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.

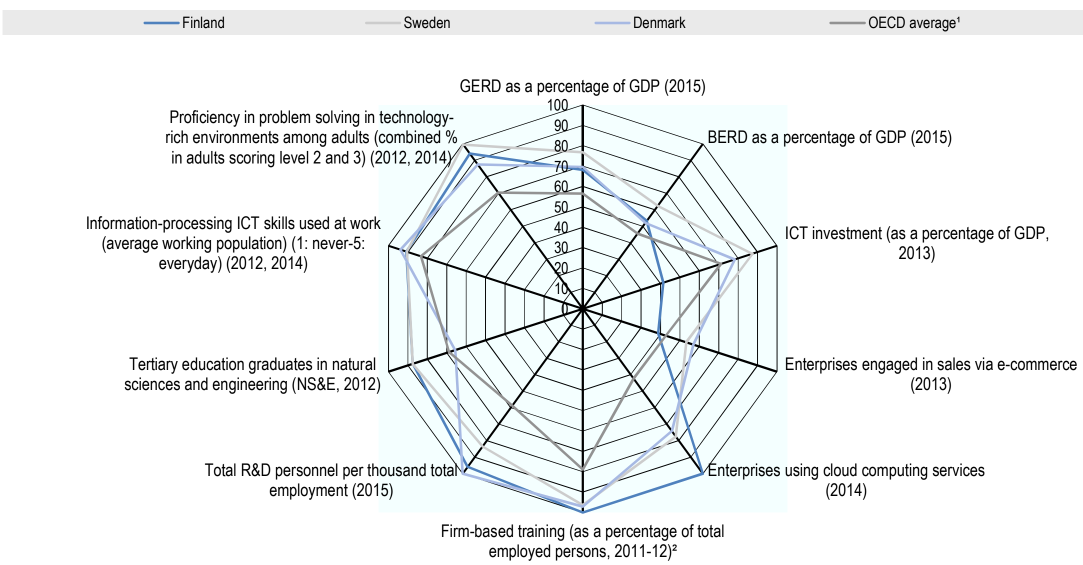
Innovation capabilities

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.

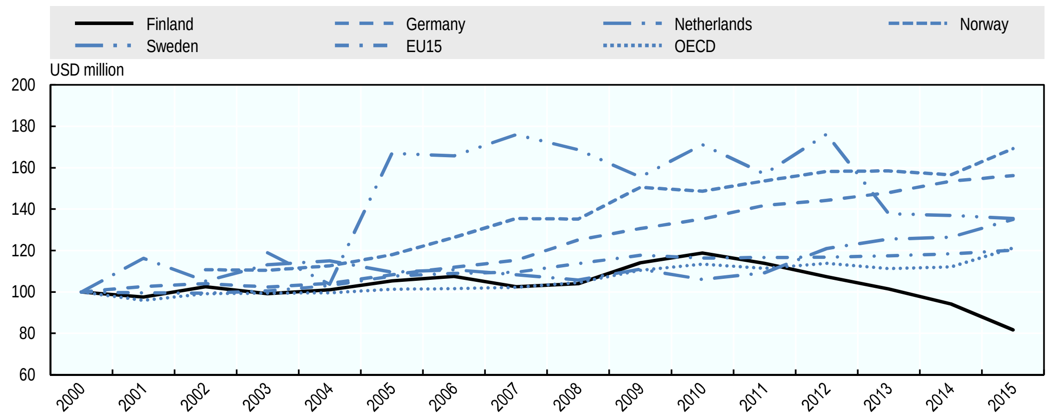
Investment in R&D: Evolution and recent trends

