding figure for Israel (0.38%) and the United States (0.33%) (Figure 2.5).

In addition, Finland also displays a high number of companies being backed by VC compared to other European countries. Fourteen percent of new enterprises receive financing by VC, which puts Finland second among OECD countries, just behind the United States (16%). In the other Nordic countries – with the exception of Sweden (12%) – this share is below 10% (Norway at 5% and Denmark at 2.8%). However, the average VC investment per firm is not very large: the average amount of financing received by new firms was USD 0.7 million in 2015 compared to USD 13 million in the United States and USD 7 million in Israel. Further, on average 60% of venture-backed companies received start-up stage and early-stage financing, while only 22% of venture-backed firms enjoyed later development stage financing in 2015. These figures are similar among Nordic countries, with the exception of Sweden. In Sweden almost 90% of venture-backed companies received start-up and early-stage funding and in the United States 45% of venture-backed deals related to later stage financing. In Finland, growth funding has not been expanding significantly in the last years, and several experts point out an important gap in this type of finance.

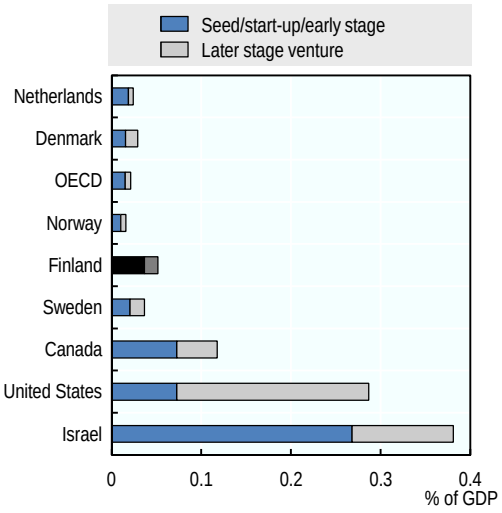
Figure 2.4. **Access to finance, 2015**

Percentage of firms obtaining finance over the last six months



Source: European Central Bank (2015), "Survey on the Access to Finance of Enterprises", www.ecb.europa.eu/stats/ecb_surveys/safe/html/index.en.html (accessed 15 February 2017).

Figure 2.5. **Venture capital investments as a percentage of GDP, 2015 or latest available year**

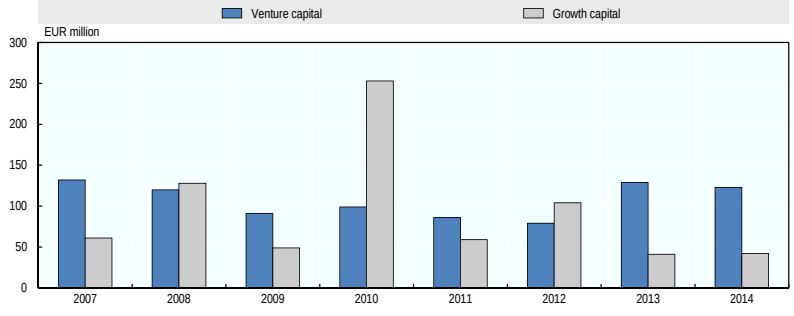


Note: The OECD figure refers to the median value of the total available country data.

Source: OECD (2016d), *OECD Entrepreneurship at a Glance*, OECD Publishing, Paris, http://dx.doi.org/10.1787/entrepreneur_aag-2016-en.

In fact, the trend by type of investment (growth versus VC) has been changing in Finland (Figure 2.6) with growth capital decreasing vis-à-vis VC in recent years. Funding of growth capital has not returned to its 2010 level (EUR 253 million) and total VC flow has averaged less than EUR 130 million per year ever since. In absolute terms, the level of VC in 2014 was similar to the level in 2007. The global crisis of 2008-10 largely impacted Finnish VC market development. The Finnish government has increased the availability of VC considerably, in particular through fund-of-fund investments, to leverage private equity funding. The EUR 230 million of government investment allocated for 2013-17 is expected to raise more than EUR 1 billion in VC investment in total. Firm growth is also promoted through a programme of 10 accelerators comprising about 100 portfolio firms. About EUR 220 million of private funding has been raised for these firms in addition to the EUR 70 million of public funding.

Figure 2.6. **Venture capital funds, Finland**



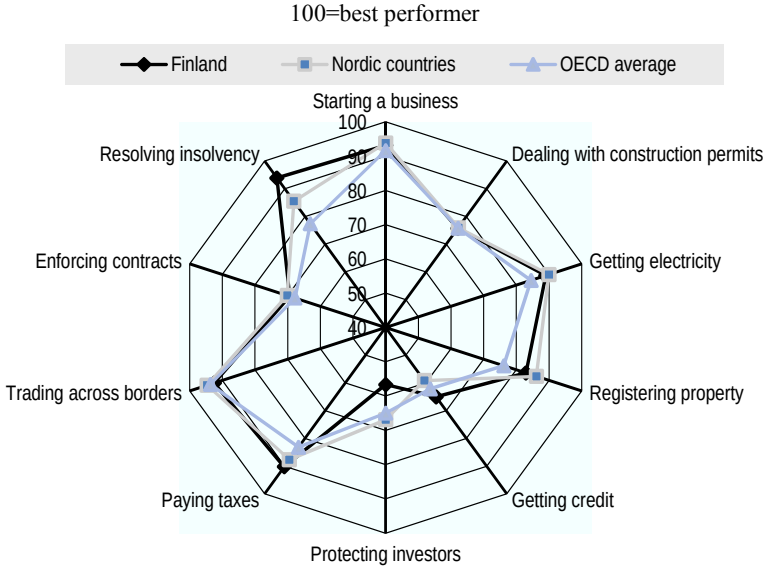
Source: Based on data from Finnish Venture Capital Association.

A favourable "doing business" environment

Finland's general business framework scores high in several dimensions. In terms of the ease of doing business, Finland's score is among the highest (World Bank, 2017). It ranks at 13th, just behind Sweden (9th) and Norway (6th). Denmark comes out as the third best country in the aggregate Doing Business index. Finland, however, has room to improve regulations regarding the protection of minority investors and contract enforcement (Figure 2.7). According to Doing Business, access to credit also deteriorated in 2016 – ranking today far from the frontier. Among the main problems cited, Finland's economic regulations offer weak protection for investors against self-dealing on the ownership and control of the business. Finland could also do better in terms of contract enforcement, taking 375 days and costing 16% of the value of the claim. The national credit information system could be improved to ease access to finance as well as the use of collateral.

Finland can address these difficulties by first instilling stronger governance safeguards to protect shareholders from undue board control and entrenchment; second, making the process of resolving commercial disputes through the courts (which are essential for entrepreneurs) more efficient and transparent and decreasing the length of time to go to trial for small enterprises; and third, by strengthening the accessibility of credit information distributed by credit bureaus and credit registries. Resolving insolvency ranks close to the frontier (best practice) (94%) and so is better positioned than the OECD average and is far better developed than the other Nordic countries. Also, starting a business is line with the best practice.

Figure 2.7. **Doing Business indicators: Distance to frontier**



Source: World Bank (2017), "Finland country profile", in *Doing Business 2017: Equal Opportunity for All*, www.doingbusiness.org/reports/global-reports/doing-business-2017.

Trade openness and integration into capital and goods markets are essential elements of an innovation-friendly environment as they allow for technology exchanges and commercialisation of knowledge assets and innovation, which allows firms to maximise returns to knowledge and intellectual investments. Foreign direct investment (FDI) can

affect a country's innovation performance through technology transfer – including diffusion of new organisational and management practices – and by facilitating integration to global supply chains and markets as well as R&D and innovation networks.

Finland scores relatively well (and above the OECD average) in terms of trade and FDI regulations. In recent years, Finland has made considerable progress in eliminating discriminatory regulations against foreign investors. In terms of FDI stock intensity (relative to GDP), Finland is behind Sweden and Norway, but FDI both in new and follow-on investments have continued to grow in recent years after having contracted sharply due to the international financial crisis, the crisis in Ukraine and the sanctions imposed on the Russian Federation.

According to Finpro's Invest, 265 new foreign-owned companies set up business in Finland in 2015, compared to 229 in 2014. The sectors with the largest number of new foreign-owned companies were business services, healthcare and well-being, ICT, and more recently clean-tech and bio-industries. The small size of the domestic market and a peripheral geographical location are among the factors explaining why Finland does not attract more FDI, except in some very specific sectors of unique competence (e.g. the software and health industries). Yet sophistication of skills, full integration in the European Union and ties with other countries, as well as an open collaborative culture and a good business environment, are strong factors to further attract FDI, including knowledge-based (or innovation-based) foreign activities such as new R&D centres by multinational enterprises.

To exceed the EU average in the stock of FDI as a share of GDP (41% in 2014) by 2020, from its current level of 34% (2014), in December 2012 the government adopted a decision-in-principle: "Team Finland – Strategy for Promoting Foreign Investment". This strategy seeks to improve the efficiency of existing FDI promotion efforts by bringing them under a single umbrella. By doing so, the government wishes to create a clear, flexible and customer-oriented model so that key actors at home and abroad work towards a coherent strategic goal.

Finland's Service Trade Restrictiveness Index scores are above the OECD average and that of Nordic countries in several areas. However, there is room for lowering barriers further in a number of industries such as transport, construction, distribution or insurance – industries where Finland shows a higher level of trade restrictions than the OECD average and for which it is far from the best performer in the OECD.

Industry regulations and product market competition

Effective regulations are essential to ensure the proper functioning of the market and address externalities. Regulations remain cumbersome in some areas, notably in retail trade, network industries, construction and land-use planning (OECD, 2016a). Streamlining regulations is one of the government's key objectives. The government also plans to promote competition in the construction industry and public services. Finland's product market regulation (PMR) is less restrictive overall than the OECD average (Figure 2.8). Only the Netherlands and the United Kingdom have significantly leaner regulations. The 2011 Competition Act brought regulation in line with the European Commission's recommendations. It reinforced merger control and enhanced damage compensation as well as "whistle-blowing" instruments. It also expanded the investigation powers of the Finnish Competition Authority, whose resources have been increased.

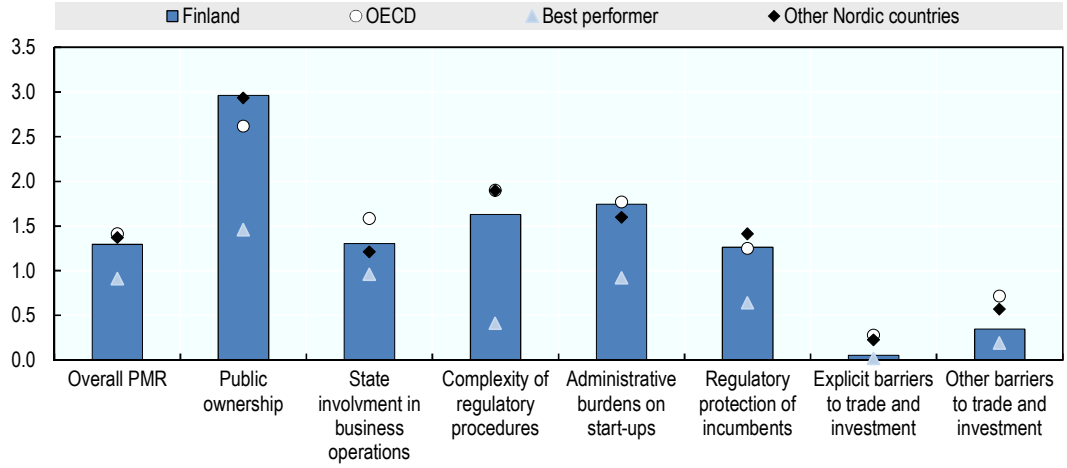
There is room for improvement regarding regulations in certain sectors. Regulations are fairly stringent both in absolute and relative terms in the gas, post, rail and retail sectors. In the gas sector, barriers to entry and vertical integration are high, there is no liberalised wholesale market, and consumers have no choice of supplier. Postal services are dominated by a government-owned group, which has a universal service obligation, but private firms are allowed to compete in some segments of the market. State ownership is also high in the railway sector, where there is competition for freight but not for passengers, although the government is considering opening the market up. Entry in the freight market remains challenging, given the dominant position of the incumbent in the organisation of the railway system (Mäkitalo, 2011).

Retail trade is an important area where stringent regulations are holding back competition and productivity. According to the 2013 OECD PMR indicators, Finnish retail trade regulations are more stringent than the OECD, EU and Nordic averages on most dimensions, with only price and discount restrictions being low. A comparison with the OECD's best performers confirms that there is room for lowering barriers further in a number of sectors, including transport and construction.

Labour market regulation

According to the World Economic Forum's Executive Opinion Survey 2015 (World Economic Forum, 2016), restrictive labour regulations, followed by taxation, are the most problematic factors for doing business in Finland. Both indicators remain highly restrictive by OECD standards. Labour regulations, in particular, limit flexibility in labour markets and weaken work incentives for individuals as well as incentives for employers to hire workers. Even though some improvements have been perceived in the labour market (up three places to 23rd), with an improvement in the efficient use of talent (up one spot to 6th), these are offset by the market's rigidity (102nd). Indeed, restrictive labour regulation is identified as the most important impediment (102nd) for doing business in Finland.

Figure 2.8. **Product market regulation could be streamlined, 2013**

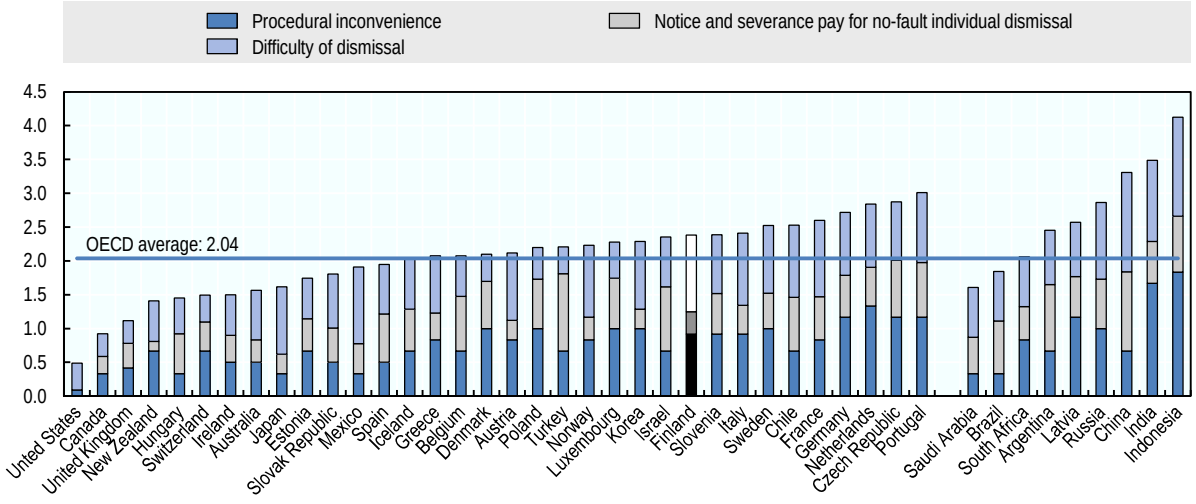


Notes: Index, scale of 0-6 from the least to the most restrictive. PMR: product market regulation.

Source: OECD (2016a), *OECD Economic Surveys: Finland 2016*, OECD Publishing, Paris, http://dx.doi.org/10.1787/eco_surveys-fin-2016-en.

In addition, Finland and the other Nordic countries have employment protection regulations that are stricter than the OECD average. This is the case of employment protection against individual dismissal (EPR). Finland scores the highest in terms of difficulty of dismissal (1.1) in the three labour regulation sub-components, together with France and Norway, followed by procedural inconvenience (0.9) (Figure 2.9). The OECD Economic Survey of Finland (OECD, 2016a) recommended reducing taxes on labour to improve work incentives, and raising recurrent taxes on personal immovable property and indirect taxes. Lowering the strictness of employment protection legislation may be particularly helpful for grass roots innovation, which requires experimentation. According to a recent study by Andrews, Criscuolo and Gal (2015), Finland could derive large gains from reforming its employment protection legislation. Improving these regulations up to the level of frontier best practice could enhance the size of national firms at the productivity frontier relative to global frontier benchmarks, thus improving aggregate productivity.

Figure 2.9. **Protection of permanent workers against individual dismissal**[1]



Notes: 1. Index, scale of 0-6 from the least to the most restrictive. Data refer to 2013 for OECD countries and Latvia, 2012 for other countries. The figure presents the contribution of different sub-components to the indicator for employment protection for regular workers against individual dismissal (EPR). The height of the bar represents the value of the EPR indicator.

Source: OECD (2013), OECD Employment Protection Database, www.oecd.org/els/emp/oecdindicatorsofemploymentprotection.htm (accessed 8 March 2016).

Entrepreneurship conditions

Start-ups are key drivers of growth due to their contribution to job creation and economic renewal through innovation and the competition pressures they impose on the established business sector. Among SMEs, young firms play a central role in creating jobs and enhancing growth and innovation. On average across all countries and years, young firms account for 17% of employment but create 42% of jobs (Criscuolo, Gal and Menon, 2014; Calvino, Criscuolo and Menon, 2015).[10]

Several recent studies indicate that entrepreneurship rates are still weak in Finland, but they have recently been showing an upward trend. According to the Global Entrepreneurship Monitor (2015), in Finland the perception of opportunities to start a

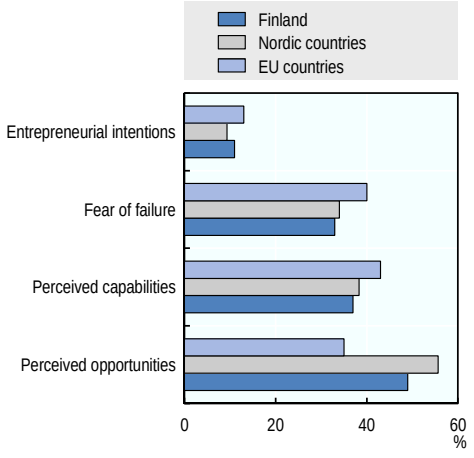
business within the next three years are still lower than the average in Nordic countries, but higher than the European average. Capabilities for entrepreneurship are perceived as similar as in the other Nordic countries, but somewhat lower than what is perceived on average in EU countries. Eleven percent of the Finnish adult population has entrepreneurial intentions and this ratio is similar across Nordic countries and slightly lower than the mean in EU member states (Figure 2.10).

The current government has emphasised the importance of improving entrepreneurship education in higher education institutions and university-business co-operation in matters of innovation. The Ministry of Education and Culture (2016) published a review on the state of promotion of entrepreneurship and entrepreneurial attitudes in Finnish higher education institutions. Among the main recommendations were: the pursuit of an entrepreneurial approach to supporting pedagogical solutions – which were found to currently be underdeveloped or underutilised – and the need for a framework for monitoring and evaluation of entrepreneurship activities. The recommendations also highlighted the need for improving entrepreneurial skills at the level of doctoral students.

According to the last Global Entrepreneurship Monitor (2015), early-stage entrepreneurial activity is higher than nascent entrepreneurship (Figure 2.11), which means that, the rates of growth of existing start-up are superior to overall new firm creation. This trend may be in line with the growing support capacity of the Finnish start-up ecosystem. These rates are, however, still lower than the EU average. The ratio of people involved in early-stage entrepreneurial activity in Finland is 6% whereas the EU average reaches 8%. About 10% of interviewees (among the population aged 18-64) declared having an established business ownership whereas the average in the region was 8% and in Europe 6% (Global Entrepreneurship Monitor, 2015). According to the Global Entrepreneurship Monitor, Finland challenges to fully exploit this asset either in existing organisations or early-stage entrepreneurial activities.

Figure 2.10. **Entrepreneurial attitudes and perceptions in EU member states, 2015**

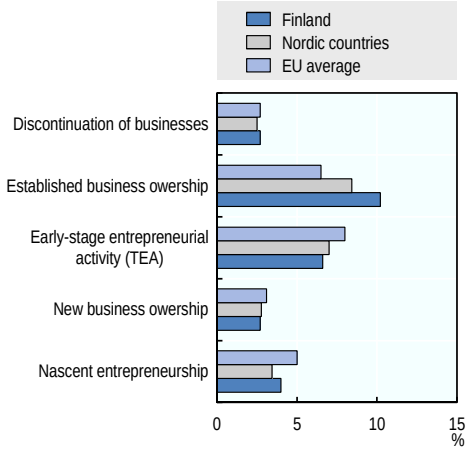
As a percentage of the population aged 18-64



Source: Global Entrepreneurship Monitor (2015), "Country profile: Finland", www.gemconsortium.org/country-profiles (accessed 20 February 2017).

Figure 2.11. **Entrepreneurial activity at different stages in EU member states, 2015**

As a percentage of the population aged 18-64



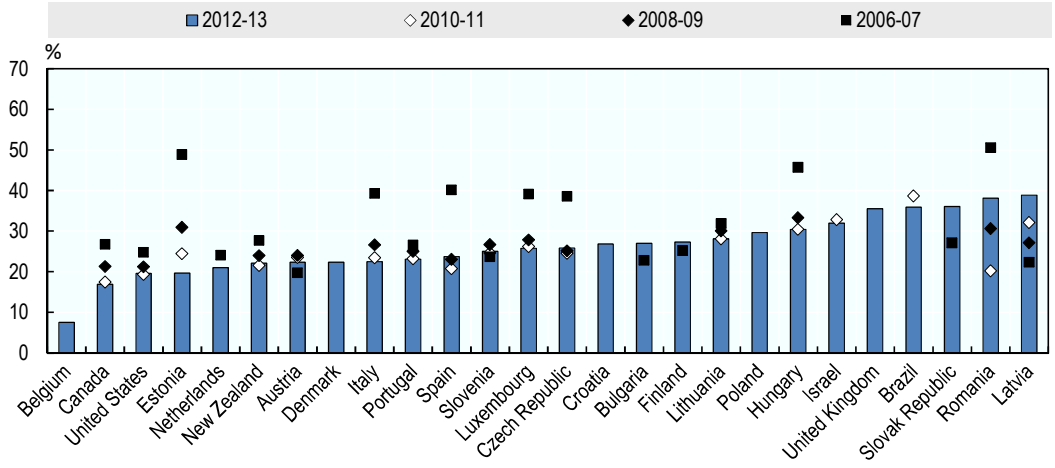
Source: Global Entrepreneurship Monitor (2015), "Country profile: Finland", www.gemconsortium.org/country-profiles (accessed 20 February 2017).

In Finland start-ups with employees[11] (up to two-year-old companies) represent 27% of active employer enterprises (Figure 2.12), which places Finland just above the median of OECD countries for which these data are available (OECD, 2016d). However, Finland's (together with Sweden's) non-employer start-up rate is one of the lowest among the OECD countries reporting on these indicators. In most OECD countries, the employer start-up birth rate decreased whereas in Finland it increased. This is consistent with recent start-up developments in Finland that suggest that entrepreneurship activity and firm creation are currently growing in Finland.[12] As discussed in several OECD reports, most countries have registered a consistent decline in start-up rates in recent years.

According to Entrepreneurship at a Glance (OECD, 2016d), business birth rates in Finland are higher in the construction and services sectors than in industry, a trend similar to the OECD average (Figure 2.12). This reflects lower fixed capital entry costs in those industries. However, the birth rate of the services sector is below that of Denmark and Sweden. In the case of manufacturing, Finland displays a higher birth rate than the other reporting Nordic countries (Denmark, Norway and Sweden). Another study of the OECD Dynemp Project[13] uses a different definition of the start-up rate (and a different period of analysis) and provides a more negative portrait in terms of start-up and birth rates (Criscuolo, Gal and Menon, 2014).[14]

Figure 2.12. **Start-up rates, employer enterprises, total business economy**

Percentage of 0-2 year old employer enterprises over total number of employer enterprises



Source: OECD (2016d), *OECD Entrepreneurship at a Glance*, OECD Publishing, Paris, http://dx.doi.org/10.1787/entrepreneur_aag-2016-en.

Accordingly, the start-up rate of Finland for the year 2010-11 (and for previous years) was among the lowest in the group of OECD countries for which data are available. And these start-up rates were already the weakest both before and during the economic downturn: reaching 8% in the period 2010-11 and 8.7% in the period 2001-03. The share of young companies among small businesses is also among the lowest in developed countries. Furthermore, young SMEs account for a smaller share in gross job creation in Finland than in any other OECD country for which data are available (Criscuolo, Gal and Menon, 2014).

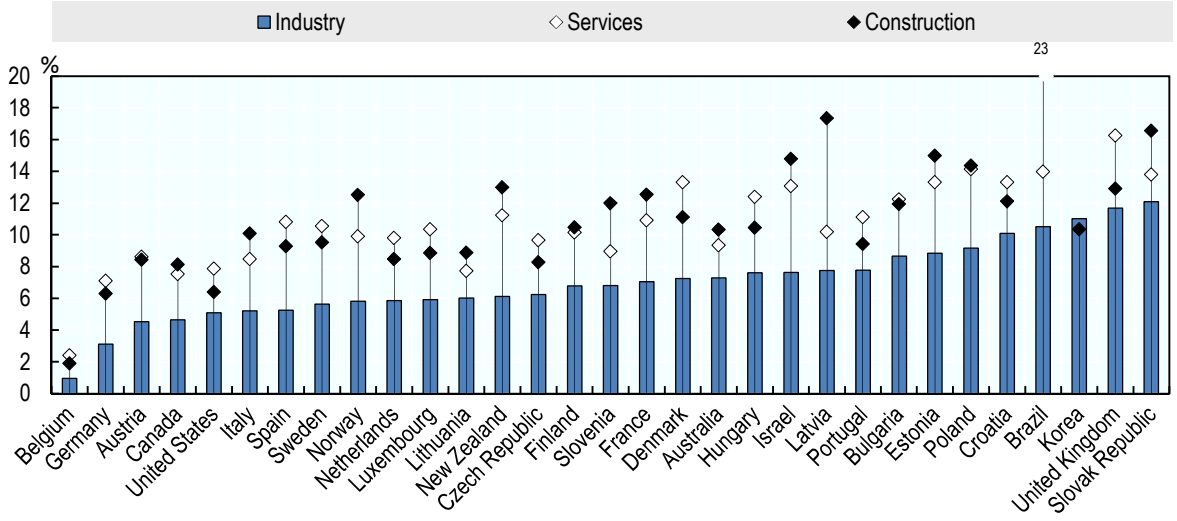
In Finland, the one-year survival rate of employer enterprises is the lowest among those Nordic countries reporting data (Denmark, Norway and Sweden) and in all economic activities (Figure 2.13). In the five-year survival statistics, Finland performs

better and remains among the OECD average (like Norway), but this rate is lower than in Denmark and Sweden (Figure 2.14). Sweden stands out, with the highest survival rate among OECD countries in both indicators (one- and five-year survival rates). In most of the countries, more than half of newly created enterprises fail within the first five years. On average, around 40% of start-ups exit within the first three years of activity.

The recent OECD publication Entrepreneurship at a Glance (2016d) shows that Finland and most OECD countries exhibit a gender gap with regards to access to entrepreneurship finance. However, the percentage of access to money to set up a business in Finland is the lowest among Nordic countries and the gender gap in Finland is higher than the OECD average. A similar gender gap exists with regards to access to training, although the perception for Finland is stronger than in OECD countries; the share is above 80% for men and women, while in Italy and Mexico the share is below 20%.

Figure 2.13. **Employer enterprise births, by sector**

Percentage, 2013 or latest available year



Source: OECD (2016d), *OECD Entrepreneurship at a Glance*, OECD Publishing, Paris, http://dx.doi.org/10.1787/entrepreneur_aag-2016-en.

ICT, transport and logistic infrastructure

Finland is one of the best prepared countries in the world to make good use of affordable ICT infrastructure and digital content. In terms of the Network Readiness Index (NRI[15]) Finland ranks second worldwide, just after Singapore. Broadband markets continue to grow, with an increase in wireless broadband subscriptions offsetting a decrease in fixed telephony. With comparatively low ICT investment per GDP compared to other Nordic countries and the OECD average (OECD, 2015), Finland has managed to establish well-developed Internet infrastructures with exceptionally high wireless broadband subscription rates – among the highest in the OECD. Finland's investment in public telecommunications reached USD 753 million in 2013, and EUR 138.5 per capita, which is below the OECD average.

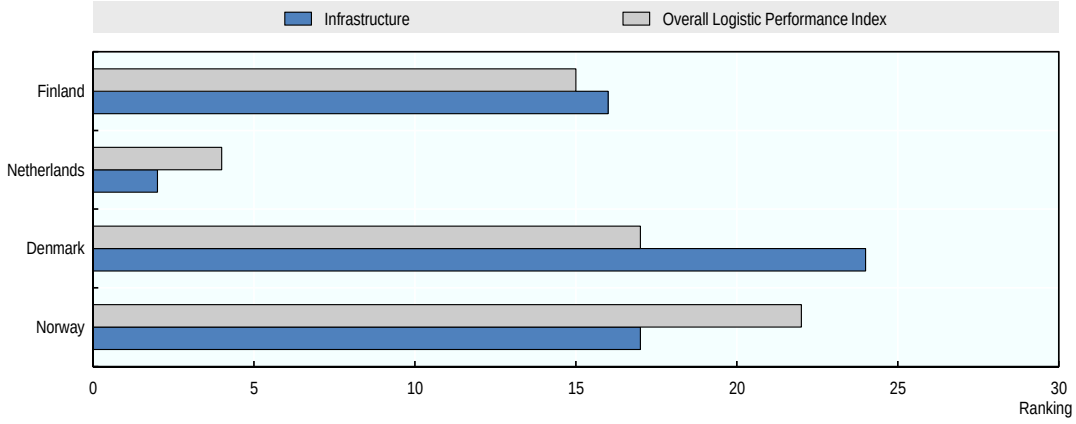
The share of ICT goods and services in Finland's total value added decreased (4.9 percentage points) between 2007 and 2013, whereas the OECD average remained stable. There is a huge potential for increased adoption and use of ICT and the Internet to

boost growth through innovation in goods, services and business organisation, across all sectors. In Finland, while firms' perception about their overall innovation capacity has increased, a stagnating rate of ICT adoption and usage by firms prevails across all regions (World Economic Forum, 2016), and is weaker in government usage.

Infrastructure investment is a key determinant of performance in the transport sector, improving market accessibility and productivity. According to the World Bank Logistic Performance Index,[16] Finland has improved its overall position, from 24th in 2014 to 15th in 2016, ranking better than Denmark and Norway (Figure 2.14). In terms of the infrastructure sub-index, Finland ranks 16th and remains in 2nd place among Nordic countries. Finland has room to improve its performance on international shipment, being the worst rating sub-index among Nordic countries.

Overall, Finland's physical infrastructure is highly competitive and developed. According to the World Economic Forum's Global Competitiveness Report 2015-2016, the quality of Finland's rail, port and air infrastructure is rated among the best in the entire European Union. Ratings for Finnish roads have slightly decreased over the past two years. Finland has improved the timeliness of shipments to a level rated above the EU average. It has completed its TEN-T Core Network for high-speed rail and inland waterways (bearing in mind that Finnish high-speed rail covers a very small section of the rail network). Completion rates for the road network and for conventional rail stand at 72% and 44%, respectively.

Figure 2.14. **Logistic Performance Index, 2016**



Source: World Bank (2016), World Bank Logistic Performance Index (LPI) 2016, http://lpi.worldbank.org/about.

Notes

1. Further information is provided in OECD (2016a; 2016b; 2016c) and IMF (2016a; 2016b). See also European Commission (2016).

2. Structural reforms Finland needs to pursue according to recent OECD assessments (e.g. OECD [2016a]) include: pension and health reform, the fiscal framework (e.g. the adoption of medium-term fiscal targets for the government balance together with debt targets and improvements in local government finance), local public finances and municipality reform, labour market reform, green growth, and tax reform (e.g. lower taxation of labour and increased taxes on recurrent personal immovable property and indirect taxes).

3. Finland's real GDP grew by 0.2% in 2015 and in the first half of 2016 its economy grew by 0.8%, compared with the same period one year before.

4. The deficit has shrunk since then, with weak domestic consumption and exports leading to a fall in imports and lower energy prices improving terms of trade.

5. Preliminary national accounts data show that the growth rate of labour productivity in the national economy was 0.4% in 2014. In 2013, labour productivity remained level and in 2012 it had contracted by 2.1%. The respective growth rate of total factor productivity in the national economy was -0.1% in 2014, -0.7% in 2013 and -2.5% in 2012 (Statistics Finland, 2016).

6. Increases in labour input and non-ICT capital deepening also made sizeable contributions to GDP growth in the decade preceding the global financial and economic crisis.

7. This largely reflects the difficulties of Nokia, which ended up exiting the mobile phone business after missing the "smartphone revolution". Other manufacturing sectors, including wood and paper production, contributed to overall productivity growth during the upswing, but stalled after 2007.

8. The slowdown in other sectors is more in line with global productivity developments and hence can be, at least partly, related to the weakness of the global economy and the associated slowdown in the diffusion of innovations.

9. Finland only has three sectors where the RCA exceeds 2 (highly specialised), these are: paper, wood/wood products, and computer and information industries.

10. Across all economies analysed, only a small fraction of start-ups actually contribute substantially to job creation.

11. Start-ups, as defined in *Entrepreneurship at a Glance* (OECD, 2016d) include all enterprises that are up to two years old. The start-up rate is the number of employer (non-employer) start-ups as a percentage of the number of active employer (non-employer) enterprises.

12. Yet, even though the share of employer start-ups increased, the share of non-employer start-ups decreased between 2006 and 2013 due to the decline in birth rates.

13. www.oecd.org/sti/dynemp.htm.

14. The data available for this study (and indicators) are, however, different; the period covered refers to 2000-11 with the latest indicators available for 2010-11. Entry rates are calculated as the number of entrants with positive employment over the total number of units with positive employment).

15. It measures how well economies use information and communications technologies to boost their competitiveness and well-being. The index assesses a total of 139 countries across 10 main pillars including environment and usage, along with social and economic impacts.

16. The Logistic Performance Index measures performance along the logistics supply chain within a country. It consists of both qualitative and quantitative measures including measures of: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness.

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Chapter 3

Innovation capabilities and performance in Finland

This chapter reviews the state of innovation capabilities, linkages across innovation actors and performance outcomes of the Finnish innovation system. It compares Finland's innovation capacities to other OECD countries and highlights areas for improvement and better use of capabilities.

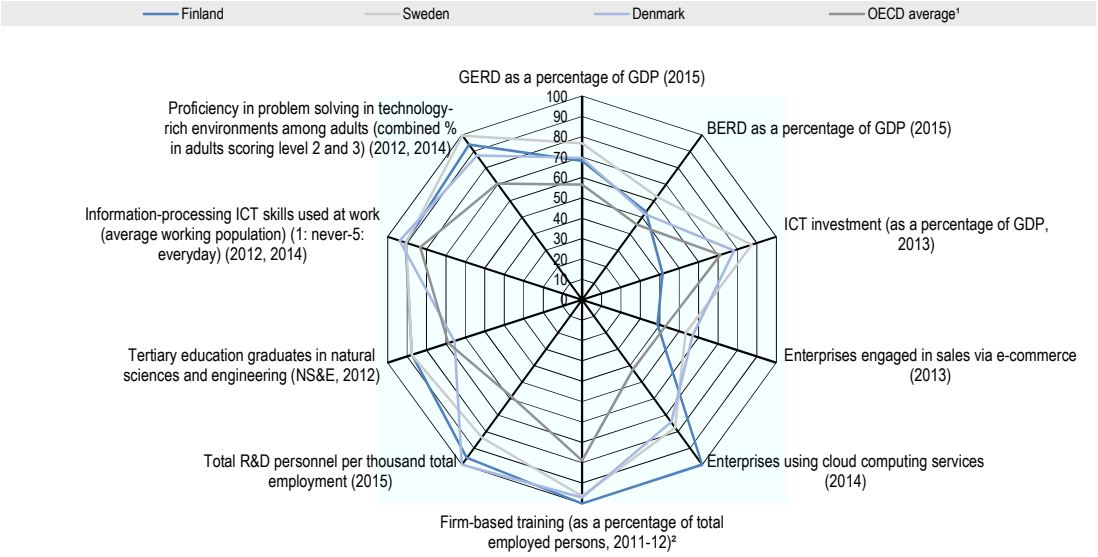
Innovation capabilities

In recent history, Finland has consistently ranked at the forefront of investment in research and development (R&D), innovation and in a wide range of innovation capabilities (e.g. human resources in science, technology and innovation [STI], quality of education and educational attainment, R&D, etc.), and innovation policy was held to be a core area of public policy until recently.

Finland still ranked relatively high in 2015 among OECD countries with regard to R&D intensity (gross domestic expenditure on R&D, GERD) – which stood at 2.9% – but had lost its former position in top ranks, following a steep decline of 0.9 percentage points from 2009, which, as recent estimates indicate, may not be over yet. More generally, the combination of the effects of recent restructuring processes in the Finnish economy and according policy responses led to cuts in R&D expenditure of both business and public actors in the innovation system. As these cuts are not fully reflected in the available data, snapshots at a certain point in time should be interpreted with caution.

Figure 3.1. **Innovation capabilities, normalised scores**

100=top performer in the OECD



1. In the calculation (OECD average *vis-à-vis* top performer), the OECD average is a simple average of 26 member countries.

2. In the calculation (OECD average *vis-à-vis* top performer), the OECD average is a simple average of 22 member countries.

Notes: BERD refers to business expenditure on research and development. GERD refers to gross domestic expenditure on research and development. The average corresponds to the EU28 average. Individual sources used in the computation of indicators were: ICT investment, by asset (2013): OECD, based on OECD (2016e), *Annual National Accounts (SNA) Database*; Eurostat (2015), *EU-KLEMS Database* and national sources, July 2015. Enterprises engaged in sales via e-commerce (2013): OECD (2015a); enterprises using cloud computing services (2014): OECD (2015); firm-based training (as a percentage of total employed persons, 2011-12): OECD (2015a); total R&D personnel per thousand total employment (2015b): *OECD Main Science and Technology Indicators Database*, March 2017; tertiary education graduates in natural sciences and engineering (NS&E, 2012): *OECD Education Database*, July 2015; information-processing skills used at work ICT: OECD (2016c).

Sources: OECD (2015c), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en; European Commission (2016), *European Innovation Scoreboard 2016*, http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en.

According to the data presented in Figure 3.1, Finland holds a strong position among OECD countries as regards the number of researchers in the labour force, university graduates in natural sciences and engineering, general skills in the population (e.g. problem-solving and e-skills in a technology intensive context), and ranges among the highest countries for a number of innovation investment indicators in firms, such as the provision of firm-based training (as a percentage of total employed persons) or the use of cloud technologies, among other assets (OECD, 2016c). These are important capabilities and assets which have to be maintained and utilised. Finland's innovation system continues to have important strengths but shows some difficulties in transforming these capabilities into innovation outputs and economic performance. Some weaknesses have persisted, even during the pre-crisis period, and these should be addressed now as part of the effort to strengthen a reconfigured innovation system. There are also a number of innovation capabilities in which Finland underperforms compared to its peers (such as Denmark and Sweden), and in which it lags behind the OECD average. Finland could do better in terms of ICT investment (relative to gross domestic product [GDP]) and stabilise and increase – together with the necessary complementary assets – GERD and business expenditure on R&D (BERD), which in the wake of the recent financial crisis have both declined significantly – and are now closer to the OECD average, falling behind global leaders.

In particular, Finland could benefit from innovation capabilities in the domain of non-technological assets and intangibles investments at firms, such as organisational capital, branding and marketing assets, and intellectual property capital. International co-invention is, in fact, the only indicator in which Nordic countries dip below the OECD median, which constitutes one of Finland's (and Sweden's) clearest weaknesses. The following sections will discuss these figures and innovation performance outputs in more detail, comparing Finland's innovation capacities to other OECD countries. Areas for improvement and better use of capabilities will be highlighted.

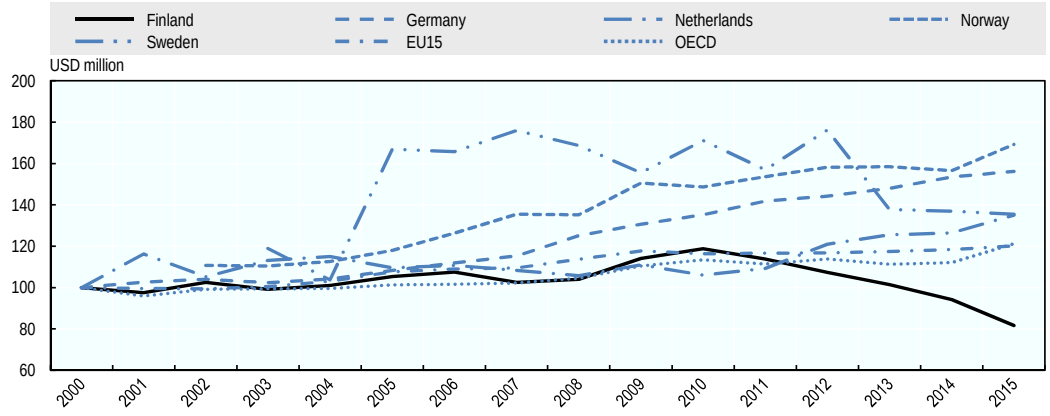
Investment in R&D: Evolution and recent trends

With the onset of the global crisis, government funding of R&D expanded over the years 2008-10, followed by a steady contraction since 2011 (Figure 3.2) as economic difficulties continued. This pattern has differed from other OECD countries, which have responded to the global economic crisis more consistently by adopting counter-cyclical policies (e.g. Denmark, Germany) and reinforcing government funding of R&D. More recently, the Netherlands and Norway have also moved from a contractionary to an expansionary R&D policy. Total R&D investment in Finland decreased by 17% between 2011 and 2016 whereas government R&D funding was reduced by 11% between 2012 and 2016 (Statistics Finland, 2017). In 2016, total GERD is expected to amount EUR 5 970 million compared to EUR 7 164 million in 2012 (Statistics Finland, 2017).

The level of R&D intensity (GERD as a percentage of GDP) was still relatively high in 2015 at 2.9% (of GDP), albeit in rapid decline, from 3.75% in 2009. There are indications that this decline is still continuing. According to preliminary estimates by Statistics Finland, R&D intensity reached 2.81% of GDP in 2016. The most recent estimate of BERD for 2017 by the Confederation of Finnish Industries indicates that BERD will continue to decrease by -3.6%. Since public funding further declines by almost 3% in 2017, this means that both the volume of GERD and R&D intensity might contract further.[1]

Figure 3.2. **Government-funded R&D**

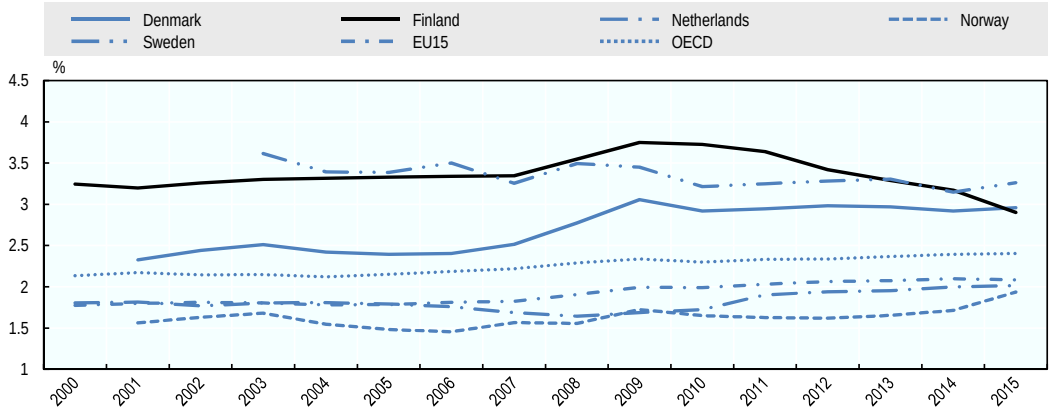
Index=2000, constant PPPs



Source: OECD (2016d), "Main science and technology indicators", *OECD Science, Technology and R&D Statistics* (database), http://dx.doi.org/10.1787/data-00182-en (accessed 8 February 2017).

Figure 3.3. **Gross domestic expenditure on R&D**

As a percentage of GDP

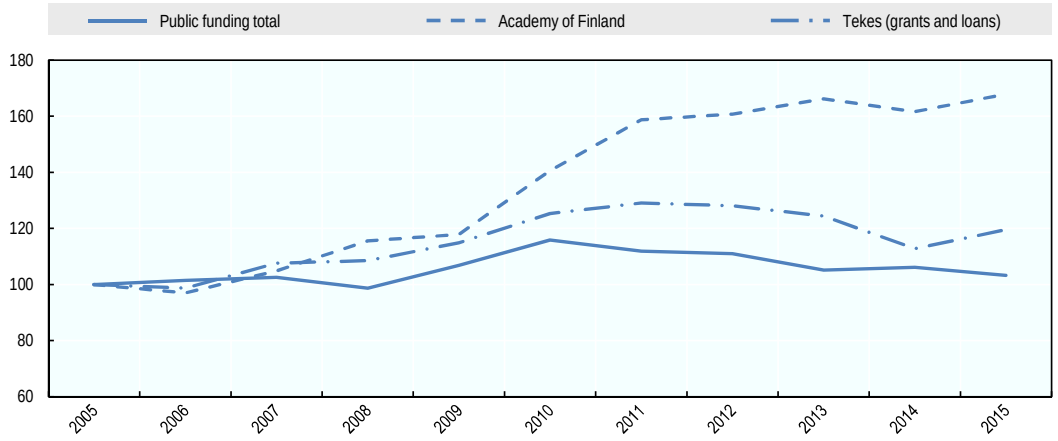


Source: OECD (2016d), "Main science and technology indicators", *OECD Science, Technology and R&D Statistics* (database), http://dx.doi.org/10.1787/data-00182-en (accessed 8 February 2017).

