economy (OECD, 2016[47]). The new programme, RITA, examines the implementation of research, development and innovation strategies in co-operation with Tallinn University, the University of Tartu, Tallinn University of Technology, Estonian Academy of Sciences and Estonian Research Council.

In order to monitor progress in the policy objective of alignment of R&D activities with the interests of the Estonian society and economy (Estonian Ministry of Education and Research, 2014[12]), the government introduced two indicators for 2020, one measuring government budget appropriations by socio-economic objectives and the other for the share of public sector R&D expenditure financed by the private sector.

In addition, in 2014, the government allocated EUR 123 million to support institutional development plans and structural reforms, including mergers of higher education and R&D organisations, and to improve the quality of research (OECD, 2016[47]). New measures to strengthen public sector innovation and to improve the capacity of higher education institutions and public research organisations to undertake socially relevant research have also been implemented (Kattel and Stamenov, 2017[4]).

The Flemish Community has also adopted measures to increase efficiency in R&D. A number of research and innovation agencies have been merged, and funding for R&D has been reformed to streamline different research activities and simplify the application process for research funding. Strengthening of policy evaluation capacity has also been a priority, both at the federal level and within individual communities. The Flemish Community, for example, has recently performed an evaluation of the application procedures for projects and grants of the Research Foundation (OECD, 2016[48]).

In **the Netherlands**, measurement and improvement of research performance takes place within large research programmes, while measurement as such is also part of national monitors of R&D activities. The National Research Agenda (NWA) was developed in a bottom up process with researchers, the private sector, NGOs, citizens and other stakeholders. Research questions were grouped into 25 'routes' that combine scientific and societal challenges (Dutch Ministry of Education, Culture and Science, 2019[9]). The measurement framework of the NWA includes parameters about collaboration between different types of actors (universities, applied research (TO2) institutes, the private sector, NGOs, government agencies, etc.). In terms of output and impact, established indicators such as publications and IPR are used alongside qualitative indicators for knowledge sharing and addressing societal challenges.

Measuring and improving research performance is also addressed in the "top sectors" initiative (see Chapter 7) and its evolution to a mission-driven innovation policy. This initiative seeks to tailor public resources to priority sectors of the economy and to strengthen coordination of activities in these sectors by government, business and knowledge institutions (OECD, 2016[49]). Every two years, the Dutch Statistical Office evaluates the progress of the "top sectors" initiative in the areas of macro-economy, enterprise development, employment characteristics, innovation performance and education output (OECD, 2017[50]). In addition, Statistics Netherlands, the Rathenau Institute and the Association of Universities in the Netherlands (VSNU) monitor investments, activities and results in R&D and innovation.

Norway has adopted a number of reforms to increase the effectiveness and efficiency of public research. This has been reflected through structural reforms involving several mergers of higher education institutions; and funding reforms, including revisions to the indicators considered in the block grant for higher education institutions, and an universities based on the number of international research projects funded through the Horizon 2020 programme.

In Norway, institutions can also benefit from additional government funding if they receive grants from European interregional co-operation initiatives. Norway's long-term strategy outlines objectives and priorities for research co-operation in the European Research Area and the Horizon 2020 programme (OECD, 2016[45]). To achieve this goal, the Research Council of Norway increased the budget to support the participation of public research organisations in the EU Framework Programme to NOK 140 million in 2015 (OECD, 2016[45]). Norway additionally has a number of policies to develop international relationships, which can benefit the higher education R&D sector, such as

- international co-supervision of doctoral candidates with a co-operating institution abroad (*cotutelle*)
- the INTPART and UTFORSK initiatives, managed by the Research Council of Norway and the Norwegian Agency for International Co-operation and Quality Enhancement in Higher Education, funds research partnerships and project co-operation with institutions in a number of countries (including Brazil, China, India, Russia, South Africa and the United States).