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**

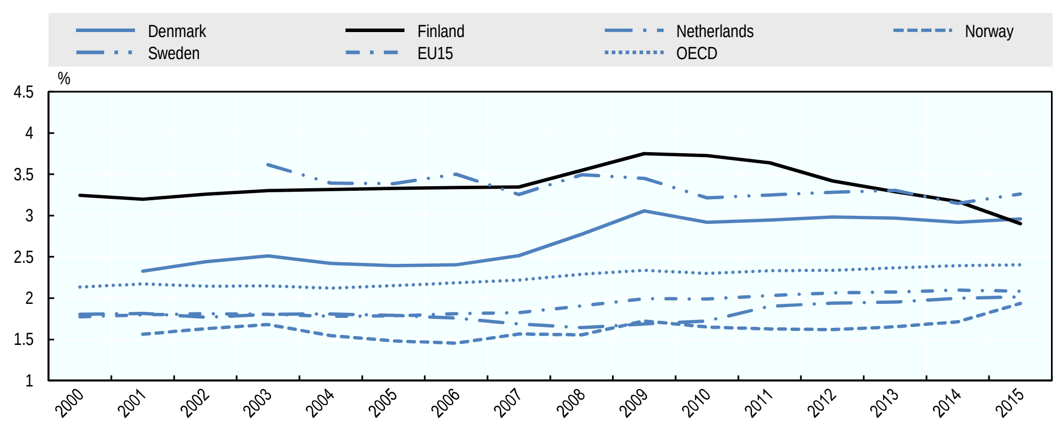
Index=2000, constant PPPs



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

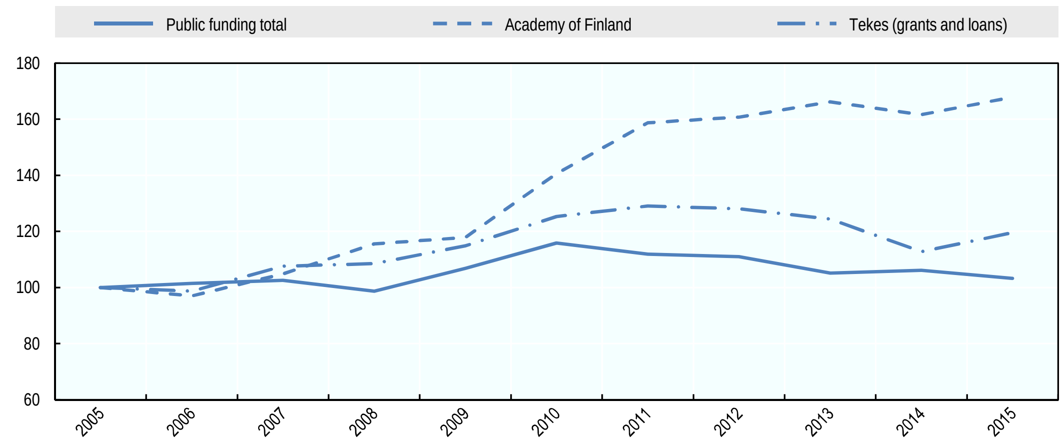


Source: OECD (2016d), "Main science and technology indicators", *OECD Science, Technology and R&D Statistics* (database), http://dx.doi.org/10.1787/data-00182-en (accessed 8 February 2017).

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.

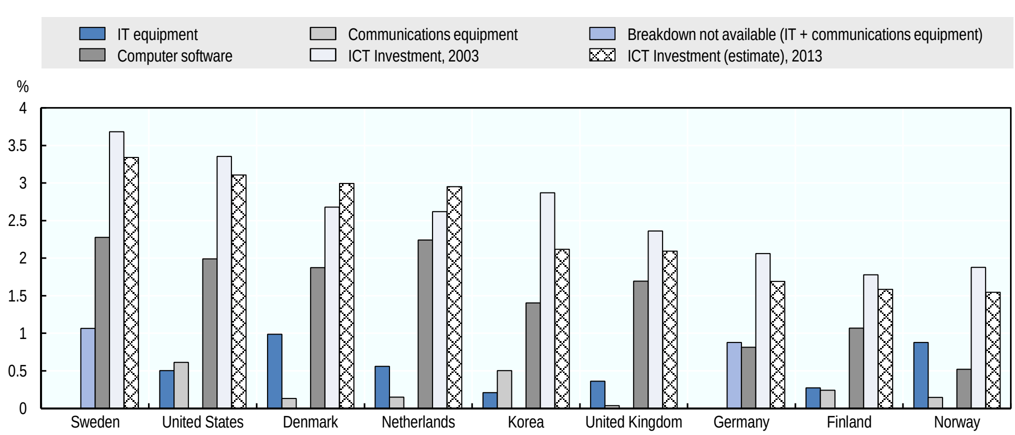
Furthermore, the diffusion (and use) of ICT and digital technologies could also be improved. Although Finnish companies rank around the average in terms of propensity to use (certain selected) ICT tools, there are several ICT areas where they rank far below the best performing country; these are: use 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