Within government funding of R&D, public support to business sector R&D (largely via Tekes, the Finnish Innovation Agency) has been the most affected by budget cuts, whereas funding of R&D for universities (through the Academy of Finland) continuously increased during most of the period 2007-15 (Figure 3.4). Reductions of Tekes' budget started in 2011, already in the beginning of a four year recession. Between 2006 and 2012 public funding of R&D for universities grew 35%, but after that it stagnated. In recent years, however, funding of R&D for universities has slightly expanded via funding channelled through the Academy of Finland.

Figure 3.4. **Evolution of government-funded R&D in Finland in 2005-2015 (constant USD PPP)**

2007=100



Source: Statistics Finland (2017), "Government R&D funding in the state budget" http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ttt__tkker/?tablelist=true&rxid=5ee89031-ca56-4bc4-b2ed-2b0b20aaafad (accessed 3 March 2017).

As in other advanced innovation systems, the business sector (still) has a dominant but relatively weaker position in R&D funding due to the downsizing, mostly related to Nokia's restructuring. In 2015, the business sector accounted for 55% of R&D funding, against 29% for government institutions (Table 3.1). This figure dramatically differs from 2004 when companies' share in R&D funding reached 69%. In terms of performing actors, companies conduct 67% of R&D whereas higher education institutions conduct 24% and governmental institutions 8%. As a response to the 2010 university reform, competitive funding was increased to strengthen universities' diversity and specific research profiles.

Public support for R&D performed in the business sector is clearly lower than in the majority of OECD countries. In 2015, the percentage of BERD financed by government in Finland was less than 3%, below half of the OECD average of 6.6%. The share of public support to business sector R&D has been relatively stable in Finland over recent years, while in Sweden this proportion has been increasing.

Higher education R&D (HERD) has been financed almost totally by government, including the funding channelled through the Academy of Finland and Tekes. However, the small business share in funding HERD has declined significantly, to 3.4% in 2015. The percentage of HERD financed by government was 93% in 2008 and 96% in 2015. These shares are close to the EU15 and OECD averages.

The role of the business sector in financing government expenditure on intramural R&D (GOVERD) has been higher in Finland than in the EU15 and OECD, on average. One reason for this is that many firms carry out product and/or process development in co-operation with VTT, the Technical Research Centre of Finland (VTT ltd). In most recent years the share of R&D funding from the business sector has nevertheless decreased and accounted for about 8% of GOVERD in 2015. This is at the same level as the EU15 average but still exceeds the OECD average.

Table 3.1. **GERD by source of funding and actor**

	Finland 2004	Finland 2015	OECD 2015
% of GERD financed by:			
Business sector	69.25	54.76	61.29
Government	26.33	28.89	27.37
Other national sources	1.21	1.83	5.24
Abroad	3.21	14.52	6.06
% of GERD performed by:			
Business sector	70.12	66.67	68.81
Higher education	19.79	24.39	17.74
Government	9.5	8.17	11.06
Private non-profit sector	0.62	0.77	2.4

Source: OECD (2016d), "Main science and technology indicators", *OECD Science, Technology and R&D Statistics* (database), http://dx.doi.org/10.1787/data-00182-en (accessed 1February 2016).

Table 3.2. **Funding sources of R&D at each performing sector, 2015**

	Performing sector		
Source of funding	**Business enterprise sector**	**Public sector and private non-profit**	**Higher education sector**
R&D expenditure (million EUR)	4 047.3	543.1	1 480.5
Total:	100%	100%	100%
Domestic enterprises	76.99%	8.30%	3.72%
Public funding	6.32%	71.39%	81.06%
Academy of Finland	..	4.81%	18.62%
Tekes (grants and loans)	5.73%	9.69%	8.02%
General university funds	..	..	47.64%
Higher education funds	..	..	1.20%
Other public funding	0.25%	7.20%	2.47%
Private non-profit-sector	0.02%	5.73%	4.11%
Foreign funding total	16.67%	14.60%	8.63%
EU funding	0.54%	8.62%	5.92%

Note: .. = data not available.

Source: Statistics Finland (2017), "Research and development", www.stat.fi/til/tkke/index_en.html (accessed 1 February 2016).

Investment in intangibles and non-R&D assets

In many countries, the importance of intangible capital in driving growth is greater than tangible capital. Investment in intangibles such as organisational capital, software and ICT, marketing and branding, or intellectual property assets are proven sources of growth, in addition to science and technology investment (including R&D).[2] In OECD countries, the share of intangible investments is 5-10% of GDP, accounting for a considerable share of total investments.[3]

According to some estimates (e.g. Corrado et al., 2016), Finland's investment in intangibles is high, reaching 11% of value added among the sample of countries for whom data are available. This level of investment is larger than in Germany or the United States, and close to that of France, the Netherlands and Denmark. In certain types of intangible assets, however, there are some differences vis-à-vis OECD trends and other Nordic countries (e.g. Denmark and Sweden). In particular, ICT investment (relative to GDP or value added) is an area where Finland clearly ranks behind other countries, and

well behind Sweden. For instance, computer software investment represented about 1.1% of GDP in 2013, whereas both Sweden and Denmark invested twice this amount with 2.25% and 2.2%, respectively.

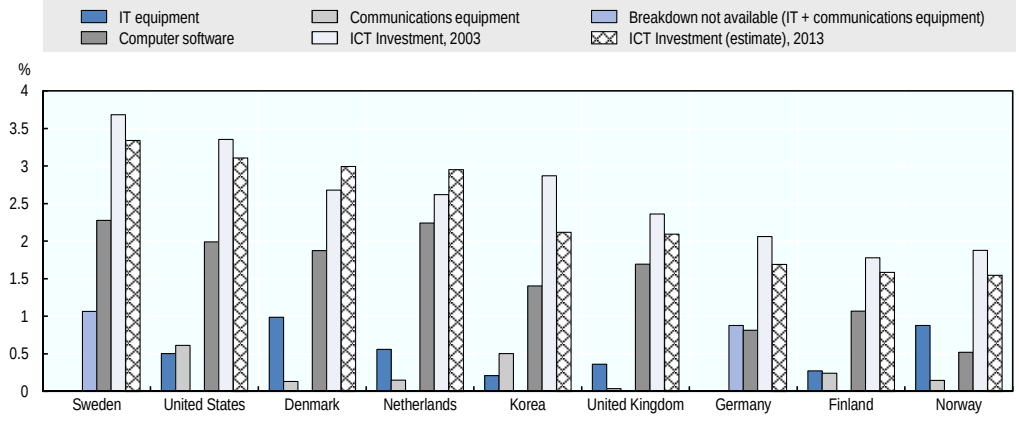
Furthermore, the diffusion (and use) of ICT and digital technologies could also be improved. Although Finnish companies rank around the average in terms of propensity to use (certain selected) ICT tools, there are several ICT areas where they rank far below the best performing country; these are: use of e-purchases, e-sales, supply chain management (ADE) and social networks (OECD, 2014a). This situation is at odds with the well-developed ICT networks and high penetration of wireless mobile communication, which ranges amongst the best in the OECD.

At the firm level, Finnish firms invest less in non-R&D activities (e.g. innovation expenditure on capital machinery, software and hardware, training, licensing of technology and intellectual property rights, etc.) than some of their European peers. According to data from national innovation surveys (Eurostat), the ratio of such expenditures to sales is lower than reported by firms in Germany or Sweden. The ratio to turnover actually decreased in Finland between 2008 and 2012, from 0.57% to 0.37% whereas Sweden saw this figure rise from 0.66% to 0.79% over the same period of time, reaching a ratio that is about twice the Finnish figure. The EU average in 2012 was 0.69% of turnover invested in non-R&D activities. In contrast, Finland scores relatively high in terms of firm-specific training, with 77% of employed persons receiving training (OECD, 2015), a figure similar to that in Sweden and Denmark (74% and 75%, respectively). Of this, as in most European countries, the largest proportion corresponds to formal and on-the-job training.

Human resources for science, technology and innovation

Human resources are the foundation of knowledge-based economies and thus a key issue for innovation policy. There are many ways individuals can build and accumulate human capital, such as education and training, workplace experience and international migration. The way countries leverage their human resources for research and innovation can often be improved through higher education and vocational education and training policy, innovation policy as well as through regional, labour market and immigration policies.

Figure 3.5. **ICT investment by asset, 2013**
As a percentage of GDP

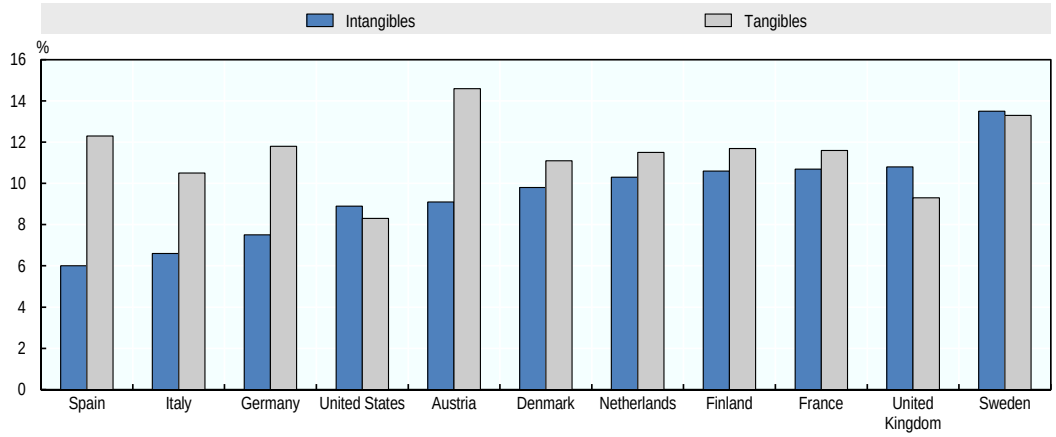


Note: Data for Sweden and Norway is for 2012.

Source: OECD (2015c), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

Figure 3.6. **Investment in Intangibles, 2013**

Adjusted by value-added shares



Source: Corrado, C. et al. (2016), "Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth", www.eib.org/attachments/efs/economics_working_paper_2016_08_en.pdf.

General skills and education

Finland has one of the highest levels of educational attainment in the OECD, with 84% of 25-64 year-olds having at least completed upper secondary education and 39% holding a tertiary degree, against OECD averages of 75% and 32%, respectively. In 2014, HERD amounted to 0.73% of GDP, which is relatively high in international comparison but lower than in Denmark (1.01%) and Sweden (0.92%). Finland's success in compulsory school is partly because teachers are valued by society and enjoy good working conditions, relatively good salaries, smaller classes and fewer teaching hours than the OECD average (OECD, 2014b; 2014a).

In 2015, 43% of the Finnish population aged 25-64 had some form of tertiary education, putting it at the top among EU member states (along with Ireland, Norway and the United Kingdom) (OECD, 2016a). This is the result of continuous efforts to improve higher education standards since the 1990s. Ever since, Finland strengthened investments in education significantly and surpassed the OECD average in terms of the intensity of this expenditure relative to GDP. By 1995, expenditure on higher education reached 0.44% of GDP whereas the corresponding OECD average was 0.34%. This trend continued until the first half of the 2000s.

Finland ranks among the best in the OECD Survey of Adult Skills (PIAAC) for literacy, numeracy and problem solving in technology-rich environments.[4] Average proficiency in both literacy and numeracy are second highest in the OECD behind Japan, and Finland is second only to Sweden for the proficiency in problem solving in technology-rich environments among adults (OECD, 2013). However, around 600 000 adults between the age of 16 and 65 still have low foundation skills (literacy or numeracy below level 2 in the survey).

In terms of quality of education, the OECD Programme for International Student Assessment (PISA) scores suggest that the quality of the Finnish secondary school system is still strong, although the scores have deteriorated since 2006. In the latest PISA survey Finland ranked sixth among OECD countries in mathematics, fifth in problem solving,

third in reading and second in science (OECD, 2016b). PISA results are also falling in other Nordic countries. At higher levels, education is good, but important hurdles remain, such as the limited flexibility in terms of moving across education programmes and universities, and long graduation time (see Chapter 4 on higher education institutions).

Human capital in S&T and researchers

The supply of graduates in the natural sciences and engineering (NS&E) may relate to opportunities in labour markets and their ability to absorb highly specific skills, both at home and abroad. Nearly 30% of tertiary education graduates in Finland have a degree in natural sciences and engineering. This share is among the highest in the OECD and is well comparable to the shares in Germany and Sweden and almost twice as high as in the United States (OECD, 2015c). Finland has thus a relatively abundant highly educated labour force for R&D activities. The percentage of tertiary female graduates in these domains is, however, lower than the OECD average (28% versus 34%) and much lower than in Denmark (36%) or Sweden (34%) (OECD, 2015c).

The share of researchers in total employment in Finland has also been among the highest of the world. In 2014 this proportion was 1.5%, about twice as high as the OECD average (OECD, 2015c). On the other hand, doctoral degree holders represent less than 20% of research personnel. Their share increased substantially in the late 1990s and early 2000s. This was at least partly due to high demand of R&D labour in the ICT sector. The share peaked at 1.8% in 2003 and has since been gradually declining.

Today 34% of doctorate holders are employed in education (Denmark, Norway and Sweden report similar figures) and about 30% work in professional services. Only 5.9% are employed in manufacturing, agriculture, mining and other industrial activities. Denmark, Germany and Sweden report higher shares for the industrial sector (14.5%, 13% and 7.2%, respectively), according to data for 2012 (OECD, 2015c).[5]

In total, the business sector employed over half of the researchers (56%) in 2014. This exceeds the EU15 average but is lower than in Sweden and the Netherlands. One-third of the researchers have been employed by higher education institutions (HEI) and about 10% by government.[6] During 2008-14 the share of researchers employed by business firms in Finland decreased and the share of researchers employed by HEIs increased.

E-skills

Finland has strong foundations for ICT and digital skills deriving from its accumulated expertise in the ICT sector and a high number of ICT professionals in the labour force. According to Table 3.3, about 6% of the total workforce in Finland are ICT practitioners – far above the 3% average in the EU27 countries. Forecasts predict 148 000 jobs in this field for 2020. Likewise, Finland displays a strong level of computer skills, which has actually increased in recent years (Table 3.4). It is estimated that 43% of individuals have high computer expertise whereas the average in EU member states is 28.5%. Forecasts predict 148 000 jobs in the ICT field for 2020.According to the Digital Economy and Society Index 2017 (European Commission, 2017), Finland ranks second in European countries and while it scores very well in four out of five dimensions (connectivity, human capital, use of Internet, integration of digital technology and digital public services), its main relative competitive strength is in the area of digital skills, where it is well ahead of all other member states. In particular, Finland has a very high share of ICT specialists, while also scoring well in basic skills and STEM (science, technology, engineering and math) graduation rates. It is also very strong in digital public services.

The information society is an important milestone for Finland as stated in the Digital Agenda 2011-20, which highlights the importance of digital skills and ICT education for the future of Finland. In 2013 the ICT Task Force prepared a strategy to mitigate the effects of sudden structural change, reform of the Finnish ICT sector, as well as to stimulate new growth. It defined a ten-year road map and measures were taken immediately. The Prime Minister's Office established a Monitoring Group to watch and speed up the implementation of the measures.

Table 3.3. **ICT skills and job prospects, Finland**

	Finland	EU27
ICT practitioner workforce as a percentage of total workforce, 2012	5.5%	3.4%
Forecast ICT practitioner jobs 2015	137 000	7 503 000
Forecast ICT practitioner jobs 2020	148 000	7 950 000
Vocational training graduates in computer science, 2011	1 499	67 000

Source: European Commission (2014), "E-skills for jobs in Europe: Measuring progress and moving ahead", Country reports, http://eskills-monitor2013.eu/results.html.

Table 3.4. **E-skills, Finland**

	2009/10	2011/12	EU27
Individuals with a high level of computer skills	33%	43%	28.5%
Individuals with a high level of Internet skills	11%	19%	13.7%
Individuals using the Internet (last three months)	82%	89%	71.3%

Source: European Commission (2014), "E-skills for jobs in Europe: Measuring progress and moving ahead", Country reports, http://eskills-monitor2013.eu/results.html.

Networks, internationalisation and finance

As regards networks and linkages across the innovation system, the picture is mixed; with both strengths and weaknesses. Finland does, however, appear less performing than Sweden (Figure 3.7) in several dimensions. In terms of overall co-operation in innovation and small and medium-sized enterprises (SMEs) collaborating on innovation with HEIs or research institutions, Finland ranks high among both OECD and EU member states. In terms of industry co-operation in R&D, as reflected in the percentage of HERD financed by the business sector, Finland ranks below the OECD average (distance to frontier) and in 2013 scored similar to Sweden and better than Denmark. In 2013, this ratio was 5.0% whereas Sweden reached 3.7% and Denmark 2.7%.

Yet these figures are far lower than those reported by Germany and Israel (14%) as well as Switzerland (11%), where industry funding of university R&D is twice or three times larger – reflecting a stronger connection between the two sectors. It must be mentioned that the most recent figures show a deterioration of this ratio. In 2015, industry funding of HERD in Finland was 3.72% (see Table 3.2), due notably to difficulties in R&D funding and ongoing restructuring of the business sector – which places Finland further behind in industry-science collaboration rankings.

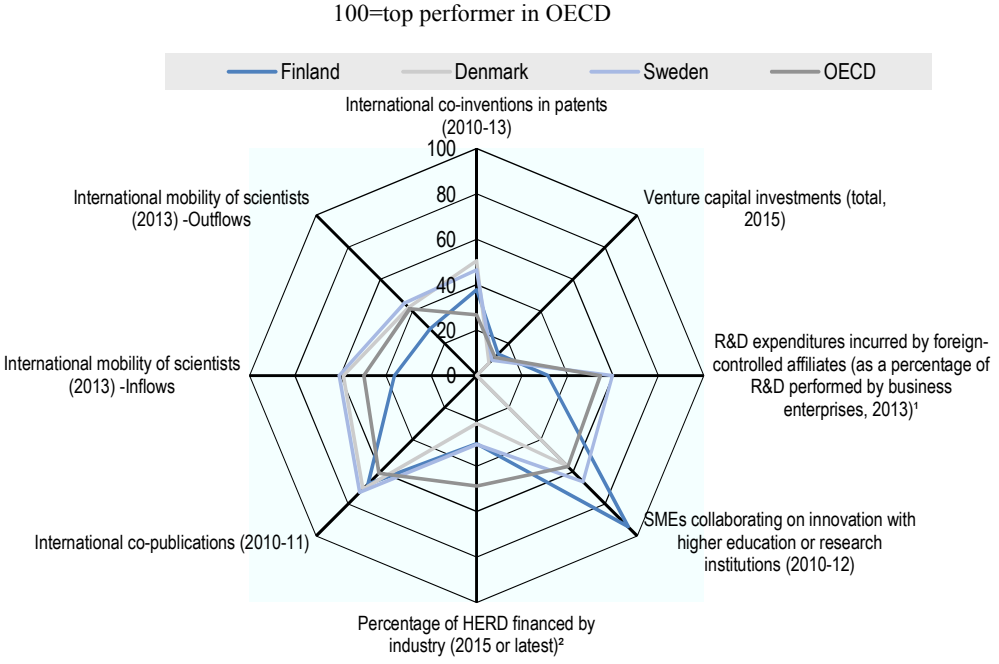
In terms of international linkages in research and innovation, however, Finland underperforms in a number of dimensions. In terms of international co-inventions as reflected in patents, Finland is farther from the top performer than Sweden and Denmark,

although it is doing better than the OECD average (with respect to the top performer). In regards to international co-operation in research as reflected in the number of international co-publications, Finland has been improving significantly, moving from 42.2% of total publications (involving co-authors located in a foreign country in total publications) in 2003 to 52.3% in 2012, which is above the OECD average. Yet most OECD countries, including the Nordic ones, have also increased this ratio significantly over the years (e.g. Denmark from 47% to 55% and Sweden from 45% to 56%).

Finland also underperforms in terms of international mobility of scientists and share of foreign researchers in the total number of doctorate holders, which suggest difficulties in attracting foreign talents and promoting the mobility of Finnish researchers abroad. According to the OECD Science, Technology and Industry Scoreboard (2015c), in 2010-11 only 7.1% of doctorates were of foreign origin whereas in Sweden and Norway this ratio was 20% and 32%. The figure for Denmark was 11%.

(Please separate these paragraphs since the approaches are different)In terms of inflows of scientists (coming to Finland as a percentage of authors and based on the last recorded affiliation), the rate of incoming researchers was 4.2% (in 2013 according[7] to Scopus data), which is lower than the OECD average (6%) and lower than Sweden (7.1%), Denmark (6.8%) and Norway (6.4%). Finland also lags behind its Nordic peers in terms of outflows: outflow rates reached 5.1% whereas in Sweden this ratio was 8% and in Denmark, 7.4%; the OECD average was 7.3%.

Figure 3.7. **Networks, internationalisation and finance**



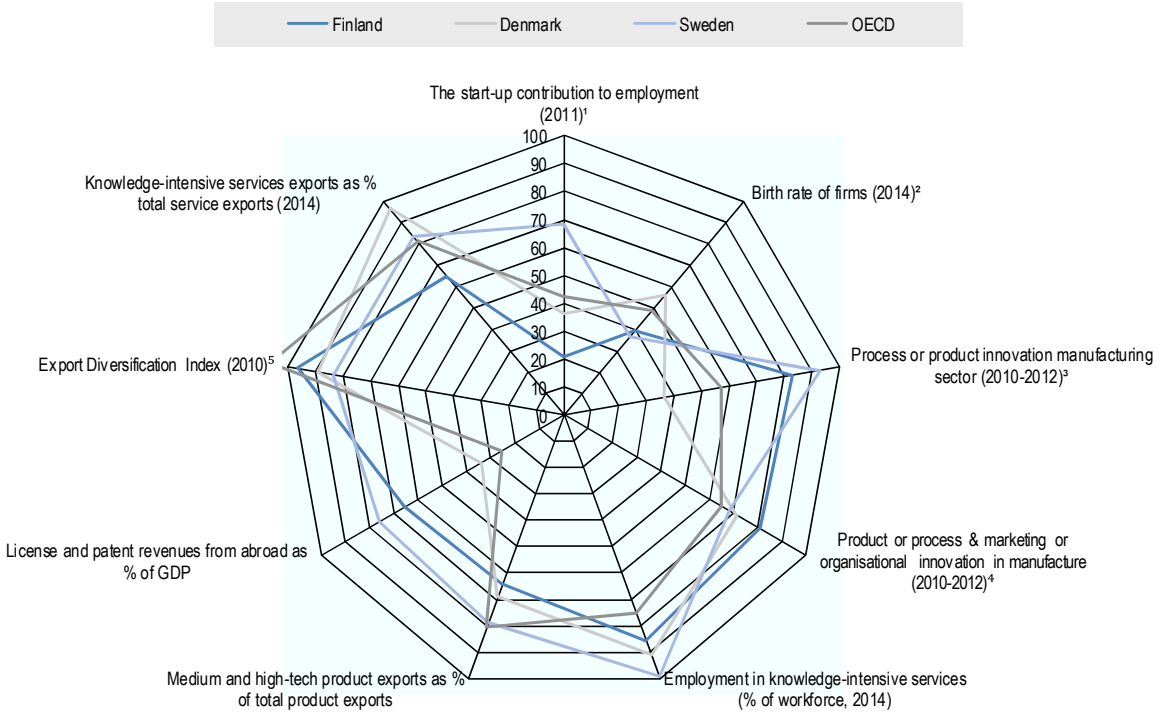
Notes: 1. The OECD average is a simple average of 20 member countries. Data for Sweden correspond to 2013. 2. The OECD average data correspond to 2014 and data for Sweden to 2013. HERD refers to total higher education spending on R&D.

Source: OECD (2015c), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

Regional centres of excellence and internationally networked competence centres are deemed to play a central role for Finland in attracting a skilled workforce, researchers, knowledge-intensive companies and investments. Moreover, the Academy of Finland promotes the international mobility of researchers by providing grants for research stays and joint projects abroad. Part of the academy's available funding to support the internationalisation of research is allocated through specific programmes, such as ERA-NET (an EU network to support and increase the co-ordination of European research programmes). As funding for these programmes is based on research-specific calls for tender, interested researchers have to pass through administrative application processes that obstruct the facile exchange of international researchers with Finland. Simplification thus remains a major target, as outlined during interviews conducted by the Ministry of Education and Culture's (2017) international policy for Finnish higher education and research. Working permits and visas also seem to be difficult to obtain for spouses, which diminishes the attractiveness of Finland for talents and scientists with families.

Figure 3.8. **Innovation output performance, normalised scores**

100=top performer in OECD



1. The OECD average is a simple average of the following countries: Austria, Belgium, Denmark, Finland, Hungary, Italy, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain and Turkey.

2. The OECD average is a simple average of 22 countries.

3. The OECD average is a simple average of 27 countries.

4. The OECD average corresponds to the EU average.

5. The OECD average is a simple average of all OECD countries.

Sources: OECD (2015c), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, http://dx.doi.org/10.1787/sti_scoreboard-2015-en; Eurostat, Scimago Research Group (2016), Scimago Journal & Country Rank website, www.scimagojr.com/countryrank.php; Dutta, S., B. Lanvin and S. Wunsch-Vincent (eds.) (2016), "The global innovation index 2016: Winning with global innovation", www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2016.pdf; IMF (2014), Export Diversification Database, www.imf.org/external/np/res/dfidimf/diversification.htm.

Innovation outputs

Outcomes from public research and quality of science

Finland has a strong science base, high public expenditure on R&D, highly ranked universities and a high rate of scientific publications relative to GDP. Its universities are listed in the top 500 universities worldwide (adjusted per GDP), reflecting their quality and global relevance, and the amount of public R&D investment and publications in top journals (per GDP) also score high in the top half of OECD rankings.

While Finland has a strong public research sector, as illustrated by its performance in terms of scientific publications, universities and public research institutes (PRIs) perform less well than those of other leading countries in filing for patents. Finland scores just at the median of the OECD, surpassed by Sweden and Denmark when academic patent filings are weighted by GDP. Major challenges to overcome are the lagging mobility of researchers between universities and the translation of research outcomes into technological performance. One of the government's strategic objectives is therefore to increase the economic and social impact of research and development through enhanced co-operation between HEIs and businesses and further commercialisation. A major issue remains the high fragmentation of research within the higher education system.

Another major concern remains the quality of scientific research – which has slightly improved over the last years. As highlighted in several reports (e.g. Academy of Finland, 2016; OECD, 2015c), in an international comparison of scientific impact, Finland ranks just above mid-table and seems to be stagnating according to certain indicators (e.g. share in top 10% of most-cited publications) and Finnish research risks to fall behind its peers and major European countries. According to a recent report by the Academy of Finland (2016), many peers have improved their performance in recent years whereas the relative status of Finland has remained the same. Ongoing efforts seek to address this necessity by promoting strategic focus through research profiling, as well as enhancing institutional collaboration (including across and within universities) and new initiatives for international research.

Innovation activity and business dynamics

As in other firm innovation indicators, Finland ranks high in terms of technologically innovative firms (percentage of firms introducing product or process innovation), as well as in terms of overall innovative firms innovation (having introduced product or process and marketing or organisational innovation). In both indicators, Finland ranks far above the OECD (and EU) average (distance to the top performer), and is slightly better than Sweden in overall innovative firms innovation whereas Sweden ranks higher in terms of technologically innovative firms.

"Creative destruction" is one way innovation manifests itself, and leads to a renewal of the industrial tissue and productivity gains (Criscuolo et al., 2014). Finland underperforms relative to its peers (e.g. Denmark and Sweden) and the OECD average in several dimensions of business dynamics. Start-up creation and firm growth (employment generation by small and young firms) are weak, although firm creation rates have been improving in more recent years. In 2014, the birth rate of firms (new firms in total business population) was 8% whereas the OECD average was 10% (Criscuolo et al., 2014). Moreover, young firms in Finland also show difficulties to grow: Finland ranks at the bottom of OECD countries in terms of contribution to employment by small and young firms. To some extent this can be attributed to the scarcity of start-up funding that impedes young firms' possibilities to scale production globally.

Intellectual property rights and technological specialisation

For the period 2010-12, Finland filed 700 international trademark applications at the Office for Harmonization in the Internal Market (OHIM) (OECD, 2015c), whereas Sweden recorded 1 700. Denmark and Norway registered 900 and 100, respectively. In an OECD comparison, Finland scores high in terms of the number of young patenting firms.

There are signs that patenting has been improving in recent years. According to the European Patent Office (EPO), the number of patents granted by the EPO to companies from Finland increased exponentially in 2016. There were a total of 1 081 new Finnish patents. Nokia applied for the most patents in Finland. The company submitted 1 059 applications, which was the 14th highest amount of all companies.[8] For Finnish companies, digital communications remained the central technology area of patent applications. In addition, Nokia was the fourth most active company in digital communications after Huawei, Ericsson and Qualcomm.

In terms of technological competencies in general purpose technologies, Finland only scores high in ICT patenting, with a level of specialisation (revealed technological advantage) barely above one (OECD, 2015c). Denmark scores much higher in terms of specialisation in ICT and also in biotechnologies and nanotech (combined). In terms of environment-related patenting, Finland is not yet highly specialised, but patenting in green technologies and clean-tech have been growing. In this domain, Denmark and Norway score higher with a level of specialisation higher than one.

Economic performance based on knowledge and innovation

Due in large part to the restructuring and downsizing of Nokia and the decline in manufacturing of ICT-related products and electronics, Finland has seen its share in medium- and high-technology intensive product exports falling (in total product exports). Although this ratio is still high, Finland now scores below Sweden and the OECD average (distance to the frontier) in the intensity of medium- and high-tech product exports but ranks similar to Denmark. Earlier deterioration of metal and machinery manufacturing and downsizing of industrial production in these sectors have also contributed to this evolution. In total, high-technology exports have dropped massively, from 23% in 2005 to 6% today.

In terms of international commercialisation of intellectual assets (e.g. license and patent revenues from abroad) Finland scores high (in terms of intensity of receipts related to GDP), but this revenue intensity is lower than Sweden according to data for 2014. Over the period 2009-12, receipts for international transactions involving knowledge assets (such as technology contracts involving disclosure of know-how or transfer through sale, licensing or franchising of designs, trademarks and patents services with a technical content and industrial R&D) decreased at an average annual rate of -0.96%, and payments also declined at a similar rate (-1.1%). This trend contrasts with Denmark and Sweden, which displayed a consistent expansion in both types of cross-border knowledge transactions (receipts and payments). Receipts for knowledge transactions from Sweden grew at a rate of 4% over the same period.

The difficulties in harnessing knowledge for innovation and new economic competences are also reflected in the level and evolution of their intensity of employment in knowledge-intensive sectors. In 2014, for instance, 45.4% of the workforce was employed in knowledge-intensive services, just five points above the EU average. Sweden, however, had a ratio of 53% and Denmark of 48%. Further, according to OECD

Trade in Value Added (TiVA) indicators (for 2011), the domestic value-added contribution in exports did not change significantly between 2002 and 2011, reaching 23% at the end of this period, with equal figures by Denmark and Sweden.

There is evidence that indicates that Finland is not specialising in education-intensive sectors in production and trade as much as some other smaller economies (Kotiranta and Rouvinen, 2016). There was – up to around 2010 – a heavy specialisation in high-tech industries, but less so in human capital-intensive production, which is still one of the structural weaknesses of the economy. Finland is probably not making full use of its skills and human capital-based growth potential (Veugelers et al., 2009). From today's perspective, it looks like the country has been specialising more in its traditionally strong industries: pulp and paper, heavy machinery and metals. There are, however, signs of success in some new high-technology and human capital-intensive industries like healthcare technologies, biotechnology-based businesses and gaming.

Notes

1. According to recent estimates, R&D intensity could decline to 2.7%, which means that Finland will no longer be part of the first tier of OECD countries in terms of R&D investment.
2. Intangibles can be divided, for example into the following categories: 1) digital systems and knowledge; 2) scientific and creative property; and 3) economic capabilities, such as company-specific human capital, company structure, and advertising and brand values. For evidence on the United States see Corrado, Hulten and Sichel (2009).
3. A recent study shows the important contribution of intangibles to productivity growth, accounting for 10% of all labour productivity growth for the 2000-13 period in European countries (Corrado et al., 2016).
4. The first round of the survey assessed adults' skills in literacy, numeracy and problem solving in technology-rich environments in 24 countries and subnational regions.
5. OECD calculations based on OECD/UNESCO Institute for Statistics/Eurostat data collection on Careers of Doctorate Holders 2014; EU Labour Force Survey (micro-data) and US Current Population Survey, July 2015.
6. The percentage of government is at the same level as the EU15 average, the share of HEIs is some percentage points lower.
7. OECD calculations based on Scopus Custom Data (see OECD [2015]), Elsevier, version 4.2015, http://oe.cd/scientometrics, June 2015.
8. Other substantial Finnish patent applicants were Kone, with 100 claims, followed by Outotec, UPM-Kymmene and Wärstilä, all of which had around 50 requests.

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Chapter 4

The role of public research institutions in the Finnish innovation system

This chapter discusses public research institutions – encompassing higher education institutions and public research institutes – highlighting the evolution of their respective roles in the Finnish innovation system. It reviews the reforms that have taken place in both types of institutions, and how these reforms and changes to public research institutions' governance and funding mechanisms shape their research and innovation activities. It also discusses how these recent changes might impact on the performance and development of Finland's research and innovation system, bearing in mind that many of them have been adopted and implemented only very recently.

Higher education institutions

Historical background and main features

Apart from the University of Helsinki, which was founded in 1640, Finnish universities are rather young. Five were founded or became universities in the first three decades of the 20th century (Åbo, Turku, Tampere, Jyväskyla and the Hanken School of Economics), while the others have been established since the 1950s. Aalto University Helsinki was established in 2010 by merging the University of Technology (established 1849), the Helsinki School of Economics (established 1904), and the University of Art and Design Helsinki (established 1871). All of these are public universities and tuition fees are only charged for students from outside the European Economic Area (EEA), starting in 2017. The first polytechnics or university colleges, now referred to as universities of applied sciences (UAS) emerged in the 1990s, with the sector expanding significantly since then. As of 2016, there were about 170 000 students in the universities and 130 000 students in the UAS sector.

The quality and reach of the Finnish higher education system are reflected in a well-educated population. In 2015, 43% of the Finnish population aged 25-64 had some form of tertiary education, putting it at the top among the EU member states, along with the United Kingdom, Ireland and Norway (OECD, 2016d). Higher education expenditure for research and development (HERD) accounted for 0.73% of GDP in 2014, which is high in international comparison, albeit lower than in Denmark (1.01%) and Sweden (0.92%) (Figure 4.1). Today, Finnish HEIs perform a significantly lower share of gross domestic expenditure on R&D (GERD) as a percentage of gross domestic product (GDP) than their counterparts in Denmark, Norway or Sweden (Figure 4.2). This is explained by the fact that Finland has a larger public research institute (PRI) sector than Denmark and Sweden and that its business sector accounts for a larger share of R&D expenditure than in Norway.

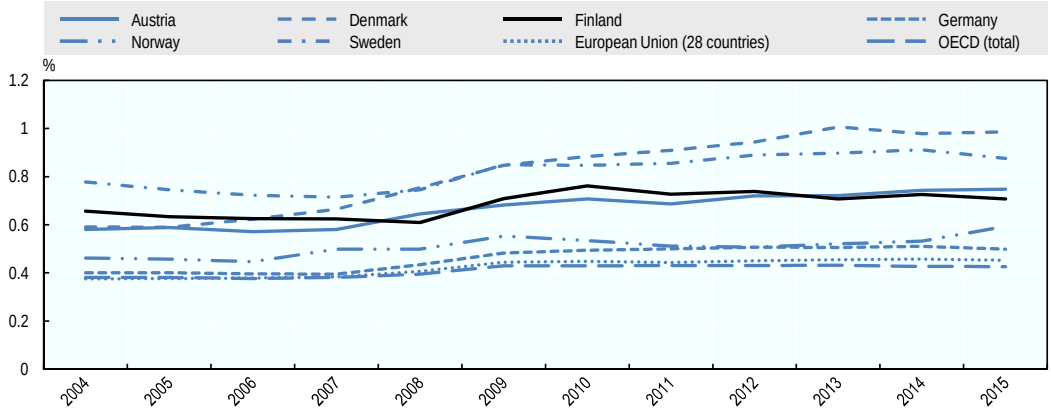
In the past decade, the Finnish higher education system has been subject to a number of substantial changes, ranging from legal and governance reforms to significant changes in funding streams and levels partially as a result of the recent global economic crisis. After a long period of continuously increasing public funding (in real terms), Finnish university funding has entered a period of stagnation and even cuts in real terms (starting in 2016). This situation, in addition to the growing necessity to enhance the contribution of HEIs to socio-economic development, reinforces the challenges for HEIs to continue adapting to a changing world while dealing with tighter resource constraints.

A dual system and different forms of innovation contribution

Since the early 1990s, Finland has had a dual higher education system, with universities and UAS, which traditionally have a strong focus on education and on meeting the needs of regional (and local) labour markets. According to Melin et al. (2015), the UAS have an explicit, legally based regional role to deliver education which is aligned with the needs of the surrounding society and industry; they undertake applied R&D and entrepreneurial activities, and help facilitate cluster development.[1] In contrast, universities have a more general obligation towards societal and economic engagement. Both universities and UAS have a legal obligation to include external stakeholders in their governance structures to ensure the relevance of education and R&D.

The dual structure of the Finnish HEI system is illustrated by the different (performance-based) funding models for its two components. Universities' orientation is reflected in a stronger emphasis on research than that of UAS, although the latter are also engaged in applied research activities and different forms of technology transfer. In 2015, 34% of universities' core funding from government was allocated on the basis of research performance; the corresponding figure for UAS was only 15%. In contrast, 85% of UAS' core funding was allocated on the basis of education performance, compared to 41% for universities. In 2014, 56.9% of total public funding for R&D went to universities, as opposed to a mere 5.5% to UAS (Statistics Finland, 2016a).

Figure 4.1. **Higher education expenditure for research and development (HERD) as a percentage of GDP**

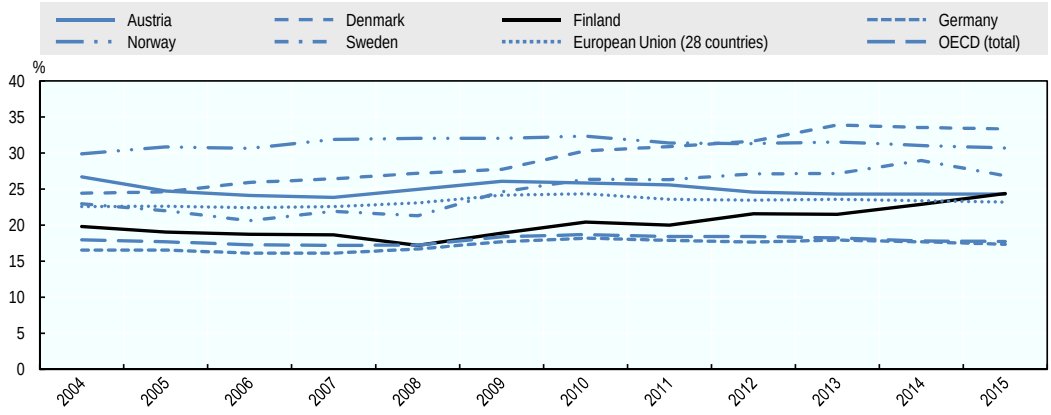


Source: OECD (2016), "Main Science and Technology Indicators (Edition 2016/1)", *OECD Science, Technology and R&D Statistics* (database), http://dx.doi.org/10.1787/db23df7c-en.

One significant change affecting Finland's system of higher education has been a wave of mergers which began in 2009. These included, in 2010, the merger of Helsinki University of Technology, Helsinki School of Economics and Business Administration, and the University of Industrial Arts Helsinki into Aalto University; the foundation of the University of Eastern Finland; the fusion of the University of Turku and Turku School of Economics and Business Administration; and the fusion of three academies of fine arts, theatre and music into the University of the Arts Helsinki in 2013 (for a more detailed account see Aarrevaara and Dobson [2016]).

Consequently, the number of HEIs (defined as universities and UAS) declined from 48 in 2009 to 38 in 2014 and will drop further to 35 by 2018, as a result of the mergers of Kymenlaakso and Mikkeli Universities of Applied Sciences into the South-Eastern Finland University of Applied Sciences in 2017 and the merger of Tampere University of Technology, the University of Tampere and Tampere University of Applied Sciences in 2018. The latter, referred to as Tampere3 will be the first merger between a university of applied science and a university.

Figure 4.2. **Percentage of gross domestic expenditure on R&D performed by the higher education sector**



Source: OECD (2016c), "Main Science and Technology Indicators (Edition 2016/1)", *OECD Science, Technology and R&D Statistics* (database), http://dx.doi.org/10.1787/db23df7c-en.

In spite of this restructuring, Finland still has a relatively large number of HEIs in relation to its size compared to other Nordic countries. Currently, there are 14 universities and 25 UAS, down from 21 universities and 27 polytechnics in 2009 (Aarrevaara and Dobson, 2016). In relation to population size, Finland has more than twice as many HEIs per million inhabitants. In relation to student enrolment, Finland has 2.18 HEIs per 10 000 full-time students and 1.24 HEIs per 10 000 total students (i.e. both full-time and part-time), considerably more than the other Nordic countries. The respective figures are 0.59 and 0.53 for Denmark, 1.14 and 0.72 for Norway, and 1.43 and 0.77 for Sweden. Table 4.1 lists HEIs and respective student enrolment for the Nordic countries. Even after the mergers of the three HEIs in Tampere and the merger of the Kymenlaakso and Mikkeli Universities of Applied Sciences, Finland will still have more HEIs than the other Nordic countries, both in relation to population size and number of students.

Table 4.1. **Higher education institutions in the Nordic countries**

	Number of universities and university colleges	Student enrolment (full time), 2014	Student enrolment (full and part time)	Population, 2015	Universities per million inhabitants	Universities per 10 000 full-time students	Universities per 10 000 students
Denmark	16	269 493	301 399	5.1	3.14	0.59	0.53
Finland	38	174 037	306 080	5.5	6.91	2.18	1.24
Norway	19	166 322	264 207	5.7	3.33	1.14	0.72
Sweden	33	230 549	429 444	9.9	3.33	1.43	0.77

Note: For comparability purposes artistic higher education institutions and business academies (of which there are several in Denmark) have been excluded. Also the Police University College has not been included.

Sources: OECD (2016d), *OECD Education Database*, http://dx.doi.org/10.1787/edu-db-data-en (accessed 9 October 2016) and national homepages (for number of higher education institutions).

Recognising that the current performance-based funding model for universities "in itself … does not provide very strong incentive to making strategic profiling choices" (Academy of Finland, 2017), the government earmarked EUR 50 million between 2015 and 2019 for a programme to be administered through the Academy of Finland to encourage HEIs to strengthen their strategic orientation by developing clearer "research profiles". In its second call, in March 2015, all of the 14 universities applied, and 12 out

of them received between EUR 600 000 and EUR 12 million for the four-year period. The need to reduce the number of HEIs and increase profiling was recognised and endorsed in a recent strategy for Finland's higher education system presented by the Rectors' Conference of Finnish Universities of Applied Sciences Arene Ry in 2016.

In addition to reducing the number of institutions, there also appears to be a need to reduce the number of small branches (around 120) of these institutions and the high number of comparatively small departments (in the same or related field of education/research) scattered across the country. The discipline units of Finnish universities are typically small. More than one-third of the university disciplines employ three professors or less, calculated in terms of full-time equivalents (FTE). Almost all universities have a maximum of nine disciplines that have at least one-fifth of the FTE of the professors of the discipline (Academy of Finland, 2016).

University reforms: The need for system consolidation and specialisation

The Finnish higher education system has undergone a number of significant changes and reforms since 2007. The purpose of the reform, according to the homepage of the Ministry of Education and Culture, was to better equip universities to secure more external funding, increase international co-operation, enable greater prioritisation and strategic focus of research, promote the quality and effectiveness of research and teaching, and "strengthen their role within the system of innovation" (Ministry of Education and Culture, 2016a). Overall, an important goal has been to strengthen the attractiveness and quality of Finnish universities by reducing what was perceived as a problematic fragmentation and duplication of research and teaching in higher education in Finland.[2]

First, as a result of the Universities Bill of 2009, Finnish universities became independent legal entities separate from the state.[3] The reform also gave universities more control over, and responsibility for, their human resources and finances.[4] The bill is in line with a recent trend in Nordic and European countries to increase the autonomy of public universities. The reform mandated that at least 40% of board members at public universities should be from outside the university. Aalto stands out in this regard, having only external board members with a very strong international orientation. Aside from Aalto, the universities of Lappeenranta, Lapland, Tampere and Vasa have a higher share of external board members than the 40% required. Overall, aside from Aalto, there seems to be potential for strengthening the international perspective and profile of the university boards.

The reform of the universities was followed by a corresponding reform of the polytechnics (UAS) in 2011 and 2015, which required them to focus primarily on teaching activities – although many of them are strongly engaged in entrepreneurial and applied research activities as well. Since 2015, UAS are limited companies with municipalities, regions and the private sector usually as joint owners (Elken, Frølich and Reymert, 2016). The vast majority of their funding, 88% according to Elken, Frølich and Reymert (2016), is in the form of direct government funding.