Estonia has set targets to strengthen international co-operation in research. It aims to increase the share of national public funding for internationally co-ordinated research to 3% of government budget appropriations or outlays for R&D (GBAORD) by 2020 (Estonian Ministry of Education and Research, 2014[12]), from a level that was at 1.3% in 2010. Estonia is also a member of or participant in various international research infrastructures and organisations specialising in health, technology, life sciences and related fields, such as the European Space Agency, European Molecular Biology Conference (EMBC) and the European Organization for Nuclear Research (CERN).

6.7. Measuring and improving research performance

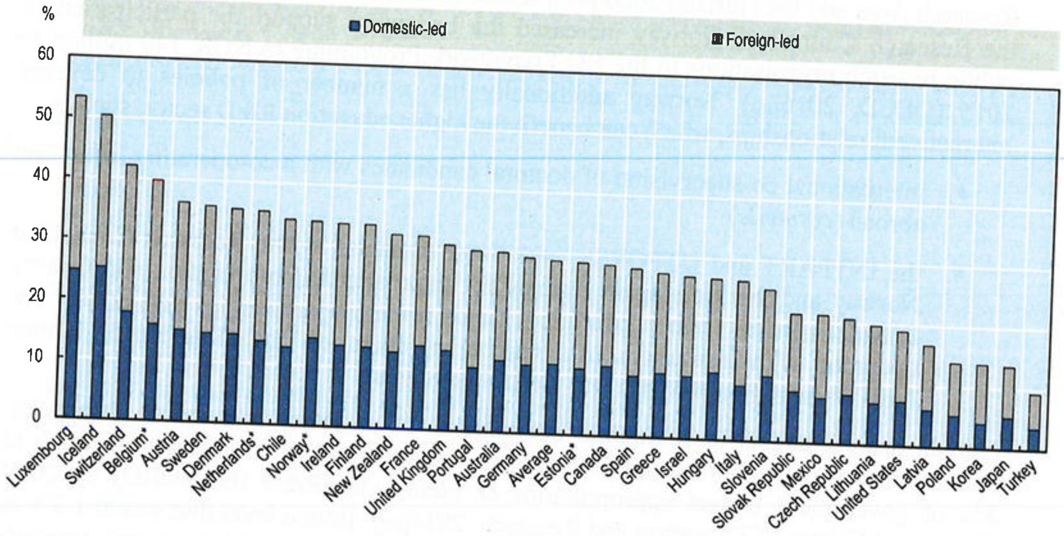
As research activity and investment increases, so does the imperative to measure its impact and evaluate its performance. This is necessary particularly in the case of public research, where there is a renewed focus on accountability for public spending and an increasing requirement for knowledge and evidence on which to base future funding decisions.

Recent OECD work has highlighted the general challenges faced across OECD countries to evaluate the outputs of research and development. The available metrics and approaches for measuring the social and economic impact of R&D suffer from a number of limitations, even as international rankings grow in importance. In addition, the links between the evaluation of research and policymaking are not always clear, including the setting of priorities for the system (OECD, 2016[46]). Developing new and robust ways to measure research performance and set systemic priorities are therefore likely to be areas of continued policy focus into the future. National initiatives are in place in many countries that aim to evaluate and improve the quality and relevance of research, including in the four participating jurisdictions.

Estonia has had a policy monitoring programme for research, development and innovation in place since 2011, coordinated by the University of Tartu. The programme was revised in 2015 to strengthen co-operation between government, higher education institutions and the private sector; and to enhance the role of science and research in the relatively advanced scientific network, which provides enhanced possibilities for national collaboration.

Figure 6.23. International scientific collaboration (2015)

As a percentage of domestically authored documents, fractional counts



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017.
Source: Adapted from OECD (2017[13]), *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation*, http://dx.doi.org/10.1787/9789264268821-en.