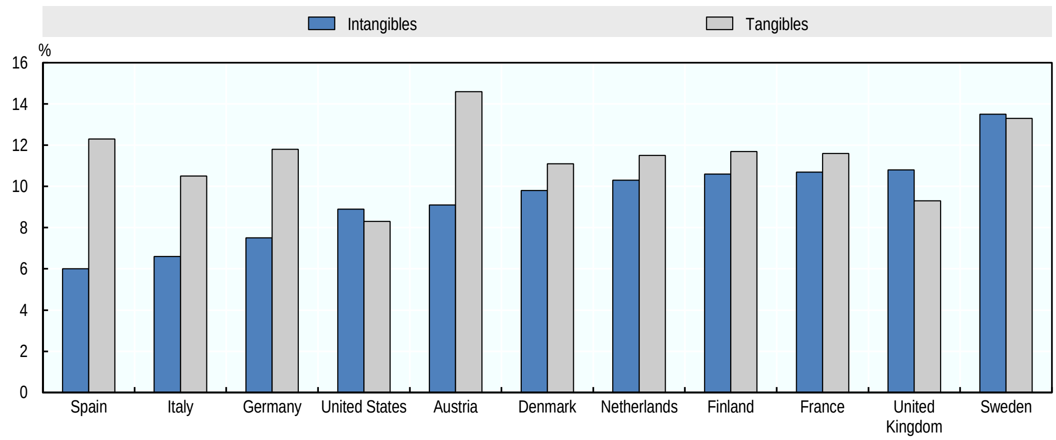


Note: Data for Sweden and Norway is for 2012.

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.

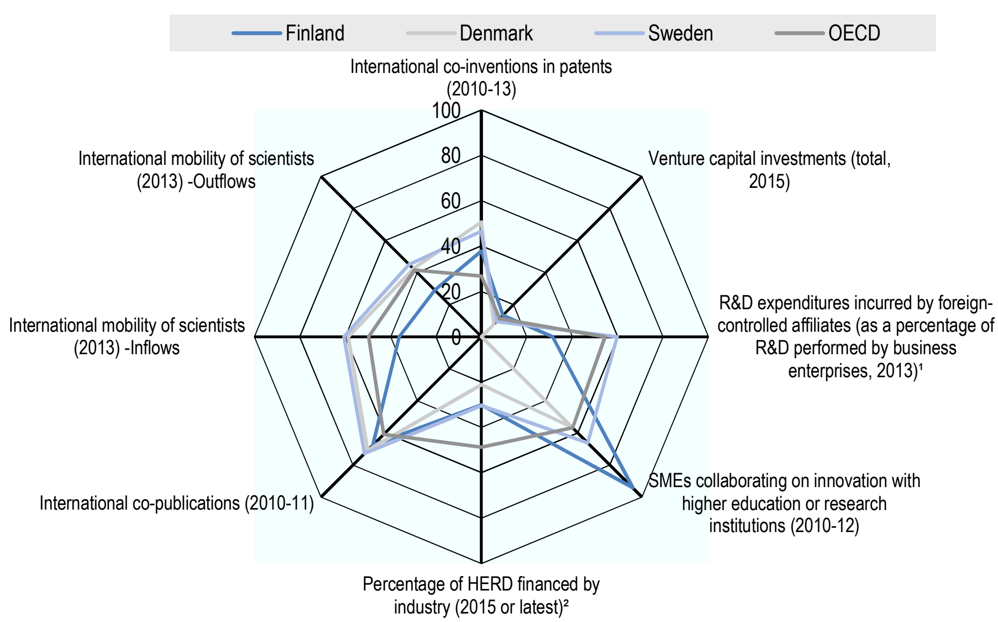
In terms of international linkages in research and innovation, however, Finland underperforms in a number of dimensions. In terms of international co-inventions as reflected in patents, Finland is farther from the top performer than Sweden and Denmark, although it is doing better than the OECD average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