One of the key elements of the recent reforms has been the move to a more performance-based system for allocating government funding. Each university and UAS negotiates individual performance agreements with the Ministry of Education and Culture every four years. It is the universities' and UAS' responsibility to provide statistics to support the monitoring of their performance (Elken, Frølich and Reymert, 2016). Each performance agreement contains institution-specific targets. Feedback on performance is

provided annually and made publicly available. The evaluation process also involves on-site visits. The model has been modified twice since it was first introduced in 2013. As a result of the reform, Finland now has one of the most performance-based funding systems in Europe in terms of the share of funding allocated on the basis of performance.

The state of progress

Overall, the process of optimisation through institutional merging and department consolidation – internally within universities – has been rather slow. Yet an evaluation of the university reforms delivered in mid-2016 found that they had "triggered a significant structural and cultural change in the way universities are led" (Owal Group, 2016). Among other things, university boards have gained greater influence in universities' strategic decisions, and the rector's position has been strengthened. The changes have been heavily criticised by many university employees as severely undermining the collegiate's role and influence in decision making. As a result, the reforms, combined with significant budget cuts particularly since 2016, have, according to the evaluation, led to a sense of alienation and dissatisfaction among a significant proportion of university staff (Owal Group, 2016).

Overall, the evaluation found that universities have started to think more strategically about where they should be headed and what they should be doing. At the same time, it is still too early to discern how this increased strategic thinking has been transformed into action, decision making and prioritisation or "re-prioritisation" in terms of recruitment and the allocation of basic funding. Thus, the evaluators found that "while the increased autonomy has improved the universities' preconditions for profiling, structural reforms have progressed rather slowly" (Owal Group, 2016). A challenge with evaluating the effects of the university reforms is that many other changes have occurred at the same time, all of which affect universities, such as funding cuts, university mergers, the drastic reduction of Nokia's R&D activities, and the economic crisis.

Findings by the recent evaluation echo an earlier analysis which examined the impact of the reforms on research (Luukkonen, 2014a). Accordingly, there has not been much impact from the recent policy changes on intellectual innovation in research in Finland. University governance influences research content very indirectly and is mediated by multiple other factors, which implies that policy changes are not, at least in the short run, translated into changed research content. The report is critical of what it sees as exaggerated and misguided faith in performance measurement and performance-based funding and points to some risks, in particular narrowing research options and variety of research.[5]

Lack of flexibility and alignment with labour demand

The Finnish higher education system has been criticised for forcing students to specialise early in narrow programmes – many of which have limited attractiveness on the labour market – rather than offering more "broad-based bachelor's degree programmes, relevant to the labour market and quality- or problem-based Master's degrees" (Melin et al., 2015). The University of Aalto has tried to address this problem by reducing the number of Bachelor of Arts programmes it offers to eight and in turn making them broader. In addition, degree programmes are highly specialised and university rules make it very difficult to move from one programme to another. It is almost impossible to move course credits from one system to the other, impeding institutional and social mobility.

A considerable number of students are formally listed in the programme they were originally admitted to while waiting to get into the programme they want to be in. In 2015 and 2016, less than one-third of all applicants to HEIs were granted a place. For some programmes, for example in behavioural sciences, political science or veterinary medicine at the University of Helsinki, the acceptance rate is below 10%.[6] Many students apply multiple times. Further, it is particularly difficult for students to transfer from universities to polytechnics or vice versa, effectively creating two silos in higher education (Melin et al., 2015).

This situation has led to repeated calls for the shortening of study completion times, easier transition between different levels and programmes of education as well as a reduction of overlaps in the educational offering (Haila, 2014). Overall, the picture that emerges is one of many people wanting to study but many being "parked" in programmes they do not want to be in and too few (for this and other reasons) completing their education in time or at all.

It should also be pointed out that Finland has a very high share of part-time students. In 2014, one-third of bachelor students were part-time students, compared to an OECD average of 18%, though Sweden and Norway had even higher shares. At master's level, 60% of all students were part-time students, compared to the OECD average of 24% and much higher than in Sweden, Norway and Denmark (OECD, 2016a). As a result, many students take relatively long to finish their education and many do not finish at all.

A long-standing challenge in Finnish higher education has been that "young people graduate later than their counterparts in other countries and enter the labour market at an older age" (Ministry of Education and Culture, 2014; see also Melin et al. [2015]). In recent years, the share of students completing their degree within three years of the theoretical duration seems to have improved slightly, although at 67.7% (of the true cohort) it is still below the OECD average of 69.2% and significantly lower than in Denmark and Norway – 80.6% and 76.1% respectively – but higher than in Sweden (53.2%) (OECD, 2016a).

The government has introduced a number of initiatives to lower the age at which people enter higher education, reduce the time it takes students to get a degree, and accelerate and improve students' entry into the labour market.[7] In an effort to make it easier for first-time applicants to get admitted to HEIs, since 2016, universities are required to allocate a certain share of places, usually between 50% and 85%, to first-time applicants.[8]

In terms of tertiary graduates in natural sciences and engineering, Finland ranks above the OECD average, just behind Sweden and Germany (OECD, 2015a). In 2012, 28% of tertiary graduates belonged to these fields, whereas the OECD the average was 22%. The percentage of tertiary female graduates in these domains is, however, lower than the OECD standards (28% vs. 34%) and much lower than Denmark (36%) or Sweden (34%) (OECD, 2015a).

However, it has become increasingly difficult for people with a tertiary education in general, but young people in particular, to get jobs. Unemployment among people with a tertiary education is high, particularly among young people, compared with other OECD countries. In 2015, the unemployment rate for 25-34 year-olds with a tertiary education was 8.1%. Among OECD countries, only Greece, Italy, Portugal, Slovenia, Spain and Turkey had higher rates. Furthermore, since 2005, Finland has suffered a comparatively large increase in unemployment rates for people with a tertiary education in general and

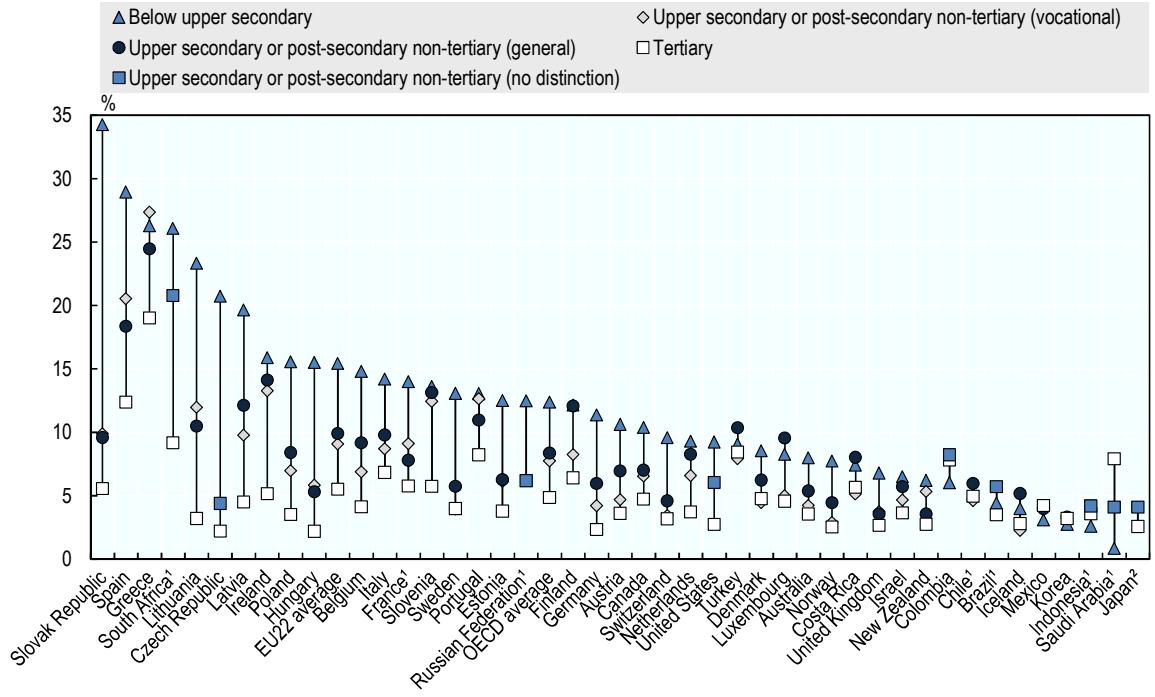
for young people with a tertiary education in particular (OECD, 2016a). Finally, the difference in unemployment between more and less educated people is low compared with many other OECD countries (Figure 4.3).

The ways universities impact economic and social development through human capital provision (tertiary and also advanced post-graduates) and their placement in industry could be improved. In regards to doctoral degrees, there is wide room for better impacting business innovation through industry placement. Strikingly, in 2015, Finland had the highest unemployment rate for people with doctoral degrees among all OECD countries for which this information is available (OECD, 2016d). This can probably be explained by a combination of the economic crisis and stagnation of funding increases to universities, both of which have squeezed the labour market for people with PhDs.

The high unemployment among people with doctoral degrees could also be explained by a mismatch between the supply of doctoral expertise and the knowledge demands by industry for advanced researchers. As recognised in the recent report on the state of scientific research (Academy of Finland, 2016), Finland should enhance the placement of doctoral researchers in industry to maximise the knowledge impact of science and innovation opportunities in the business sector. In doing so, Finnish universities and business could collaborate more actively in developing content of researcher training so that scientists can be better equipped to assume demanding positions and tasks in business and industry.

Figure 4.3. **Unemployment rates by education attainment, 2015**

25-64 year-olds



Notes: 1. Year of reference differs from 2015 and refers to last year available. 2. Data for tertiary education include upper secondary and post-secondary non-tertiary programmes (less than 5% of the adults are under this group). Countries are ranked in descending order of the unemployment rate of adults with less than an upper secondary education.

Source: OECD (2016a), *Education at a Glance 2016: OECD Indicators*, OECD Publishing, Paris, http://dx.doi.org/10.1787/eag-2016-en.

It is also important to expand career options and opportunities for young researchers in order to harness and retain this talent; the risk of migration abroad is high. With tighter budgets it is more difficult for young doctorates to find employment or temporary positions. Some universities have introduced tenure, but there are very few such opportunities and it is not solving the big issue of how such young researchers can develop their careers at universities.

An evolving funding model

The university reforms included changes to the funding model, which have made external as well as institutional funding for research performance-based and dependent upon results.[9] However, major changes have been made since the reform was introduced. The current university funding models emphasise scientific merits and publishing, and can be seen as implicitly discouraging knowledge utilisation, relevance or interaction with surrounding society. This applies to both research and education.

A new funding model was introduced at the beginning of 2017. In the new model, 39% of funding is allocated by the education metrics, 33% is based on research performance and 28% is based on a mix of the university's strategic development intentions, its activities in specific fields and its performance of various national duties, such as professional education needed by the state. The number of PhDs awarded to foreign nationals as a separate indicator has been excluded from the current model (although it is included in the indicator measuring the overall number of PhDs).

Aside from educational goals (such as the number of graduates), which account for 39% of the total basic funding allocation, the funding model for universities places a strong emphasis on research excellence in terms of peer-reviewed publications in well-known journals, on strategic development, on the ability to attract external funding and on internationalisation. The emphasis on strategic development is echoed in the targets for the government's research policy listed on the homepage of the Ministry of Education and Culture, one of which is to support the "profiling" of universities (Ministry of Education and Culture, 2017). In contrast, impact or utilisation of research, societal relevance, and co-operation or interaction with society seems to have quite low priority.

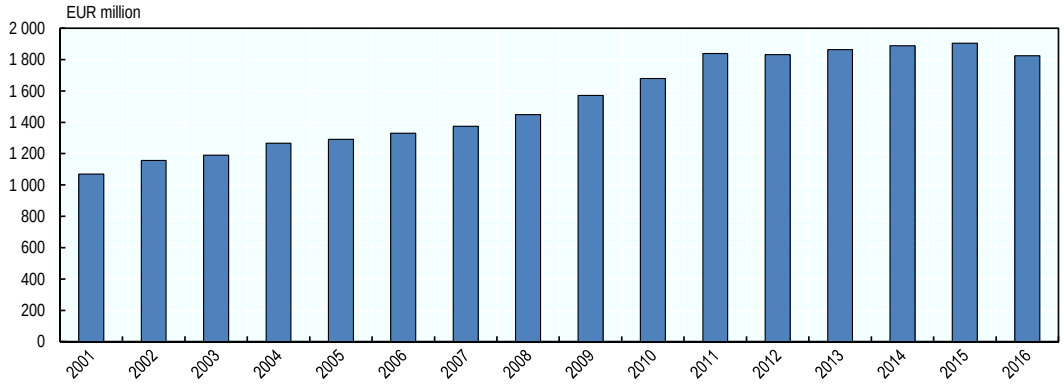
Comparing the initial 2013 model with the changes made in 2015 and 2017, there is a gradual increase in the weight assigned to peer-reviewed publications in well-known journals and in the importance assigned to strategic development. The latter also applies to UAS. In both funding models, the emphasis has been slightly reoriented towards the employability of graduates (from 1% to 2% for universities and from 3% to 4% for UAS), although the number is still low, and too low to guide universities in educating people in areas and ways useful to society. The funding model also seeks to shorten the average study duration by awarding 10% of funding to universities based on the number of students who have gained at least 55 study credits. The funding model for UAS clearly emphasises education, although its weight has declined from 85% to 79% between 2013 and 2017. The decline is explained by refocusing part of the base funding model towards strategic development.

Funding trends

In parallel to the changes in the funding model, there has also been a change in the overall trend of public funding to universities. Whereas public funding to universities increased continuously from 2001 to 2011 at an average annual rate of 6.2% in nominal terms, since 2011 total public funding to universities has stagnated, and even fell by 4.2%

in 2016 compared to the previous year (Figure 4.4). Public research funding to universities increased continuously between 2001 and 2012, at an average annual growth rate of 4.8% in nominal terms, but in 2012–2017 the funding volume has remained more or less the same, at around 585 million EUR.[10] As a result of this development, some universities have had, or will have, to reduce their staff or even lay people off; something that has been unheard of in the history of Finnish HEIs (University of Helsinki, 2015). It can be argued that the university reform has made it easier to lay people off since university staff is no longer employed by the state.

Figure 4.4. **Public funding for universities, nominal value**

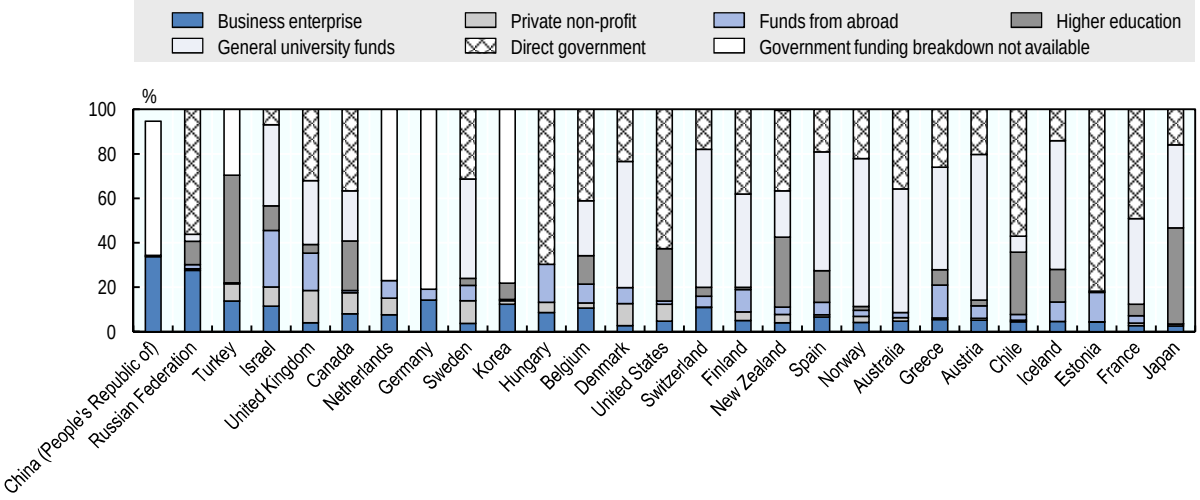


Source: Ministry of Education and Culture (2016b), Database, https://vipunen.fi/en-gb/higher-education-and-r-d-activity (accessed 5 March 2017).

Funding of R&D in higher education in Finland was predominantly from general university funds (42%), followed by direct funding from the government (38%), funds from abroad (10%) and business enterprise funding (5%) (Figure 4.5), which is broadly comparable with other Nordic countries and commensurate with OECD countries in general.

Figure 4.5. **Funding of R&D in higher education by source, 2013**

As a percentage of HERD



Notes: Data for Austria and Belgium are for 2011. Data for Australia, France, Israel and Switzerland correspond to 2012.

Source: OECD (2015), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

R&D trends and scientific performance

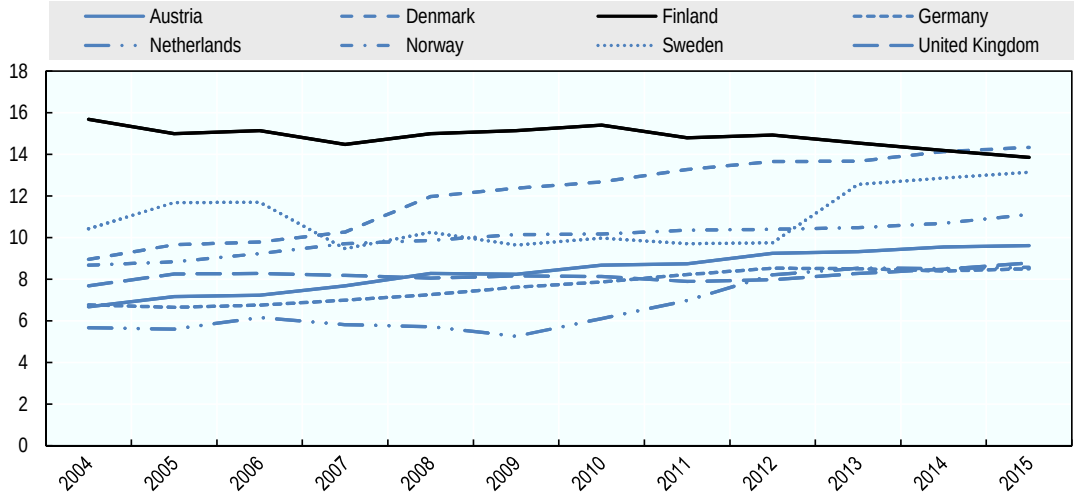
Between 2011 and 2015 universities' total research funding increased by 5.7%, largely due to a 23% increase in basic funding from the Ministry of Education and Culture. At the same time, R&D funding by Finnish companies fell by 24% between 2011 and 2015 (Statistics Finland, 2016c). In the long run, the percentage of universities' R&D expenditure funded by the business sector has fallen from 8.0% in 2008 to 4.4% in 2015. Concurrently with the changes in public funding to universities, a number of other shifts in public funding to other actors have had impacts both on HEIs' funding streams and the innovation ecosystem in which the universities and UAS operate.[11]

The number of research staff remained roughly the same between 2011 and 2015 although its composition changed. The number of administrative staff declined by close to 20% while the number of PhD students increased by 37% between 2011 and 2015 (Ministry of Education and Culture, 2016).

At UAS, total research income fell by 17.3% (in nominal terms) between 2011 and 2015. This is largely explained by a 37% drop in external research funding during that period, primarily driven by the steep cuts in funding from ministries (29% since 2012) but also business enterprises (a 41% drop since 2012) and municipalities (by 54% since 2011). As a result, the number of researchers (full-time equivalents) fell by nearly 25% during that time and the number of other R&D staff fell by even more (the exact number was not available at time of print).

Finland has long had one of the highest numbers of researchers (per thousand labour force) among OECD countries (see OECD [2015a] and Figure 4.6). In response to the budgetary stagnation and cuts, this figure gradually declined from about 15.7 in 2004 to 13.9 in 2015.

Figure 4.6. **Total researchers per thousand labour force, selected countries**



Source: OECD (2016b), *Main Science and Technology Indicators*, *Volume 2015, Issue 2*, OECD Publishing, Paris; http://dx.doi.org/10.1787/msti-v2015-2-en.

UAS and universities differ very clearly in terms of the amount and sources of external R&D funding (Raunio, Räsänen and Kautonen, 2016). Further, profiles of individual institutions vary greatly within both categories. Importantly, co-operation with business is strongly biased to only a few universities in terms of corporate funding. For example, a recent study on open innovation platforms as policy tools for fostering co-

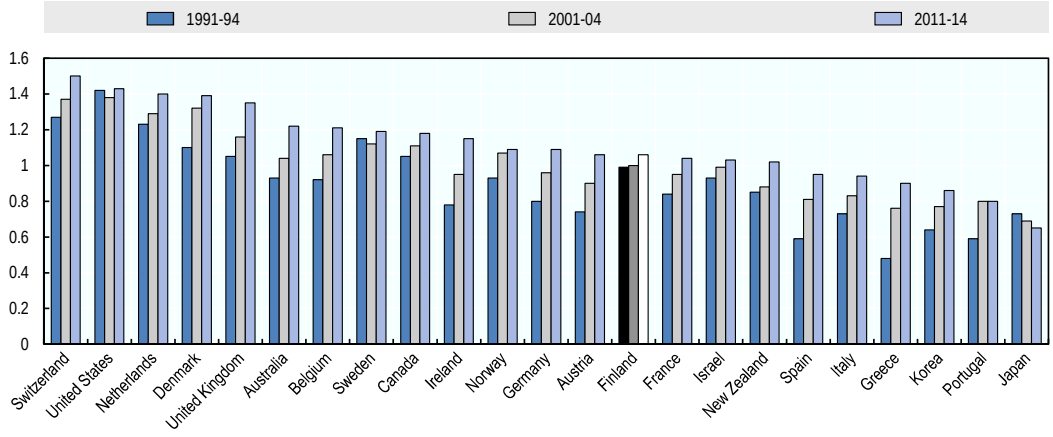
operation and value creation in a knowledge triangle (Raunio, Räsänen and Kautonen, 2016) found that:

- in 2014, the University of Tampere alone gathered 57% of the total funding from foreign companies in Finland, mainly due to its vaccination-related research
- Aalto University (technology-oriented) and Tampere University of Technology together gathered about 45% of total funding from domestic companies (about EUR 10 million each).

An important concern remains the quality of scientific research, which has slightly improved over recent years (Figure 4.7). As reported in several reports (e.g. Academy of Finland [2016] and OECD [2015a]), in an international comparison of scientific impact, Finland ranks just above mid-table and seems to be stagnating or slightly improving according to certain indicators (e.g. share in top 10% of most-cited publications). Looking at scientific impact, measured in terms of the relative proportion of a country's publications that are among the top 10% most cited in the world compared to a world average of 1, Finland is slightly above the world average at 1.06 for 2011-14. However, although there has been a gradual improvement since 1991, many other countries' top 10 index has increased significantly faster than Finland's and a number of countries that were below Finland in 1991 have now caught up with or overtaken Finland, such as Australia, Austria, Belgium, Germany, Ireland and Norway.

Furthermore, Canada, Denmark, Switzerland and the United Kingdom, which were already ahead of Finland in 1991, have seen stronger improvements in their index. Breaking down the top 10 index according to academic disciplines, business studies and economics, humanities and engineering have seen the biggest improvements when comparing the period 2011-14 to the period 2001-04 (Academy of Finland, 2016). In contrast, the top 10 indices for health sciences and mathematics have dropped, with the indicator for health sciences going from being clearly above to below the world average.

Figure 4.7. **Top 10 citation index in selected OECD countries**



Source: Academy of Finland (2016), *The State of Scientific Research in Finland 2016*, www.aka.fi/en/research-and-science-policy/state-of-scientific-research.

Ongoing efforts seek to address the risk of Finland falling behind its peers and major European countries. These include promoting strategic focus through research profiling as well as enhancing institutional collaboration (including across and within universities) and new initiatives for international research.

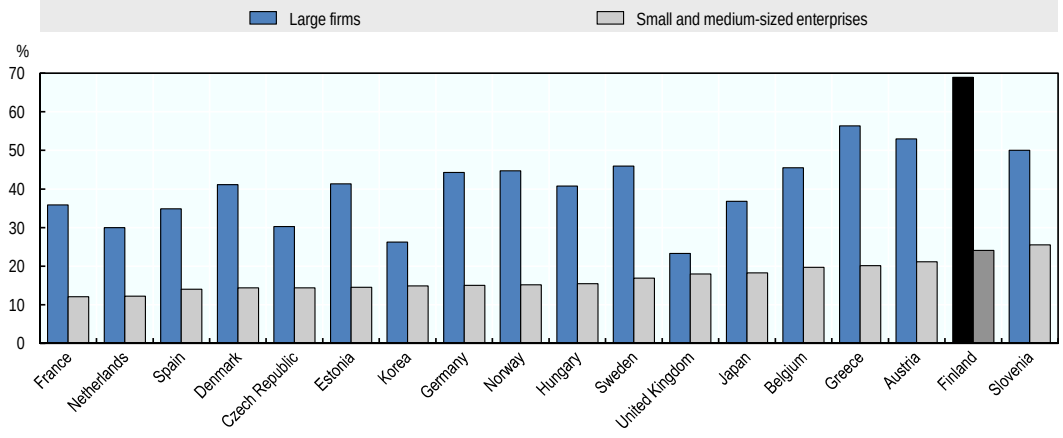
Industry-academia linkages in innovation and new forms of engagement

The volume and share of HERD financed by industry has dropped significantly since the latter part of the 2000s. Industry-financed HERD decreased from EUR 81 million in 2008 to EUR 56 million in 2015, constituting one of the biggest declines across the OECD, in relative terms (OECD, 2016b; Statistics Finland, 2016c). However, aggregate figures from national innovation surveys indicate that industry-university collaboration in research in Finland is among the highest in OECD countries. However, as in most countries, there is a wide disparity between large firms and SMEs, with the former actually being the main players in industry-science co-operation. In this case, Finland's divergence between large firms and SMEs is outstanding; larger than in most OECD countries (Figure 4.8).

There are indications that the number of co-publications involving industry and academia have been falling across the Nordic countries. At Aalto University, for example, while co-publications with their top three academic partners increased by 18% to 26% between 2011 and 2015, co-publications with their three top corporate partners fell by 37% to 98% in the same time period. Similarly, at the University of Helsinki, co-publications increased for nine out of ten of the university's top academic partners, while they fell for six out of their top ten corporate partners (Elsevier, Scival database 2016).

Figure 4.8. **Firms collaborating on innovation with higher education institutions or research institutions, by firm size, 2010-12**

As a percentage of product- and/or process-innovating firms in each size category



Note: Data for Korea are for 2011-13 and data for Japan are for 2009-12.

Sources: OECD (2015a), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth and Society*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_scoreboard-2015-en based on Eurostat Community Innovation Survey (CIS-2012) and national data sources, June 2015.

Another type of knowledge interaction between industry and science is technology commercialisation and licensing of intellectual property rights. The HEI Invention Law reform of 2007 provided universities with the right to own intellectual property rights of the results of publicly funded research. Prior to the reform researchers owned rights to their inventions. In the case of Finland, the establishment of universities' patent policies, technology transfer offices and the new Act on the Right to Inventions Made at Higher Education Institutions have played an instrumental role in fostering university technology transfer and commercialisation, as a variety of actors have tried to increase the relevance

of universities to economic competitiveness and encourage researchers to participate in patenting activities (Kauppinen and Kaidesoja, 2014). Yet it seems that the reform has not had any significant impact or change on the magnitude and types of knowledge transfer activities.

A survey conducted by the Ministry of Economic Affairs and Employment in 2014 on universities' and UAS' commercialisation activities between 2010 and 2013 indicates that commercialisation activities are still rather limited. The number of commercialisation projects at universities has increased, as has the number of people at universities working with commercialisation of research results, but this was from a low level, 19 FTE in 2010 (for 14 universities) compared to 41 in 2013. The number of patent applications fluctuated between 50 and 100 per year with no clear upward trend, licensing revenues in 2013 were lower than in 2010, as was the number of companies founded by researchers (41 in 2010 compared to 32 in 2013).

The cuts in Tekes' funding can be argued to have shifted resources away from long-term industry-academia collaboration (particularly with larger firms) and from commercialisation and technology transfer. The effective termination of public funding of the strategic centres for science, technology and innovation and therewith perhaps of the government's most ambitious effort to establish industry-academia networks and linkages as well as more industry-driven research agendas has not been mitigated by the introduction or ramping up of other initiatives for more long-term platforms or strategies for industry-academia research and innovation co-operation.

There are, however, numerous examples of close and mutually beneficial co-operation between large and medium-sized companies (Wärtsila, Oilon, Stora Enso) and universities and UAS in the form of investments in research infrastructure, donating equipment, student interns, etc. Such companies work closely with universities where they are located to secure the long-term supply of competence and knowledge resources. These forms of co-operation and interaction are hard to capture with quantitative indicators such as patent, licensing or co-publication data. Aalto University has strategic partnerships with ABB and Nokia involving research and education. In addition, HEIs are engaging in new forms of innovation and entrepreneurship initiatives which, increasingly, involve students, start-ups and SMEs (see for example the Open Innovation Partnership [OIP] in Tampere described in Box 4.1).

The OIP approach in Tampere also has several locally important qualities in terms of knowledge transfer (Raunio, Räsänen and Kautonen, 2016). As a new form of civic engagement and university-industry collaboration, the OIPs, as a part of the regional innovation ecosystem offering an innovative trial and testing environment for firms and other organisations, provide a stronger role for the new university in the region, and maybe even globally. The role of students as innovators is stronger in OIPs than in more traditional cluster projects; the link between learning and education with innovation is strong and direct.[12]

Box 4.1. **Knowledge triangle and three open innovation platforms in the Tampere region**

Clusters and regional or national innovation networks have evolved towards an Open Innovation Partnership (OIP) approach in the Tampere region, which encompasses research, education and innovation as well as entrepreneurship. OIPs frequently bring together multiple higher education institutions (HEIs) and other stakeholders and are examples of partnerships

Box 4.1. **Knowledge triangle and three open innovation platforms in the Tampere region** (*cont.*)

with private and/or public partners at institutional level. OIPs in the Tampere region are diverse and accommodate different activities and nature of universities and universities of applied sciences. Examples of OIPs in the Tampere region include:

- **Demola:** This case illustrates the OIP serving a large coalition of universities as it accommodates students from all three HEIs of the region, and occasionally also students from other universities outside of the region. It also clearly supports the idea of related variety, as the student teams in Demola are always multidisciplinary.
- **Mediapolis:** This case focuses on an institution with a strong regional profile, as the Tampere University of Applied Sciences (polytechnic) is a key HEI. It is based on strengthening a fairly weak knowledge base (symbolic) as no strong media cluster exists in Tampere. To some extent, it also supports related variety by bringing different knowledge bases of media (symbolic) and ICT (synthetic) together.
- **Campus arena** is located on the campus of the technical university and builds on the strongest knowledge base (synthetic) and clusters (ICT and machinery) in Tampere.

There is an emerging network of open innovation platforms in the region as this is a systemic challenge, rather than simply an organisational one. Further, OIPs also have links to wider urban development (e.g. citizen participation, innovative procurement), provision of public services (e.g. digital platforms, open data) and business development practices beyond knowledge transfer. The national 6Cites programme's OIP spearhead projects have heavily used the experiences from the work done in Tampere with OIPs, and in New Factory (est. 2008) especially. The 6Cities strategy in Tampere is implemented by teams from the city of Tampere, Tredea development agency, the University of Tampere and the Tampere Regional Council, as a joint effort.

Source: Raunio, M., P. Räsänen and M. Kautonen (2016), "Tampere: Open innovation platforms as policy tools fostering the co-creation and value creation in knowledge triangle".

Internationalisation: A continuing challenge

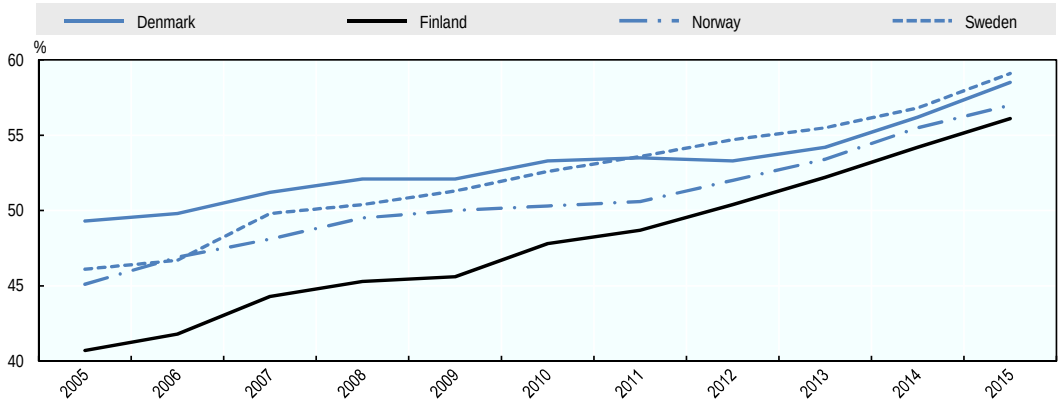
Finland has a relatively small share of international students considering that it is a relatively small country and does not charge tuition fees for non-EEA students, although it plans to introduce tuition fees in 2017. In 2014 only 19% of all doctoral students were international students, which is lower than in all the other Nordic countries (excluding Iceland for which data were not available) and 8 percentage points lower than the OECD average (OECD, 2016a).

Availability of courses or programmes in English is an important determinant of a country's attractiveness to international students (OECD, 2016a). UAS are a lot more active than universities in tailoring undergraduate education to international students. They also currently rely heavily on third-country (non-EU) students. Thus, in February 2017, there were 81 bachelor programmes in English in UAS on the "Study in Finland" website. When it comes to master's programmes in English, Finnish universities currently offer 283 programmes leading to a degree, as opposed to 44 at UAS.

Finland is the least internationalised of the Nordic countries in terms of international co-publications and co-inventions, though the differences are relatively small and the gap has been shrinking in recent years (Figures 4.9 and 4.10; Academy of Finland, 2016). The

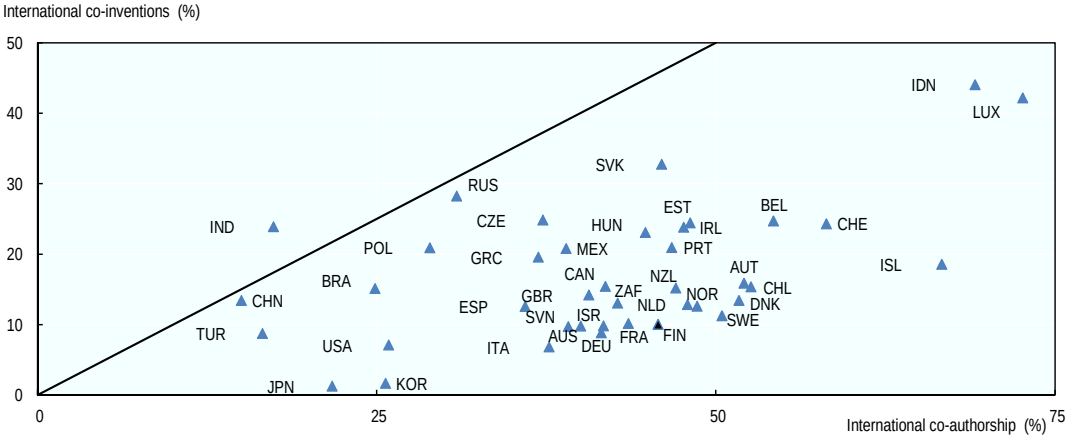
improvement is largely explained by Finland catching up to the other Nordic countries in the fields of medical science, engineering and technology, and natural sciences. The largest and most persistent gap is in the humanities, which is the area where Finland has traditionally had a very low level of international co-publications (based on the Frascati Manual [OECD, 2015b] research area classification). Overall, the Nordic countries' level of co-publications is lower than for Switzerland or Singapore, the latter of which departed from a much lower level than any of the Nordic countries only ten years ago.

Figure 4.9. **International co-publications as a share of total publications, 2005-2015**



Source: Authors calculations based on SciVal® database, Elsevier B.V., www.scival.com, downloaded on 18 October 2016.

Figure 4.10. **International collaboration in science and innovation, 2003-12**



Sources: OECD, *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, June 2015; OECD and SCImago Research Group (2016), "Compendium of bibliometric science indicators 2014", http://oe.cd/scientometrics.

A comparison of some of the top universities (in terms of publications) in Finland, Norway and Sweden reveals some interesting insights (Table 4.2). Finnish institutions tend to have fewer foreign institutions among their top collaborating institutions than their Swedish or Norwegian counterparts. For all institutions, the Field-Weighted Citation Index is higher for international co-publications than for all publications (mirroring other analyses on citation impacts of international co-publications).

Table 4.2. **Comparison of Finnish, Norwegian and Swedish universities, selected indicators, 2011-15**

	Number of foreign institutions among top ten collaborating institutions	Total number of scientific publications	Largest publication areas	Field-weighted citation index (FWCI)	FWCI for international co-publications	Top corporate co-publication partners
Comprehensive universities with large medical faculties						
University of Helsinki	4	26 632	NS (39.6) MS (33.6)	1.87	2.44	Novo Nordisk (66) Nokia (65)
University of Turku	3	10 658	NS (39.4) MS (34.3)	1.64	2.07	Nokia (23) Novo Nordisk (22)
Lund University	6	27 177	NS (38.5) MS (33.5)	1.88	2.36	Novo Nordisk (117) Astra Zeneca (101)
Uppsala University	4	24 929	NS (42.6) MS (32.8)	1.88	2.31	Astra Zeneca SE (259) Astra Zeneca UK (79)
University of Oslo	7	25 588	MS (39.6) NS (35.4)	1.86	2.47	Lockheed (56) Statoil (52)
Technical universities						
Aalto University	2	13 389	NS (51.0) E&T (30.7)	1.65	1.93	Nokia (207) Nokia Siemens (35)
Royal Institute of Technology (KTH)	6	18 059	NS (52.4) E&T (34.4)	1.67	1.92	ABB (110) Ericsson (104)
Norwegian University of Science and Technology (NTNU)	4	18 678	NS (42.9) E&T(24.9)	1.6	2.04	Statoil (211) GE Healthcare (27)

Notes: MS = medical sciences; NS = natural sciences, E&T = engineering and technology. Institutions have been selected according to their size (top national institutions according to publications) and their comparability (in terms of makeup of research disciplines).

Source: SciVal® database, Elsevier B.V., www.scival.com (downloaded 18 October 2016).

The government has tried to promote internationalisation by including four internationalisation indicators in the budget formula according to which it allocates basic funding to universities. International student mobility, the share of Master's degrees awarded to international students, the share of international research and teaching personnel, and the share of research funding obtained in international competition (or from non-Finnish sources) account for 1%, 2%, 2% and 3%, respectively, in the funding model for 2017, for a total of 8%. However, it has removed the share of PhD degrees awarded to foreign nationals, which made up 1% of total funding in the 2013 and 2015 funding models.

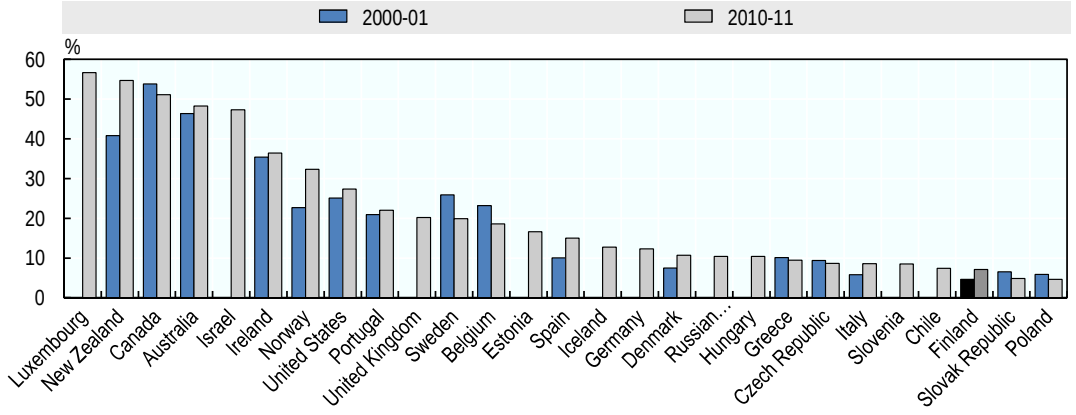
Overall, internationalisation has been given considerable attention in the new university funding models. Judging from the Swedish experience, the introduction of tuition fees for third-country students is likely to lead to a significant drop in the number of these students. Sweden suffered a nearly 80% decline in non-EEA students after it introduced tuition fees.

International mobility is an important driver and determinant of the globalisation of science, technology and innovation. According to Athreye and Cantwell (2016: 76), the ethnic composition of the inventive workforce of firms based the United States "… is an important factor in whether the firm engages in international collaboration". Similarly

Kerr and Kerr (2015: 6) argue that "[e]thnic networks have been shown to play important roles in promoting international trade, investment, and cross-border financing activity, with recent work particularly highlighting the role of educated and/or skilled immigrants…". The low share of foreign-born doctorate holders (Figure 4.11) – around 7% in 2010-11, compared to 32% in Norway and 20% in Sweden – as well as the low share of highly educated individuals in the immigrant population (Figure 4.12) and the relatively large gap between immigrant and native populations compared to other OECD countries indicate that Finland is currently not attracting global talent to the degree it could.

Figure 4.11. **Foreign-born doctorate holders, 2013**

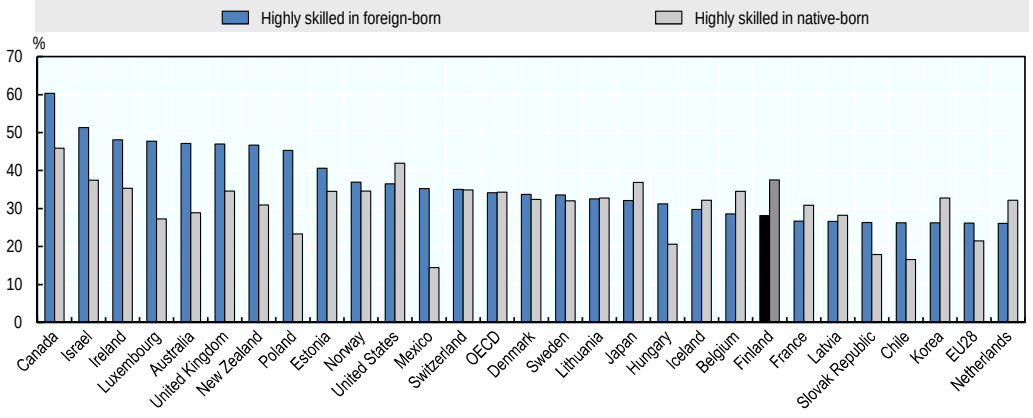
As a percentage of all doctorate holders



Source: OECD (2013), *Database on Immigrants in OECD Countries* (DIOC), www.oecd.org/els/mig/dioc.htm.

Figure 4.12. **Highly educated individuals in immigrant and native-born populations, 2013**

As a percentage of relevant group, 15-64 year-old population not in education



Note: Data for Japan are for 2010; for Chile and Israel for 2011; and for Mexico and the United States for 2012.

Source: OECD/European Commission (2015), *Indicators of Immigrant Integration 2015: Settling In*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264234024-en.

The mobility of students and researchers, though improved, remains a challenge for Finland. This constitutes an untapped potential for strengthening the research, innovation and competitiveness of Finnish actors. Greater international mobility of students and researchers could contribute significantly to strengthening the linkages of Finnish firms to emerging and strategic markets and innovation hubs. Currently, however, given the limited degree of internationalisation of Finnish HEIs, this avenue is sorely underexplored. The expected introduction of tuition fees is likely to result in a drop in international inward mobility of students, unless it is accompanied by other initiatives to strengthen Finland's attractiveness to international students and international talent more broadly speaking.

Box 4.2. **STINT Internationalisation Index**

STINT, the Swedish Foundation for International Cooperation in Research and Higher Education, has developed a tool to measure how international a higher education institution is. The STINT Internationalisation Index covers several aspects of internationalisation. The results indicate large differences between the 28 Swedish institutions that have been studied. With this internationalisation index, STINT offers a novel opportunity to measure in a relatively comprehensive manner how international a higher education institution is. Data come from established sources such as Statistics Sweden, the Swedish Higher Education Authority and Elsevier. Six aspects of internationalisation are covered:

1. research collaboration using international co-publications
2. student mobility in and out
3. international PhD students
4. educational offer in English
5. staff's international academic experiences
6. leadership's international academic experiences.

Overall the Stockholm School of Economics receives the highest value and scores five stars in the STINT Internationalisation Index. Other higher education institutions (HEIs) with a clear scientific profile such as KTH, the Royal Institute of Technology, Karolinska Institutet, the Swedish University of Agricultural Sciences and Chalmers University of Technology score high and some of the comprehensive HEIs are not far behind. The younger and smaller HEIs are, on the other hand, often considerably less internationalised.

To conclude, after a long period of continuously increasing public funding (in real terms), Finnish universities have recently entered a period of funding stagnation and even real-term cuts. The concurrence of increasing focus on research excellence – as defined by peer-reviewed papers in top journals – combined with drastic cuts for funding of long-term industry-academia co-operation (partially through Tekes' budget cuts and Tekes' reorientation towards SMEs) as well as cuts in research institutes' funding does not appear to be part of a grand design or explicit strategy. It has, however, unintended and potentially rather damaging consequences for the utilisation, relevance and societal impact of Finland's public research and the long-term competitiveness of Finnish enterprises.