StatLink https://doi.org/10.1787/888933941652

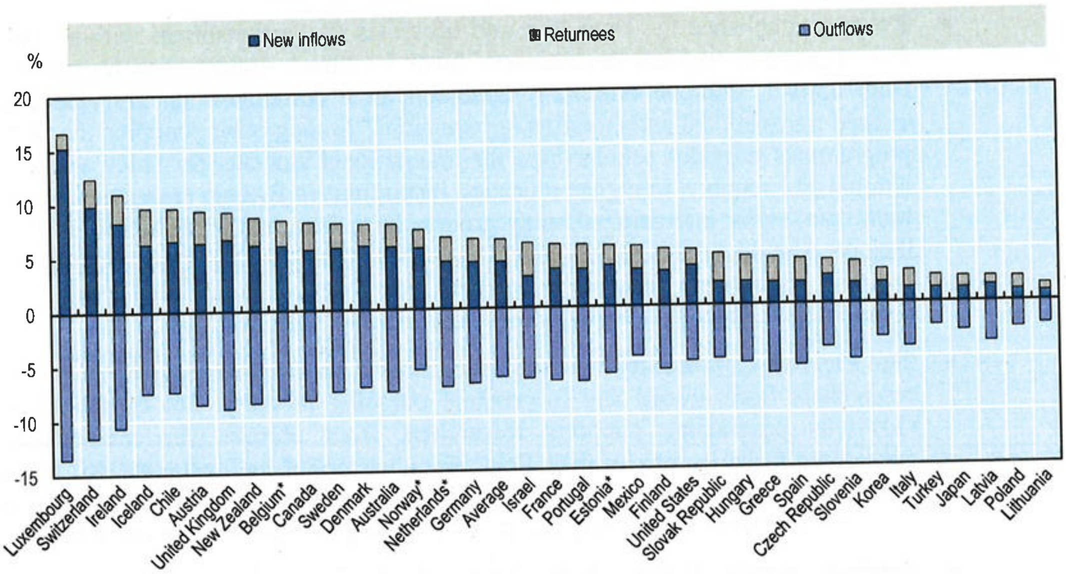
Language may also create barriers to international collaboration. While English has been adopted as the common international language for scientific publications, the majority of scientists globally are not native English speakers, and there are differences between countries in the proportions of scientific publications that are published in English. This can cause problems both in terms of transferring knowledge and discovering potential collaborators in the field (Meneghini and Packer, 2007[44]).

In the participating jurisdictions, Belgium, the Netherlands and Norway all had higher shares of international collaboration in publications than the average in 2015, while the share in Estonia was just below the average. The share of publications involving international collaboration was particularly high in Belgium, where almost 40% of all scientific publications in 2015 involved some form of international collaboration.

The above-average level of international collaboration in the Netherlands may be explained by an active involvement of higher education institutions in international alliances and consortia, such as the League of European Research Universities, the European Consortium of Innovative Universities and the IDEA League. Many universities are also active members of research consortia funded by the European Commission. Moreover, under the SEO (*Stimulering Europees Onderzoek*) scheme, the Netherlands Organisation for Scientific Research (NWO) provides additional funding to

Figure 6.22. International mobility of scientific authors (2016)

As a percentage of scientific authors, by last main recorded affiliation in 2016



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017.
Source: Adapted from OECD (2017[13]), *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation*, http://dx.doi.org/10.1787/9789264268821-en.

StatLink https://doi.org/10.1787/888933941633

Differences in flow patterns can also be observed across the participating jurisdictions. Belgium has one of the largest rates of brain circulation among OECD countries, with new inflows and returnees combined accounting for 8% of all scientific authors in 2016, while outflows were also of the order of 8%. Norway had a slightly positive overall inflow (+1.7%), though overall flow rates were lower than in Belgium. In Estonia and the Netherlands, there was less than one percentage point difference between inflow and outflow rates in 2016.