100=top performer in OECD



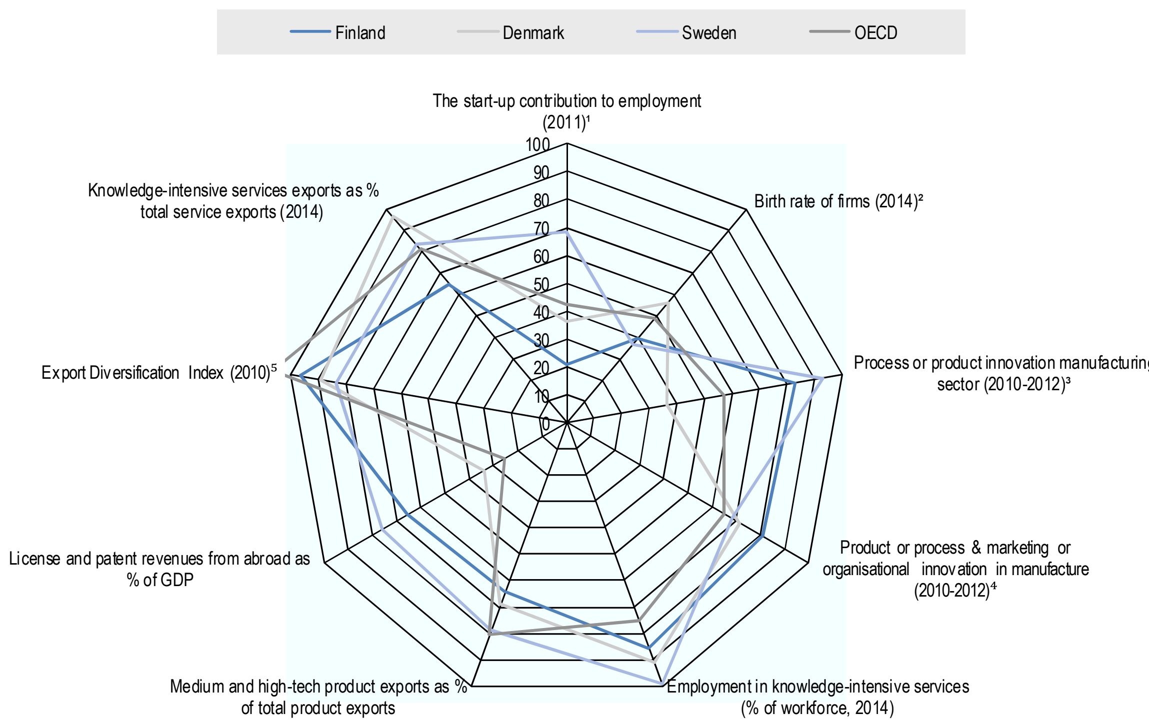
Notes: 1. The OECD average is a simple average of 20 member countries. Data for Sweden correspond to 2013. 2. The OECD average data correspond to 2014 and data for Sweden to 2013. HERD refers to total higher education spending on R&D.

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.

References

Academy of Finland (2016), *The State of Scientific Research in Finland 2016*, Academy of Finland, Helsinki, www.aka.fi/globalassets/30tiedepoliittinen-toiminta/tieteentila/aka_tieteen_tila_2016_eng_150317.pdf.