In general, it seems that a large redimensioning of public funds for research and innovation has taken place and is still taking place without a clear direction, strategy or vision of what the government wants to accomplish. Particularly, the cuts in Tekes'

budget seem to have, at least to some extent, an unintended consequence of general fiscal consolidation rather than being based on a conscious shift in policy emphasis away from industry-related research and innovation funding.

There are some signs that the emphasis that has been placed on peer-reviewed publications in the new funding models, combined with the cutbacks for industrially oriented collaborative research, have led to an excessive focus on peer-reviewed top-tier publications in "safe-bet areas" at the expense of societal interaction; more explorative, experimental or interdisciplinary research; problem-oriented research; and the utilisation of research results.

Public research institutes

Public research plays a key role in innovation systems by providing new knowledge and pushing the knowledge frontier (OECD, 2014a). Public research institutes (PRIs) in Finland carry out a substantial part of the country's public research funding, totalling EUR 501.9 million in 2016 (Statistics Finland, 2016). Research performed by PRIs and government agencies accounted for 8.2% of total research in 2015, down from 10.6% in 2000 (OECD, 2016c; 2017a). The comparable figures for Sweden and Norway for the same year were 3.4% and 15.1%, respectively, though it should be pointed out that the Swedish figures do not include the research performed by the industrial research institutes or research and technology organisations grouped under the umbrella organisation Research Institutes of Sweden (RISE), since these are categorised as enterprises. The Finnish PRI sector is thus larger than in Sweden in terms of the share of total research performed, but smaller than in Norway (Table 4.3). GERD as a percentage of GDP performed by PRIs was 0.30% in 2014.

An important research performer in Finland

Historically, government research institutes have constituted an important component of the Finnish research system (Lemola, 2014). Their importance was especially pronounced from their creation in the late 19th century up until the 1960s, when there were only few universities in Finland and business sector R&D was low. Since their existence, Finland's PRIs have adjusted their objectives over a broad range of activities, governance mechanisms and funding structures, reflecting the evolution of technologies and subsequent policy priorities.

Originally, many research institutes were set up to target specific research needs of industrial sectors important within the Finnish economy, such as agriculture and forestry or health. The formation of a Finnish innovation system was facilitated in particular through the formulation of science and technology policies from the mid-1960s to the mid-1970s, building the basis of Finland's innovation system. These policies were partly triggered as a response to sluggish private sector R&D that was considered low compared to international levels (Oinas, 2005). In 1967, the Finnish National Fund for Research and Development was established to provide research and development grants financed from the revenues the fund generated over the long-run (Torregrosa, 2016). Eventually though, the allocation and administration of competitive R&D funding was assigned to the Finnish Funding Agency for Innovation (Tekes) with its inception in 1983.

Following the initial phase that had built the foundation of Finland's innovation landscape, policies increasingly focused on the support of technological innovation (Georghiou et al., 2003). Over the course of the 1980s, policies to frame Finland's national innovation system emphasised technical research along with the rapidly evolving

ICT sector (Oinas, 2005). Subsequently, Tekes' distribution of competitive research grants was adapted to funnel R&D financing increasingly to firms and research organisations, with the goal to eventually improve interaction and co-operation across firms, universities and public research institutes in Finland (Lemola, 2003).

With increasing evidence of the need to complement the support of innovative technologies with strategies to facilitate the development of innovative services, Tekes' innovation support strategy over the past decade has shifted, while sector-specific technology programmes, such as in the healthcare sector, have remained an important focus area of the agency (Toivonen, 2007). As a reaction to this call for better aligning research activities along innovative services that reflect economic and societal challenges, institutional responsibilities have shifted, and new capacities have been created, such as at Tekes and the Technical Research Centre of Finland (VTT). In addition, with shifting industrial and technological specialisation, policy design increasingly reflects changing priorities in Finland and other OECD countries (Georghiou et al., 2003). To facilitate the funding of long-term and programme-based research addressing major societal challenges in Finland, the Strategic Research Council (SRC) at the Academy of Finland was created. Chapter 6 of this report provides a detailed overview of the SRC.

Today Finland is a country with a strong, but not overly prominent, research institute landscape. There has been a trend towards increasing the share of state-funded R&D in the higher education sector, both in Finland and internationally, with a concurrent reduction in the share of R&D resources allocated to research institutes (Arnold, Barker and Slipersæter, 2010). This trend has been witnessed across all Nordic countries.[13] Finland, the Netherlands, and Norway have retained a policy of supporting a strong system of research institutes focusing on applied research and development. Sweden on the contrary "has consolidated and strengthened its rather small, applied industrial research institute system and slightly increased its core funding in recent years" (Loikkanen et al., 2013).

Yet the Finnish PRI sector's share of R&D has fallen since 2000 (Table 4.3), primarily reflecting cuts in basic government funding, and is likely to fall further as the brunt of further government budget cuts will be applied between 2015 and 2019. Public funding of PRIs has been slashed both as part of overall austerity measures and as a result of a reform specifically targeting the PRI sector, which will be discussed in greater detail below. The changes in the Finnish PRI sector are not as dramatic as those in Denmark, where many government research laboratories were merged into universities. At the same time, as opposed to Germany and the Netherlands, where R&D expenditure in the PRI sector has been relatively stable or even slightly increased, Finland's PRI sector has been shrinking continuously since 2009 and is likely to contract even further in the coming years, unless the significant cuts in public funding can be matched by increases in external funding.

PRIs made up 6 of the top 20 Finnish publishing institutions between 2011 and 2015. In Norway 7 public research institutes are among the top 20 largest publishing institutions, while in Sweden there are not any. Overall, Finnish PRIs and government agencies account for around 11% of total Finnish publications, compared to around 14.5% in Norway and less than 3% in Sweden for the period 2011-15 (calculation based on data from SciVal). The comparison underlines the greater importance of PRIs in Norway and Finland compared to Sweden, but also the fact that with SINTEF and VTT, Norway and Finland have large industrial research institutes that dominate their national contexts, while also being significant international players.

Table 4.3. **Percentage of gross domestic expenditure on R&D (GERD) performed by the government sector**

	2000	2009	2010	2011	2012	2013	2014
Austria	..	5.34	5.24	5.14	4.58	4.44	4.44
Denmark	..	2.07	2.21	2.03	2.37	2.32	2.32
Finland	10.58	9.10	9.25	8.85	9.01	8.92	8.65
France	17.32	16.31	14.02	13.85	13.16	13.03	13.10
Germany	13.58	14.81	14.79	14.52	14.34	14.88	14.83
Netherlands	12.04	12.75	11.74	10.78	11.84	12.23	11.85
Norway	..	16.38	16.41	16.44	16.42	15.98	15.24
Sweden	..	4.37	4.87	4.31	4.80	3.68	3.75

Note: .. = data not available.

Source: OECD (2016c), "Main Science and Technology Indicators (Edition 2016/1)", *OECD Science, Technology and R&D Statistics* (database), http://dx.doi.org/10.1787/db23df7c-en.

There is one research and technology organisation in Finland: VTT, under the Ministry of Economic Affairs and Employment. Other PRIs under other ministries are mission-oriented, with a broad range of research objectives. Some of them are primarily focused on research (both basic and applied), while others have a number of additional responsibilities, such as monitoring, data collection and management, certification and inspection. VTT has been unique in Finland, both due to its size and its role as a research and technology organisation with a strong focus on industry-oriented R&D (Loikkanen et al., 2013). In 2015, VTT accounted for 47.8% of all researchers (FTE) in PRIs, and it allocated 50.3% of all R&D funding, 91% of all R&D funding from Finnish companies, 97% of all R&D funding from foreign companies and 61% of all EU funding (Ministry of Education and Culture, 2016). An evaluation of VTT in 2013 concluded that "research institutes are especially important for industry in Finland because companies are more dependent on external innovation partners than is the case in the other Nordic countries or the Netherlands" (Loikkanen et al., 2013: 19).

In 2013, i.e. before the reform of public research institutes that is discussed in detail below, basic or institutional government funding accounted for 49% of PRIs' total research funding (Halme et al., 2016). In Norway, basic funding accounts for 12% of total R&D funding on average (Kotiranta and Rouvinen, 2016). In general, basic funding from government accounts for a significantly higher share of institutes' total revenue than for corresponding institutes in Norway or Sweden. At VTT, Finland's largest public research institute, basic funding from government has accounted for 20-30% of total public funding, whereas for most other institutes the share of basic public funding is 50-80%. In Norway, "block funding as a share of total operating revenue varies among the institutes, it is on average 7% among the technical-industrial institutes and 12-14% in the other arenas" average (Kotiranta and Rouvinen, 2016). For the Swedish industrial research institutes, which should be compared primarily with VTT, basic funding from the government has accounted for 18-20% of total funding in recent years (RISE, various years). By comparison, for the German Fraunhofer institutes as a whole, basic funding from the government accounted for 29% of total research funding in 2015; this does not include major infrastructure capital expenditure and defence research (data supplied by Fraunhofer Gesellschaft).[14]

A far-reaching reform of Finnish public research institutions

In September 2013, the Finnish government adopted a Resolution on Comprehensive Reform of State Research Institutes and Research Funding,[15] which focuses on building up multidisciplinary, high-level research of significant societal relevance and research in support of government decision making. The resolution covers the reorganisation of PRIs, reallocation of some public research funding to competitive research funding, and the creation of a new, strategic research funding instrument within the Academy of Finland to support long-term research on challenges facing Finnish society. The Team Finland Strategy published in June 2013, which is becoming an essential element of Finnish science, technology and innovation (STI) policy, will be updated annually but not continually reinvented, in order to maintain its long-term perspective and continuity. A first-ever evaluation of the Research and Innovation Council was conducted to support the development and strengthening of the operation of the council. The government is also carrying out the Central Administration Reform Project (KEHU) to improve co-ordination and coherence in government (OECD, 2014a).

Leading up to this reform, the Finnish government has significantly changed the funding and structure of the country's public research institutes over the past decade. The number of national research institutes has declined from 19 in 2009 to 12 in 2016 as a result of several mergers, the integration of 2 institutes into the University of Helsinki and the fact that the Institute for the Languages of Finland (KOTUS) is no longer a PRI as its research activities have been transferred to universities. Table 4.4 lists public research institutes in Finland, their mission, vision or tasks, ministry affiliation, budget and staff. The institutes vary considerably in terms of research scope, and particularly the extent to which they focus on basic academic research, as opposed to applied research, with the goal to facilitate innovation in specific sectors.

In addition, evaluation has also taken on greater importance. All the STI institutions have been evaluated, including the Funding Agency for Technology and Innovation (Tekes); the VTT Technical Research Centre; the Academy of Finland; the strategic centres for science, technology and innovation; and the Research and Innovation Council (OECD, 2014b). Subsequent to this evaluation process, changes in the organisational structure of some of the research institutes have been implemented. Thus, since 2015, the largest research institute (in terms of research funding), VTT, is now a not-for-profit, fully state-owned limited company.

The changes were initiated by the 2013 reform of PRIs, which can be argued to have been on the policy agenda since the 1970s, based on a widespread view of the need to reorient institutes in response to a rapidly changing economy and to focus them more on societal needs (see also Solberg et al., 2012). Prior to the reform, PRIs had been "under increasing pressure to ensure more evidence-based decision making and to provide effective and cost-efficient support for the ministries" (Lähteenmäki-Smith, 2014). A special study argued that PRIs' orientation along silos corresponding to individual ministry interests was out of date in the context of today's global challenges, and that they needed to be reorganised into larger, more polytechnic entities, and in some cases be merged with universities (Lankinen, Hagström-Näsi and Korkman, 2012). An international evaluation of the Finnish research and innovation system commissioned by the Ministry of Education and Culture and the Ministry of Economic Affairs and Employment in 2008 and published in 2009 pointed to the need for reform of the PRIs and "sectoral research" more generally in order to better meet the contemporary needs of society and the economy (Edquist, Luukkonen and Sotarauta, 2009).

Table 4.4. **Public research institutes in Finland**

	Mission/vision/tasks	Ministry	Budget[1]	Staff (full-time equivalents)
Technical Research Centre of Finland (VTT)	To create knowledge and know-how which benefits the renewal of business in companies	Ministry of Economic Affairs and Employment	250.7 (turnover) (2015) (34%)	2 057 (2015)
Natural Resources Institute (LUKE)	"a research and expert organisation that works to advance the bio-economy and the sustainable use of natural resources"	Ministry of Agriculture and Forestry	118.7 (2016 est) (65%)	1 319 (2016 est) (person years)
National Institute for Health and Welfare (THL)	– To promote the welfare and health of the population – To prevent diseases and social problems – To develop social and health services	Ministry of Social Affairs	165.2 (2016) 81%	946 (2016) (person years)
Finnish Meteorological Institute	"To provide the Finnish nation with the best possible information about the atmosphere above and around Finland, for ensuring public safety relating to atmospheric and airborne hazards and for satisfying requirements for specialised meteorological products"	Ministry of Transport and Communications	73 (total expenses) (2016) (63%)	627 (2016) (person years)
Finnish Environment Institute (SYKE)	Crucial information and innovative solutions for a sustainable society	Ministry of the Environment	54.8 (2016) (52%)	580 (2016)
Finnish Institute for Occupational Health (FIOH)	Specialises in well-being at work, research, advisory services and training	Ministry of Social Affairs	60.2 (2015) (55%)	590 (2015) (person years)
GTK: Geological Survey of Finland	To create solutions that embrace new technologies, advance emerging business areas and promote sustainable growth	Ministry of Economic Affairs and Employment	48.7 (2015) (73%)	460 (FTE) (2016)
National Land Survey of Finland	Performs cadastral surveys such as parcelling and reallocations of pieces of land, produces map data, and promotes the joint use of such data	Ministry of Agriculture and Forestry	136.7 (2016) (33%)	1 766 (2016)
Government Institute for Economic Research (VATT)	"An expert economics research unit focusing on public economics issues and policy evaluation"	Ministry of Finance	5.5 (2016) (ca. 66%)	ca. 50 (2016)
Finnish Institute of International Affairs (FIIA)	Produces topical information on international relations and the European Union, realising its aims by conducting research as well as by publishing domestic and international reports on current international issues	Parliament	4.1 (2016) (83%)	47 (2016)
Radiation and Nuclear Safety Authority	Protect people, society, the environment from the harmful effects of radiation, while preventing radiation and nuclear accidents	Ministry of Social Affairs and Health	39.9 (2016) (30%)	321 (2016)
Finnish Food Safety Authority	"Ensuring food safety, promoting animal health and welfare, and developing the prerequisites for plant and animal production, and plant health"	Ministry of Social Affairs and Health	55.8 (2016) (86%)	644 (2016) (person years)

1. Of which basic funding from government.

Sources: Organisations' websites.

One of the original and principal objectives behind the reform that was adopted in 2013 was that resources allocated to research institutes should be shifted from basic or primary knowledge creation to more "high value-added areas" addressing economic and social challenges prevailing in Finland. A second objective of the reform was to strengthen knowledge- and evidence-based policy making in Finland. There was also a desire to increase the share of PRIs' competition-based funding. Evaluations, for example of the National Institute for Health and Welfare, found that there was a need to increase the impact of research, and to communicate better the research results to decision makers, customers and citizens, confirming that PRIs needed to become more relevant and responsive to the changing needs of society. Finally, the reform of Finland's PRI sector intended to build their role as intermediaries between firms and universities.

The objectives were to be achieved by cutting funding from the research institutes and reallocating it, firstly, to the SRC established at the Academy of Finland, and, secondly, to a newly established Government Policy Analysis Unit at the Prime Minister's Office. Thus, basic or institutional R&D funding to public research institutes has been cut drastically, from EUR 319 million in 2009 to EUR 197 million in 2016. As a share of the government's total spending on R&D, basic or institutional funding for PRIs sank by one-third, from 15.8% in 2008 to 10.7% in 2016.

The funding cuts were applied evenly across all institutes, using a "cheese slicer" approach, i.e. funding was cut by the same percentage using each institute's government basic R&D funding in 2012 as a basis. As a result, VTT's government basic funding will fall by EUR 20.7 million between 2014 and 2017, accounting for over 30% of the total funding transferred from PRIs to the new instruments, in particular the SRC and the central government's research and analysis resources (Prime Minister's Office, 2013). The share of basic funding the various institutes receive from the government differs greatly, ranging from between 20% and 30% for institutes like VTT – which obtains a significant part of its funding from industry and competitive funding sources – to institutes that receive 70-80% of their revenue in the form of basic funding. In 2015, when cuts had already been initiated, for the largest research institutes after VTT (the Natural Resources Institute, the National Institute for Health and Welfare, the Finnish Meteorological Institute, the Finnish Environmental Institute, and the Finnish Institute of Occupational Health), basic government funding accounted for between 50% and 67% of total funding.

This approach to cutting funding could be argued to hit institutes with a lower share of basic funding significantly harder than institutes with larger shares of basic funding. As of January 2016, the funding cuts and institute mergers had resulted in staff reductions of 335 persons at VTT and 210 full-time equivalents (FTEs) at the Natural Resource Institute (data from the Prime Minister's Office). Overall, the number of researchers or equivalent at PRIs (FTEs) fell by 24.2% between 2011 and 2015 and overall R&D funding fell by 23.6% (Table 4.5). The merger of some of the research institutes was driven by a similar will to overcome disciplinary and ministerial boundaries. As stated earlier, one of the key driving forces behind the reform, adopted in September 2013, is to increase PRI's orientation towards problem-oriented and long-term research targeting solutions to societal challenges.[16] The merger of some of the research institutes, effectuated in 2015, sought to create larger and stronger organisations that can perform multidisciplinary research, rather than being limited by a narrow sector perspective, and that can compete for funding at the European level. Thus, rather than serving one ministry, the ambition is that the research needs of various ministries are well co-ordinated to guide the activities of the reformed research institutes.

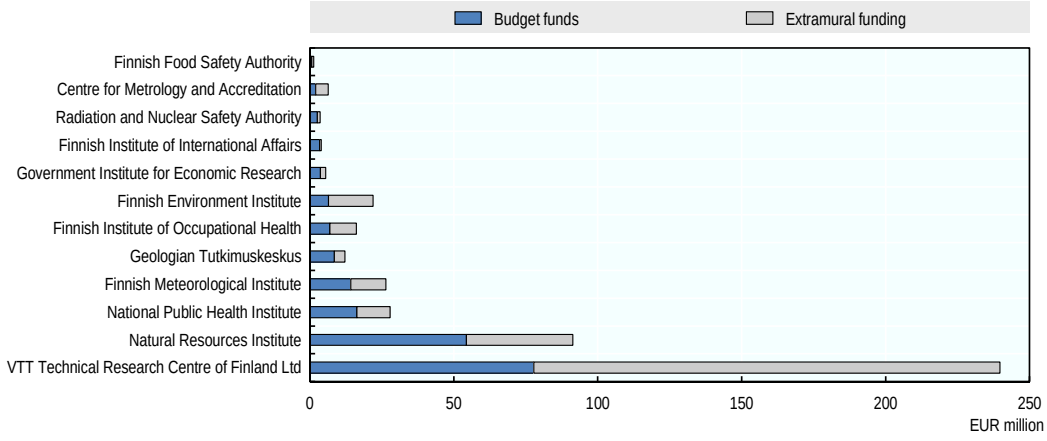
Table 4.5. **Number of researchers and research funding at public research institutes in Finland**

	Researchers and equivalent (full-time equivalent)	Research funding (EUR thousand)
2011	4 023	558 741
2012	3 849	536 947
2013	3 876	517 114
2014	3 522	488 058
2015	3 051	426 866
Change 2011-15	-24.2%	-23.6%

Source: Ministry of Education and Culture (2016), *Higher education and research and development activity database*, https://vipunen.fi/en-gb/higher-education-and-r-d-activity.

The government also expressed a desire for improved co-operation between research institutes and universities.[17] Currently, joint employment between universities and PRIs remains limited; institutes and universities co-operate primarily based on joint research projects. Some of the institutes, such as the Finnish Natural Resources Institute (LUKE), the National Institute for Health and Welfare (THL), and the Finnish Environment Institute (SYKE) maintain regional offices on university campuses, e.g. in Oulu, Turku and Jyväskylä. Figure 4.13 provides additional information of the composition of the R&D budget of public research institutes in 2016.

Figure 4.13. **R&D budget of public research institutes, 2016**



Source: Statistics Finland (2016a), "Statistics on state budget-funded research institutes, research activities, and total research funding in 2016", http://tilastokeskus.fi/til/tkker/2016/tkker_2016_2016-02-25_tau_005_fi.html (accessed 5 March 2017).

VTT was founded in 1942 and is by far the largest of the Finnish PRIs today. It provides research, technology and innovation services in Finland and internationally. VTT differs from other Finnish PRIs in size, the share of funding secured from competitive sources, and its strong focus on supporting innovation in business and industry (Loikkanen et al., 2013). In 2015, the VTT group had a turnover of

EUR 252 million and a total staff of 2 309 (FTE; data provided by VTT). It operates under the mandate of the Ministry for Employment and the Economy.

VTT is the largest multi-technological applied research organisation in Northern Europe. VTT's turnover was EUR 251 million in 2014, external revenue of EUR 163 million (65% of turnover), block funding EUR 88 million (35% of turnover) and revenue from abroad EUR 52 million (21% of turnover). VTT has four subsidiary corporations: VTT Expert Services Ltd, VTT Ventures Ltd, VTT International Ltd and VTT Memsfab Ltd. VTT Expert Services Ltd. offers certification and product approval services, testing and inspection services and calibration services. VTT Memsfab Ltd. provides contract manufacturing services in the area of microelectromechanical systems (MEMS) and other micro- and nanoelectronic devices, while VTT Ventures invests in new ventures in the seed phase. VTT has a critical role in driving Finnish participation in EU research programmes, illustrated by VTT ranking first in Finland in raising funds from EU framework programmes (22% of all framework programme funding allocated to Finland). According to the European Research Ranking, VTT is ranked fifth among research and technology organisations, and tenth among all European research organisations (public research organisations, HEIs, research units of enterprises, funding organisations) based on a composite score of project funding, number of projects, networking rank or reputation, partner constancy and project leadership (Halme, Saarnivaara and Mitchell, 2016; www.researchranking.org). This puts VTT at the top of all research organisations (including universities) in the Nordic countries. VTT Group receives basic research funding from the government to carry out its principal task, the creation of knowledge and know-how to benefit the renewal of business in companies.

For about 15 years, Nokia was VTT's primary customer, contributing up to EUR 15 million in annual funding at its peak. By contrast, in 2016 VTT only invoiced around EUR 1.5 million to Nokia. However, VTT has successfully diversified its customer base and has become an important international actor in recent years, with income from foreign sources of funding tripling in the past five years. VTT has been one of the largest recipients of EU funding in Finland in recent years, channelling around 35% of total EU funding allocated to Finland. In recent years, VTT has been targeting areas of research that could attract multinational companies to Finland (e.g. Internet of Things, healthcare). It is currently organised according to three principal business areas: "knowledge-intensive products and services" (including sensing and integration, connectivity, and data-driven solutions), "smart industry and energy systems", and "solutions for natural resources and environment". Traditionally, collaboration with universities in Finland and abroad has been extensive, very much driven by a bottom-up approach, i.e. the collaboration of individual researchers or research groups.

In terms of public funding, VTT has been hit particularly hard by the recent reforms and budget cuts to PRIs. Prior to these reforms, approximately one-third of VTT's budget for basic funding came from the government; another third came from Tekes, the Academy of Finland, EU programmes and other sources of competitive funding; and the remaining third from industry (both domestic and foreign). The reform of PRIs will lead to a significant reduction in VTT's basic funding from government (this does not make sense and the point has been said already in many other places). Furthermore, cuts in Tekes' budget have led to a sharp decline in direct funding of VTT, which was expected to drop from around EUR 50 million in 2015 to EUR 39 million in 2016. Cuts in Tekes' funding indirectly impact VTT's revenues, as large companies receiving funding from Tekes have fewer resources available to purchase research and development services from VTT. The impact of Tekes' budget cuts on VTT is expected to increase in 2017

and 2018 in addition to the cuts already applied in 2016. This is a matter of concern as VTT has played a critical role in R&D research that has more of a long-term and strategic orientation as compared to Finnish companies that are more reluctant to invest in this type of research today. Hence, Tekes' funding cuts have adverse effects on long-term and strategic collaboration across industry and academia, but also on the ability to drive radical innovation and on the ability of the private sector to develop and absorb new and enabling technologies.

While VTT continues to be successful in obtaining funding from competitive sources and from industry, the cuts in public funding, either directly from ministries or through Tekes, are restricting its ability to enter new and strategic areas for technological development. This also impedes the commercial application of new technologies with and for companies, as their development requires a long-term horizon, and funding mechanisms that companies are currently unable or unwilling to provide. In particular, Tekes' funding – often funnelled to VTT – can be argued to have been important for more strategic or long-term corporate R&D. Government funding of VTT is project- or programme driven and the result of close co-ordination with the Ministry of Economic Affairs and Employment. In this process the ministry has become more involved in setting the research specificities of VTT as compared to the pre-reform model.

Other research institutions

LUKE: This PRI was created in 2015 as the result of the merger of three institutes – MTT Agrifood Finland, Forest Research Institute Metla, and the Game and Fisheries Research Institute RKTL – and the Information Centre of the Ministry of Agriculture and Forestry (TIKE). LUKE operates under the Ministry of Agriculture and Forestry. Between 2014 and 2016, LUKE's – or the combined amount of its predecessors' – basic government funding shrunk by 20%, amounting to 65% of the institute's total funding in 2016 (LUKE estimate, 2017), compared to 67% in 2014 and 69% in 2015. The funding cuts were implemented mainly through a 20% reduction in staff. Other than in Helsinki, LUKE operates principal offices in Jokioinen, Joensuu and Oulu. LUKE's strategic objectives include the promotion of "new bio-based products and new business activities", "productivity through digital solutions" and "revitalising regions through the circular economy". In addition to research, LUKE monitors natural resources and works with certification of plant production, inspection of control agents, storing genetic resources, collecting data on greenhouse gases, supporting natural resource policies, and producing Finland's official food and natural resource statistics. In 2015, the average age of LUKE's employees was 51.

THL: The primary mission of the National Institute for Health and Welfare, under the Ministry of Social Affairs and Health, is "to promote health and welfare in Finland".[18] Among other things its objectives are to develop and promote measures that improve welfare and public health, and mitigate welfare and health problems. Further, THL is concerned with R&D relevant to meet these objectives, to promote innovation, and put forward initiatives and proposals for developing social welfare and healthcare services promoting the health and welfare of the population.[19] In addition to research, THL performs other major functions, such as operating as statistical authority, managing electronic processing of social welfare and healthcare client data, overall responsibility for state mental hospitals and social welfare units, and ensuring the supply and monitoring the quality of vaccines. In 2014, basic government funding accounted for 67% of its total funding (EUR 111 million). In 2014, THL received EUR 74.6 million from the state budget to cover its operating costs and EUR 50.2 million for specific purposes,

which constitute 82% of its total funding (EUR 152.4 million). By 2019, basic government funding will be cut to EUR 47 million from EUR 74 million in 2014. In terms of staff, THL reduced the number of employees by 23% from 2009 to 2015, from 1 238 to 951.

Finnish Meteorological Institute: The Finnish Meteorological Institute is an institute under the Ministry of Transport and Communications. Its finances consisted of appropriations from the state's budget for its core activities, and revenues from commercial services and co-funded operations. Appropriations from the state budget covered 64% of the institute's expenses. Its budget financing reached EUR 46 million in 2015 and revenues amounted to EUR 26.1 million. The institute provides weather forecasting services and is also the official expert authority on air quality, including research, development and testing of air quality equipment.

SYKE: SYKE is a research centre for environmental expertise under the Ministry of Environment. In 2016, it had 580 staff and an operating budget of around EUR 55 million. SYKE's basic funding as a percentage of total funding has declined from around 70% in 1996 to 52% in 2016. The institute's main objectives[20] can be summarised as follows: 1) produce crucial information and innovative solutions for an ecologically, economically and socially sustainable society; 2) respond proactively to society's ever-changing information needs; 3) support decision making in the public and private sectors through internationally competitive R&D activities and excellence in expertise.[21] SYKE is organised into a number of centres, such as the Natural Environment Centre, the Marine Research Centre, the Centre for Sustainable Consumption and Production, the Freshwater Centre, and the Climate Change Programme. It also has laboratories on ecotoxicology, metrology and environmental chemistry and works with data collection.

Finnish Institute of Occupational Health (FIOH): Basic government funding for the FIOH was around 55% in 2015. Outside Helsinki, the FIOH has offices in Kuopio, Oulu, Tampere and Turku. External funding amounts to a total of EUR 8.5 million in 2015, of which EUR 1.3 million were received from the European Union, EUR 2.4 million from the Finnish Work Environment Fund, EUR 1.3 million from Tekes, EUR 1.2 million from different ministries, EUR 0.7 million from the Academy of Finland, and EUR 1.6 million from various other sources. In 2015, it employed 590 persons, down from 736 in 2011. In addition to conducting research, the FIOH offers training courses in areas of occupational safety and health.

The reductions of governmental support for the three institutes that are organised under the Ministry of Social Affairs and Health – THL, FIOH, and the Radiation and Nuclear Safety Authority – have had a significant impact on research. All of these institutes have redefined their strategies, and the number of staff has continued to decline each year since the beginning of the reforms. For example, the FIOH held three co-operation negotiations between 2013 and 2016, leading to a reduction of 146 person-work-years. The reduction for THL is 287 person-years. This has an impact on further research as well as on the collaboration.

Reform of research funding for more strategic research and better decision making

One principal aim of the reform of public research funding has been to strengthen the ability of research and analytical work to inform and support policy making more systematically. To this end, the government has established lines and programmes for

funding "strategic research". The reform also seeks to strengthen co-operation across research institutes and universities through shared research equipment, laboratories, closer co-operation in research and education that includes shared staff, and the establishment of agreement-based consortia (Kotiranta and Rouvinen, 2016).

Basic funding to public research institutes was cut, and in line with the overall objectives listed above, a new funding instrument for long-term and programme-based strategic funding for research to tackle major societal challenges were set up at the Academy of Finland and the Strategic Research Council. According to the budget cut decision, EUR 70 million will be cut from Tekes, the Academy of Finland and the PRIs by 2017, and reallocated to the SRC and to the so-called TEAS-projects[22] (Prime Minister's Office, 2013).

Funding of the SRC will be around EUR 55 million, and universities as well and public and private research institutes are eligible to apply for funding. The objective is to open up competitive-based funding, which will be allocated to strategic, problem-oriented research aimed at finding solutions to societal challenges, with an explicit emphasis on supporting and strengthening policy making (Regeringens Proposition, 2014).

So far PRIs participate in the majority of projects funded by the SRC. However, relatively few research projects are under the leadership of these same institutes. In 2015, 4 out of 16 projects funded by the SRC were led by PRIs, while in 2016 in 2 out of 14 projects the consortium leader was from a PRI (based on funding decisions listed on the SRC homepage) and 1 from the Research Institute of the Finnish Economy, ETLA. Thus, the vast majority of the projects currently funded by the SRC are led by universities.

Overall, given that many of the changes referred to in this section took place only in 2015 and later, it is hard to gauge the effects of the institute reform, on PRIs and on Finland's innovation system more generally. Overall, the reform of the research institutes and research funding was driven by the desire to make institutes more dynamic, as well as making research (carried out both in universities and at research institutes) more responsive to societal and industry needs, as well as more effective in their ability to meet this demand. Table 4.6 lists the principal objectives of the reform, identifies the measures implemented and provides an assessment of their effects.

The SRC is one of the ambitious efforts to strengthen knowledge-based decision making, particularly on complex policy issues such as societal or grand challenges. These efforts do so by promoting policy-relevant, cross-cutting and multidisciplinary research and analysis on themes selected and prioritised by the government. They also put a strong emphasis on continuous interaction with potential users and beneficiaries of the knowledge produced as an integral part of the projects (particularly the SRC). The SRC requires that around 10% of project funding be earmarked for dissemination activities.

The pooling of resources and the establishment of a co-ordinating function at the Prime Minister's Office addressed an important need to overcome ministerial silos and address horizontal policy issues more effectively, as well as signalling the importance of experimentation as an integral part of innovation policy (for a description of the experimentation unit see OECD, 2017b). The attempt to strengthen knowledge- and evidence-based decision making as well as to train academics to carry out policy relevant analysis is ambitious and quite unique, at least among the Nordic countries. However, it is too early to tell to what extent efforts to strengthen co-ordination have led to improved

policy making and how the reports commissioned by the Prime Minister's Office will be used in policy making and what impact they might have. Furthermore, horizontal policy making might be strengthened further by promoting mobility among ministries, which currently seems to be very low.

Table 4.6. **Reform of research institutes and research funding**

Objective	Measure	Assessment/effect
More strategic research oriented towards societal goals	Strategic Research Council	Not clear this has been accomplished in terms of strategic research on key enabling technologies or prioritised areas, or on applied research and development (with companies and users) for concrete, competitive and scalable products and services. The Strategic Research Council is a good start to strengthen research for policy making and multi-disciplinary research, but not yet matched by translational efforts and innovation.[1]
More dynamic institutes	Cut basic funding, institutes to compete more for funds	Too early to say, but given institutes' rather generous basic funding (especially institutes other than VTT) it should mobilise institutes to seek more external funding (and thus might become more dynamic and relevant)
More knowledge- and evidence-based policy making	Pooling research resources and experimentation at the Prime Minister's Office.	Seems promising to overcome ministerial "silos", but too early to tell how the results of the analysis and research will be used in policy making
Better co-ordination of ministries' research funding and more horizontal/cross-cutting agenda for research/analysis	Ministries annually provide an overview of planned research within their respective area	This has been strengthened
More cross-disciplinary/multi-disciplinary research	Merging of institutes; Strategic Research Council	More needs to be done, such as changing education but also rethinking government programmes and focusing more on policies/initiatives that really address societal challenges; such policies and initiatives need to be both long term and flexible/reflexive; strengthen multi-disciplinary within higher education institutions.

Note: 1. In particular, development of concrete and scalable solutions where companies should play a critical role (so far there are only 3 participating business companies in 31 projects).

Cutting basic funding and merging research institutes makes sense insofar as some institutes receive rather generous basic funding, but one should reconsider the "cheese slicer approach" to institute funding. The latter can be argued to have hit VTT particularly hard, since it had significantly lower basic government funding than all the other institutes. In doing so, it also hit one of the key innovation actors in the Finnish system, and the one that focuses perhaps the most on strategic renewal of Finnish industry and industrial competitiveness.

The relatively slow rate at which external and competitive funding has increased at some institutes in recent years (particularly from the European Union, the Academy of Finland and Tekes) could be seen as a confirmation that some of the institutes could become more dynamic and responsive to changing demands. Some actors are also calling for better collaboration and co-ordination activities among institutes regarding EU

projects and the establishment of a joint venture capital institution to promote commercialisation and utilisation of research results. It is too early to say but the funding cuts, combined with new sources for funding for research on societal challenges – such as the SRC and the Prime Minister's Office's resources for research and analysis – could mobilise institutes to seek more external funding, which in turn could help them become more dynamic and relevant. It is not evident that the reform of the research institutes has led to a reallocation of resources, and a strengthening of more strategic research, which was one of the key objectives behind the reform.

Finally, the research funded by the SRC might be considered to be "strategic" in the sense that it targets important questions in society. However, while systematic efforts to identify and support strategic research and innovation in the sense of investing in the development of "key enabling technologies", or targeting areas identified by the government, such as "bio-economy", "health" or "clean-tech" are under way, there is room for more significant support in these areas. Overall, further developing strategic research, including through adequate steering and funding of public research institutions, remains a challenge.

Notes

1. One of the strengths of the UAS is close interaction with the small and medium-sized enterprise sector as well as developing entrepreneurial competence as a part of higher education curricula.
2. For an overview and analysis of these changes see, for example, Luukkonen (2014a), Aarrevaara and Dobson (2016), and Melin et al. (2015).
3. Ministry of Education and Culture (2009).
4. For further details see Ministry of Education and Culture (2016b).
5. From the same study: "In the UK, the established practice of performance measurement of universities seems to narrow notions of appropriate research content and standards of performance and is becoming an ominous factor in reducing variety and risk-taking in university research. This phenomenon is further developed in the UK, but Finland seems now to be 'catching up'…" (Luukkonen, 2014b).
6. https://www.helsinki.fi/sites/default/files/atoms/files/hu-forstagangssokande-2015.pdf.
7. www.helsinki.fi/sv/studier/kvot-for-forstagangssokande.
8. See, for example, https://www.helsinki.fi/sites/default/files/atoms/files/hu-kvot-for-forstagangssokande-2016.pdf.
9. Although the model is mostly performance-based in principle, all the funding is allocated to universities as a lump sum. Universities then decide internally how it is allocated. All metrics are calculated by using three-year averages to eliminate fluctuation in the institutional funding.
10. http://stat.fi/til/tkker/2017/tkker_2017_2017-02-23_tie_001_fi.html.
11. Starting in 2011, government R&D funding to Tekes was cut, resulting in an overall drop of 47% between 2010 and 2017, in nominal terms. At the same time funding to the Academy of Finland increased by 39%.
12. In addition, there are several practices that support entrepreneurship and innovation initiatives in the Tampere region with links to research and education, e.g. research parks, incubators or technology transfer offices, to promote student entrepreneurship and entrepreneurship training, etc. (Raunio, Räsänen and Kautonen, 2016).
13. For example, in Denmark the merger of many government research institutes into the university system is responsible for the dramatic change that has taken place in the Danish PRI system.
14. Basic funding for the individual Fraunhofer institutes varies widely and is paid out by its central organisation based on a formula including total budget volume, revenue from industry, participation in EU projects and institute spinoffs or start-ups.

15. The study also emphasised that the rest should have access to strategic research funding, some of it disconnected from their "sector" missions, in order to improve or maintain quality and encourage them to carry out more longer term research than is needed to satisfy the short-term needs of their sector masters (Lankinen, Hagström-Näsi and Korkman, 2012).

16. http://vnk.fi/documents/10616/336804/sv.pdf/f137938f-6a22-4add-993c-a2bf93fc8b49.

17. Ibid.

18. www.thl.fi/en/web/thlfi-en.

19. www.thl.fi/en/web/thlfi-en/about-us.

20. www.syke.fi/en-us/syke_info/strategy.

21. According to SYKE, joint publications with universities account for more than 70% of total publications, 20% of joint publications are with foreign universities, but the majority publications is with Finnish universities. SYKE has offices outside Helsinki, namely Oulu, Jyväskylä, Kuhmo and Joensuu.

22. The Government adopts a plan for analysis, assessment and research annually that underpins policy decision making and steers studies and research towards specific priority areas. Under the leadership of the Prime Minister's Office, a specific working group is in charge of formulating the plan. The group comprises experts from all administrative branches. The resources amount to EUR 11 million annually and they will be used for analyses, assessments, foresight reports, impact comparisons of various policy instruments and evaluations of situation awareness scenarios. These TEAS-projects span from a few months to three years.

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Chapter 5

Business sector innovation challenges in Finland

This chapter discusses the main economic and innovation challenges that the Finnish business sector is encountering today. It analyses the main features of the Finnish industry, its economic structure and business demographics, and their recent evolution, as well as current trends in terms of firm productivity and different types of business investment in innovation. The analysis reflects on the ability of Finnish businesses to engage in more radical innovation, and current efforts to strengthen small and medium-sized enterprises' involvement in R&D and innovation. The chapter further discusses what new economic competences for global markets and value-chain integration are required to facilitate access to (global and public) markets. In concludes by examining industry-science collaboration and how growth of young innovative firms and start-ups can be effectively enabled.

Background and overall country profile

The Finnish business sector is facing critical challenges. Finland has not recovered from the industrial decline that began in 2008 and led to a loss of an important part of the country's economic base. The crisis has strongly affected Finland's economic performance and prospects in parts of the manufacturing sector. Sector-specific problems (e.g. in electronics and forestry) combined with external shocks have deteriorated Finland's industrial performance, indicating major problems with regard to productivity growth (see Chapter 2). Finland's productivity in manufacturing has been weak relative to that of Denmark, Sweden and the OECD in total; services have performed better but also lag behind peer countries.

The current situation can be interpreted as the result of a lack of competitive advantages and a highly polarised private sector where small and medium-sized enterprises (SMEs) still play a minor role in generating value added, innovation and global integration. Overall, the business sector has not yet diversified sufficiently and SMEs and several industries (including services) are encountering difficulties to catch-up, generate new competitive advantages and reinforce their position in global markets (OECD, 2016a). The lack of radical (new to global markets) innovation in the business sector, the limited participation of SMEs in R&D activities and weak firm dynamics seem to restrain the process of economic renewal.

A loss of price competitiveness (with wages growing faster than productivity), technological disruption (e.g. in the smartphone market, the rise of digital content to the detriment of traditional paper products), and external shocks have affected business sector development. This has been accompanied by increasing competition from global low-cost competitors, uncertainty and volatility of business cycles, and high domestic costs that have put pressure on margins and opportunities for business growth and recovery. In parallel, budget cuts for funding research and innovation risk further reducing the business sector's ability to recover and forego growth opportunities through innovation.

The combination of productivity erosion, loss of competitiveness and a sluggish international economic environment in Europe has made it hard for Finnish industries to regain their dynamism. To overcome this situation, there needs to be innovation resulting in new products and services and a more efficient use of new technologies (both hard and soft) to boost productivity in the short and long terms. New economic competences as well as more competitive business organisation are needed, based on knowledge, innovation skills and technology.

The Finnish business sector has been dominated by high- and medium-high technology industries but industry structure is currently undergoing change. In 2014, high- and medium-high technology manufacturing represented 4.7% of total employment, which is less than in Germany and the EU28 average (5.7%), but comparable to Sweden (4.4%) and Denmark (5.1%) (Eurostat, 2016b). Knowledge-intensive services have been gaining in importance and today account for 45% of total employment, above the EU28 average of 40%.

After services, manufacturing is the largest business sector in terms of employment and production. The four largest industries in 2015 were: metal industry (41.4% in total value of output); chemicals (21%); forest industry (19.9%); food, and alcohol and tobacco industries (10.8%) (Statistics Finland, 2016a). According to data on industrial output from Statistics Finland, the total value of the sold output of manufacturing industries was about EUR 77.8 billion in 2015.

Finland's manufacturing output has not returned to its 2008 levels (Figure 5.1). This is mainly due to the contraction of the electronics industry and the declining demand for of forestry and metal machinery.[1] Manufacturing has seen its share in the economy shrinking in recent years while services have expanded substantially. As shown in Chapter 2, manufacturing remains the biggest contributor to value added in Finland, accounting for 17% in 2015, which is above the EU average (15.5%) and the level of Sweden (15%). Nevertheless, the share of manufacturing has dropped significantly, from 23.3% in 2007, which is the opposite of Sweden and Norway (which was later affected by the impact of the drop of oil price on its economy). A large part of this decline is due to the decline in manufacturing of computer, electronic and optical products, where value added dropped sharply, from over EUR 8 billion in 2007 to less than EUR 800 million in 2012 (European Commission, 2016). This evolution largely reflects industry restructuring involving Nokia, the largest Finnish firm.

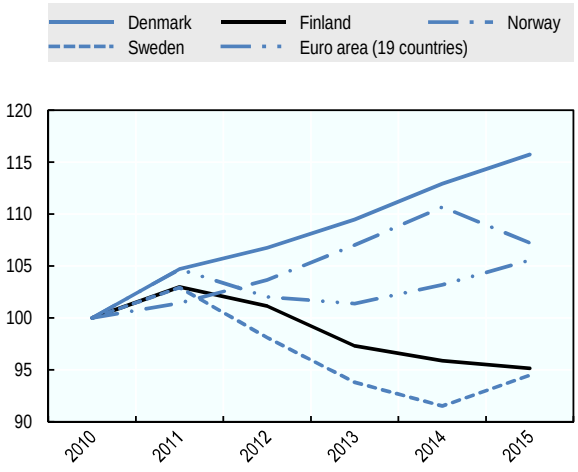
Although Finland still has a strong specialisation in information and communication technology (ICT), wood and paper industries, metal-machinery and basic metals, the share of these sectors in the economy has been shrinking. With the crisis in the electronics industry, exports and output have declined sharply. At the same time the contraction of the paper industry has continued and metal processing has suffered from low market prices. All this is reflected in a deterioration of profitability in manufacturing (Holmström, Korkman and Pohjola, 2014). The services sector, in contrast, has been less affected by the crisis as the evolution of value added between 2005 and 2012 shows (Figure 5.2).

While important parts of the "technology industries" have been struggling in recent years, they continue to play a major role in Finnish exports. According to the Federation of Finnish Technology Industries (2017), "technology industries"[2] are responsible for half of Finnish exports, 75% of private sector R&D and over 31% of employment (direct and indirectly combined). These industries employ around 290 000 employees directly and 700 000 in total. Within these industries, mechanical engineering is the largest and the one with the most employees. In recent years, however, its growth has come to a halt, and the industry is lagging approximately 15% behind its peak in 2008. The electronics and electro-technical industry has traditionally invested heavily in R&D, accounting for 75% of total R&D investment of high-technology industries in 2010. Today this participation has decreased substantially owing largely to Nokia's decline and its impact on other ICT firms.

As in other developed countries, services have substantially increased their weight in the Finnish business sector and the economy, accounting nowadays for 40% of total output. In recent years, services have generated the largest number of new businesses, the majority of which (55%) are experiencing growth. An increasing share of the Finnish workforce is employed in the service sector; since 2000, the private service sector has generated more than 240 000 new jobs in Finland. This positive picture should, however, be interpreted with care. Although service sector growth has been impressive, it has been slow compared to that of Sweden, where recovery from the recession has fundamentally been driven by the strong growth of the service industries, and not by manufacturing (Holmström, Korkman and Pohjola, 2014).