6.6.2. International collaboration

Along with mobility of talent, levels of international collaboration indicate the ability of research systems to participate in global research and innovation networks. On average across OECD countries, just under 30% of domestically authored documents involved some collaboration with researchers in other countries in 2015 (Figure 6.23). The share of publications with international collaboration was more than 50% in Iceland, Luxembourg, both relatively small countries where the need to collaborate internationally in research might be stronger given the lower likelihood of national networks of specialists within particular fields.

At the other end of the scale, less than 15% of publications in Japan, Korea, Poland and Turkey involve international collaboration, and international collaboration is also below 20% in the United States. The lower rate in the United States may be explained by the

In recent years, OECD countries have made substantial efforts to attract international doctoral students and more established researchers to help enhance their research performance. Most recently in the participating jurisdictions:

- **Estonia** established the Dora Plus and Mobilitas Plus programmes with support from European regional development funds to attract students and researchers from abroad, improve Estonia's reputation as a destination for research and expand transnational collaboration opportunities. Among other supports, the Dora programmes provides scholarships for international students for study visits to Estonia and supports to higher education institutions in Estonia to organise short-term courses for international study groups. Initiatives under the Mobilitas Plus include post-doctoral research grants for researchers coming from abroad, and retuning researcher grants for researchers returning to Estonia after completing some research abroad. The programme will continue until 2023.
- **The Flemish Community** has established several programmes to attract talented researchers from abroad and to promote outgoing mobility. For example, the Odysseus programme supports researchers from abroad who are already considered to be leading in their field, including promising post-docs, to start a research group in a Flemish university. These individuals are offered a permanent position at a Flemish university and project funding to establish a research team.
- Similarly, higher education institutions in **the Netherlands** encourage incoming and outgoing mobility of researchers and have designated funds to support such initiatives. Some research universities set aside annual funds for the recruitment of talented foreign research fellows and visiting professors. The Academy of Sciences and the Research Council also provide funding to stimulate international mobility among researchers.

Despite the increasing policy focus and an expansion of initiatives of recent years, it appears from bibliometric analysis that, in any one year, the vast majority of researchers are not internationally mobile (Figure 6.22). In 2016, on average across the OECD, 94% of scientific authors were classed as "stayers" meaning that their 2016 affiliations and pre-2016 affiliations were based in the same country (OECD, 2017[13]). However, mobility patterns and the extent of brain circulation tend to vary across economies. For example, in Greece, Hungary, Spain and the Slovak Republic, among others, the majority of inflows are returnees originally affiliated with an institution in the country. However, in most countries, the majority of researchers with an international mobility record represented new inflows (Figure 6.22).

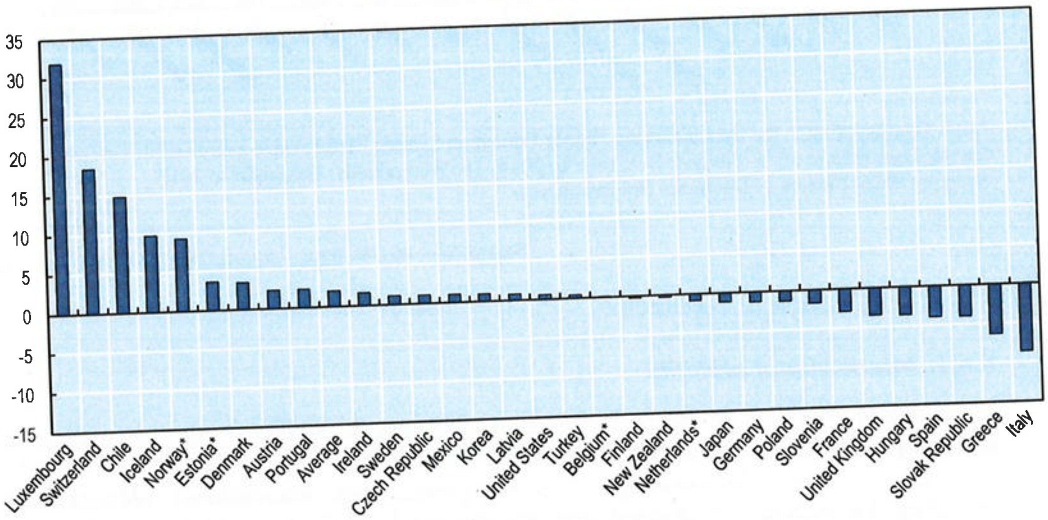
indication of those who move to another country or economy, those who stay in the same location, and those who return to the economy in which they first published (Figure 6.21 and Figure 6.22).[2] According to the Scopus data, researchers who conduct research abroad and return to the economy in which they first published contribute to raising the overall impact[3] of domestic research by 20% on average (OECD, 2017[13]).