Corrado, C. et al. (2016), "Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth", *EIB Working Papers*, No. 2016/08, European Investment Bank, www.eib.org/attachments/efs/economics_working_paper_2016_08_en.pdf.

Corrado, C., C. Hulten and D. Sichel (2009), "Intangible capital and U.S. economic growth", *Review of Income and Wealth*, Vol. 55/3, September, pp. 661-685, http://onlinelibrary.wiley.com/doi/10.1111/j.1475-4991.2009.00343.x/epdf.

Criscuolo, C., P. Gal and C. Menon (2014), "The dynamics of employment growth: New evidence from 18 countries", *OECD Science, Technology and Industry Policy Papers*, No. 14, OECD Publishing, Paris, http://dx.doi.org/10.1787/5jz417hj6hg6-en.

Dutta, S., B. Lanvin and S. Wunsch-Vincent (eds.) (2016), "The global innovation index 2016: Winning with global innovation", Chapter 1 in: *The Global Innovation Index: Winning with Global Innovation*, Cornell University, INSEAD, and the World Intellectual Property Organization, pp. 3-48, www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2016.pdf.

European Commission (2017), "Digital Economy and Society Index 2017: Finland", https://ec.europa.eu/digital-single-market/en/scoreboard/finland.

European Commission (2016), *European Innovation Scoreboard 2016*, European Union, http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en.

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

Eurostat (2015), *EU-KLEMS Database*, www.euklems.net/index3.shtml.

IMF (2014), *The Diversification Toolkit: Export Diversification and Quality Databases*, www.imf.org/external/np/res/dfidimf/diversification.htm.

Kotiranta, A. and P. Rouvinen (2016), *OECD Reviews of Innovation Policy:* ETLA background report, unpublished.

Ministry of Education and Culture (2017), "International policy for Finnish higher education and research", http://minedu.fi/en/artikkeli/-/asset_publisher/suomalaiselle-korkeakoulutukselle-ja-tutkimukselle-kansainvalisyyslinjaukset.

OECD (2017), *OECD Main Science and Technology Indicators Database.* https://stats.oecd.org/index.aspx?datasetcode=msti_pub.

OECD (2016a), "Education at a Glance 2016: OECD Indicators – Country note: Finland", OECD, Paris, http://gpseducation.oecd.org/content/eagcountrynotes/eag2016_cn_fin.pdf.

OECD (2016b), *PISA 2015 Results (Volume I): Excellence and Equity in Education*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264266490-en.

OECD (2016c), *Skills Matter: Further Results from the Survey of Adult Skills*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264258051-en.

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

OECD (2016d), *Annual National Accounts (SNA) Database*, https://stats.oecd.org/Index.aspx?DataSetCode=NAAG.

OECD (2015a), *OECD Digital Economy Outlook 2015*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264232440-en.

OECD (2015b), *OECD Education Database,* www.oecd-ilibrary.org/education/data/education-database_edu-db-data-en.

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.

OECD (2014a), "Education at a Glance 2014, Finland country note", OECD, Paris, www.oecd.org/edu/finland-eag2014-country-note.pdf.

OECD (2014b), *TALIS 2013 Results: An International Perspective on Teaching and Learning*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264196261-en.

OECD (2013), *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264204256-en.

Scimago Research Group (2016), Scimago Journal & Country Rank website, www.scimagojr.com/countryrank.php.

Statistics Finland (2017), "Research and development", www.stat.fi/til/tkke/index_en.html.

Veugelers, R. et al. (2009). *Evaluation of the Finnish National Innovation System – Policy Report*, Taloustieto, Helsinki University Print, Helsinki, www.etla.fi/wp-content/uploads/innoevalfi_policy_report_28-oct-2009.pdf.

From:

OECD Reviews of Innovation Policy: Finland 2017

Access the complete publication at:

https://doi.org/10.1787/9789264276369-en

Please cite this chapter as:

OECD (2017), "Innovation capabilities and performance in Finland", in *OECD Reviews of Innovation Policy: Finland 2017*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/9789264276369-6-en

OECD