Figure 5.1. **Manufacturing production, selected countries**

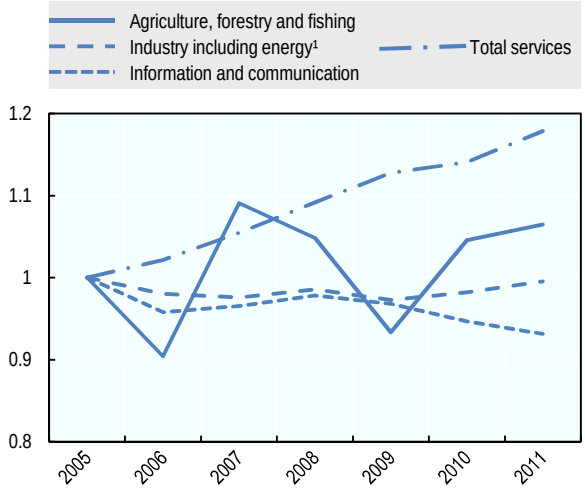
Index 2010=100



Source: OECD (2010), "Production and sales (MEI)", http://stats.oecd.org/Index.aspx?querytype=view&queryname=90.

Figure 5.2. **Value added by sector, Finland**

2005=100



1. Includes mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply; water supply, sewerage, waste management and remediation activities.

Source: OECD (2012), *STAN Database for Structural Analysis* (ISIC Rev. 4), https://stats.oecd.org/index.aspx?datasetcode=stani4.

Business demography

According to data for 2015 (Statistics Finland, 2017), 5 656 large firms operate in Finland alongside 272 245 SMEs. Sixty-six percent of SMEs and 47% of large firms are in the services sector, which is the largest sector in the economy, representing 62% of the total industry value added in 2015. The composition of the Finnish business sector does not differ substantially from a typical OECD or EU28 economy (European Commission, 2016; OECD, 2016b), with large firms representing the bulk of value added (Figure 5.3) and SMEs providing two out of three jobs.

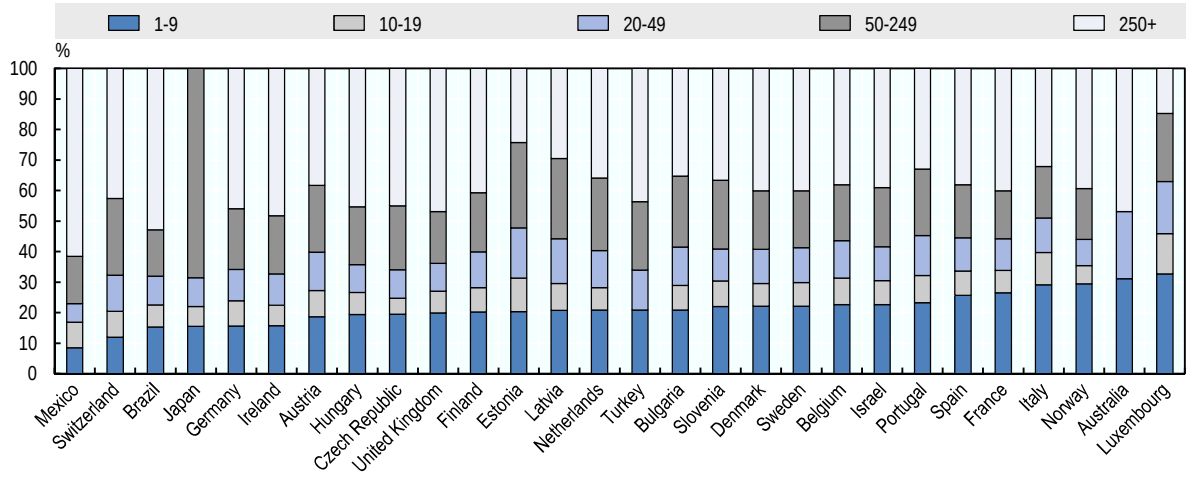
In 2013 SMEs (including micro firms – firms with less than 10 employees) accounted for 59.3% of value added whereas large companies (with more than 250 employees) represented 40.7% (OECD, 2016b). The share of large firms is higher in manufacturing and mining and quarrying, where they account for about 70% and 76% of value added, respectively. In services, the distribution of value added between SMEs and large companies is even greater (48% and 52% for large enterprises and SMEs, respectively). SMEs account for around 65% of total employment, which is comparable to the EU average (European Commission, 2016). Similar to the rest of the European Union, SMEs in wholesale and retail trade, manufacturing and construction together account for more than half of total SME value added and employment. Unlike the non-financial economy as a whole, which stagnated over the period 2010-15, SMEs experienced strong growth, illustrating a growing resilience of these firms.[3]

However, Finland differs from most other OECD countries (for which the respective data are available)[4] in terms of firm age; in particular, young firms play a much smaller role in the Finnish economy than those of other countries. Figure 5.4 describes the age

composition of Finnish firms with less than 50 employees. It shows that the age profile of micro and small firms in Finland is the second oldest of all countries in the sample.[5] Furthermore, the share of young companies among small businesses is also among the lowest in developed countries. This suggests difficulties for the Finnish economy to renew itself and may reflect a limited role of innovation in fostering new economic activity. The nascent SME recovery is not yet reflected in the number of new start-ups, which declined steadily from 2010 to 2014.

Figure 5.3. **Value added by enterprise size, total business economy**

Percentage of total value added, total business economy, 2013 or latest available year

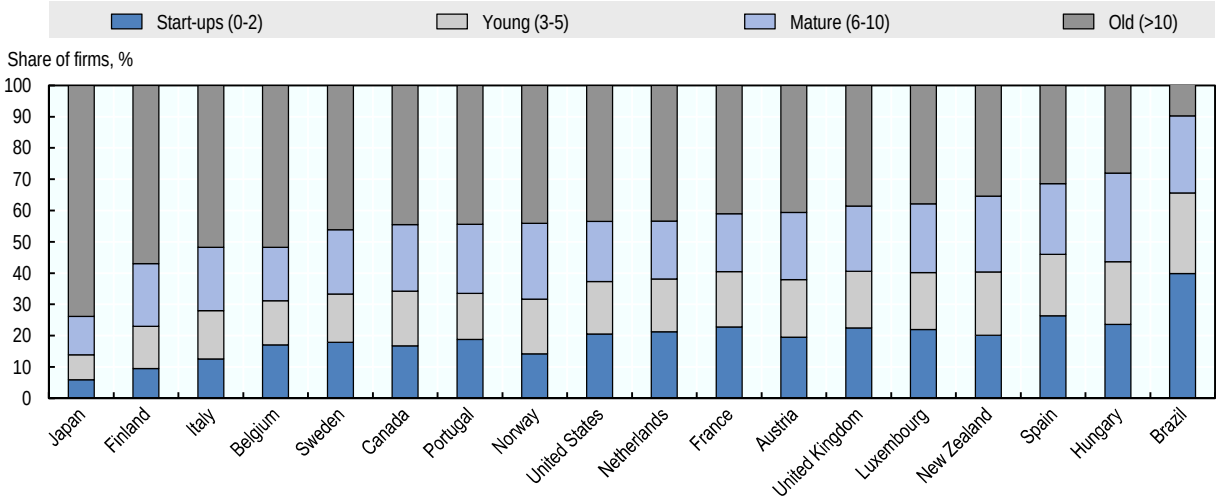


Note: Data cover business economy excluding financial intermediation. Data refer to value added at factor costs in European countries and value added at basic prices for other countries.

Source: OECD (2016d), "SDBS structural demographics business statistics (Isic Rev. 4)", http://stats.oecd.org/index.aspx?datasetcode=ssis_bsc_isic4.

Figure 5.4. **Age composition of small businesses**

Average over time, firms with less than 50 employees



Note: See Criscuolo, Gal and Menon (2014) for the methodology.

Source: OECD DynEmp Project with data for 2010-11, www.oecd.org/sti/dynemp.htm.

The renewal of ICT industries and traditional sectors

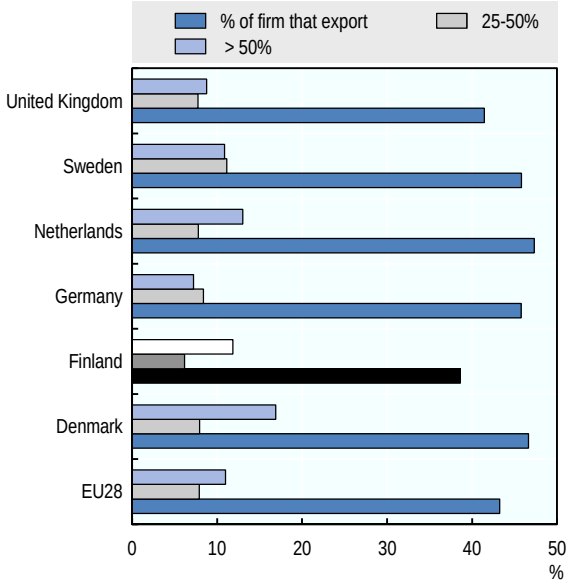
There are signs of industry renewal and hard-hit sectors such as electronics and forestry are currently revamping their business strategy. Nokia is focusing on new network technologies. Telecoms, radio technology and mobile technology continue to grow; the ICT subcontracting industry is competent and lean; and the Finnish gaming industry has been booming. The ICT services sector is in good shape and has weathered the crisis well (OECD, 2016a). Areas where Finland already has strong technical competences (e.g. liquefied natural gas) are expected to grow and have great potential for internationalisation and contributing to reviving industry. The chemical industry has been expanding and shipbuilding is being revived, partly based on its capacity to produce greener ships propelled by liquefied natural gas.

Strengthening small and medium-sized enterprises and their ability to access markets

In Finland, as in other countries, the majority of exports are accounted for by large enterprises. At the same time Finnish SMEs are less engaged in exporting than their counterparts in other small open economies. According to the Access to Finance Survey 2015 (European Central Bank, 2015), 39% of Finnish firms export whereas the corresponding figure for Swedish, Danish and Dutch companies ranks between 46% and 47% (Figure 5.5). According to a recent survey, large enterprises in Finland and Sweden accounted for 66% of total exports of goods in 2013, and over half in Norway (60%), Iceland (57%) and Denmark (52%).[6] These firms are mostly corporate firms, being part of groups.[7]

Figure 5.5. **Firms participating in export markets**

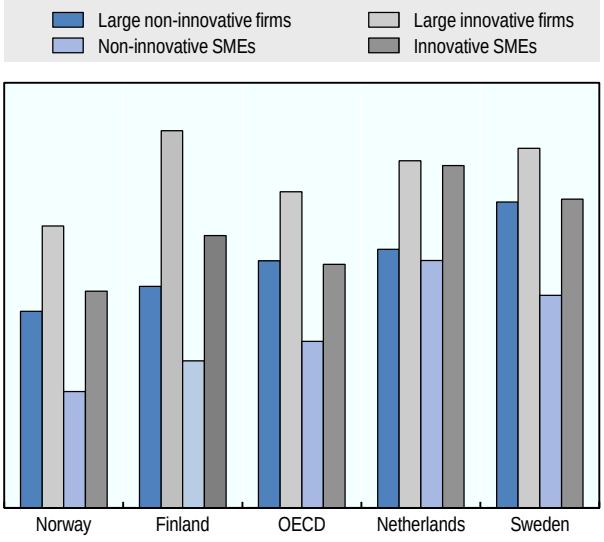
As a percentage of firms by category



Source: European Central Bank (2015), "Survey on the Access to Finance of Enterprises", September to October 2015 (wave 13), www.ecb.europa.eu/stats/ecb_surveys/safe/html/index.en.html.

Figure 5.6. **Export propensity to international markets by small and medium-sized enterprises and large firms, by innovation status, 2010-12**

As a percentage of firms in the relevant group



Source: OECD (2015a), *OECD Science, Technology and Industry Scoreboard 2015,* http://dx.doi.org/10.1787/sti_scoreboard-2015-en based on Eurostat Community Innovation Survey (CIS-2012) and national data sources, June 2015.

SMEs which innovated (i.e. those which have introduced a product or process innovation) in Sweden and the Netherlands show higher shares of firms that export than their Finnish counterparts (OECD, 2015a). While 65% of Swedish SMEs classified as innovative firms and 73% of their Dutch peers engage in export activity, the corresponding figure for Finnish innovative SMEs is 58% (Figure 5.6). The gaps are larger for non-innovative SMEs. This suggests that even innovating Finnish firms face greater difficulties to export than similar firms from Sweden and the Netherlands (this indicator is only available for a few countries).

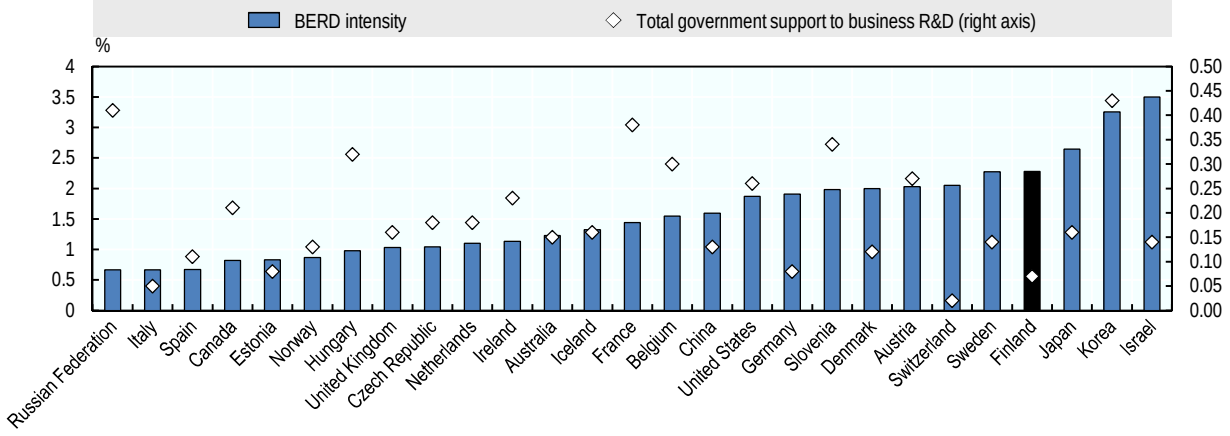
The divergence between large firms and SMEs in their ability to access markets is also noticeable in public markets. Forty-nine percent of large firms in Finland have procurement contracts whereas the corresponding figure for medium and small firms is only 36.8% and 31%, respectively, according to the Innovation Survey 2014 (Statistics Finland, 2016c). The difference in access to public markets is larger in the provision of services: 58% of large firms currently have procurement contracts whereas in medium and small firms the figures are 37% and 46%, respectively. Given the small size of the domestic market, enhancing demand for innovative products and services is key to encourage innovation activity and firm growth.

Trends in Finnish business innovation

Finland's business R&D intensity – business enterprise expenditure on R&D (BERD) as a percentage of gross domestic product (GDP) – is still high and above the OECD average (1.65), but has declined steeply in the wake Finland's industrial restructuring, from 2.68% in 2009 to 1.94% in 2015, and is now similar to that of Denmark (1.99) but below that of Sweden (2.27). Finland's government support for business R&D is among the lowest in the OECD (Figure 5.7).

Figure 5.7. **BERD intensity and government support, 2013**

As a percentage of GDP



Note: Data for Australia, Austria, Belgium, Spain, Sweden and the United States are for 2011.

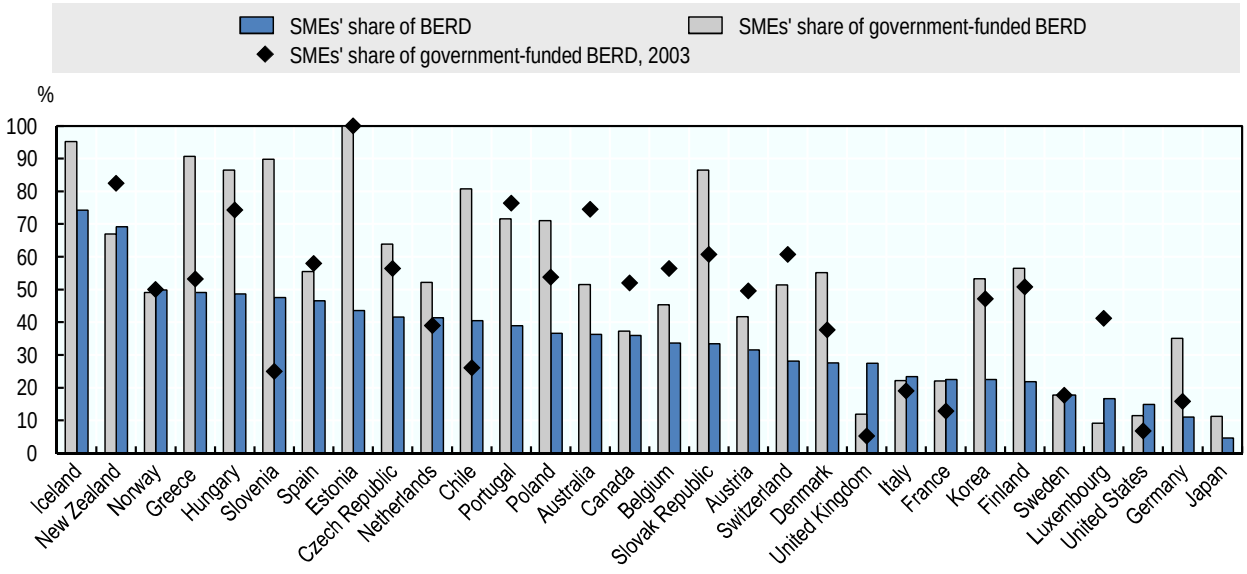
Source: OECD (2015a), *OECD Science, Technology and Industry Scoreboard 2015*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

Finland's BERD is primarily performed by the high-technology manufacturing sector and heavily concentrated in large firms. Compared to OECD average trends, Finland displays a lower share of SMEs performing business R&D as well as a lower share of medium- to low-tech manufacturing and low knowledge services industries. The participation of SMEs in BERD is weaker in Finland than in the OECD on average (OECD, 2015a; 2016c) and in other Nordic countries (e.g. Denmark and Norway): SMEs account for less than a quarter of BERD (21.8% in 2013), well below the OECD average (35%) (Figure 5.8). In Sweden, with its strong and varied multinational enterprise (MNE) sector (OECD, 2013), the share of SMEs is even lower than in Finland (18% in 2011, the latest year for which data are available). According to the most recent R&D survey (Statistics Finland, 2016b), in 2014 very large firms (those with more than 500 employees) represented about 76% of BERD. Domestic companies in Finland, in contrast, show a much greater involvement in BERD than the OECD average. The same holds true for manufacturing. Correspondingly, services account for a lower share in BERD compared to the OECD average, which is twice as high as the Finnish share. On the other hand, the volume of R&D in the service sector has increased by more than 36% (in nominal terms) during 2010-15, compared to a decline by almost 30% in the manufacturing sector.

Figure 5.9 shows the evolution of BERD over the period 2000-14, and Figure 5.10 breaks down BERD (indexed at 2008) for Nokia on the one hand and for the aggregate of all other companies on the other. It shows that Nokia's reduction of investment in R&D has been the main source of the drop in Finland's BERD. In the aggregate, the other firms show a much more stable pattern. Their R&D expenditure (in real terms) even slightly increased during 2010-12, but started to decline again afterwards. BERD in the services sector displays a more stable pattern than in the manufacturing sector. However, the part of Nokia (recently Nokia and Microsoft Mobile) in Finnish BERD is still relatively high, but has fallen. In 2010, Nokia accounted for 50% of BERD whereas in 2015 it represented 20% of BERD and Microsoft Mobile 10%.

Finnish firms invest less in non-R&D innovation (relative to total sales; see Figure 5.11) and intangibles (e.g. ICT and intellectual property) than some of their European peers, and are below the EU average (Figure 5.11). Expenditure of firms for non-R&D investment for innovation (expenditure on machinery and equipment, software and hardware, training, licensing of technology or external intellectual property rights, etc.) relative to sales is lower in Finland than the same ratio reported by firms in Germany or Sweden. In Finland, the ratio of expenditure on non-R&D investment for innovation to turnover actually decreased between 2008 and 2012, from 0.57% to 0.37%, whereas Sweden saw this figure rise from 0.66% to 0.79%. The EU average in 2012 was 0.69%.[8] Innovative Finnish firms (according to data from the Innovation Survey for 2014) seem less involved than their peers from Denmark, Norway or Sweden in design activities (to improve or change the shape or appearance of products or services); they are also less engaged in the acquisition of other external knowledge.

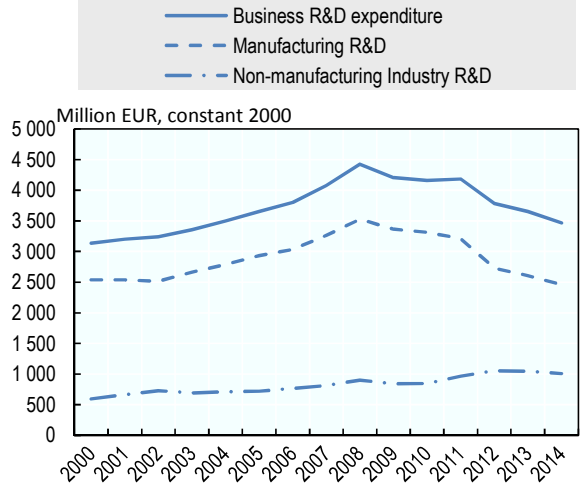
Figure 5.8. **Share of small and medium-sized enterprises in BERD**



Note: Data for Denmark and Luxembourg are for 2009. Data for Australia, Austria, Belgium, Greece, France, Italy, Germany, Sweden and the United States are for 2011. Data for Portugal, Switzerland and the United Kingdom are for 2012. Data for all other countries are for 2013.

Source: OECD (2015a), *OECD Science, Technology and Industry Scoreboard 2015*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

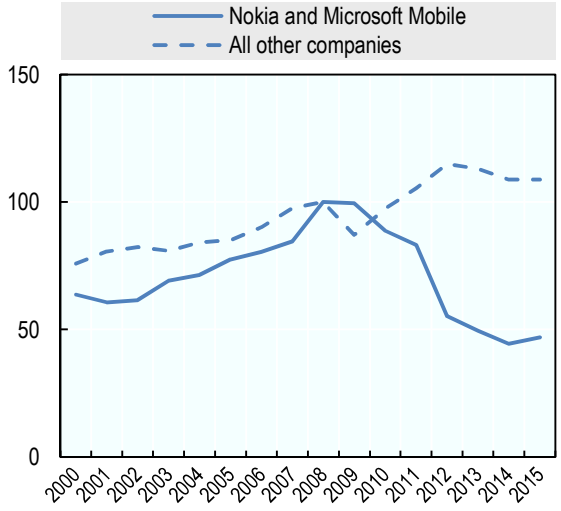
Figure 5.9. **Business R&D (BERD)**



Source: OECD (2017a), *ANBERD Database*, http://stats.oecd.org/Index.aspx?datasetcode=anberd_rev4.

Figure 5.10. **BERD (real)**

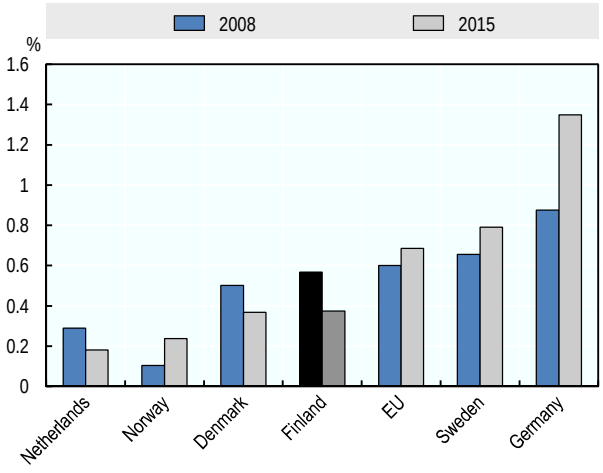
2008=100



Sources: Statistics Finland (2016b), Research and development database; Research Institute of the Finnish Economy (Etla).

Figure 5.11. **Non-R&D innovation expenditure**

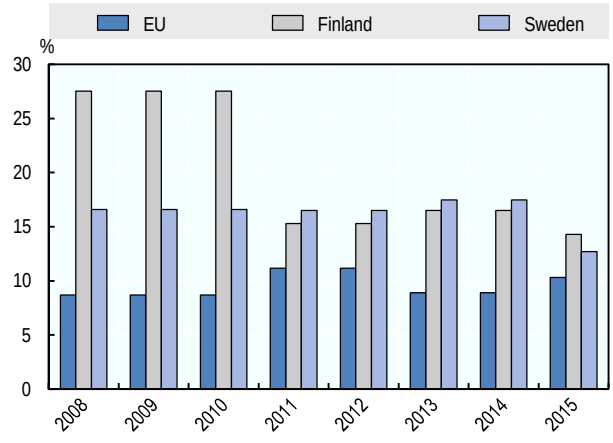
As a percentage of turnover



Source: Eurostat.

Figure 5.12. **SME collaboration with others**

As a percentage of SMEs

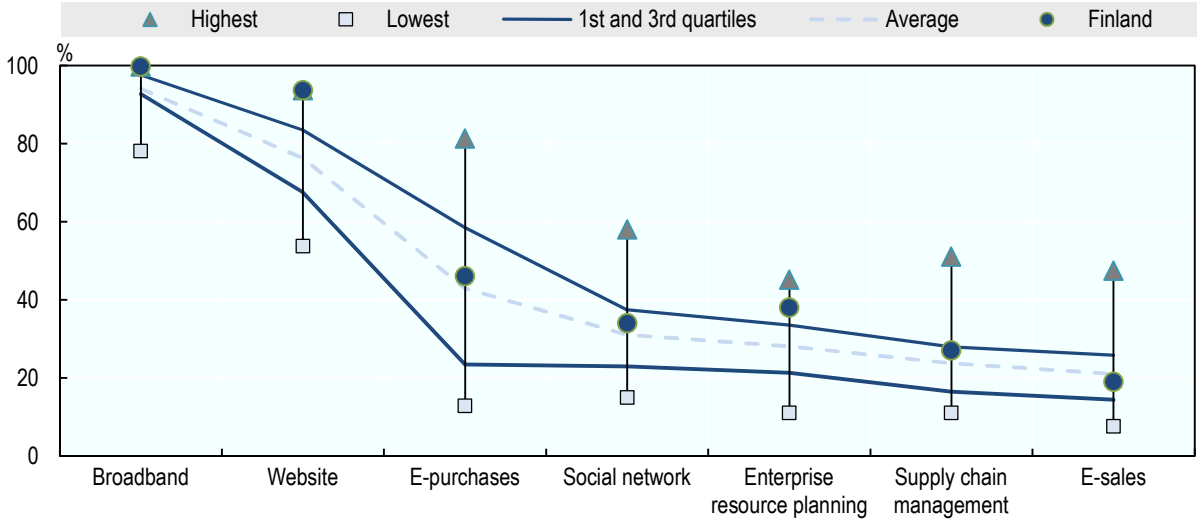


Source: Eurostat.

There is also scope for improvement with regard to the use (diffusion) of ICT and digital technologies. Although Finnish enterprises rank around the average (OECD, 2014; 2015c) in terms of propensity to use e-sales, supply chain management and social networks (OECD, 2015c), there are several key ICT tools and activities on which Finland ranks far below the best performing country. These include the use of e-purchases and e-sales, supply-chain management and social networks (Figure 5.13).

Figure 5.13. **Diffusion of selected ICT tools and activities, 2013**

As a percentage of enterprises with ten or more employees



Source: OECD (2014), *Measuring the Digital Economy: A New Perspective*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264221796-en.

Today, digitalisation is a major transformative technological force, and Finnish companies – as companies around the world – are well advised to fully leverage digitalisation in the development of the industrial services and solutions they offer. Digitisation, e.g. in the form of remote-controlled equipment, not only improves cost efficiency and productivity but also leads to entirely new business models through closer integration with customers' core businesses. According to the Finnish Innovation Survey, the importance of digitalisation for enterprises' business activity is clearly more strongly acknowledged in services than in manufacturing firms: 41% of services firms consider one form or another of digitalisation key to firm operations, compared to 25.4% of manufacturing firms.[9]

According to Eurostat (2014), about half (51%) of Finnish enterprises are "in the cloud". Nordic and Benelux countries typically score high, with Denmark and Sweden in the top four and the Netherlands and Belgium in the top 10. Twenty-four percent of enterprises in the United Kingdom use cloud computing services. In 2014, Tekes introduced three complementary programmes to further boost the Finnish position as a significant producer and user of new ICT and digitalisation solutions in various sectors, namely: 1) Bits of Health programme (for companies utilising digitalisation and developing innovations promoting health, the early diagnosis of diseases, health monitoring and personalised care); 2) the Industrial Internet; and 3) the 5th Gear programmes. With its highly developed e-skills, Finnish industries and the economy should be well placed to benefit from digitalisation. With ICT practitioners accounting for nearly 6% of total employment in 2011, the country has the second highest share of ICT professionals in the European Union. This endowment provides an opportunity for maximising the benefits from digitalisation services and their use in Finnish industries.

Innovation collaboration and the nature of innovation outputs

Firm collaboration in innovation is also an area that deserves attention. In principle, aggregate figures place Finnish firms at the top of OECD countries in terms of co-operation (co-operating with others in innovation – all types of partners combined). A more detailed look at the figures shows that:

Co-operation activity by SMEs seems to have suffered dramatically since the crisis and has not recovered to its 2008 levels: whereas 28% of SMEs collaborated with others in 2008, this propensity has contracted to half that amount (15%) since 2011 (Figure 5.12) (Eurostat, 2016a).

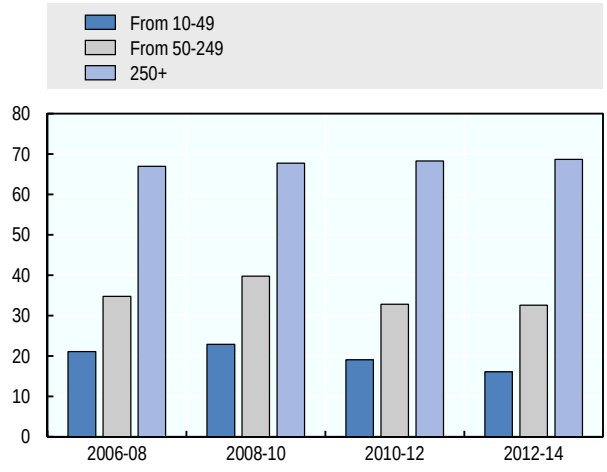
Important differences exist across firm size (Figure 5.14). Although on average 38% of firms declared in 2014 to be engaged in some type of co-operative activity, this figure reached only 31.9% in small firms and 48% in medium-sized firms. This is in strong contrast to large firms: 75% of large firms (with more than 250 employees) co-operate with others in innovation.

In terms of industry-academia collaboration, SMEs generally consider that collaboration with academia is not of high importance for their innovation activities (Figure 5.15). According to the Innovation Survey, in 2014, 14% of large firms declared that co-operation with universities and polytechnics is of high importance whereas only 2% and 4.6% of small and medium-sized firms, respectively, considered this activity valuable (Statistics Finland, 2016a). This finding calls for further investigation regarding: 1) the knowledge needs of SMEs and how universities can better connect with them to foster firm innovation; 2) whether there are obstacles or frictions that limit interactions and knowledge exchange between the two parties.

In terms of innovation outputs, Finnish firms mostly generate product improvements rather than "new to the world" innovation. The Innovation Survey indicates that most product innovation concerns products that are "new to the enterprise" (72% of enterprises with product innovation declared so); the share of companies declaring that products were new to the market was 60%. A recent business survey (Synergy Group Europe SGE Ltd, 2013) showed that Finnish companies fail to invest enough in radical innovations.

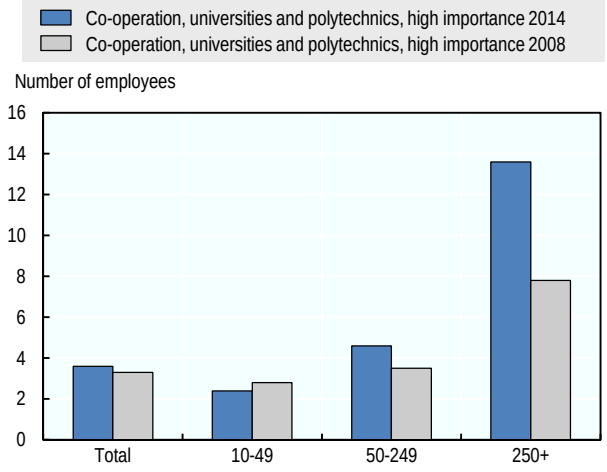
From the 211 companies surveyed, 56% of their innovations were improvements and modifications to existing products whereas 31% were additions to existing product lines. Only 6% of innovations were considered "new to the world" innovations. Finnish companies underinvest in truly innovative (and risky) projects that could disrupt and create competitive advantage. According to this study, Finnish companies tend to be risk averse and not to focus sufficiently on finding truly innovative products.[10] The report also found that Finnish companies rely too much on internal resources when looking for new product or service ideas. Accordingly, Finnish firms do not involve customers enough in their efforts to gain a better understanding for what could be a successful product on the market. Nor do they sufficiently utilise partners or research.

Figure 5.14. **Co-operation with higher education institutions, by size**



Source: Statistics Finland, with support from ETLA.

Figure 5.15. **Small and medium-sized enterprises that consider co-operation with academia is highly important, by firm size**



Source: Statistics Finland.

Obstacles to innovation

Past Innovation Survey data indicate that Finnish firms confront fewer obstacles to innovation in comparison to firms from other EU member states. Access to finance does not seem to be a major concern according to innovation and business surveys. In fact, Finland ranks high in Europe with regard to many key financial indicators. Loan application grant rates are high and private equity investment as a percentage of GDP is one of the highest in Europe.

According to the Access to Finance Survey (European Central Bank, 2015), the most important constraints to firm competitiveness reported by companies are competition and (high) costs of production or labour. Finnish firms rank access to finance relatively low. Although credit standards for SMEs have been tightened somewhat, finance has remained accessible compared to most other European countries since the crisis.[11] Furthermore,

innovative firms benefit from public funding. However, as public funding has been scaled back, other funding sources need to be found or public support needs to be reinvigorated. For young innovative firms, access to finance, especially growth funding (see Chapter 2) is still an issue, in spite of the increase in start-up finance witnessed in recent years.

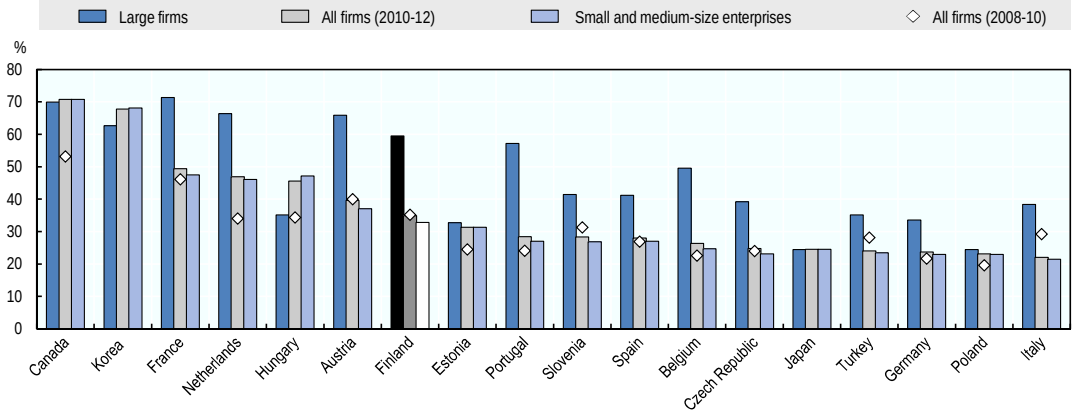
The use of public funding for innovation activities in firms, however, seems widespread among SMEs compared to large enterprises: about 60% of large innovating firms (Figure 5.16) received public support in 2010-12 for innovation, whereas the corresponding figure for SMEs was 32%, a share that is similar to what can be observed across many OECD countries with the exception of Canada, France, Hungary, Korea and the Netherlands, who report shares above 40% (Canada at 70%).

Availability of skilled staff and experienced managers is also ranked lower as a constraining factor than in other countries, including Denmark, Germany and the Netherlands. According to McKinsey (2015), the vast majority of industrial firms (machinery, metals and electronics) responding to the survey (92%) cited salary and wage levels as the main disadvantage, followed by tax liabilities (87%). These factors, combined with increased competition and falling prices, could be a challenging combination for companies that do not take measures to tackle the changing competitive environment.

The small size of the domestic market is a major barrier to both innovation and business growth, which is aggravated by a highly dispersed population. These factors make it harder for firms to grow quickly, but can also provide an incentive to enhance commercialisation through the use of the Internet and digital services. Firms in the machinery, metals and electronics sectors (the largest sectors in the technology industry) seem to be under pressure from developments which often originate in the international environment, including increasing price pressure from low-cost competitors, uncertainty and volatility of business cycles, and domestic costs putting pressure on margins (McKinsey, 2015).[12]

Figure 5.16. **Firms receiving public support for innovation, by firm size**

As a percentage of product- and/or process-innovating firm



Note: Data for Japan are for 2009-12 only.

Sources: OECD based on Eurostat Community Innovation Survey (CIS-2012 and CIS-2010) and national data sources.

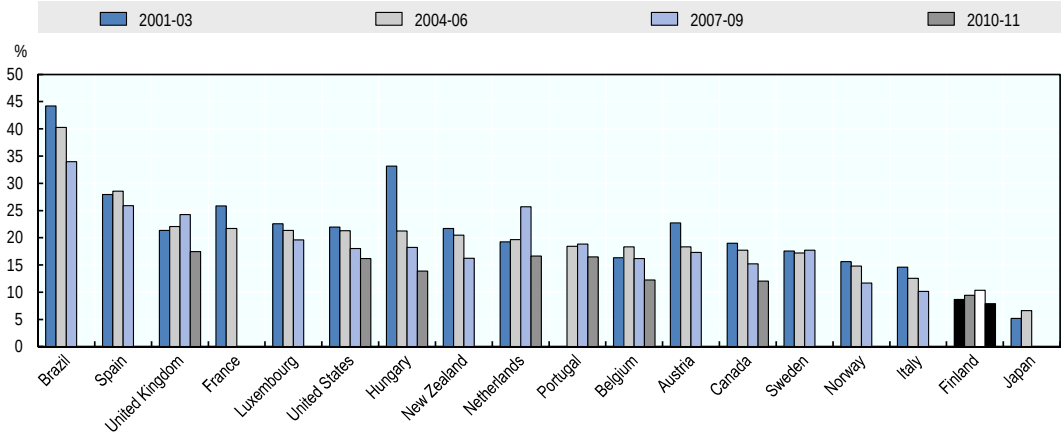
Entrepreneurship and business dynamics

The lack of business dynamics in the Finnish business sector lowers the potential of industry to renew itself through a process of "creative destruction" through innovation, and hence is an obstacle to Finland's productivity growth and full recovery of the Finnish economy.

In OECD countries, young firms provide the main contribution to employment growth (Criscuolo, Gal and Menon, 2014, Calvino, Criscuolo and Menon, 2015). Even though growing is a challenge for small firms in most OECD countries, the contribution of young firms to job creation and employment growth in Finland from 2001 to 2011 was particularly weak. Further, young firms in Finland play a much smaller role in the economy than those of other OECD countries, despite low barriers to entry in most markets and the cost of bankruptcy for entrepreneurs, which are among the lowest in the OECD (OECD, 2015b; 2016b). Furthermore, the growth of young firms has been fairly slow on average. Other noteworthy features in Finnish business dynamics are:

Finland's start-up rates have been among the lowest in a comparator group of OECD countries (including peers like Denmark, the Netherlands, Norway and Sweden) (Calvino, Criscuolo and Menon, 2015), both before and during the downturn (Figure 5.17). Moreover, the share of young companies among small businesses is also among the lowest in this study of 14 OECD countries.

Figure 5.17. **Start-up rates**



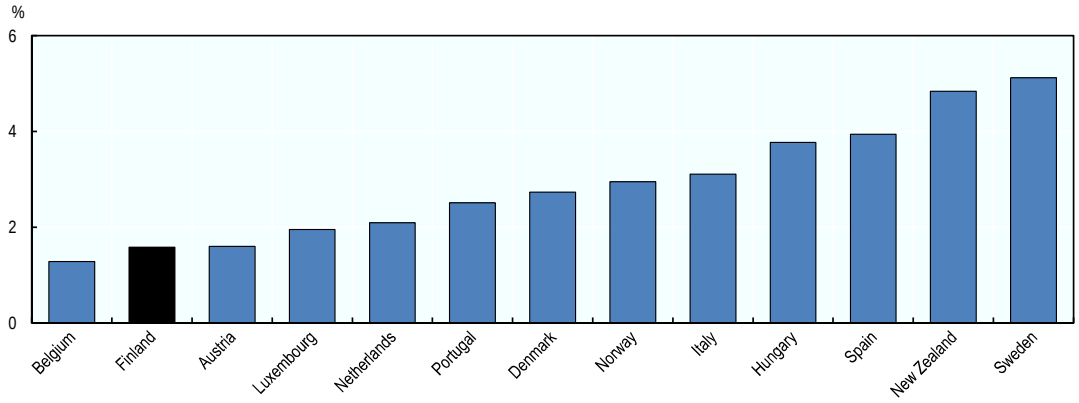
Source: Criscuolo et. al. (2014), Calculations based on the *DynEmp v.2 Database*, preliminary data, www.oecd.org/fr/sti/dynemp.htm.

Young SMEs account for a smaller share in gross job creation than in any other OECD country for which data are available (Figure 5.18) (Criscuolo, Gal and Menon, 2014). While small SMEs account for around 40% of gross job creation in most countries and over 50% in New Zealand or Spain, they account for just 27% of the overall gross job creation in Finland. In terms of net job creation, young Finnish SMEs make one the smallest contributions among all countries for which data are available. Finnish SMEs are also older than in many comparison countries: close to 60% of small business are more than ten years old, which is also an exceptionally high share compared to countries like the Netherlands, Norway, Sweden or the United States (Criscuolo, Gal and Menon, 2014).

The small contribution of Finnish start-ups to aggregate employment is entirely due to the small number of start-ups, as captured by the start-up rate. In contrast, the survival rate and post-entry growth in Finland are similar to those in other countries, and the average size at entry is even slightly above average in Finland.

Figure 5.18. **Start-up contribution to employment, 2001-10**

Net job creation by surviving entrants over total employment, non-financial business sector



Source: Criscuolo et. al. (2014), calculations based on the *DynEmp v.2 Database*, preliminary data, www.oecd.org/fr/sti/dynemp.htm.

It is worth noting that an important heterogeneity prevails across start-up firms, and some young firms – qualified as high-growth companies ("gazelles") – differ substantially from the average growth and survival pattern. According to a study by Nordic Innovation (2012), Finnish gazelle companies[13] grow faster and become larger than their Nordic peers, even though Finland had the lowest start-up rate.[14] Therefore, this group of "high-growth" firms is key for enhancing economic performance and restoring dynamism in the economy. In Finland nearly half (48%) of the gazelles employed over 50 persons at the end of the observation period; in Sweden this was a clearly smaller share (25%). This study revealed, however, that throughout the Nordic region there is a lack of ability and skills to accelerate growth in young firms, particularly a lack of experienced management skills, which results in difficulties in attracting later-stage venture capital and going international.

More recent evidence suggests that the entrepreneurship is evolving. Compared to ten years ago, new start-ups are increasingly more innovation-oriented, with higher growth perspectives (Kotiranta, Pajarinen and Rouvinen, 2016): a third of all new entrepreneurs intend to engage in innovation activities and almost three-quarters of growth-seeking entrepreneurs intend to do the same. Also, growth is increasingly sought after by international markets. Accordingly, about half of all new business activity in Finland can be categorised as being entrepreneurial. In particular, the share of entrepreneurs who are seeking significant growth has increased. And these growth-seekers are also more highly trained and experienced than before.

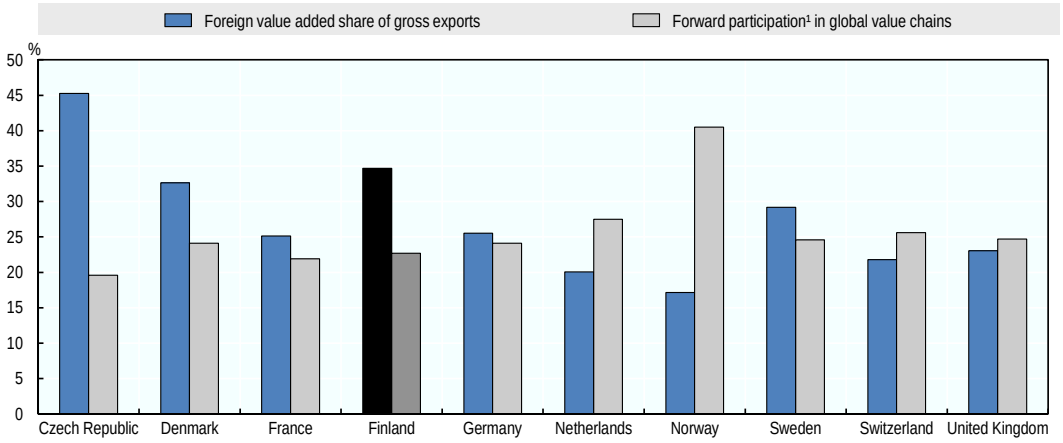
According to this study, several barriers affect start-up development. Half of all new entrepreneurs have encountered some kind of barrier, delay or problem with setting up their business. Problems with accessing finance have been experienced especially by growth-seeking companies, and these problems have increased in the last decade.

Continuing global value chain integration

Since the mid-1990s, Finland has shown high levels of global value chain (GVC) integration, reflecting in particular integration of the vibrant electronics sector. In 2009, nearly 15% of Finnish exports were derived from electronics GVCs. In particular, foreign value added contained in exports ("backward linkages") was already quite high in the early 1990s and this continued into the late 2000s (Figure 5.19), reaching 35% of gross exports, well above several large European economies. Denmark also recorded a high share of foreign value added contained in gross exports in the late 2000s (33%).[15] The sectors with the highest levels of backward participation have traditionally been electronics and chemicals and mineral industries, reflecting the high content of imported intermediate goods in these industries.

Figure 5.19. **Participation in global value chains, 2011**

Percentage of gross exports



Notes: 1. Domestic value added embodied in foreign exports, as a percentage of total gross exports. Forward participation refers to domestic value added embodied in foreign exports, as a percentage of total gross exports. For further details see: www.oecd.org/sti/ind/gvcs%20-%20finland.pdf.

Source: OECD-WTO (2017), *Trade in Value Added (TIVA) Database*, https://stats.oecd.org/index.aspx?queryid=66237.

However, as the electronics sector has been in a process of downsizing and some traditional industries struggling to keep up with global competition, Finland encounters the challenge to develop new economic competences and value-added activities to keep up with GVC integration and ensure the economic and knowledge gains that such global linkages entail. While traditional sectors such as chemicals and metals are already well integrated into GVCs, Finnish companies in new economic sectors like bio-medicine and biotechnologies, green or health technologies, may require support for integrating in GVCs (Reid et al., 2016).

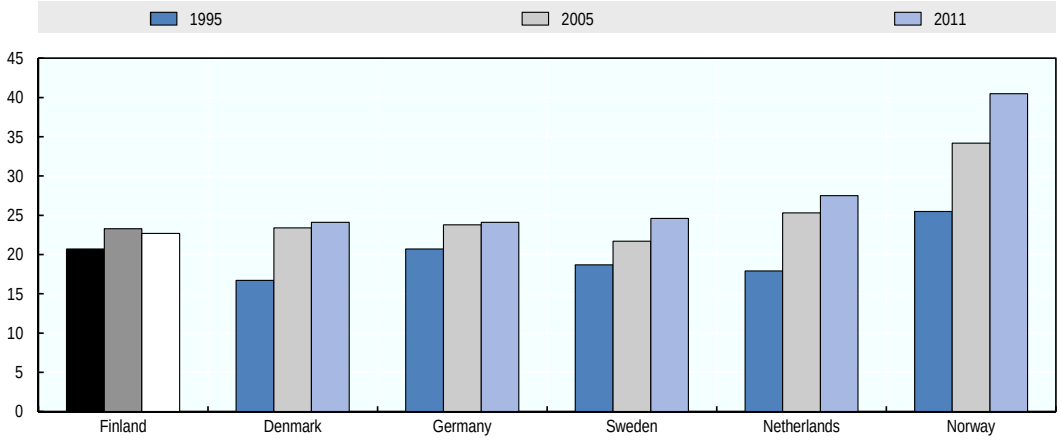
In contrast to "backward linkages", "forward participation" of Finnish industries (the share of domestic value added embodied in foreign exports) only slightly changed between the mid-1990s and 2011 (Figure 5.20). More recent data should display lower figures, reflecting ongoing downsizing in manufacturing.[16] Norway differs from this trend owing to its specific economic specialisation pattern (dominated by the oil and gas sector and related industries). The industries with the highest levels of forward participation

(domestic value added in gross exports) are services industries such as transport and telecommunications (and real estate). Intermediates account for three-quarters (76%) of Finnish exports according to OECD Trade in Value Added (TiVA) data for 2011 (the latest year available), which is also an exceptionally high share by international comparison.

Further, the linkages between domestic services and manufacturing exports in Finland seem weaker than in Denmark or Sweden but their contribution to value added in exports has been increasing. Finland could benefit from improving connections between domestic services and manufacturing industries. The Netherlands and Denmark report 55% and 44% of domestic service content in manufacturing exports whereas the corresponding ratio for Finland is 37% (up from 33% in 1995) and 43% for Sweden. A high share of domestic services content in exports illustrates the upstream role of (domestic) services industries through their provision of transportation, wholesale and retail services, as well as financial and other business services. OECD analysis shows that services, e.g. business services, transport and logistics, account for over half of value creation in GVCs in many OECD countries, and over 30% in the People's Republic of China (OECD, 2015b).

Figure 5.20. **Participation in global value chains, forward participation**

As a percentage of gross exports



Note: Forward participation refers to domestic value added embodied in foreign exports, as a percentage of total gross exports.

Source: OECD-WTO (2017), *Trade in Value Added (TIVA) Database*, https://stats.oecd.org/index.aspx?queryid=66237.

The role of foreign direct investment in the economy and in innovation

Attracting foreign direct investment (FDI) is essential for Finland's economic and industrial recovery for several reasons. First, MNE activity contributes to strengthening manufacturing production and enhancing market demand (for production components and raw materials, and innovation). Second, MNE activity is also important for competing in global knowledge production (and the generation of new technological competences), which entails attracting global foreign R&D-intensive companies.

In Finland, the share of FDI in GDP is lower than in Denmark and Sweden (Figure 5.21), and MNEs' share in BERD was half the share reported in Sweden in 2013 (OECD, 2015a).[17] In 2012, FDI stocks in Finland represented 38% of GDP whereas in

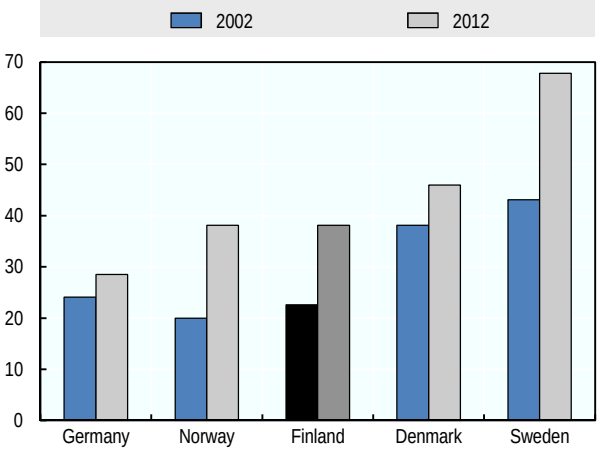
Denmark this figure was 46% and in Sweden 68% (OECD, 2016c). For many reasons (earlier industrialisation, a larger manufacturing base and a more favourable geographical location, etc.), Sweden has attracted more FDI, especially through a wave of mergers and acquisitions starting in the mid-1990s. Overall, compared to neighbours, and especially Denmark and Sweden, Finland has not been very successful in attracting FDI. Weak MNE activity restrains opportunities for domestic firms' GVC integration and knowledge spillovers and global innovation networks. Several recent studies illustrate Finland's weakness in attracting FDI.

Among the Global 2000 companies that have established operations in the Nordic region with regional headquarters, about 64% have chosen to locate their regional headquarters in Sweden, 20% in Denmark, 8% in Norway and 9% in Finland (Øresunds Instituttet and Stockholm, 2015).[18]

Denmark and Sweden have been able to attract about half of all MNEs' regional head offices located in the Nordic region. The share of Helsinki was less than 10% (ibid). Locational competition among advanced economies often focuses on R&D units and the head offices of multinational firms which employ high-skilled professionals.

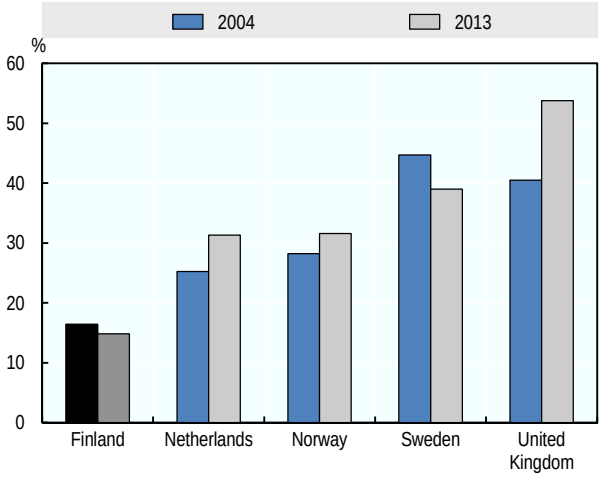
In order to surpass the EU average in the stock of FDI as a share of GDP (41% in 2014) by 2020, from its level of 34% in 2014, in December 2012 the government adopted a decision-in-principle, "Team Finland: Strategy for Promoting Foreign Investment". Rather than create a new initiative or add a new layer of bureaucracy, this strategy seeks to improve the efficiency of existing FDI promotion efforts by bringing them under a single umbrella. By doing so, the government strives to create a clear, flexible and customer-oriented model so that key actors at home and abroad work towards a coherent strategic goal. The views on the effectiveness of the Team Finland initiative however have been mixed and the programme has been in a process of redesign lately.

Figure 5.21. **Foreign direct investment stocks as a percentage of GDP**



Source: OECD (2017b), *Foreign Affiliates Database*, http://stats.oecd.org/index.aspx?datasetcode=amne_in.

Figure 5.22. **Multinational enterprise participation in BERD**



Source: OECD (2017b), *Foreign Affiliates Database*, http://stats.oecd.org/index.aspx?datasetcode=amne_in.

Notes

1. See also OECD (2016a), Reid et al. (2016) and Halme, Saarnivaara and Mitchell (2017).
2. "Technology industries" comprise five sub-sectors: electronics and electro-technical (data and communications equipment, electrical machinery and medical technologies), metals (steel products, non-ferrous metals and metallic minerals), mechanical engineering (machinery, metal products and vehicles), information technology (IT services, applications and programming) and consulting engineering services.
3. SME value added and employment rose by 12% and 6%, respectively (European Commission, 2016). In particular, SMEs in the information and communication sector generated growth of 26% in value added and 11 % in employment.
4. See the website of the OECD DynEmp Project at: www.oecd.org/sti/dynemp.htm.
5. Micro and small firms are older only in Japan, which may be due to the fact that Japan is the only country with establishment-level, rather than enterprise-level, data.
6. See Statistics Denmark and OECD (2017).
7. Independent firms account for a very limited share of exports: 26% of total export goods in Finland, 14% in Norway and 8% in Sweden.
8. According to the most recent Innovation Survey (Statistics Finland, 2016c), 75% of firms invest in in-house R&D whereas only 50% invest in external R&D. About 40% of firms invest in the acquisition of external knowledge or in training for innovation activities. Around a quarter only conduct design activities (shares of enterprises with innovation activity related to products and processes).
9. Firms were asked if at least one of the following items were considered to be of high importance: digital products for business activity, cloud services, social media, Internet of Things, use of robotics in production processes, and use of digitalisation in producing products, designing products, marketing or distributing products.
10. Whereas incremental development projects renewing an established product line are, of course, needed, it is short-sighted to believe that sticking only to the 'tried and true' will bring competitive advantage in the long run. The risk is that these companies will be out-innovated by their competitors, instead of taking the lead themselves.
11. There is also econometric evidence that confirms that, on average, Finnish firms do not suffer from financial constraints (Einiö, 2009).
12. In 2013, total annual revenues of technology industries reached EUR 65.1 billion, accounting for 50% of annual exports (EUR 24.8 billion).

13. In this study, a gazelle is defined as a company whose revenue grew by 100% from 2011 to 2014; whose revenue was over EUR 135 000 in 2011; and whose profit was positive each year (2011-14).

14. The gazelle birth rate is 0.56% in Finland and 0.70% in Sweden but, on average, a Finnish gazelle increased its employment by 83 persons in three years, which is twice as much as the corresponding Swedish figure.

15. Estimates of foreign value added in exports ("domestic participation" in GVCs) highlight the importance of imports for export performance, while domestic value added embodied in the exports of partner countries shows how industries within a country reach consumers abroad even when no direct trade relationship exists (OECD, 2015a).

16. The evolution of this indicator over the period 1991-2011 was similar to other European countries such as Denmark, Germany and the Netherlands (and also similar to other Nordic countries except Norway). See also Statistics Denmark and OECD (2017).

17. In 2013, MNEs conducted 15% of BERD in Finland whereas in Sweden this figure was 39% and in Norway 32%. The United Kingdom reports a higher share: 54% of BERD is currently carried out by foreign-owned firms (OECD, 2015a).

18. Stockholm (Stockholm-Mälardalen region) dominates with 51% of these offices followed by the Danish-Swedish region of Greater Copenhagen (the Öresund region) with a 24% share, of which Copenhagen accounts for 16%, Greater Malmö 4% and Helsingborg 2%.

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Chapter 6

Innovation policy and governance in Finland

This chapter examines public sector activities that have a bearing on the Finnish innovation system. It begins with an overview of the historical evolution of science, technology and innovation policy in Finland. It then examines the main policy actors and governance arrangements. Finally, it reviews current policies in light of the observations made in the preceding chapters and concludes by identifying areas in need of policy attention.

Science, technology and innovation policy in Finland: An historical overview

Since the 1990s, Finland has been seen as an exemplary model of how to make and implement good science, technology and innovation (STI) policy. Two aspects of Finland's STI policy have been especially important: first, its commitment to public investment in R&D and education, even in the face of recession (as in the early 1990s), and the expansion of this investment in the second half of the 1990s; second, the leading role of what is now the Research and Innovation Council (RIC) in co-ordinating policies that took a systemic approach and led the development of STI policies. Finland's recovery and success through the 1980s and more than the decade before the 2008 global financial crisis was built on these policies, as well as strengths established in earlier periods. Finland initially responded to the global financial crisis in a similar way as in the 1990s. However, since the early 2010s there has been a loss of confidence in the power of research and innovation to drive development and growth and a corresponding loss of coherence in STI policy. The recent revival of the RIC provides an opportunity to establish new and systemic policies that address national needs, development and growth.

Historical background

Finding itself on the losing side in World War II, Finland was obliged to pay substantial reparations to the Soviet Union in the form of ships and machinery across a period of eight years. The need to produce these goods forced the state to set up large, state-owned companies and a stronger banking system and to promote R&D in enterprises – in effect launching a process of accelerated industrialisation that continued through the end of the 1980s. The period also saw heavy investment in education and the establishment of a Nordic-style welfare state. Restrictions on foreign ownership were lifted during the second half of the 1980s as part of a wider effort to open up the economy that culminated in Finland's accession to the European Union in 1995 and adopting the euro in 2002. This process of opening up and internationalising is still ongoing as – after markets for goods and services, company ownership and location – science and business R&D have also become increasingly globalised.

The recession of the early 1990s hit Finland peculiarly hard. The government responded by increasing public investment in education, research and innovation to compensate for reduced business R&D expenditure. In the second half of the 1990s, public and private investment in R&D increased at a fast pace. Public investments in R&D during this period were primarily channelled through the Academy of Finland and Tekes. The Academy was a traditional research council or science foundation, largely funding "bottom-up" proposals from the universities. Tekes was founded in 1983 as a technology development agency, funding R&D within companies and in academic-industry partnerships – both bottom-up and, where networks of stakeholders with common interests could be established, in the form of technology programmes. The policy focus on innovation was reflected in the fact that Tekes' budget was consistently much larger than that of the Academy of Finland. Finland's policy contributed to the rise of Nokia (Box 6.1).

Finland since the global financial crisis

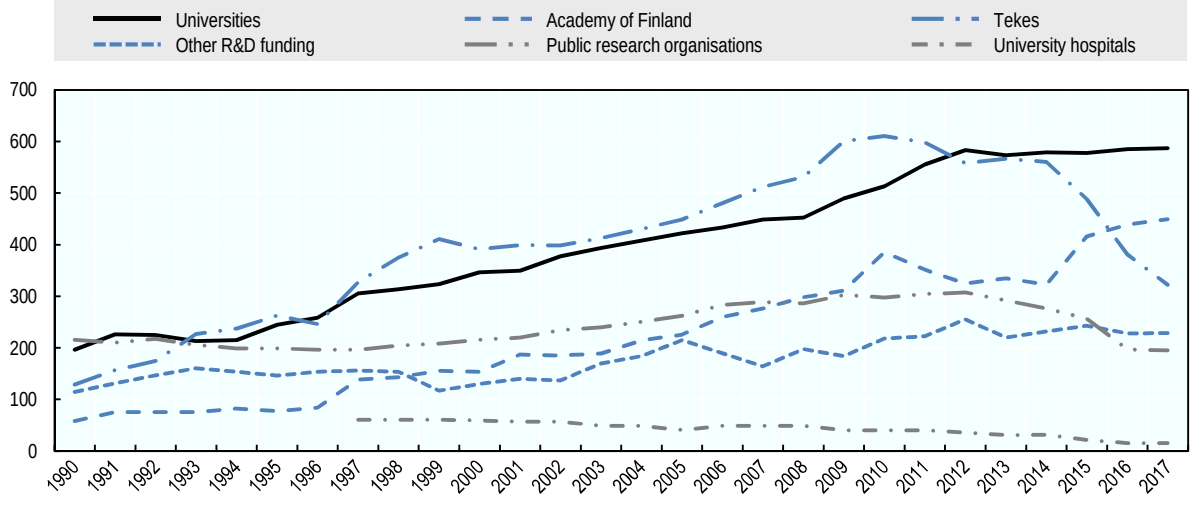
In contrast to the 1990s, there have been significant reductions in both public and business enterprise investment in R&D as economic difficulties have continued (see Chapter 2). On the business side, Nokia started to lose its position because it was unable to maintain leadership across the disruptive transition from simple mobile phones to

smartphones. An alliance with Microsoft in 2011 was followed by substantial lay-offs in 2012, and while Nokia continues to be a strong contender in mobile phone infrastructure, its failure in handsets took on a symbolic value. Government budget appropriations or outlays for R&D (GBAORD) as well as higher education expenditure on R&D (HERD) peaked in 2010 and have since been declining. The overall effect of policy was that – in relative terms – funding shifted away from innovation towards research policy. Tekes has been significantly de-funded while institutional research funding to the universities has remained stable at the same level and research funding through the Academy of Finland continued to increase (Figure 6.1).

Box 6.1. **The rise of Nokia**

Finland's policy commitment to innovation contributed to the growth of Nokia, which at its peak accounted for about 4% of gross domestic product (GDP) and one-third of Finland's gross domestic expenditure on R&D (GERD). As with the earlier industrialisation process, other circumstances were also supportive of growth in the mobile telephone business. The fragmented historical structure of Finnish telecommunications meant there was local strength in network interconnection issues, which are fundamental to mobile systems which initially functioned as access networks to the existing wired infrastructure. The state was part of the Nordic consortium that developed the second-generation Nordic Mobile Telephone standard, upon whose system architecture the third-generation GSM system was built. Nokia was therefore well placed to ride the wave of expansion as the technological shift to the third generation transformed the mobile phone into a mass-market product. Nokia's success further built upon existing advantages and entailed large-scale development and mobilisation of national and international stakeholders and supply chains. These ingredients will also be important in the future in identifying and seizing opportunities for innovation and growth, especially in the areas defined by the "societal challenges".

Figure 6.1. **Government R&D funding at current prices**



Source: Tekes (2015).

In the aftermath of the crisis, many countries have scaled down their public R&D budgets (government budget appropriations or outlays for R&D). However, the cuts carried out in Finland, combined with an effective reallocation of resources away from innovation, do not appear to be based on any clear rationale. This concerned above all funding through Tekes, including the withdrawal of the budget for the strategic centres for science, technology and innovation (SHOKs). The effects were to reduce R&D investment at a time when it was needed the most and to significantly reduce the national effort in applied or "strategic" research to underpin innovation. These appear to have arisen as a result of a disconnected sequence of decisions, made possible by a lack of a system perspective.

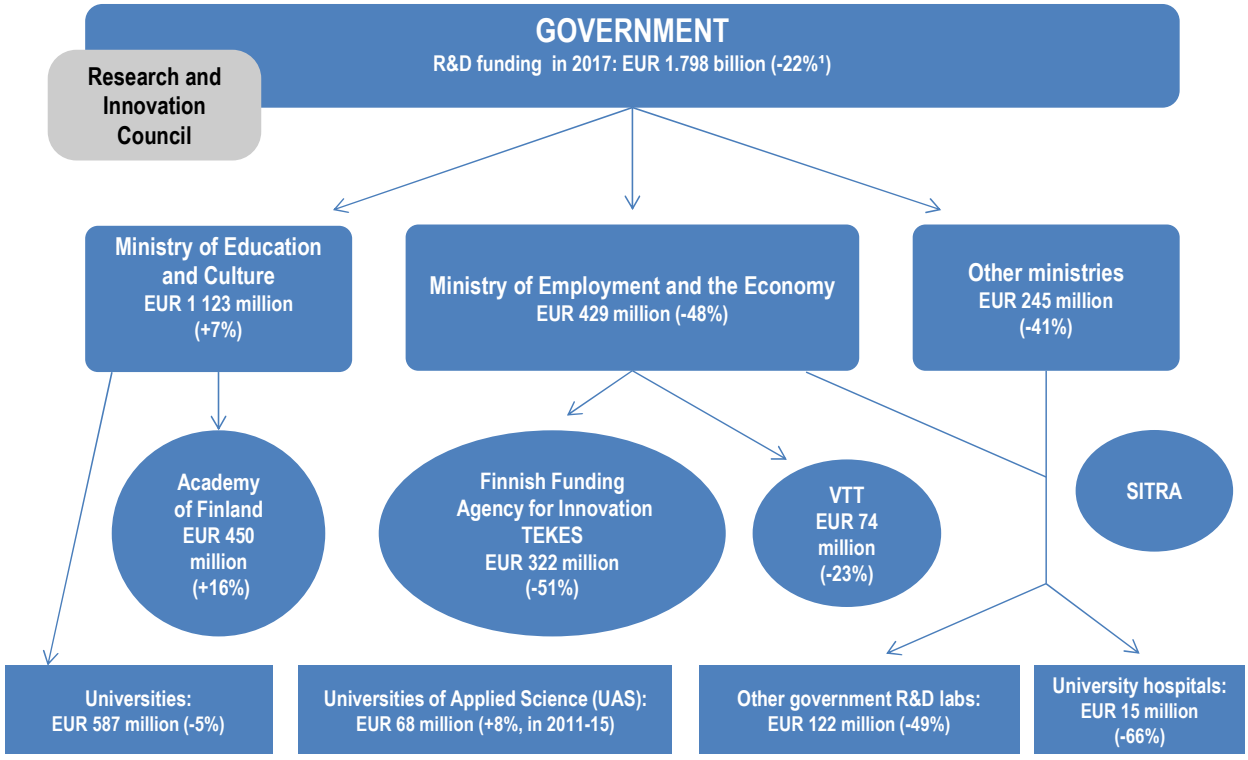
Both the university and the university of applied sciences (UAS) systems have been under reform since 2010. The two sectors have been encouraged to form closer links and even "consolidated corporations" (see Chapter 4). Restructuring reforms were finally launched in the public research institute (PRI) sector in 2014, responding to the recommendations of the earlier systems evaluation and of a panel of Finnish experts (Lankinen, Hagstrom-Näsi and Korkman, 2012) with the intention of rationalising the structure and making the institutes more effective.

The strategic objectives of Prime Minister Sipilä's government (in office since 2015) are: 1) improving employment and competitiveness; 2) reforming knowledge and education; 3) promoting welfare and health; 4) facilitating the bio-economy and clean solutions; and 5) reforming ways of working through digitalisation, experimentation and deregulation. Each of these objectives has been allocated to a group of ministries to work together on. They are, inter alia, to be reached via 26 "spearhead projects" with a collective budget of EUR 1.6 billion. Ten of these projects include aspects of research and innovation. The government programme aims for a clearer division of labour between the higher education and the public research sectors (accompanied by greater co-operation) and to increase the economic and social impact of R&D. At the same time, the government intends to further reduce public R&D spending by 5% to 10% compared with 2015. A Strategic Research Council (SRC) was added to the Academy of Finland in 2015 to fund policy-relevant research, with money formerly allocated to government research institutes' core funding, further decreasing the amount of R&D and innovation funding.

The resulting changes are illustrated in Figure 6.2, which also reflects the research and innovation content of the spearhead projects. The expansion of the total budget for the Academy of Finland is caused by the reallocation of money from the government lab sector and Tekes to the new Strategic Research Council within the Academy and the transfer of money for "profile" projects in the universities, encouraging rationalisation and more specialisation. In 2015, the government abruptly decided to terminate the Innovative Cities Programme (INKA) by 2017. This programme aimed to generate new business and facilitate job growth by creating a test bed for new technologies and services, as well as new operating models for competence-based entrepreneurship. Organized around regional hubs, new development environments were piloted in co-operation with users, companies and the public sector. It was decided at the same time to discontinue the substantial system of public-private partnerships (PPPs) or competence centres (SHOKs) that had been established in preceding years with the intention to advance the relevance of research and science-industry co-operation in areas of economic importance to Finland.

The largest absolute cut was imposed on Tekes, where the ratio of loans to grants had already been rising and where a big cut in grants is to a considerable extent a result of the government's decision to cancel the SHOK programme. VTT's budget was cut by 23%, but the funding for the government laboratories and for research in the university hospitals was more dramatically reduced. Individual institutes such as that for public health have been laying people off as a result. In addition to reducing the amount of research carried out in government labs, the government also decided to further reduce the amount of research and innovation funds channelled to large companies, instead focusing further on small and medium-sized enterprises (SMEs) and start-ups. The government is committed to supporting SME growth and development, for example through Finpro's Growth Programmes and the Team Finland co-operation among the innovation and business support agencies. Expenditures in these areas have to some degree displaced parts of the earlier applied research effort devoted to existing industry (for more detail see the section on "Supporting business R&D and innovation" below).

Figure 6.2. **Government R&D funding budget for 2017, main funding flows and percentage changes compared with 2011**



Note: 1: Volume of government R&D funding in 2017 and the development of funding in 2011-2017 in real terms.

Source: Statistics Finland (2017).

The period since the 2008 global financial crisis has seen considerable reflection at the policy level in Finland, responding to an increasing sense of uncertainty whether the institutions and policies which were effective in the past, continue to be relevant. An international evaluation of the Finnish innovation system carried out in 2009 (Veugelers at al., 2009) highlighted a number of issues, including the fragmented structure of the research and innovation system in Finland, the fact that 40% of professors

would be retiring within ten years, the low degree of internationalisation and concerns about the quality of research.[1] Concerns about the continued relevance of established institutions appears to have underpinned the RIC's recommendation in 2010 that international evaluations of the Academy of Finland and Tekes should be launched in 2011 and 2012 (Research and Innovation Council, 2010). These were followed by evaluations of Sitra, Finnvera, the Finnish Industry Investment and the RIC itself in the period up to 2014 so that within a short period of time all the funding organisations key to research and innovation in Finland were evaluated.

Taking stock of developments in recent years, it appears that the global financial crisis and the decline of Nokia shook Finland's faith in its established and successful strategy of systemic use of research and innovation to drive growth and economic performance and in its research and innovation institutions such as the RIC and Tekes in a way that does not do justice to either the successes or the lessons of the past. As the strategic perspective weakened, so decisions were increasingly taken that were inconsistent with national needs and sometimes mutually inconsistent, reducing the research and innovation effort in ways that undermine future growth. Successful research and innovation policy depends on using these lessons in the new circumstances of the 21st century.

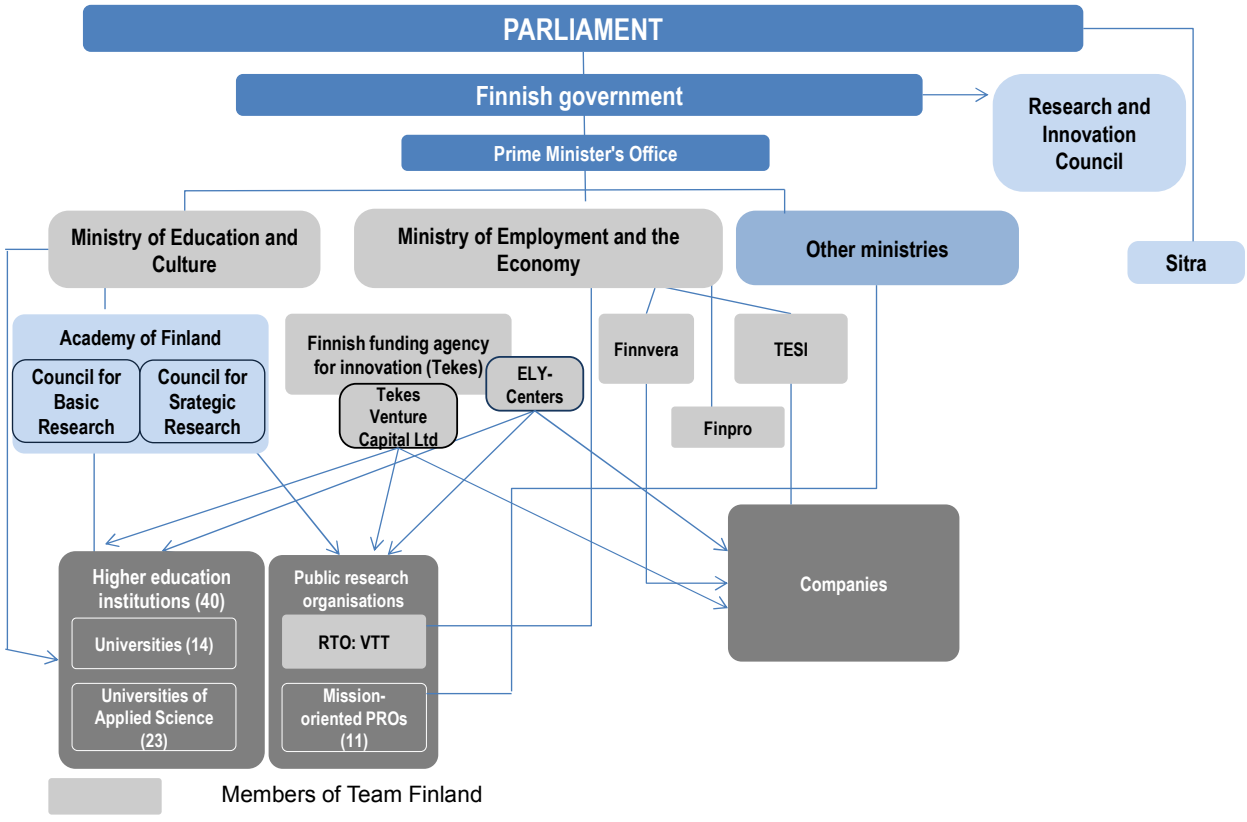
Main policy actors in innovation in Finland

Finland is sometimes described as a "two pillar" system where the ministries of education and economic affairs dominate research and innovation policy, and control key research agencies and organisations (Figure 6.3). The Finnish government has been advised for some time by the RIC and its predecessors, but the Prime Minister's Office has started playing a role in policy co-ordination, operating at the level of government itself. At the second level are first and foremost the ministries for education and industry that form two central actors in the Finnish innovation landscape. "pillar". Other ministries also fund research and innovation, while some have affiliated government labs.

At the third level are a number of funding agencies, reporting to the respective ministries. Central funding agencies are Tekes, affiliated with the Ministry of Economic Affairs and Employment, and the Academy of Finland under the Ministry of Education and Culture. On the fourth level are universities, research institutes and hospitals performing R&D activities. Finally, the independent innovation fund Sitra reports directly to the parliament, and stands apart from the government system.

This section describes the different levels of innovation policy actors, before discussing key ministries and their agencies. Finally, the independent innovation fund Sitra and its role in the Finnish innovation system is explained.

Figure 6.3. **Main innovation policy actors in Finland**



Notes: Sitra: Finnish Innovation Fund; Finnvera: a specialised financing company owned by the state, it is the official export credit agency of Finland; TESI: Finnish Industry Investment Ltd, a government-owned investment company; ELY-Centres: centres for economic development, transport and the environment, responsible for the regional implementation and development tasks of the central government; Finpro helps Finnish small and medium-sized enterprises go international, encourages foreign direct investment in Finland and promotes tourism; RTO - Research and Technology Organisation; VTT: Technical Research Centre of Finland.

Source: Halme, K., V. Saarnivaara and J. Mitchell (2016), *RIO Country Report 2015: Finland*, https://rio.jrc.ec.europa.eu/en/library/rio-country-report-finland-2015.

The Research and Innovation Council

In recent decades, monitoring and soft governance of the Finnish research and innovation system as a whole has focused on the Research and Innovation Council (RIC) and its predecessors. After a period of inactivity, it has been reconstituted by the government and is currently redefining its new role. With growing concern of how "societal challenges" can be better addressed by innovation, a need for broader and deeper innovation system governance was formulated, involving the breadth of government and a wider range of stakeholders than has traditionally been the case. With its pivotal position, the RIC is well positioned to take the lead in this change.

Finland has had some form of Science Policy Council since 1963, and following several changes in its name and structure, it became "Research and Innovation Council" in 2008. Pelkonen (2006) argues that initially the Council was to mediate between academic research and industrial innovation, represented by "their" respective ministries. Recent generations of the RIC included two sub-committees, one on science and

education and the other on technology and innovation – reflecting the interests of its ministry affiliations. The current RIC does not have a sub-committee structure.

Beyond the involvement of ministers that are central to research and innovation policy, the RIC is chaired by the Prime Minister. In addition to the ministers, it includes five members chosen on the criterion that they widely represent the research and innovation system as a whole. The heads of key agencies, notably Tekes and the Academy of Finland and three permanent secretaries from the ministries are present in the meetings as permanent experts. Generally the RIC had been seen as a high-level key co-ordinating mechanism in the national innovation system. Its permanent tasks included:

- directing and steering research and innovation policy
- developing research and innovation funding, increasing the impact and effectiveness of research
- developing sector research and the government R&D institutes
- international co-operation in STI
- other various issues such as exploitation of R&D results, evaluation, etc., as required.

RIC's success has been based not only on its structural characteristics, but also on important cultural features of modern Finland. One of these is a corporatist tradition in which this type of representative council is seen as a normal way of shaping policy (Pelkonen, 2006). Another is the council's place in a rather centralist administrative culture where the people involved are highly networked. This results in co-ordination that is little reflected in formal processes, such as the choice by Tekes and the Academy of Finland to complement R&D areas in the late 1990s, despite the fact that there was no formal consultation (Arnold and Boekholt, 2003). It is also noteworthy that the council became much more influential at the end of the Cold War, when the collapse of about a third of Finland's export markets triggered a recession, and Finland, on the advice of the council, increased national investment in R&D. The sense of being "all in one boat" in a crisis appears to have facilitated the council's change of function from mediation to strategic leadership.

Traditionally the RIC has produced reports and statements about Finnish research and innovation policy, e.g. on issues such as the need to increase the internationalisation of the research and innovation system, as well as periodic reviews of policy and policy guidelines. While historically the Council has set the main research agenda, including the broad budget statement, detailed implementation has been carried out by ministries and agencies. This multi-stakeholder involvement is widely understood to be an important reason for the RIC's effective co-ordination of research and innovation policy (Veugelers, 2009; Schwaag Serger, Wise and Arnold, 2015). In practice, the influence of the RIC has varied and depends substantially upon the amount of interest the Prime Minister gives it. The "six pack" coalition government of 2011-15 is said to have been sceptical of the role of the RIC and of research and innovation policy more generally, leading to an increasing disconnect between the RIC's systemic approach and that of the government.

A 2014 evaluation of the RIC stated that its influence had declined since 2005. While it was supposed to co-ordinate research and innovation policy, the evaluation argued that its binary support structure resulted in separate research and innovation policy "silos". Key conclusions were that the council had an important role bringing together politicians and experts, with significant impact on government programmes, R&D funding and in

placing research and innovation policy on the political agenda. However, it had lost some of its position and effectiveness in the research and innovation system, due to unnecessary segregation between education, research and innovation, and a weak position in horizontal policy, often working reactively.

The last substantive contribution of the old RIC was to publish the "Reformative Finland" review for 2015-20 (Research and Innovation Council, 2015), setting three high-level objectives: 1) increase the quality of research; 2) renew the structures and functions of the public research system; and 3) diversify the economic structure to support regeneration of the enterprise base. In addition, the review proposed a list of approximately 50 actions along 6 themes, which included the radical reform of the higher education system; promoting the exploitation and impact of R&D; strengthening new sources of growth, intellectual capital and entrepreneurship; improving the overall knowledge base and selective support for cutting-edge skills; reforming the public sector and closer cross-administration co-operation; and ensuring the adequacy and targeting of R&D funding.

The review recommended increasing government R&D funding from the 2015 level by 2% annually over the second half of the decade. Of this increase of some EUR 210 million in real terms, EUR 85 million should go to Tekes and EUR 50 million to the Academy of Finland, to be distributed under competition. The RIC stressed the need for greater certainty in research and innovation funding, involving academic-industrial consortia more in policy making, improving the co-ordination between Tekes and the Academy, adjusting the incentives for universities so as to encourage specialisation and more strategic thinking, reversing the downward trend in business expenditure for R&D (BERD), and being more engaged in international R&D activities, notably the Framework Programme.

In its current form, the RIC is chaired by the Prime Minister, while the Ministers for Employment and the Economy and for Education and Culture are vice-chairs. The defence minister is the fourth minister member of the RIC.

The Prime Minister's Office

In addition to the SRC within the Academy of Finland, the Prime Minister's Office (PMO) administers an annual budget item (11 million EUR) supporting research in line with the government's policy priorities. The motivation for centralising research funds at the Prime Minister's Office was to ensure that government-commissioned research would be relevant to society, not only to an individual ministry. The pooling of research resources at the PMO was thus an attempt to generate a common research agenda.

The PMO calls for tenders each year, based on themes and topics outlined in the government programme and plan for analysis, assessment and research. To identify relevant topics, the government set up a "government working group for the co-ordination of research, foresight and assessment activities", which consists of representatives from all ministries. In addition to an annual plan for analysis, foresight, assessment and research, it supports decision making and is also responsible for monitoring and disseminating the generated knowledge. The budgets for individual projects are typically between EUR 100 000 and EUR 600 000.

Key ministries and strategies

Finland has historically assigned considerable importance in research and innovation matters to the Ministry of Employment and the Economy and the Ministry of Education and Culture. Other ministries nonetheless play important roles. Their significance is growing as a result of the development of cross-ministry strategies in areas such as the bio-economy and healthcare, and will need to grow further in the future in order to respond to societal challenges addressed in research and innovation agendas.

Ministry of Employment and the Economy

The Ministry of Employment and the Economy is responsible for the regulation of markets for labour, goods and services, industry, energy and employment policy as well as for regional development. It makes policy in the following areas: industry; energy and climate; innovation and technology; internationalisation; health and safety at work; employment, labour relations and the working environment; regional development; competition; consumer policy; and the integration of immigrants. The ministry's scope is therefore quite broad, bringing together research areas that in other systems are often handled by separate ministries. It maintains significant levels of analytic capacity in order to provide the strategic intelligence needed.

The Ministry of Employment and the Economy's principal agencies are Tekes, Finnvera, the Finnish Industry Investment and the network of regional ELY centres that provide local interfaces between companies and the state. In the Finnish system, as in Norway and Sweden, agencies have high degrees of freedom from their parent ministries. Funding and other instruments are typically designed at the agency level. In the context of a future need for more decentralised, system-changing policies this presents a considerable advantage over more centralised ministry-agency relationships.

Ministry of Education and Culture

The Ministry of Education and Culture is responsible for education, science, cultural activities, sport and youth policies, as well as international co-operation in these fields. It designs policy on daycare, education, training and research; arts, culture, sports and youth; public archives, museums and libraries; the churches and other religious communities in Finland; financial support of students; and copyright. Responsibility for the schools is decentralised at the regional level, though the ministry regulates them. The Academy of Finland operates under the auspices of the Ministry of Education and Culture. Higher education institutions (HEIs) are autonomous and operate mostly in the administrative branch of the MEC that steers their activities and channels government funding to HEIs.

Other ministries are involved in funding research and innovation, several of them via government research institutes (see Chapter 4). The emergence of cross-ministry strategies implies these ministries are starting to find new roles in the development of overall policy for research, innovation and, potentially, for system innovations or transitions. Box 6.2 provides examples of ministerial co-operation carried out along cross-sectorial innovation strategies in national strategic areas (spearhead projects) and new innovation initiatives in cities.

Box 6.2. **National innovation strategies and co-ordination across ministries and agencies in Finland**

The Health Sector Growth Strategy for Research and Innovation Activities

This strategy identifies the parts of the Finnish healthcare system that have potential to enable innovation and growth, in Finland and abroad. It analyses the status of health sector research and innovation policy in Finland and research-based opportunities to close gaps and develop competitive advantage. The Health Sector Growth Strategy was published in 2014. It was developed by the Ministry of Employment and the Economy, the Ministry of Social Affairs and Health, and the Ministry of Education and Culture, together with Tekes, the Academy of Finland, and research funders and organisations in the health sector. They were supported by a wider expert group and several consultations in the field. The emphasis is on developing a health "ecosystem".

The Bio-economy Strategy

The aim of the Finnish Bio-economy Strategy is to generate economic growth and new jobs in bio-economy business and high value-added products and services while protecting ecosystems and ensuring their sustainability. "Bio-economy" involves reduced dependence on fossil resources and shifting the basis of production towards renewable resources such as biomass or organic matter in the forests, soil, lakes and sea combined with greater reuse and recycling in order to be more sustainable. It aims to increase the value of the Finnish bio-economy from EUR 60 million to EUR 100 million per year over a decade, increasing employment from 300 000 to 400 000 in the same period. The strategy was devised in a project set up by the Ministry of Employment and the Economy. Participants included the Prime Minister's Office, the Ministry of Agriculture and Forestry, the Ministry of the Environment, the Ministry of Education and Culture, the Ministry of Social Affairs and Health, the Ministry of Finance, the administrative branches under these ministries, as well as VTT and Sitra.

The Six City Strategy

The Six City Strategy was set up in 2014 and is a seven-year strategy for sustainable urban development approved by the Ministry of Education and Culture and carried out by the cities of Helsinki, Espoo, Vantaa, Tampere, Turku and Oulu. The idea is to use these large cities as a milieu to develop innovation by improving city services and using the cities themselves as reference sites for future product sales. The combined scale of the six cities is intended to support the scaling up of innovations through pooled procurement.

Some EUR 80 million in European Regional Development Funds (ERDF) have been allocated across the life of the strategy, and the regions themselves must contribute one-third of the funding for projects falling within the strategy. Projects are carried out by networks of organisations, in order to build a basis for subsequent commercial exploitation. Results are then shared and disseminated, not least with other Finnish cities, as a basis for encouraging further take-up and innovation. The strategy is run by a joint management group, comprising the cities' directors in charge of business innovation and/or service development, and managed from the Häme ELY centre.

Agencies

Tekes – the Finnish Funding Agency for Innovation

Tekes was established in 1983, styled on Sweden's National Board for Technological Development (STU, currently VINNOVA). Close-to-market work could be funded via loans – a principle Sweden abandoned as unworkable in the 1980s but which persists in

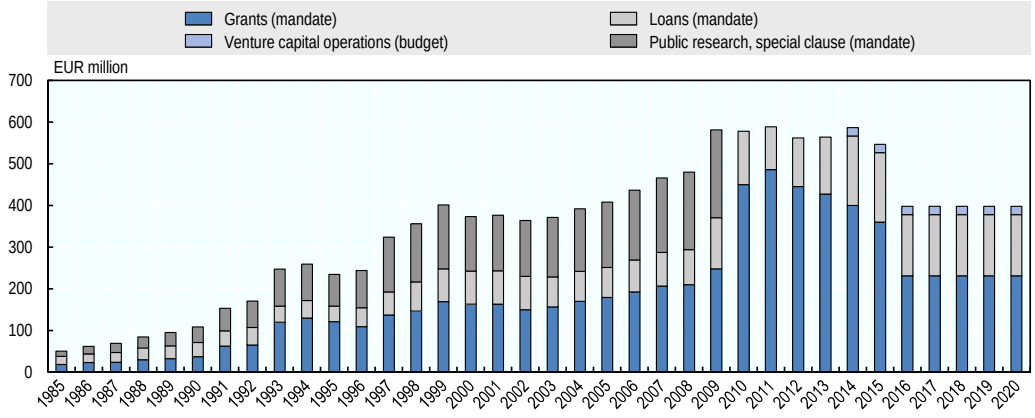
Tekes practice today. Tekes technology programmes have played a significant role in the Finnish industrial development since the 1980s. Some of these programmes have been focused on product and process improvement in existing firms, others have focused on capacity development and yet others on enabling technologies. They have therefore addressed both competitiveness and productivity, both by aiming to improve productivity in existing industries and businesses and by supporting restructuring into new, high-productivity businesses. Most conspicuously, multiple programmes strengthened the capabilities of the IT supply chain, generating a domestic supply community for Nokia and others.

Large firms were often involved as recipients of Tekes funding on the basis that they would then pass the subsidy upstream to the research sector or to smaller companies. While this generated benefits to large companies through the development of technologies and ecosystems of relevance to their business, typically 90% of the subsidy was passed on to SMEs and public research organisations.

A key change in Tekes' role was introduced following the 2008 crisis, when it was required to extend its activities to supporting start-ups and entrepreneurship. Tekes' funding for companies less than six years old more than doubled between 2006 and 2015 and the importance of loans in its portfolio has increased substantially since the crisis. This new role entailed acquiring new skills and setting up new kinds of programmes in addition to its traditional activities. In 2014, Tekes set up Tekes Venture Capital Ltd, which invests in venture capital funds with the aim of encouraging private participation. By 2016, the company had invested in 8 funds, which in turn had collectively invested in 75 companies (Kotiranta and Rouvinen, 2016).

Another key development around the time of the crisis was the setting up of the SHOK programme, which was launched in 2006 at the request of the RIC. The SHOKs were long-term public-private partnerships that received Tekes money to help fund R&D of interest to a group of stakeholders (see below).

Figure 6.4. **Evolution of Tekes' budget**



Note: The continuation of Venture Capital operations funding for 2018-20 has not yet been fixed.

Source: Tekes (2015), "The impact of Tekes and innovation activities 2015", Tekes, Helsinki.

Figure 6.4 shows that the combined effect of Tekes' changed role and the creation of the SHOKs was to reduce substantially national investment in technology programmes. This implied a reduction in "strategic applied research" or key enabling technologies

conducted in and with the university and institute sectors. In effect, a funding gap has been created in this area (Arnold et al., 2013) and there has so far not been any policy move to close it. The cancellation of the SHOK programme meant that Tekes lost the corresponding budget, so there have not been funds to close the gap again.

Tekes' current strategy focuses on businesses seeking renewable growth from international markets and emphasises business development to create opportunities for global growth. It supports emerging business ecosystems, builds a top-level innovation environment together with partners and offers a path to market via the Team Finland co-operation. Tekes states that it "promotes the development of industry and services by means of technology, innovations and growth funding". Table 6.1 provides an overview of the services delivered by Tekes in 2017.

Table 6.1. **Tekes' services, 2017**

	Start-ups	Small and medium-sized enterprises	Large firms	Research organisations	Public services
Tempo: Testing business concepts, demand, prototypes	X				
Research grants	X	X	X		
Loans for development and piloting	X	X	X		
Young innovative company scale-up funding: Grants and loans	X				
Info: Consultancy for international growth	X				
Innovation vouchers	X				
Team Finland Explorer: Market information from abroad	X	X			
Digiboost: Consulting help for digital renewal in business	X	X	X		
Kiito: Help to develop an internationalisation plan		X	X		
Into: Consulting on foreign market entry	X	X			
Trade fair grants		X			
Energy aid, production funds for film and media industries		X			
Pubic research networked with companies			X	X	
Public research in technology programmes			X	X	
Commercialisation support				X	
Kiito: Leadership and operational models					X
Innovative procurement: New products, pre-commercial procurement and catalyst test/demonstration procurement					X
Market opportunities programmes (Team Finland)	X	X	X		
International network access: Brussels, the People's Republic of China, India, Japan, the Russian Federation, the United States (Team Finland)	X	X	X		

Source: www.tekes.fi (accessed 19 March 2017).

Thematically, Tekes focuses on natural resources and resource efficiency, digitalisation for renewing business and industry, well-being and health, new business ecosystems and market access. Currently, it runs eight technology programmes, a significant reduction compared to before the financial crisis, when a much larger number of technology programmes was active.

Tekes was evaluated in 2012 (van der Veen et al., 2012). The evaluation noted that Tekes had a clear and positive effect on innovation activities, firm-level productivity and business renewal. It supported many of the most successful high-growth and start-up firms and appeared to compensate for the lack of private venture capital available to support early-stage firms. It was administratively efficient. However, co-ordination with other agencies could be improved. The findings on Tekes' impact on productivity and renewal have been confirmed by a more recent analysis (Viljamaa et al., 2014). While the main spearhead activity relevant to Tekes is to fund academic-industry collaboration projects, budget changes in recent years have tended to shift resources away from these activities and towards the third objective of building start-ups and ecosystems.

Finnvera

Finnvera is also an agency of the Ministry of Employment and the Economy. It was created in 1999 through a merger of Kera Corporation, which provided start-up and development loans to companies, and the Finnish Guarantee Board, which offered export credit guarantees. Finnvera has some 28 000 customers and raises capital by issuing bonds and receives an amount of credit loss compensation from the state. This compensation has risen from about EUR 10 million in 2007 to about EUR 80 million in 2015, reflecting Finnvera's growing provision of export guarantees.

The most recent evaluation of Finnvera (Heinonen et al., 2012) found that it is sufficiently capable to effectively compete with other countries' export guarantee arrangements, and largely satisfies the goals laid out by its parent ministry. However, it could take higher risks in cases where potential rewards are big and could play a larger role in company internationalisation.

Finnish Industry Investment (FII)

The FII was set up in 1995 and is an investment company owned by the Ministry of Employment and the Economy. It invests about two-thirds of its resources through private equity funds and the remainder directly. It only takes minority positions, however, with the aim of increasing the amount of capital available for these kinds of investments. Its current portfolio comprises about 670 firms, and in 2015 it invested EUR 93 million.

Following the rearrangement of the division of labour among Tekes, Finnvera and the FII, the FII is expected to focus on later stage venture capital and on growth finance. It should play a stronger role in direct investments, for example in biotechnology, clean technology, digital and health industries, and reduce its role in international funds and investments in order to focus more resources on the Finnish venture capital market.

A recent evaluation (Saarikoski et al., 2014) was positive about the FII's influence on the Finnish private equity market activities in the way it operates but argued that it was not especially proactive in market development. The evaluation suggested that Finland suffered from a poorly functioning late-stage venture capital market and ecosystem in terms of quality and investment volumes. Key bottlenecks were lack of commercialisation know-how, small investment sizes, the large share of the public sector

and a lack of liquidity in the exit market. To remedy these problems would require the FII (or another actor) to go beyond its current role. The evaluators also point out that the process through which the Ministry of Employment and the Economy sets the FII's objectives is complex and suggests that a more "hands-off" governance that leaves the FII's management to decide how to achieve its goals would improve its performance. At the same time, the evaluation argues that the FII's day-to-day operations could be better co-ordinated with those of the Ministry of Employment and the Economy's other agencies.

Finpro

The Finpro Oy is also an agency of the Ministry of Employment and the Economy, which was set up early in 2016 through a merger of the former Finnish Tourist Board and Finpro Ry, which was the agency responsible for supporting both Finnish exporters and foreign direct investment into Finland. Its 2016 budget was EUR 34 million and it operated 36 trade centres in 31 countries. Today it has three main activities: Export Finland, Invest in Finland, Visit Finland.

Finpro currently administers the government's growth programmes on behalf of Team Finland. These have a combined budget of EUR 51.3 million for 2015-17 in the areas of bio-economy, clean-tech, ICT and digitalisation, life sciences and health, foodstuffs, creative industries, teaching and learning, manufacturing, artic competence, tourism, and various cross-cutting themes such as emerging markets and business intelligence.

Team Finland

Linking all of the Ministry of Employment and the Economy's agencies under an umbrella organisation has been discussed since the early 2000s, triggered in part by the realisation that the business and innovation support system was fragmented and an increasing focus on internationalisation in the Finnish industry and innovation policy. Studies reporting to the government in 2012 led to the creation of the Team Finland network. This ultimately reports to the Prime Minister's Office, since it straddles the Ministry of Employment and the Economy, the Ministry of Education and Culture, and the Ministry for Foreign Affairs.

The Team Finland network consists of the three above-mentioned ministries and their agencies (Finpro, Tekes, Finnvera, Finnfund – which funds investment projects in developing countries); *Finnpartnership* (a programme which supports the creation of partnerships with companies in developing countries); Finnish Industry Investment; VTT; the Finnish Patent and Registration Office; the centres for economic development, transport and the environment; Finland's cultural and academic institutes; the Finnish-Russian Chamber of Commerce; the Finnish-Swedish Chamber of Commerce. The network also operates at the regional level, largely through the ELY centres.

A collective evaluation of Team Finland's various growth programmes (Salminen, 2016) found that the programmes are effective in supporting the internationalisation of SMEs. The visible effects are short term but positive and industry is enthusiastic about the programmes, although there have been many complaints about their implementation. Potential key improvements include a revised funding and oversight model, and enhanced co-operation with other programmes and service providers.

There still appear to be co-ordination issues across Team Finland. Operationally, these organisations lack a common customer management system so there is little overview of the individual customers and how they could benefit from the system as a whole. This may partly result from banking privacy regulations. Equally, there do not appear to be working-level routines for co-ordination at the level of customers, so a major form of co-operation appears to be the ability to refer customers towards other organisations better able to meet their needs. However, the government announced its intention to regenerate Team Finland in November 2016, focusing it around six programmes. Immediate measures to be taken included the inclusion of Finpro's 33 growth programmes and Tekes' 11 innovation programmes in Team Finland programmes, under the 6 themes of bio-economy and clean-tech, digitalisation, well-being and health, arctic business, tourism and special themes. In the future, services will be provided for common customers of both Tekes and Finpro, based on these six themes. Another new element will be the adoption of a voucher-based funding service for internationalisation.

It is not clear that Team Finland's activities in capital lending are sufficient. Tekes Venture Capital is a fund of funds, and so does not provide early-stage capital directly to companies. The closure of Finnvera's Vera fund means that Finnvera is no longer a source of such direct investment. The FII co-invests with private equity funds and private investors, focusing on later stage venture capital and growth finance. The state system depends, therefore, on encouraging private investment at the early, most risky phases of venture capital while playing a more direct role (as well as an indirect one) at the later, less risky stages.

The Academy of Finland

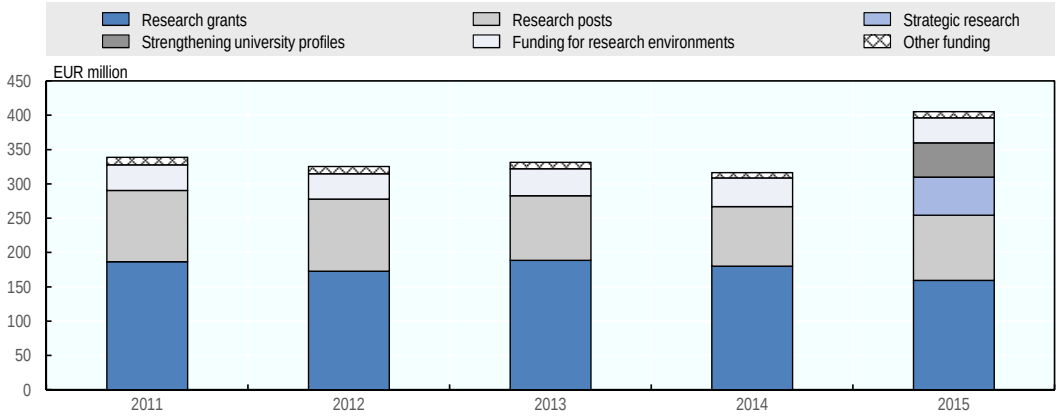
The new Academy of Finland started in 1970 and comprised the Central Board of Research Councils, the Academy's highest decision-making body, six research councils and an administrative office. The number of research councils grew to seven but was reduced to four in the 1995 reorganisation, when the Central Board of Research Councils was replaced by the board of the Academy of Finland, led by the Academy's President.

After its most recent amendment, the Act on the Academy of Finland (2009) states that the Academy's formal objectives are to foster scientific research and its use; promote international scientific co-operation; provide science policy expertise; grant funding for scientific research, researcher training and developing research capacity; and undertaking other science policy expert tasks at government request. The Academy's board comprises seven people appointed by the government, of whom three are currently Finnish academics. Four rather traditional research councils composed of Finnish academics appointed by the government form the main pillars of the Academy: biosciences and the environment, culture and society, natural sciences and engineering, health.

The Academy has a separate committee funding research infrastructure and a new Strategic Research Council that was created in 2015. Figure 6.5 shows how the Academy has allocated its funds in recent years, continuing to spend a large part of its budget on personal fellowships. The research grants funded cover both principal investigator-initiated proposals and a number of small programmes, proposed by the research community, which focus on grand challenges and supporting emergent fields of research. Few grants are less than EUR 200 000, so the Academy has followed the trend among research councils to reduce the importance of small grants and encourage the formation of larger research groups.

Figure 6.5 shows the new expenditure of the Strategic Research Council (SRC) in 2015 and also a second initiative: strengthening university profiles. These are grants to individual universities aiming to strengthen and consolidate areas of expertise. They are intended to be tools for strategic management by the rectors, allowing the universities to specialise, producing a clearer thematic division of labour and supporting strong points in the university system.

Figure 6.5. **Academy of Finland funding decisions and funding type per year**



Source: Academy of Finland (2016).

Since 1996, the Academy of Finland has run centres of excellence (CoE), providing an incentive for defragmenting the academic structure. A major issue is to what extent these CoEs have an impact on knowledge transfer and generating industry or socially relevant research for innovation.

The most recent evaluation of the Academy (Arnold et al., 2013) found that it was well functioning, but constitutes a traditional research council, which needs to modernise in order to deal with the changing context. The Academy did rather little in its role as science policy advisor to the government. Its internal governance was not conducive to change while the Ministry of Education and Culture steered the organisation rather softly. Success rates were declining over time to some 30%. Recently, the success rates have fallen clearly below 20%, close to the rates at equivalent organisations in Norway and Sweden.

In the most recent period, it is clear that the role of the Academy has shifted further away from the old mode of reactively responding to researchers' funding requests towards a more strategic approach, aiming to influence the shape and performance of the system.

The Strategic Research Council

One aim of the recent reform to the funding system and the PRIs is to increase the ability of research and analytical work to inform and support policy making in a systematic way. To this end, the government has established lines and programmes for funding "strategic research". The reform also seeks to strengthen research institutes' co-operation with universities through common research equipment, laboratories, close co-operation in research and education – including shared staff – and the establishment of agreement-based consortia (Kotiranta and Rouvinen, 2016).

At the same time that basic funding to PRIs was cut, a new funding instrument for long-term funding for research to tackle major societal challenges was set up at the Academy of Finland: the Strategic Research Council. The funding, to be allocated in competition, is for strategic, problem-oriented research aimed at finding solutions to societal challenges, with an explicit emphasis on supporting and strengthening policy making. EUR 70 million were to be cut – from Tekes (10 million EUR), the Academy (EUR 7.5 million) and especially the public research institutes (EUR 52.5 million) – for allocation to the SRC. The largest share was to come from VTT (EUR – 16.6 million) (Government's decision-in-principle 2013). Annual funding of SRC is around EUR 55 million. Universities as well as public and private research institutes are eligible to apply for funding.

The members of the Strategic Research Council currently comprise two persons working in the senior management of government research institutes (VTT and Finnish Environment Institute), four university professors (two of whom hold the title of Academician), two senior executives of a private company and one retired senior civil servant (also professor of practice). The largest grant so far has amounted to EUR 4.77. Once a year the SRC prepares a proposal on strategic research themes based on a consultation process which it then presents to the government for approval. The government decides the final themes based on which the SRC then designs research programmes and funding calls. The SRC's current priorities are shown in Table 6.2.

Table 6.2. **The Strategic Research Council's key priorities, 2015-18**

Year	Key themes
2015	Utilisation of disruptive technologies and changing institutions A climate-neutral and resource-scarce society Equality and its promotion
2016	Knowledge, know-how and the changing working life Health and the changing of lifestyle Overall security in a global environment Dynamics of urbanisation
2017	Changing citizenship - society in a state of global flux
2018	Reform or wither – resources and solutions

Note: In 2016, the government also decided that a common priority area would be to take into consideration the effects of migration on Finnish society. In 2017, the government also decided that a common priority area for both 2017 and 2018 themes would be harnessing scientific knowledge in decision-making and achieving sustainable growth.

Source: Academy of Finland.

Public research institutes participate in the majority of projects funded by the SRC so far. However, relatively few projects are led by institutes. In 2015, 4 out of 16 projects funded by the SRC were led by PRIs, while in 2016 in 2 out of 14 projects the consortium leader was from a PRI (based on funding decisions listed on the SRC's homepage). Thus, the vast majority of the bottom-up projects currently funded by the SRC are led by university researchers. Some 75% of the 2015 SRC funding went to university projects and the remaining 25% to institutes, representing a reallocation of just under EUR 40 million from the institute to the university sector that year.

Sitra

Sitra is an independent foundation reporting directly to the Finnish parliament, which is capable of making policy interventions without a government mandate. It was established in 1967 as an organisation of the Bank of Finland. Its mission was to promote balanced economic growth and international development. In 1991 Sitra was externalised, becoming an independent foundation using the revenues from its fund to finance its activities. At the end of 2015, the fund stood at EUR 771 million and Sitra had spent about EUR 38 million on its activities that year.

Sitra's independence has enabled it to play a variety of roles over time, focusing on ways to trigger change. It has fairly consistently maintained a rolling programme of change-orientated projects, training and events such as workshops. In the past, it has run foresight projects (and still runs foresight networks), reorganised the state's regional provision of venture capital and invested in start-up companies. In 2012, Sitra adopted a project-based form of organisation, based on three themes:

1. empowering society, currently described as "capacity for renewal"
2. resource-wise and carbon-neutral economy
3. new working life and sustainable economy.

Projects involve research, policy experimentation and piloting; workshops and other events; funding policy-relevant research; networking; foresight; strategy development; calls for ideas and challenge competitions. This range of project types is increasingly needed as Sitra addresses aspects of transitions in socio-technical systems. This tends not to mean head-on attempts to change existing systems, but rather experimenting with and piloting partial solutions that can run parallel to them.

Sitra was last evaluated in 2012 (Ramböll, 2012). The evaluation endorsed the quality of Sitra staff and the effectiveness of its work in triggering and encouraging change. Sitra often achieves impact by temporarily entering areas where there are no other effective actors and experimenting with social innovations such as health kiosks and municipal service centres. It has a good reputation and influences public opinion (for example, in the area of green energy) as well as policy making.

In a time of new policy requirements, Sitra's potential for experimentation and as a change agency are important assets for Finland, which could be exploited in the search for new ways to define and implement policy. The Director General of Sitra is a member of the "6DG" group, together with heads of key agencies, so there is an established channel for co-ordination between its independent actions and those of the state.

The regions

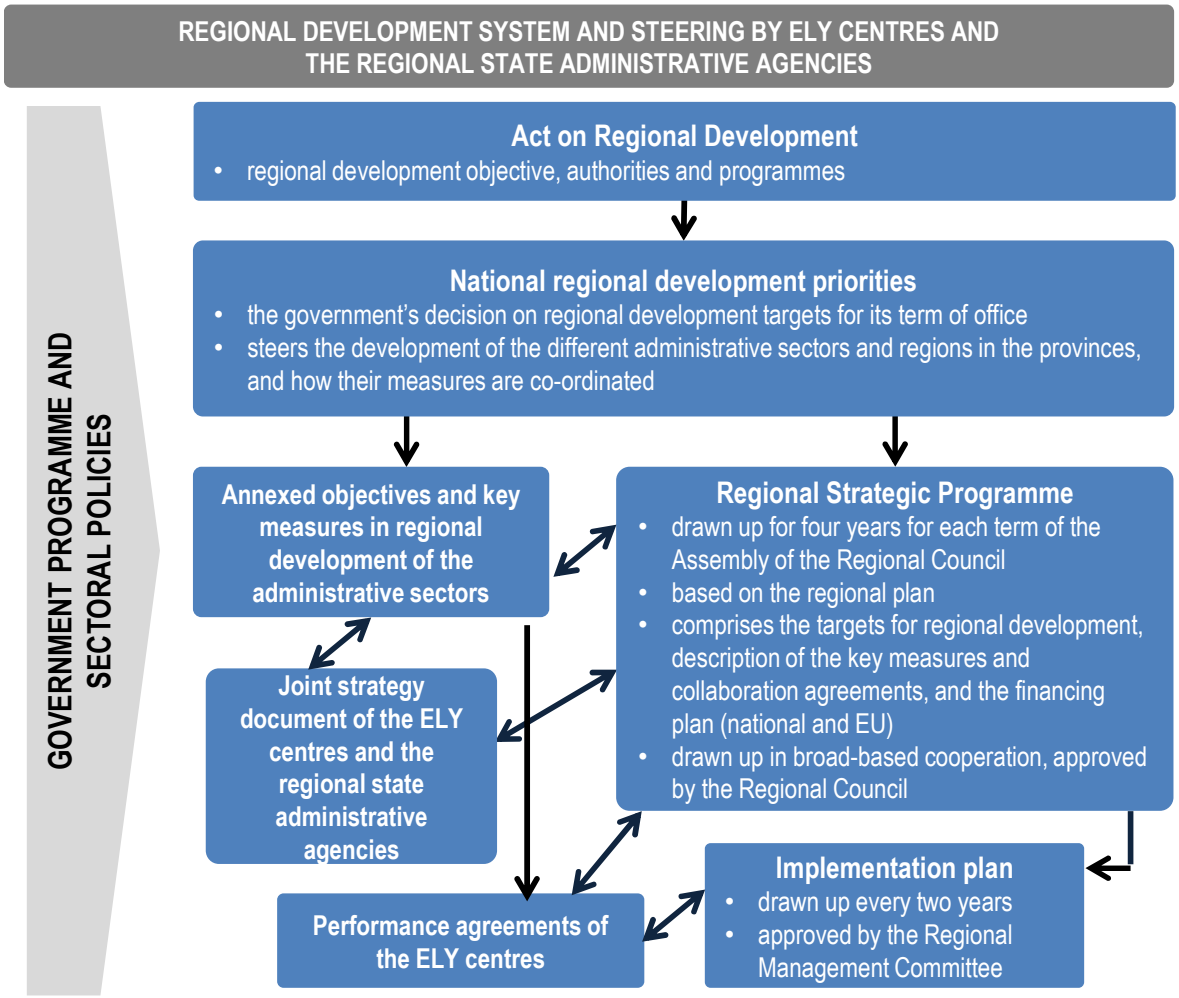
Finland is a relatively centralised state, where the regions play less of a role in policy development and implementation than their larger counterparts in more regionalised countries like France, Germany or Spain.

Between 1634 and 2009, Finland was divided into a number of provinces, from which government managed the regions based on Swedish administrative practice where the lowest level comprised self-governing municipalities. At the time of their abolition in 2009, there were six provinces. Today, the municipalities have responsibility for healthcare and social services, schools, infrastructure and land use, economic development, and aspects of law enforcement not handled by the police. In the early

1940s there were a little over 600 municipalities, falling to some 450 by about 1990. In 2016, there were 20 regional associations (including the autonomous region of Åland) made up of 313 municipalities of varying sizes. Given the small size of many municipalities, it is hard for them to fulfil their responsibilities – a problem which many solve by outsourcing services.

Since the early 2010s, both the government and the Association of Finnish Local and Regional Authorities (Kuntaliitto) have been pushing for more municipal mergers, aiming to create a threshold population for a municipality of 20 000-30 000 people. From 2012, Kuntaliitto has been running a development programme to improve the capacities of the municipalities and inspire development, with limited success. The current government has revamped local and regional reform, aiming to merge municipalities and certain central government authorities into 18 counties with directly elected councils, replacing the existing regional associations. These will be responsible for healthcare and more widely for about 60% of the local and regional government budget. To what extent these 18 counties will take on responsibilities for formulating innovation policies remains to be seen, while national-level organisations should ensure their co-ordinating role to avoid any risks of fragmentation of the research and innovation system.

Figure 6.6. **Current regional development framework in Finland**



Source: Ministry of Economic Affairs and Employment.

The regional associations have been the focus of regional planning and in recent years have been the level at which regional development subsidies from the European Social Fund and ERDF have been planned. Every region developed an innovation and development plan some years ago, so the tradition for such planning is well embedded at this level. Previously, the provincial level was a useful one at which EU support could operate, since the number of provinces was small enough and the size of each province large enough to be handled by EU programmes, notably the Regional Innovation Strategy programme, currently known as "Smart Specialisation" or RIS3. The loss of the provincial level has entailed a more fragmented dialogue between the regional and EU levels.

There is a strong interplay between the regions and the national level, based on the government's national regional development priorities. Figure 6.6 provides an overview of the current regional development framework of Finland. The government's "spearhead projects" frequently have a regional dimension and the government has started to sign development contracts with major cities, having abandoned a more fragmented approach to regional innovation via the Centres of Expertise programme in 2013. Central government has maintained different generations of representative offices at the level of the regions. Known as TE-Keskus in the 1990s and more recently as ELY centres, they provide regional outposts for the work of a (slightly shifting) constellation of national ministries spanning work, industry and development issues. The ELY centres not only deliver state services, but serve as a key interface for regional development planning between the regions and the central state.

The Ministry of Education and Culture's policy of encouraging universities to focus their thematic research "profile" also has potential synergy with the regions. For example, it has allowed the University of Vaasa to expand its research activities in partnership with the local industrial clusters, centred on Wärtsilä and ABB Group (ASEA Brown Boveri), with expected effects not only on the university's ability to support industrial R&D but also on education at all levels, therefore improving the local availability of skilled and educated people who are otherwise difficult to attract and retain in the more peripheral regions.

Overall, despite the fragmentation of the municipalities, the regional development system combines the ability to act locally with a degree of central government steering and opportunities to use central government initiatives and programmes in support of regional innovation and development. There is a trend in government policy towards handling regional development in larger blocks, encouraging defragmentation and the emergence of strong, city-centred regions rather than attempting to empower every municipality or even region. Given the context of global competition and the fact that Finland's population is comparable to that of German Bundesland or a French département, this aim to operate in larger entities is reasonable, as is (within reason) the city-centric approach. It is well documented that urban regions tend to produce higher rates of innovation than other regions.

Governance: Agenda setting, co-ordination and evaluation

Research and innovation governance in Finland

The RIC has for decades been the cornerstone of the system, forming an "arena" where central actors from government, agencies, academia and industry can hammer out a policy consensus that has the authority of government based on a system-wide

overview. In relation to research and innovation policy, all the needed voices have therefore been heard.

The RIC's policy statements were traditionally evidence-based, but brief. They set directions but do not go into the details of implementation, leaving those to the expertise of the ministries in the case of reforms and regulation, the agencies in relation to policy instruments and their use, and to the industrial and research communities. The Academy of Finland and Tekes involve their stakeholders on their boards, so that they are in close touch with their constituencies. The analytic and operational capabilities of the ministries and agencies mean that the state's part of the research and innovation system has considerable "distributed strategic intelligence" (Kuhlmann et al., 1999) which is needed to be effective at both strategic and operational levels. However, there are concerns that there is a serious shortage of free, untied financial resources for policy analysis and development in the ministries.

Despite the imperfections detected in its recent evaluation (Pelkonen, Nieminen & Lehenkari 2014), the RIC has provided Finland with a uniquely powerful way to understand the national research and innovation system, to develop the main lines of policy for it, and to co-ordinate the implementation of policy. It has been able to tackle systemic issues such as the balance between research council-style bottom-up funding on the one hand and applied and thematic funding in support of innovation on the other. It has identified the constraints that fragmentation within and among higher education institutions impose on research quality, relevance, critical mass, the reputation and international attractiveness of Finnish universities and proposed measures ranging from setting up SHOKs and centres of excellence through to "profile" funding, institutional reorganisations and mergers to address these issues. It has highlighted the need for internationalisation of both public and private sector R&D as well as higher education and triggered measures to address the problem.

The PMO has in the past played small role in research and innovation policy. However, as part of the package of reforms that created the Strategic Research Council and restructured the government research institutes, a new budget item was created under the PMO for funding studies) to support government decision making, with a proportion of the money being used to study aspects of the research and innovation system. The central position of the PMO means that it is a potentially powerful place from which to tackle the increasingly difficult and complex task of co-ordinating policy.

The new government of May 2015 did not appoint members of the RIC until a year later, so the government programme was launched without the benefit of work by the RIC. However, with the exception of RIC recommendations on the PPP instruments and education and R&D funding, the government programme did not deviate considerably from the lines proposed by the previous RIC in its final policy review "Reformative Finland" (Research and Innovation Council, 2015). Hence, neither the systemic and integrative focus of Reformative Finland nor the attached recommendation to increase government R&D spending by 2% per year is reflected in the new government's policy. The decision by the new government to defund the SHOKs and dismantling INKA without replacing them with other instruments fails to acknowledge the systemic role the RIC foresaw for them. The new government's 6 strategic objectives, to be reached through cross-ministry co-operation and 26 "spearhead projects" (10 of which involve research and innovation measures) constitute a challenging, and in many ways forward-looking, programme. However, the absence of the RIC during the period when these objectives were formulated means that they are not connected to a coherent overall

research and innovation policy. A new government decree on the RIC was issued in March 2016 and a re-structured Council finally met in September 2016. The thrust of its activities is not yet clear but the revival would suggest it to launch a new policy agenda, to generate the restructuring and growth needed in the economy.

Governance, economic and societal challenges and transitions

There is growing international recognition of the need to adapt the way countries govern research and innovation policy in order to meet the societal and increasingly complex economic challenges that globalised economies encounter today. As discussed in previous chapters, Finland needs to develop new and sustainable export strengths, and revitalise traditional industries, fostering their capability to compete globally through new economic competences. This transformation will require Finland to engage more in "radical innovation" and become more effective in utilising its valuable knowledge capabilities and transforming them into globally competitive innovation. Raising productivity levels also requires making innovation and commercialisation more effective, which entails rethinking the innovation strategy and ensuring the benefits of new technological paradigms (e.g. digitalisation).

Finland, along with other countries, faces the challenge of ensuring the future quality of life and well-being and addressing societal challenges such as energy efficiency, healthcare for an ageing population and climate change, and developing new solutions in innovative ways and based on innovation. The system-changing nature of these challenges means that they require a new style of innovation system governance, which is more participatory and more inclusive of a wider set of stakeholder groups – in the economy and society, in government, among final users, and abroad – and which is more open to societal input to the process of innovation. These elements are also pertinent for addressing economic challenges in more effective ways through innovation policy than in the past. The "societal challenges" also provide massive opportunities for knowledge-based innovations and new kinds of business, including for global markets. Addressing them should be based on a forward-looking strategy and vision promoted at the highest level of policy decision making.

The necessary new style of governance needs to coexist alongside earlier styles that remain relevant in many parts of the system and are adapted to other important purposes. As it requires a system-wide approach, it has encouraged experimentation, but there is no established "best practice". Finnish experience with innovation system governance positions the country well to take a lead. The RIC would play a central role in this endeavour. Implementing this new form of governance implies developing new policy instruments, an area in which Finland has also gathered considerable experience. But these will only function well in a system that invests strongly in research and innovation, and uses and further develops more traditional instruments where these are appropriate.

An emerging literature describes tackling the societal challenges in terms of "transitions" between socio-technical systems or systems innovation (Geels, 2010; Kuhlmann and Rip, 2014; OECD, 2016a). The commonly used exemplar of a transition is the one needed in the energy system in order to combat global warming, but a similar logic applies in areas such as ageing and healthcare, where system-wide changes in production, consumption, markets, regulation and social attitudes will be needed to cope with change (see Box 6.3 for some OECD examples). At the core of the transition is a shift in governance structures that not only allows change to occur, but also directs and orchestrates some of the changes. The "smart city" and "circular economy" initiatives that

mobilise technological and social innovations to make the production and consumption of a city's goods and services more sustainable illustrate this point.

One implication is that transitions need to be managed on a more decentralised basis and with bigger networks than in traditional research and innovation policy. The scope of these networks will be specific to each system innovation: the shape and composition of the needed networks will be different among climate change, ageing, HIV/AIDS and so forth. There will be considerable limits to the ability of a single co-ordinator to manage these in detail. Significant power and initiative will have to be devolved to the level of the networks tackling the individual challenges. At the same time, a degree of national prioritisation and co-ordination will be needed if overall national strategy and policy are to be coherent.

Taking these opportunities requires more coherent and thought-through cross-cutting national strategies and more integrated funding and governance that will allow researchers to play their part. The need for scientific excellence and industrial relevance do not disappear but policy and research need to be better co-ordinated and connected to grand challenges. Inevitably, small countries like Finland need selectively to choose the areas where they will grow or strengthen the capabilities needed for specific grand challenges. A key dimension will be to balance research potential with innovation potential, based to a great extent on the availability of strong domestic industrial partners.

Box 6.3. **System innovation transition programmes in OECD countries**

The concept of system innovation can be characterised as a horizontal approach to innovation policy directed at problems that are systemic in nature, such as transitioning towards low carbon energy systems or low carbon transport systems. It is one that involves engaging a range of private and public sector actors and takes a longer term view in policy (OECD, 2016a). The rationales for a system innovation go well beyond traditional motivations for innovation policy such as market failures; other failures such as demand articulation failures (i.e. hidden or weak demand) and transitions failures are considered reasons for public action. Furthermore, system innovation theories argue that destruction – or at least disassembly of existing infrastructures, regulations, norms or standards – may be needed for new solutions to emerge and scale (ibid).

Implementation of system innovation as a framework for policy making is a recent development spurred by forward-looking governments, innovation agencies and regions in countries such as Belgium, Finland, the Netherlands, Sweden and the United Kingdom but also Korea and Japan, which are experimenting with a systems approach and use the systemic policy instruments such as longer term (five to ten years) innovation funding programmes; road mapping; new cluster policy; smart regulation and demonstrators. Many OECD countries are also mainstreaming system-based approaches to innovation policy in the context of a dedicated green economy agenda or as part of energy and industrial regeneration strategies. Examples of recent policy initiatives are discussed below.

Austria: National Platforms for Industry 4.0 are an example of a national initiative that is mainly policy driven that has been set up in a top-down mode. The platform explicitly addresses the complex challenges of the transition of small and medium-sized enterprises towards Industry 4.0. Although initiated top-down, platforms encourage the participation of all stakeholders.

Belgium: Flanders has been a pioneer in using system innovation as a policy approach. Transition management tools were first adopted in 2004 to tackle the systemic challenge of sustainable living and housing by starting a transition arena called DuWoBo.

Box 6.3. **System innovation transition programmes in OECD countries** (*cont.*)

Korea: A full-scale discussion on autonomous vehicles in Korea began with the announcement of "Autonomous Vehicle Service Commercialisation Support Measures" in the 3rd Regulatory Reform Ministerial Meeting held in May 2015 under the chairmanship of the President. Legislative and regulatory initiatives have been implemented to facilitate system transformation as well as raising public acceptance.

Sweden: The Re:Source initiative, one of Sweden's 16 strategic innovation programmes, provides long-term support for system transformation by supporting innovative business and governance models for the transition to a circular economy. The first phase was initiated in 2016 and will last three years but from the beginning, consortia actors have planned for a 12-year duration.

Japan: The Ministry of Economy, Trade and Industry reviewed four large-scale smart city demonstration projects in different areas of Japan which were called "next-generation energy and social systems demonstration areas" and launched the Virtual Power Plant Demonstration project in 2016 to demonstrate business models in smart cities. Policy and institutional measures for facilitating communication and engagement with end-users have been particularly important in the development of innovation for smart cities.

Source: OECD (2016a), "System innovation", in: *OECD Science, Technology and Innovation Outlook 2016*, http://dx.doi.org/10.1787/sti_in_outlook-2016-9-en.

New approaches to innovation policy through public-private partnerships

Increasingly OECD countries are beginning to use public-to-public (P2P) partnerships and public-private partnerships (PPPs) to cope with broad industry- or economy-wide issues such as skills or infrastructure as well as societal challenges. These typically involve the creation of a platform for relevant stakeholders, which generates a strategic research agenda. The strategic research agenda is approved by the government or one of its agencies and the partnership is then left to manage certain aspects of implementation. Each partnership forms an "arena", in the terminology of the previous section.

Policy instruments can then be matched and utilised by the consortiums to address their innovation needs. In some cases, new instruments are launched to support implementation. In some cases, this can involve the partnership in issuing calls for proposals, evaluating and funding research using money provided by the state. The power of wide partnerships is their ability to move beyond the confines of research and innovation policy to deal with the broader, systemic issues involved in addressing the societal challenges and the transitions among the socio-technical system that they require. Finland could benefit from a renewed approach to PPPs to address sectoral (and cross-sectoral) challenges by promoting stakeholder innovation co-ordination (supporting self-organisation) via jointly agreed strategic research innovation agendas and implementation of resulting innovation programmes. While there are some networks or clusters (remaining SHOKs), (cross-)sectoral innovation strategies and road mapping are currently lacking. Innovation road mapping consists of the identification of both technology and non-technology bottlenecks (e.g. regulation; skills) and innovation priorities and value-chain development needs.

The Swedish Strategic Innovation programme (SIO) provides an interesting example of such partnerships and their governance (Box 6.4). This programme seeks to reinforce the foundations for new, long-term and in-depth collaboration (across a wide set of innovation actors) based on a bottom-up approach where innovation needs and priority areas are defined by actors themselves with the government facilitating the process and

establishing a framework of selection criteria reflecting societal challenges, high scientific quality, collaboration, cross-disciplinarity and co-financing (OECD, 2016d). A number of strategic innovation programmes in different areas have been launched, among them the Strategic Innovation Programme Aeronautics (INNOVAIR) or the Strategic Innovation Programme for the Swedish mining and metal-producing industry, STRIM, based on their innovation agendas. The cross-ministry "21" strategies in Norway provide another example. Like the Finnish Health Sector Growth Strategy and the Bio-economy Strategy, these represent steps towards the kind of P2Ps and PPPs needed, but so far under-emphasise the non-R&D-related aspects of networking, road mapping and policy development.

Box 6.4. **The Swedish SIO programme: A renewed approach to public-private partnerships**

The SIO programme was formally created in 2012 in response to a formal task assigned to VINNOVA, the Swedish Energy Agency, and the Swedish Research Council for Sustainable Development (Formas) by the Swedish government to identify and jointly support strategic innovation areas (SIO) in Swedish areas of strength. The purpose of investing in strategic innovation areas is to lay the foundations for sustainable solutions to global social challenges, economic renewal and international competitiveness by means of new, long-term and in-depth national collaboration between universities, research institutes, the business sector, the public sector, civil society as well as international collaboration. Specific goals are to renew Sweden's innovative strength in a number of strategic areas, develop new value chains and strengthen cross-sectoral competence, knowledge, technology and service development (Palmberg and Schwaag Serger, 2017; OECD, 2016d). The programme includes two types of efforts:

- Strategic research and innovation agendas, which aim to stimulate a strategic dialogue between actors so as to, through a joint research and innovation agenda, highlight areas for improvement and the needs and possibilities available.
- SIO programmes, which aim to support the implementation of the research and innovation agendas that are most important for Sweden, as well as those that have the greatest potential to create conditions for international competitiveness and to find sustainable solutions to global challenges for societies.

Funding for implementation is initially provided for three years, "with the possibility of renewal for a maximum of nine further years based on a triennial review process. Thus, a further key characteristic is the long-term horizon of the programme. An SIO programme must have an organisation in order to ensure that the goals can be met, and in order to be able to adapt activities and initiatives to external changes. Its management should be proactive and have the trust of actors in the field. The organisation should at the very least consist of a board of directors and have an active programme management that sees to the operations of the SIO programme.

As of December 2016, there were a total of 16 SIO programmes in Sweden, including lightweight materials; metallic materials; mining and metal extraction; production 2030; process industrial information technology and automation; aeronautics; graphene; ICT electronic components and systems; Internet of Things; bio-innovation, among others. Between 2013 and 2016, the total public budget for the SIO initiative amounted to around SEK 1.1 billion (roughly EUR 120 million). Between 2017 and 2024, around SEK 600 million (approximately EUR 62 million) annually have been budgeted for the initiative. Many of the large Swedish-based companies are involved in one or several of the SIO programmes.

Sources: VINNOVA (2013); VINNOVA (2017), VINNOVA website, www.vinnova.se/en; OECD (2016d), *OECD Reviews of Innovation Policy: Sweden 2016, OECD Publishing, Paris,* http://dx.doi.org/10.1787/9789264250000-en.

Whilst there is no one-size-fits-all model for PPPs, several factors recurrently appear as fundamental in the design and implementation of successful PPP schemes. In particular, good governance and public leadership are key factors ensuring the success of PPPs. These include setting clear objectives and well-defined activities/responsibilities for each participant, operational rules and implementing regular monitoring and evaluation, transparency, the establishment of dispute settlement and exit strategies (OECD, 2015). Among the most important principles of good practice in setting challenge focused PPPs are:

- Define clear challenges/necessities through innovation agendas addressing sectorial/industries' challenges.[2] Such agendas will tackle R&D needs and technology diffusion needs and more broadly innovation strategies for the medium/long run. When necessary they should involve end-users, regulators and other actors whose actions are necessary for success.
- Ensure that governance standards are in line with good practices in PPPs (road mapping, accountability, clear commitments, ex ante governance criteria, intellectual property rights, etc.), planning and periodical evaluation. This will also require a stronger involvement of the government; the government should be an active member of the PPP. The PPP should take the form of a legally binding contract agreement.
- The PPP should integrate the participation of SMEs, including start-ups, and foster (and facilitate) linkages between start-ups and large firms.
- Maintain close monitoring and evaluation of the partnerships. Ensure that project selection within the programme is done under competition and is quality assured by an external agency, in order to ensure that the best possible work is done and to avoid capture by the stakeholder group.
- Encourage and facilitate new cross-sectoral collaborations with the involvement of users, including the public sector. One example is the Challenge-Driven Innovation Programme carried out by VINNOVA in Sweden which has resulted in new, strategic, collaborations – e.g. between the mining industry and ICT companies.

Box 6.5. **The Finnish digital cluster: A successful public-private partnership development and ecosystem**

DIMECC (Digital, Internet, Materials and Engineering Co-Creation Ltd.) is a non-profit company previously part of the strategic centres for science, technology and innovation (SHOKs) financed by Tekes and one of the public-private partnerships (PPPs) with successful performance and growth. DIMECC is a leading breakthrough-oriented co-creation ecosystem that speeds up time to market and is the Finnish industry's answer and response to the digital revolution. It is an innovation ecosystem combining the industry's relevance and needs with research competence. The network consists of 2 000 R&D&I professionals, 400 organisations, 69 shareholders and 10 co-creation facilitators. DIMECC was built by combining two of the most efficient innovation platforms in Europe. These are the manufacturing industry's FIMECC Ltd. and the digital industry's DIGILE Ltd. Its administrative costs have been only 3.5%; this is a European record. The results calculated by the industrial companies themselves show that EUR 1 invested in FIMECC Ltd. innovation programmes has returned an average of EUR 20.

Box 6.5. **The Finnish digital cluster: A successful public-private partnership development and ecosystem** (*cont.*)

DIMECC's vision is to be the leading co-creation platform for digital transformations. This is achieved through PPP-based co-creation activities in the following thematic areas: enabling technologies, technology cross-utilisation and business on emerging technologies. DIMECC accelerates R&D&I activities through three types of services: 1) programmes and projects; 2) co-creation; 3) network as phases of "innovation funnel". DIMECC programmes and projects are built and implemented openly together with companies, universities and research institutions in order to accelerate R&D&I. They follow the principles of open innovation, co-creation and agile development. Co-creation services offer a partnership for strategic research, development and innovation activities through the construction of ecosystems to create competitiveness for the future, and boost new business creation and new market entries.

DIMECC's organisation and operating model are based on lean operations through which network-based co-creation activities can be effectively steered and managed. The activities to accelerate the research work of the programmes include, for example: Demobooster (rapid commercialisation), PoDoCo (strategic renewal and technology transfer), Innovation Camp (idea crowdsourcing), industry-driven doctoral schools, and effective utilisation of partnership networks. According to its 2016 annual report, the company achieved a EUR 50 million research portfolio, had more than 400 customers and 40 significant international partners and stakeholder organisations. Also, more than 3 000 people were involved in DIMECC activities, there were 13 full-time employees, 3 part-time employees and 10 programme managers. In terms of its activities, it had 4 DIMECC factories (in Espoo, Tampere, Turku and Oulu), 42 PoDoCo scholarships by private foundations, 2 doctoral schools (breakthrough materials and CEESIMP), 4 demo days, 34 Demobooster customers, 150 student participants and 6 companies at Innovation Camp, 7 FiDiPro professors and 5 Academy of Finland projects linked to DIMECC.

Sources: DIMECC (2017), DIMECC website, www.dimecc.com; DIMECC (2016), *2016 Annual Report*, http://dimecc.com/wp-content/uploads/2017/03/AR-2016-final.pdf.

Future role of the Research and Innovation Council and the ministries

Translating changed governance needs into practice requires: a process of prioritisation; obtaining consensus about the resulting priorities; establishing a national co-ordination mechanism; and innovating instruments that enable implementation. The revival of the RIC under the current government provides an opportunity to redefine its role towards the wider mission of defining and co-ordinating the implementation of a national vision for addressing both economic and societal challenges.

First, a high-visibility, national exercise is needed to create and generate support for a new vision and all-of-government strategy for using knowledge to tackle the societal challenges and drive economic performance. The strategy needs to identify areas where aspects of societal challenges can be coupled with actual or potential Finnish comparative advantages, so that innovations within networks that also reflect needs and the demand side can be focused on areas where they will generate competitiveness, productivity and growth. This should involve wide-ranging consultation. Advanced joint foresight activities would be required but needs to extend to road mapping in order to establish a consensus about implementation, reduce the perceived risk of innovation and identify lead markets.

In addition to the technology experts, industry and sector representatives, such foresight exercises should involve a wide range of stakeholders and experts – such as various categories of consumers, regulators, "users" such as healthcare and transport

providers, social scientists, philosophers, artists, students and immigrants – to ensure a broad, ambitious and socially relevant perspective. This effort should not only seek to define a set of priorities but also be deliberately public and inclusive, in order to establish a social consensus and boost morale.

Box 6.6. **Enhancing innovation governance: Japan's Cross-ministerial Strategic Innovation Promotion Programme**

In 2014, the Japanese government established the Cross-ministerial Strategic Innovation Promotion Programme (SIP). This is a national project for science, technology and innovation, spearheaded by the Council for Science, Technology and Innovation in its role to lead science, technology and innovation beyond the framework of government ministries and traditional disciplines. Its creation is based on the directives of the 2013 Japan Revitalization Strategy and the Cabinet's comprehensive strategy on science, technology and innovation.

The SIP has identified ten themes that will address the most important social problems facing Japan, as well as contribute to the resurgence of the Japanese economy. These programmes include: energy (innovative combustion technology, next-generation power electronics and energy carriers), structural materials for innovation, new technologies for the exploration of ocean resources, automated driving systems, infrastructure (e.g. cyber-security for critical infrastructure), technologies for next-generation agriculture, forestry and fisheries; and innovative design and manufacturing technologies. The SIP Program promotes focused, end-to-end research and development, from basic research to practical application and commercialisation.

Each project is led by an experienced and talented programme director who is responsible for end-to-end focused research and development, facilitating co-ordination among government, industry and academic entities. These directors have been charged with guiding their project from basic research to practical application and commercialisation, and ultimately to a clear exit strategy. The programmes utilise and mobilise developments in regulations, systems, special wards and government procurement, among other public policies for innovation.

Source: Government of Japan (2015), "Cross-ministerial Strategic Innovation Promotion Program", http://www8.cao.go.jp/cstp/panhu/sip_english/5-8.pdf.

There is a need for better co-ordination across the government to ensure that the ministries are aligned and involved with the policy and to take an overview that identifies synergies and opportunities, for example to boost the generation of knowledge and skills to support (selected) transitions (e.g. regarding digitalisation or the bio-economy). The RIC appears nonetheless to be well placed to lead these processes because it encompasses the highest level of government and is, in principle, capable of reaching across multiple ministries, agencies, sectors of society and stakeholder groups.

The RIC needs to become an "arena of arenas" to co-ordinate the implementation effort and keep the vision up-to-date. Economic and societal challenges are too big to be addressed by one central body and must involve so many stakeholders (participating in various arenas). Rather, each will require its own arena or co-ordinating mechanism to be effective. The role of the arena of arenas should be to provide a place where these mechanisms can meet and where it is possible to link the needs of the various arenas to overall research and innovation policy – while recognising that each arena must maintain its own links with other policy areas.

The priority challenges should improve the steering and impact of research and innovation policy by supporting stakeholder co-ordination and innovation agenda setting as well as the implementation of their resulting strategic research and innovation agendas. This entails using new instruments for linking the relevant actors. These are most likely to be in the form of PPPs, and are explored in the next section. Extending governance and developing new policy instruments means that it will also be necessary to examine the mission, organisation, operations and skills of the key public innovation actors. For example, Tekes has a long and successful experience of creating and moderating stakeholder networks in support of its technology programmes. This provides a strong basis for taking a broader role in supporting, monitoring and managing the individual "arenas" needed for implementing system innovations and transitions.

Strategic intelligence and evaluation

In deploying these efforts, there is a need for policy experimentation and innovation in order to find models that will work in Finland. Learning by doing and experimentation – both in mainstream policy formulation and potentially by Sitra – will establish what the most effective implementation mechanisms are for Finland. Finland has an important potential advantage in that it is accumulating experience in how to tackle change policies that go beyond traditional research and innovation. Key examples are: the Six City Strategy, the Health Sector Growth Strategy and the Bio-economy Strategy (see Box 6.1).

Finland has established a strong evaluation culture in research and innovation over the past quarter century. Tekes was an early leader, establishing a practice as early as in the beginning of the 1990s of evaluating all its programmes, and more recently introducing ex ante impact assessment. The Academy of Finland has a long tradition of peer review-based field evaluations and has for many years published reports on the state of scientific research in Finland, largely based on international comparisons of bibliometric indicators.

Evaluation activities have intensified since 2008. Since the evaluation of the national innovation and research system (Veugelers, 2009), VTT, Tekes, the Academy of Finland, Finnvera, the FII, the SHOKs and even the Research and Innovation Council have been evaluated. Evaluations are systematically followed up and many of their recommendations are implemented (Halme, Saarnivaara and Mitchell, 2016). Some use is also made of foresight and national capability in this area has been marshalled under the National Foresight Co-operation and the Government Foresight Group in the Prime Minister's Office. The research and innovation system and those who govern it are therefore well served with evidence in support of policy. Creating a Strategic Research Council and a budget in the Prime Minister's Office explicitly to fund research for policy created the opportunity for policy making to benefit from a massively increased volume of strategic intelligence.

Supporting business R&D and innovation

Support to industrial R&D and emerging technologies

Tekes was originally established to provide support to industrial R&D and technological development and has done this through a combination of predominantly loan-based subsidies to individual companies that perform industrial innovation activities and technology programmes, linking groups of private stakeholders (mostly companies)

with public research. Tekes has applied a variation of the Nordic technology support approach that has also been practised in Norway and Sweden. In consultation with relevant stakeholders, this approach identifies areas of opportunity, designs a research agenda and facilitates their implementation through calls for proposals addressing the various parts of the research agenda.

The need for thematic technology programmes is also apparent in the appearance of technology clusters based on similar bottom-up proposals. Programmes are overseen by stakeholder committees, but funding decisions are exclusively taken by Tekes to prevent capture by its beneficiaries. By nature, such programmes tend to address established companies and industry sectors, but would benefit from being complemented by separate measures that address longer term scientific and technological opportunities (Academy of Finland), but also supporting start-up businesses in new technology fields that eventually could drive the formation of entirely new industries.

Tekes' technology programmes have facilitated both incremental innovation as well as the generation of more radical change, such as the development of new enabling technologies. These technologies have been important in the development of the electronics cluster, supporting not only Nokia but the development of the large-scale capabilities in industrial ICT, as well as in other branches of industry, increasingly involving "soft" innovation in the services sector. Since 2010, however, the proportion of Tekes' budget allocated to these programmes has decreased significantly, and is being replaced by instruments supporting start-ups and internationalisation.

A key development of the past decade was the implementation of the SHOKs programme, which was launched in 2006 at the request of the RIC. The SHOKs were long-term public-private partnerships that received money from Tekes to help fund R&D of interest to a group of stakeholders (see below). This money came from the part of Tekes' budget normally used for technology programmes. Unlike equivalent "competence centre" programmes in other countries that use state subsidies to encourage industry into longer term co-operation with academia that addresses more basic research than is typically handled in technology programmes and therefore typically handling enabling technologies, the SHOKs used it to conduct activities closer-to-market than those normally supported by such programmes (Lähteenmäki-Smith et al., 2013).

National expenditure in public applied research and technological development has fallen significantly, effectively creating a funding gap in areas that have been and remain crucial for innovation and ultimately economic growth. Tekes now has a rump of 11 technology programmes clustered in a small number of research areas – compared with about 40 such programmes at the end of the 1990s – and that have to address the needs of a wide range of industries.

In terms of scale, scope and the degree to which fundamental research questions are addressed, generating innovation, technology programmes requiring substantial deployment of R&D often go beyond what firms are able to fund themselves. Therefore, reducing the degree of government support for business R&D bares the risk of reducing innovation opportunities for the Finnish industry, and in return can be expected to exacerbate the decline in BERD that may amplify the stagnation in productivity growth from which the Finnish industry is currently suffering.

The decision to defund the SHOKs has aggravated this problem. The SHOKs were designed to provide a Finnish presence in the emerging landscape of international "competence centres". These PPPs are organised as academic-industry consortia to

collaborate in long-term R&D programmes, providing better access to more fundamental research for industry, and clearly signal to the research community what areas of research are important to industry. Key requirements for successful centres are a balanced governance between academia and industry, combined with steering and monitoring through the state to prevent capture (Stern et al., 2013; Luukkonen, Arnold and Martínez Riera, 2016). In Finland the implementation of this idea failed to a large degree due to a faulty governance design (Lähteenmäki-Smith et al., 2013). The potential to defragment university research through competence centres and improve industry-academic co-operation to secure the socio-economic impact of research calls for a new attempt to create such centres in Finland. Despite the absence of such centres current budget reductions are damaging to Finland's prospects for innovation and growth. Urgent attention is needed to address this industrial need.

Support to business development, innovation and internationalisation

Tekes provides access to the largest number of business support instruments. These include:

- services and consultancy to test start-up business ideas and help companies internationalise
- research grants and loans for product development and piloting
- support funding for scaling up SMEs
- direct assistance to companies with information, contacts and presence in foreign markets
- consulting help with digitalisation (Digiboost)
- innovation vouchers
- participation in research networks between companies and public research organisations
- participation in research in larger scale technology programmes
- participation in innovative procurement programmes.

Tekes also runs a number of specialised programmes such as on energy and production support for the audiovisual industry, short-term funding – e.g. for drone and computer game development – or healthcare business opportunities in India. The range of instruments is fairly complete, and is comparable to those in other European agencies that support business innovation. Recent evaluations have found the availability and impact of these instruments to be satisfactory, however, networking and cluster instruments are largely absent, with the exception of public sector research. Apart from public business support, Finland has a well-developed system of science parks and incubators, some owned by universities and others operating in the private sector. Entrepreneurship education and business support services are available, however, these are largely concentrated in the Capital region.

A major issue in business innovation is the weak participation of SMEs in BERD, which remains below the OECD average (see Chapter 5). According to Statistics Finland's last R&D survey, large firms with more than 500 employees represented about 76% of BERD in 2014. In fostering SMEs' participation in innovation, it is important to pay attention to the entry of new firms into policy programmes and innovation activities,

including R&D. Examples of programmes that encourage first time entry of SMEs into innovation programmes include the Engage Grants programme in Canada, KMU-innovativ in Germany and InnovationAgent in Denmark (Box 6.7).

One way to strengthen the participation of SMEs in innovation is through the promotion of innovation linkages between large firms and SMEs. Tekes promotes such linkages. One funding criterion for large companies is research co-operation with other innovation actors: SMEs, research organisations and universities. In doing so, it is important to promote innovation linkages between SMEs and large firms through capacity-building projects and encourage joint research and co-development, e.g. by creating common spaces that give SMEs access to large firms' research infrastructure and expertise (an example is Synerleap in Västerås Sweden, where ABB Group houses a number of SMEs in a common innovation space and gives them access to their research facilities and experts).

Box 6.7. **Innovation in small and medium-sized enterprises: Denmark's Innovation Agent Programme**

The Innovation Agent Programme, financed by the Danish Agency for Science and Higher Education, is operated by a network of 35 competent innovation agents from 8 independent research and technology organisations in Denmark. The innovation agents offer knowledge and guidance to small and medium-sized enterprises (SMEs) in the field of technological innovation and business development, with referrals to knowledge experts and partners best suited to help the company move its innovation endeavors forward.

The focus of the programme is to uncover potential areas of technological innovation and development in less innovation active SMEs. Through an "innovation check-up", the innovation agent, together with decision makers in the company, examines the company's processes, products, market approach, organisational setup and strategy in order to identify opportunities for technology-driven innovation. An innovation check-up nudges the SME to review and renew its commercial basis and to improve its innovation capacity and activity levels. This is likely to strengthen competitiveness and the productivity of firms and may lead to growth opportunities for participating SMEs. Overall, the programme benefits both the individual company and society as a whole.

Over 3 000 companies from many different industries have already taken advantage of the offer of a free innovation check-up. More than half of the companies have been launching concrete innovation with a focus on new value-added solutions. The programme found that new customers increased revenue, improved competitiveness, got new products, processes and services, and access to the latest high-tech knowledge. The Innovation Agent Programme has been successfully exported to New Zealand and has trained 24 innovation agents in Austria. Algeria, Jordan, and Trinidad and Tobago are on the way with similar programmes. More countries, like Ghana, have also shown interest in the programme.

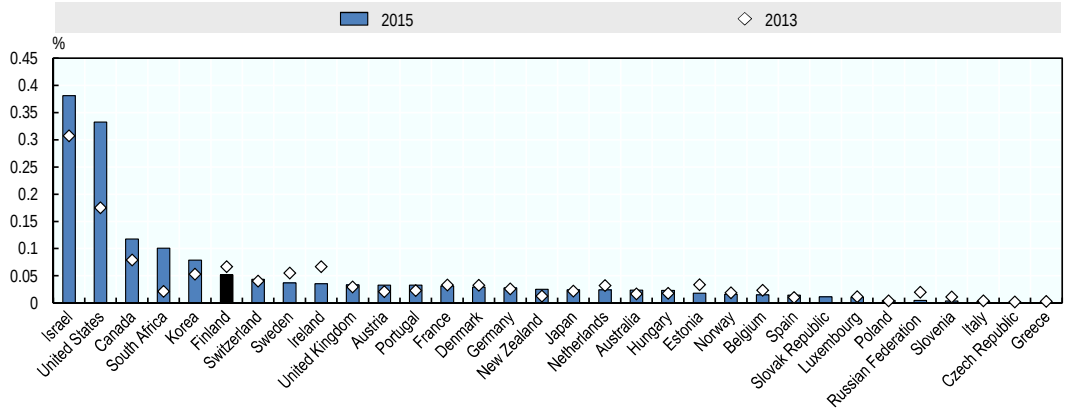
Sources: Danish Technological Institute website, www.dti.dk/specialists/innovation-agent-program/31424; Innovation Agent Program website, http://innovationstjek.dk (in Danish).

Venture capital, private equity and entrepreneurship environments

Private venture capital and support is well organised through the Finnish Venture Capital Association and the Finnish Business Angels Network, and the amount of funding available remains high relative to the size of Finland's GDP. Though the share of venture investments as a proportion of GDP in 2015 has slightly declined vis-à-vis 2013, but

remains above the respective shares of its Nordic neighbours (Figure 6.7). Taking private and public activities together, Finland has a well-developed system of venture capital and development banking that also handles the need for loan and export credit guarantees. The state played a key role through the financial crisis in maintaining the availability of capital and this is now being supplemented via growth in the availability of private money. However, the private sector is not taking over the state's contribution in areas such as business concept testing, services supporting internationalisation and support to scaling-up. In the Finnish context, scaling-up and internationalisation often have to be pursued hand in hand, yet the market is especially poor at delivering venture capital for this purpose, especially growth-stage venture capital.

Figure 6.7. **Venture investments as a proportion of GDP**



Note: Data provided for Canada correspond to 2011; Japan to 2012 and 2014; Israel to 2014; New Zealand to 2012; the Russian Federation to 2014; South Africa to 2012 and 2014.

Source: OECD (2016c), *Entrepreneurship at a Glance 2016*, http://dx.doi.org/10.1787/entrepreneur_aag-2016-en; OECD (2014), *Entrepreneurship at a Glance 2014*, OECD Publishing, http://dx.doi.org/10.1787/entrepreneur_aag-2014-en.

The Finnish government has devoted considerable efforts to supporting start-up entrepreneurship. Among the different government-launched funding mechanisms for start-ups with high growth potential are: the Finnish Industry Investment, running EUR 133 million in 2014; Veraventura and a direct investment instrument, the Start Fund Vera Ltd. with EUR 126 million in investment volume in December 2014, and Tekes, which has funding programmes for young innovative firms ("Young Innovative Growth Companies"), and the Vigo Accelerator Programme – a government lead accelerator programme established in 2009The EUR 230 million of government investment allocated for 2013-17 is expected to raise more than EUR 1 billion in venture capital investment in total. Firms' growth is also promoted through a programme of 10 accelerators comprising about 100 portfolio firms. Tekes has also a small early-stage fund of funds investments (established in 2014). In 2015, a third of Tekes' funding went to young small firms (EUR 140 million; of which, EUR 27 million were for young innovative firms). The role of the private sector is expected to increase jointly with foreign venture capital and the state will be able to reduce its activities over time. However, this expectation should be seen in the context of the increased difficulty in recent years of finding private investors who will invest in the early stages of company growth, especially in smaller economies.

Given the limited size of the Finnish market, small companies need to internationalise rapidly. This weakness cannot successfully be tackled with money alone. First, company formation and growth needs to take place within ecosystems that are international in nature, connecting new firms to sufficiently big markets to provide a base for scaling up. Further, these entrepreneurial ecosystems also need to be well anchored in the Finnish economy and have enough participants to enable the development of supply chains and complementarities, to build "critical mass" and reach over time. With a respective business environment in place, scaling-up investment becomes less risky and funding sources can become more international, increasing the likelihood that young Finnish firms can establish themselves internationally, which in return will be receptive to further market penetration and growth. The conditions are also likely to create new ecosystems where there is a substantial number of stakeholders involved and where activities are explicitly linked to addressing societal challenges that have both a Finnish and an international dimension. The total volume of new venture investment in 2015 was about EUR 113 million, an average investment of about EUR 375 000 per firm.

Finland boasts a considerable number of start-up environments such as the Otaniemi Science Park and corresponding parks at other universities as well as the Helsinki Business Hub. Well-developed start-up services such as the Aalto Start-up Sauna course at Otaniemi are available and there is a small community of investors and entrepreneurs providing informal advisory services. The Finnish Business Angels Network has about 500 investing members. Helsinki regularly hosts the Slush conference for young, innovative companies, which attracted some 2 000 participants from abroad in 2016. Tekes was a substantial early-stage investor, accounting for 33% of early-stage funding. However, this is a significant decline compared to 2011, when Tekes provided 55% of early-stage investment.

Fiscal incentives

While currently, Finland does not offer R&D tax incentives, the government introduced a temporary R&D tax credit scheme in 2013 in an attempt to counteract firms' tendency to respond to the economic climate by reducing R&D expenditure. This allowed SMEs to set off 100% of their R&D-related personnel costs against their corporate tax, providing they were pursuing basic or applied research or experimental development. Since the tax credit worked against corporate tax, it was only effective for profitable companies and was therefore of little use to many start-ups. Firms had to perform more than a minimum amount of R&D in order to qualify for tax benefits, while the tax incentive was subject to a cap. Those firms already receiving other forms of support, such as grants through Tekes, were ineligible to the tax benefit programme.

Data from the Finnish the tax administration show that in 2013, 550 companies applied for a total of EUR 63.6 million in tax relief, compared to the tax administration's expectation that it would have to forgo EUR 155 million in tax. The tax incentive scheme was to run for three years. However, the reduction of the corporate tax to 20% in 2014 reduced the attractiveness of the incentive and increased pressure on the government budget. It was therefore decided to terminate the scheme after its second year. ETLA's evaluation shows that take-up was low (Kuusi et al., 2016). In the end, companies only claimed 8% of the taxes the government had expected to forgo. It was not clearly possible to identify a target group of companies to which the credit would provide a unique incentive or to demonstrate that it had had much impact on company behaviour.

Human capital from the universities

With the university research system being directly linked to higher education, including the production of PhDs, the way university research is designed also has importance in supporting Finland-based industry. Universities' research specialisation has an immediate effect on the specialisation of PhD graduates. Hence, the thematically focused research funding (for example, through technology programmes and especially via longer term competence centres, where PhD education is explicitly built into the strategic research agenda) feeds back to the production of industry-relevant PhDs. Competence centres are particularly interesting in this context, as their co-operation with industry supports the graduation of PhDs that bring skills relevant to the Finnish industry, and scientific research also feeds back to both Masters and Bachelors education. Graduates are normally much more likely than faculty members to start new businesses; hence, in terms of supply of relevant human capital for start-ups as well as established firms, it is important that Finland maintains a strong funding portfolio for applied and industry-relevant research – much stronger than is the case today.

Demand-side innovation policies

While there has been growing interest in demand-side innovation policies internationally, Finland has done little in this area so far, with the exception of innovation procurement. Tekes runs a programme that provides help to organisations trying to undertake innovative procurement, but little of this activity is actually visible. Similarly, the use of cluster and supply chain development policies is limited and the idea of using US-style "challenge funding" to encourage the attainment of specific social and technological goals (Hicks, 2016) is not applied. Finally, there appears to be little use of regulations or norms as ways to stimulate innovation. Adopting the third-generation "societal challenge" approach discussed previously would necessitate the use of some of these demand-side instruments in the context of a common programme affecting demand as well as supply. Leaving that possibility aside, however, there is clearly space to explore innovation policy opportunities on the demand side in order to complement the weight of existing activity on the supply side.

As regards procurement, it has been argued that the process of adoption across the government has been slow as new types of skills, working methods and attitudes in general in the public sector are required. Innovation procurement means higher risk (financial, technological, political and societal) and there is currently a lack of skills and tools to manage that risk (OECD, 2017). Finland is currently working on these areas. Improving skills for procurement at public agencies, risk-sharing tools and practical support to public contracting authorities are provided through a number of initiatives, including the Tekes Smart Procurement services for strategic areas and cities, the Forerunner Cities programme and the government central purchasing body. The adoption of monitoring, measurement and evaluation procedures of procurement activities remains underdeveloped.

The government continues to improve the regulatory framework and strengthened promotion and knowledge support at the different levels to increase expertise and innovation procurement. New public procurement legislation was adopted in 2016 to better consider innovation and environment aspects in public procurement agendas. This revision is based on the EU Public Procurement Directives. The government also initiated national training for innovative public procurement for the 15 largest cities in 2015 and all 20 health districts in 2016. The government recently passed a resolution that

encourages public actors to adopt sustainable procurement, particularly in the areas of energy, construction and housing, transport, food services, and energy services. Further, the government programme 2015-19 includes for the first time a numerical target of 5% for innovative public procurement. This target is a strong encouragement to conduct innovation procurement.

Box 6.8. **Innovation procurement in Finland**

According to the OECD Public Governance Review of Finland (2016b), there is no stand-alone innovation procurement action plan in Finland; however, the country has an overall national strategic framework with objectives. Innovation procurement takes part of the government's strategic projects (bio-economy, clean-technologies, digitalisation, health) and embeds them into several national sector strategies and programmes (e.g. ICT 2015, Innovative Cities, intelligent transport, clean-tech strategy, etc.). The government aims to link sectorial policy objectives with procurement and the development of markets and technologies in more strategic ways. The scope for innovation procurement policy is wide; it encompasses both public procurement of innovation and pre-commercial procurement.

The first policy steps in the promotion of public procurement of innovation dates from 2008 as emphasised in the national innovation strategy; this was followed by a new financing programme by Tekes in 2009. The importance of the issue was further stressed in the "Demand and User Driven Innovation Policy" (2010-13) and in a government decision to encourage innovation in sustainable procurement (2013).

Tekes' Smart Procurement Programme is a programme for public procurement of innovation and pre-commercial procurement. The goal of the programme is to support the development of new innovations with smart, innovation-friendly public procurements. The programme encourages public buyers to use procurement to solve societal problems, renew public services, and improve market access for new products and services. Over the period 2009-16, funding covered a total of EUR 11 million for 73 ended projects. The main areas that received funding are environment/building (36%) and social and health (26%). The programme currently covers horizontal themes such as digitalisation, energy efficiency and the environment. Apart from providing financing, the programme also promotes awareness raising, networking, training, and supports sharing best practices among the government.

Strengthening industry-science collaboration

This section considers technology programmes, SHOKs and Tekes' commercialisation measures as instruments for promoting industry-science collaboration. New kinds of PPPs can also improve industry-science links. Finally, it is important that policy instruments adopted across the innovation system are mutually consistent. In this respect, there is a need to adjust the performance-based funding system used at universities in a way that does not discourage industry-science collaboration.

Technology programmes

Tekes' technology programmes have over time provided strong support to both emerging and existing industries, building capacity, pursuing applied research and developing enabling technologies. These programmes have been Finland's biggest arena for industry-science collaboration. Budget cuts and the refocusing of much of Tekes' start-ups and entrepreneurship support have resulted in the disappearance of most of this effort.

The decline in technology programmes has greatly reduced opportunities for industry-science collaboration, despite Finnish organisations participating in the EU Framework Programme, in which several priorities overlap with those of Tekes. While it is important for Finland to participate in a wide range of technology areas, it is striking that among Tekes' technology programmes, "Arctic Seas" is the only one to focus distinctly on needs and opportunities specific to Finland. With a gap in funding technology programmes and the importance to continue and to strengthen industry-science links, policy should emphasise either a growth in the number and scope of technology programmes, or identify additional instruments that can fulfil this purpose.

An important issue is the signalling effect of technology programmes to the research community. Industrial problems, needs and opportunities affecting research agendas, and eventually higher education requirements, need to be communicated to develop capacities respective to the technologies found important to the growth of the Finnish industry. This in return affects the supply of human capital to industry.

The strategic centres for science, technology and innovation

The design of the SHOKs was originally inspired by the "competence centres" set up in other countries. These models are all PPPs involving an academic-industrial consortium pursuing collaborative research, typically over seven to ten years. The level of subsidy is typically high in order to encourage fundamental research, involving PhD education that strengthens the role of the collaboration in human capital formation. Evidence from international evaluations about these programmes are strongly positive, but also point to the importance of a balanced governance power between the academic and industrial stakeholders to guarantee successful outcomes.

At their peak in 2012 six SHOKs existed, absorbing about EUR 100 million in subsidy from Tekes:

- Cleen Ltd (environment and energy) – now part of CLIC Oy
- Finnish Bio-economy Cluster (FIBIC Oy) – now part of CLIC Oy
- FIMECC Ltd (metals and engineering)
- SalWe Oy (health and well-being)
- Digile Oy (previously TIVIT Oy, Internet economy)
- RYM Ltd (built environment sector).

Like other competence centres, the SHOKs developed strategic research agendas. Overall, about 60% of the research was funded by Tekes and the remainder by participating companies. The Academy of Finland contributed indirectly by funding strategic research in the areas of interest to the SHOKs. In the period 2008-15, Tekes provided EUR 544 million, the participating companies EUR 441 million and other public sources EUR 118 million.

The evaluation of the SHOKs pointed to significant challenges in their operational model, multiple and often conflicting objectives, weak governance, and a failure to achieve a cross-disciplinary perspective or wider scientific engagement. The open PRI model used appeared to ensure that potentially disruptive research was conducted outside the SHOKs. Adjustments were made to the way the SHOKs were operating, but the programme was discontinued from 2015 and is being phased out.

Variations of the "competence centre" funding instrument are of increasing importance internationally because of the effectiveness of the academic-industry links involved, their long-term impact on innovation and innovation capacity, their production of valuable "industry-ready" human capital (especially but not only PhDs), and their effects on defragmenting university research capacity by providing incentives to direct that capacity towards societally important problems. Further, it exacerbates the lack of "strategic technology" research investment in Finland. Consequently, the closure of the SHOK programme leaves a significant gap in Finland's research and innovation policy.

Significant overhaul is therefore needed of the Finnish centres of excellence policy. The profusion of small basic research centres over the past two decades appears to have had little effect on generating quality peaks and there is no centres of excellence instrument working around innovation. Bigger basic research centres and a revived competence centres programme appear to be necessities for tackling the quality "peaks".

Commercialisation

Larger Finnish universities have technology transfer offices, making public engagement to encourage such a development redundant. For the most part, universities are not in a position to fund the early-stage commercialisation of research results, a capacity gap that is filled through Tekes' commercialisation programme "New business from research ideas".

There does not appear to be a Finnish equivalent to the United States' Small Business Innovation Research programme. This sets aside a very small fraction of the budget of government laboratories or institutes to transfer research results to the business sector via joint R&D projects with small companies. The programme is widely imitated (for example in the Netherlands, Sweden and the United Kingdom) and like its imitators abroad is evaluated positively. Given the policy focus on streamlining government laboratories and ensuring that they are societally relevant, Finland should consider setting up such a programme.

Box 6.9. **The United Kingdom's Small Business Research Initiative**

The United Kingdom's main vehicle for taking forward innovation procurement is the Small Business Research Initiative (SBRI). The programme contains a well-established process to connect public sector challenges with innovative ideas from industry. The SBRI is a competition-based innovation programme managed by Innovate UK, which provides 100% R&D funding to support companies to develop solutions. The intellectual property rights remain with the company, which is then able to market the product commercially more widely.

The SBRI was established in 2009 and closely modelled on the United States' Small Business Innovation Research programme. The SBRI is run under EU rules for pre-commercial procurement. It works by setting up a competition when a government department or public body wants to procure an innovative product or service to solve a particular problem. The most promising applications are awarded development contracts. Companies can be granted up to GBP 1 million to develop their ideas into innovative solutions for the public sector; 100% of the development and prototyping or demonstration cost of developing a new product or service are funded.

Box 6.9. **The United Kingdom's Small Business Research Initiative** (*cont.*)

The SBRI has been growing steadily since 2009, with the value of contracts awarded through the programme increasing from GBP 13 million in 2010/11 to GBP 83 million in 2014/15. Overall, the SBRI has provided businesses with over GBP 270 million of contracts since 2009. There are now over 70 departments and agencies that have used the programme. Examples of successful projects include the development of long-endurance marine unmanned surface vehicles, intelligent fabrics, solutions to combatting online fraud, novel light bulbs and many more (ERAC, 2015). Recently, Innovate UK has established an SBRI Practitioners Community of Practice which provides a forum to share best practices across government departments. There is no central funding, and departments need to fund their own SBRI competitions.

Sources: OECD (2016b), "OECD Public Governance Reviews: Public procurement for innovation: Good practices and strategies", www.oecd.org/gov/ethics/procurement-innovation-practices-strategies.pdf; ERAC (2015), "ERAC opinion on innovation procurement", http://data.consilium.europa.eu/doc/document/ST-1209-2015-INIT/en/pdf.

Open science and research infrastructure

With the objective to have open access to all scientific publications by 2020 (Ministry of Education and Culture, 2017), open science is paramount to current science policies in Finland. In 2014, the Ministry of Education and Culture launched the Open Science and Research Initiative (ATT) with the aim of creating a national open access and open science policy and building the infrastructure necessary to reach this goal. The ATT aims to make open and collaborative science more visible to innovation system actors, and to promote not only open access to research data and publications, but also transparent, collaborative research and the skills, knowledge and support services necessary to achieve these goals. In the framework of the ATT, the ministry plans to organise an annual "Open Science and Research Forum" to gather all relevant stakeholders and promote fruitful discussion about the ATT and its implementation. In addition, the Academy of Finland currently requires open access publishing as well as open access data whenever possible (in the limits of juridical framework and available infrastructure), while training sessions will be launched in higher education institutions to train researchers and students in data management and data ownership.

Evaluation on the impact of the Finnish Open Science and Research Initiative, both nationally and internationally, was conducted externally under the request of the Ministry of Education and Culture. The evaluation finds the Finnish initiative able to raise interest in open science among its target groups (Tuomi, 2016). According to the evaluation, although the impact on politics and strategies has been medium strong, on the operational level, impact has been weak. However, many instructions and services are still in the development phase. Thus, the impact is expected to increase during the final period of the initiative (Tuomi, 2016). The initiative's target groups generated a set of ideas that fed back directly in its final year, 2017. These ideas cover the active participation in international forums, the collection of best practices, special attention to open innovation, and specific actions to engage researchers and staff members.

The Finnish Research Infrastructure Committee (FIRI Committee), a body appointed by the Academy of Finland, was responsible for updating the national roadmap for research infrastructure in 2013. The FIRI assesses the urgency and priority level of research infrastructure projects included in the roadmap. In addition, the committee drafts

proposals on the funding of PRI projects for the state budget, as well as for other funding sources where necessary. Decisions on funding for research infrastructures are taken by a subcommittee appointed by the Board of the Academy of Finland. The Academy of Finland provides funding for the acquisition, establishment or upgrading of nationally significant research infrastructures that promote scientific research.

The updated National Research Infrastructure Roadmap (2014-20) also considers enhancing open science mechanisms and supports the activities of a broad-based co-operation initiative (2014-17) between ministries, universities, research institutions and research funders such as the Academy of Finland and Tekes, the Finnish Social Data Archive (FSD), the National Library of Finland, the Federation of Finnish Learned Societies, FinnOA (the Finnish Open Access Working Group), CSC – IT Center for Science Ltd. As an example of higher education institutions, the University of Helsinki plays a key role in open access in Finland.

The National Research Infrastructure Roadmap is a plan for key research infrastructures in Finland that are either under development or that will be newly required over the next 10-15 years. Research infrastructures form a reserve of research facilities, equipment, materials and services. As such, they are essential instruments for research (OECD, 2015). The state of national research infrastructures, the progress of the 19 infrastructure projects and the 13 developing research infrastructures listed in the 2009 report had to be brought up to date. The field of national research infrastructures has, in many respects, become clearer since the drafting of the previous roadmap in 2009.

Fostering public research excellence and impact

Applying high-quality science matters for several reasons:

- An internationally competitive research community attracts international partnerships and foreign direct investment (FDI).
- It helps ensure a supply of high-quality human capital from research and higher education sectors.
- It provides significant and accessible knowledge resources to national industry, both in the form of knowledge for production and in terms of policy advice.
- It helps ensure that industrial, social and policy development are based on reliable forms of knowledge.

Viewed through the lens of citation analysis, the average quality of Finnish science has been climbing, from below the world average in the mid-1980s up to a point where it is clearly above that average, about the same level as Norway and Sweden, but still well behind Denmark. However, measuring the Finnish presence in the most highly cited 10% of research publications indicates that Finland is not well represented, and that it has fallen behind the leading countries over time. The challenge, therefore, is that while the average quality of Finnish research is good, there is only relatively little world-class research performance. Therefore, policy should address the "peak quality" problem rather than focusing on average quality.

The main "levers" available to policy makers for improving the quality of university research can be summarised as follows:

- providing competitive, quality assured external funding to supplement institutional funding

- adjusting the ratio between institutional and external funding
- making some of the institutional funding for research that universities receive dependent upon past performance
- internationalisation, not least international collaboration
- influencing university governance, which determines their ability to develop and manage research strategies and portfolios, so as to allocate resources towards promising and high-performing groups and research fields.

Finnish universities already have a high ratio of external to institutional funding. Many countries, including Finland, have adopted the idea of funding centres of excellence, with the intention of building critical mass and creating competitive environments in which quality is driven to higher levels than can be obtained in fragmented systems. Centres of excellence are instruments that can be used to drive the needed "peaks" of quality in the Finish research system.

Other funding instruments can also be brought into play. Like other research councils, the Academy of Finland has long been addressing the well-known challenge of funding interdisciplinary research under a peer review system. Such research is seen as important both because of the view that new disciplines and opportunities often occur at the boundaries of existing ones and because it is needed in order to tackle real-world problems. It should therefore be quality-enhancing over time. The Academy has studied the matter (Bruun et al., 2005), but in the end resorted to "mainstreaming" interdisciplinary research in existing panels, which is not very effective (Arnold et al., 2013). It has also tried to address the need for high-risk, potentially "transformative" research (Häyrynen, 2007), and very recently has introduced a small funding programme. These efforts are important, but their overall effectiveness would be enhanced if a more explicit mechanism could be devised to address interdisciplinary questions and the efforts in transformative research were also reproduced in the funding of research for innovation.

Part of universities' institutional funding for research has been based on performance and the formula was revised in 2015 and again in 2017. The performance-based component is an unusually large fraction of total institutional funding for research. With the exception of the United Kingdom, other countries steer only a small part of institutional funding in this way, in order to combine a degree of stability with incentives for performance improvement. There is limited evaluation evidence internationally about the effectiveness of performance-based research funding system (PRFS), in part because most of the systems introduced this century appeared in a context where performance was already improving. Hence it is hard to identify the net effect of the PRFS on changing performance. There is evidence that the PRFS tend to increase the volume of published research outputs – sometimes without affecting the quality of research – and it is clear that the main pathways to impact for the PRFS go through researchers' careers, as they encourage university managers to recruit and promote people whose performance is likely to maximise the university's returns from the PRFS.

A PRFS tends to increase the power of the researchers who perform well against its criteria, so universities are encouraged to direct the rewards to those who "earn" them – a behaviour that promotes lock-in and undermines the university's ability to make strategic investments in new groups and areas (Arnold et al., 2017). Since the positive effects of the PRFS appear to be available even when the proportion of funding they govern is low, it might be better for Finland to reduce the amount of institutional funding it governs,

retaining its positive effects but leaving the universities in some other way the strategic headroom provided by non-competitive institutional funding.

Governance changes take a long time to have an effect on quality, but are nonetheless important. Both the university and the polytechnic systems have been under reform since 2010. The universities have become independent legal entities separate from the state. The universities of applied science became independent legal entities in 2015. Mergers have been encouraged in both sectors. However, Finland still has roughly twice as many higher education institutions per head of population as its Nordic neighbours. The two sectors have been encouraged to form closer links and even mergers, in the context of recent, very significant cuts in funding for higher education and research.

The universities have long suffered from duplication and internal fragmentation. As a result, departments are often small and have few professors, making it difficult to follow the international pattern of increasing the size of research groups in order to increase their quality and (especially) sustainability. The current development plan for higher education relaxes this pressure and the Academy of Finland has been given money to help universities "profile" their research activities more sharply. Continued efforts at "profiling" combined with the modernisation of academic governance are pre-requisites not only for a more efficient higher education and research system, but also for a higher quality one.

Supporting international knowledge linkages

The limited extent of internationalisation of Finland's research and innovation system has long been recognised, and was one of the driving factors for Finnish participation in the EU Framework Programme ahead of EU accession. This was singled out as a problem by the Science and Technology Policy Council (now the RIC) in 2003 (Science and Technology Policy Council, 2003). The council stressed that this was not only a problem for the research community but an issue for industry as well. In order to encourage internationalisation, Tekes introduced an internationalisation dimension into its project funding assessment criteria fairly immediately. Limited degrees of internationalisation nonetheless remain an acute problem.

Industry

There are five main internationalisation issues in industry: international co-operation on R&D; the small size and peripheral nature of the Finnish market and the need for growing companies to internationalise at an early stage; limited FDI into Finland, restricting the access of the Finnish R&D community to world developments, limited FDI from Finland, with the same effect and constraints for Finland-based companies to access international R&D workers.

The EU Framework Programme is the largest and most accessible way for Finnish companies and research institutions to participate in international R&D collaboration. Finland received EUR 32 per capita from the 7th Framework Programme (FP7). This placed it fifth after Cyprus,[3] the Netherlands, Denmark and Sweden, and compares very favourably to the average of EUR 14 across the EU15 (Fresco, 2015). While the Framework Programme by no means addresses all thematic interests relevant to the Finnish industry, there is a strong overlap between its foci and those of Tekes, which links relevant EU national contact points to its programmes. As in other Nordic countries, however, industrial participations comprise a modest 10% of the total (Table 6.3). In

contrast, 24% of total funding for the Seventh Framework Programme went to companies (Fresco, 2015). Grants are available from Tekes to support proposal-writing and there is a strong network of national contact points which can be accessed nationally or through regional ELY centres. Finnish industrial participation is nonetheless disappointing, and there is significant scope to further increase it.

Table 6.3. **Distribution of participation of different types of organisation in the Seventh Framework Programme, Nordic countries**

Type of organisation	Denmark	Finland	Iceland	Norway	Sweden
Higher education institutions	51%	36%	27%	27%	54%
Research organisations	12%	31%	18%	34%	13%
Small and medium-sized enterprises	17%	14%	14%	20%	14%
Industry	10%	10%	17%	10%	13%
Public bodies	8%	6%	23%	8%	6%
Non-profit bodies	1%	2%	0%	1%	1%
TOTAL	100%	100%	100%	100%	100%

Source: VINNOVA et al. (2013), *FP7 and Horizon 2020: A Comparative Study of the Support Services in Nordic Countries*, http://www2.vinnova.se/upload/EPiStorePDF/va_13_16.pdf.

The need for young firms to internationalise from an early stage of their development has long been appreciated in Finnish policy. There is a rich variety of support mechanisms available from Team Finland members, while the main obstacle of available venture capital for scaling up and internationalisation persists.

While Finland is not a "headquarters economy", it relies significantly on inward FDI to generate interaction with global industrial developments. Team Finland provides supportive measures to increase international links, whose effectiveness would be considerably strengthened if Finland could boast more internationally attractive research excellence, preferably linked with domestic industry.

Finnish start-up companies indicate that they experience difficulties in hiring non-EU nationals, owing to visa restrictions, even in areas of skill shortage, such as coding. Documentation required to start a company can only be provided in Finnish. Recruitment of foreign students upon graduation is also challenging, impeding the internationalisation of companies, and legal hurdles to remain in Finland are high. For people coming from outside the Schengen area, permission to start a firm can take up to one year, indicating room for improvement to streamline entrepreneurship opportunities for immigrants.

The research community

In the research community, there are three main internationalisation issues: international co-operation and co-publication; attracting foreign talent to the Finnish research community and funding conditions and regulations limiting Finland's ability to attract foreign students.

The evidence presented in Chapter 4 indicates that the proportion of Finnish scientific publications produced with one or more international co-authors is over 55%, which is high in international comparison and similar to other Nordic countries. These co-publications tend to be more highly cited than national publications, indicating that the average quality of Finnish research as measured in terms of citations is improving.

Universities and government research organisations account for two-thirds of Finnish participation in the Framework Programme (Table 6.3). In terms of research co-operation, the Finnish research sector appears to be well integrated into the global community.

However, while leading research nations such as the Netherlands, Switzerland, the United Kingdom and the United States rely heavily on tapping a large talent pool by importing researchers from other countries, the proportion of foreign researchers in the Finnish system is low. One cause of this is an inability to attract large numbers of foreign-born PhD students, who become important to research elsewhere. The PRFS rewards both the number of foreign-born PhD students graduated and the share of foreign-born researchers in the total faculty. However, the combination of language barriers, climate and pay do not make Finnish academia particularly attractive. In order to import research talent, more flexible and attractive pay and research facilities would be helpful, as would increasing the amount of English-language teaching that will have positive effects on the attractiveness of both Finnish education and research.

The Academy of Finland and Tekes did run the Finland Distinguished Professor Programme (FiDiPro) in 2006–2015. The Academy funded about eight professors (or other senior researchers) per year to spend two to five years working part time at Finnish universities and funding small research teams for them in Finland. Tekes also provided a similar number of FiDiPro grants, so that roughly equal numbers of people with a basic and an applied orientation were involved. An evaluation shows that the scheme was well received and had substantial effects both on the universities and on the companies involved, improving their international research networks, transferring capabilities and methods, increasing international co-publication, and creating commercial opportunities (Wennberg, Oosi and Toivanen, 2014). In general terms, the Academy of Finland currently supports internationalisation of research through all its funding instruments. Roughly one quarter of the project and researcher funding goes to funding international researchers or to funding researcher mobility. This is complemented by Finland's access to the EU Marie Sklodowska-Curie mobility programme.

More radical approaches are possible. One adopted with apparent success is Chile's International Centres of Excellence Programme, which invites and subsidises selected foreign research organisations to establish centres of research excellence within the country, contributing knowledge but also establishing networks within which local researchers can participate. Selective use of such an instrument could help establish better links with researchers abroad, especially companies operating in Finnish areas of specialisation.

Box 6.10. **The Chilean International Centres of Excellence Programme**

Research centres of excellence have been under development in Chile since the late 1990s, originally through the World Bank's Millennium Science Initiative and subsequently funded by the Chilean government. In 2009, InnovaChile, the innovation agency, opened the first call for the installation of international centres of excellence. The programme "Attraction of International R&D Centers of Excellence (ICEs)," in its first call selected four large-scale and prestigious ICEs from among dozens of large R&D centres from all over the world. Fraunhofer-Gesellschaft (Germany), CSIRO (Australia), INRIA (France) and Wageningen UR (the Netherlands) were the first entities selected by the Chilean government, setting up an "ICE-Chile" branch to promote R&D and technology transfer by generating links and formal networks with key local industries and universities.

Box 6.10. **The Chilean International Centres of Excellence Programme** (*cont.*)

In the wake of the success of the first ICE application round, the Economic Development Agency established a second call for applications to be made in the second semester of 2012. In this call, the proposal emphasised high-impact projects for the Chilean economy or with the potential to create new industries. Two kinds of centres were foreseen: 1) institutional ICE, with a non-profit orientation, and a maximum grant of USD 12.8 million (matching contributions in cash and in kind required) over a term of eight years. Applicants could be universities, non-profit R&D centres or government entities. 2) Corporate ICE, for-profit orientation, with a maximum grant of USD 8 million (matching contributions in cash required) over a term of four years. Applicants could be large companies with significant R&D efforts.

Applicants to the ICE programmes, whether institutional or corporate, had to fulfill several requirements, including "critical masses" of personnel (scientists and technologists); R&D activities in accordance with measurable global standards in terms of scientific production and technological innovation; focus of activities in areas at the cutting edge of R&D; high levels of visibility and international scientific and industry connections; applied research and technology development capabilities; specialised capabilities in technology transfer and commercialisation processes for R&D results through the sale of technology licenses or other relevant modalities. As of 2014 the Economic Development Agency had supported 12 ICEs.

Sources: Ministry of the Economy, Development and Tourism (2016), MSI website, www.iniciativamilenio.cl; CORFO (2016), "ICE Program", www.corfo.cl/programas-y-concursos/programas/atraccion-de-centros-de-excelencia-internacional-en-id; World Bank (2013), "Research centers of excellence in Chile", https://innovationpolicyplatform.org/sites/default/files/rdf_imported_documents/researchcentersofexcellenceinchile_0.pdf.

More broadly, the type of societal challenge networks and PPPs discussed above would need to involve foreign as well as national partners, in order to ensure that they include relatively complete supply chains. This would provide a mechanism to involve and eventually anchor more foreign research-performing companies and institutions in the Finnish innovation system.

Notes

1. The evaluation (Veugelers, 2009) argued that despite the existence of the RIC, co-ordination across different ministries'" sector interests and the innovation system as a whole was poor. Having reached the "technology frontier" and built up a large industry, Finland needed to innovate in new ways by "pioneering" innovation, increasingly in smaller companies. The evaluators recommended reorganising the Finnish "sector" research and transferring the basic research done by the government labs to the universities.

2. Such agendas will tackle R&D but also subsequent stages in the innovation process and technology diffusion needs and, where necessary, involve end-users, regulators and other actors whose actions are necessary for success.

3. Note by Turkey:

   The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

   Note by all the European Union Member States of the OECD and the European Union:

   The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

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