Net flows of research authors for the OECD as whole since 2002 appear to be negative according to the Scopus data; over the period 2002-2016 in total there was a net outflow of almost 14 000 researchers (OECD, 2017[13]). Relative to the size of the population of 25-64 year-olds, Luxembourg, Switzerland, Chile, Iceland, and Norway have the largest positive net flows of researchers, while Italy and Greece, have the largest negative relative flows (Figure 6.21). In the participating jurisdictions, both Norway and Estonia experienced a net brain gain over the period, though the gain for Norway was over double the gain for Estonia. At the same time, between 2002 and 2016 Belgium and the Netherlands experienced close to even flows overall relative to the population.

In general, individual researchers who move to other countries are more likely to be associated with higher impact publications than researchers who have stayed in their original countries or returned. This appears to be mostly the case when moving from lower to higher performing research systems. For example, in the United States, researchers who leave the country tend to have lower journal scores, while those who move to the United States have higher scores than those who have stayed there, providing an indication that this country is very attractive for talented researchers (OECD, 2017[13]).

Figure 6.21. International net flows of scientific authors, selected economies (2002-2016)

Difference between annual fractional inflows and outflows per 100 FTE researchers

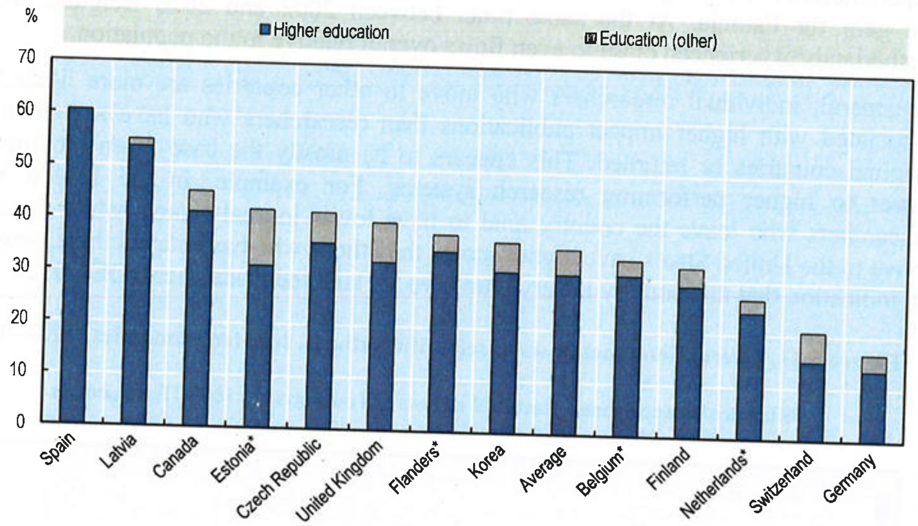


Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017.
Source: Adapted from OECD (2017[13]), *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation*, http://dx.doi.org/10.1787/9789264268821-en.

StatLink https://doi.org/10.1787/888933941614

Around 35% of doctorate holders were employed in the education sector in 2016, on average across OECD countries with available data (Figure 6.20). In Estonia and Flanders, the shares of doctorate holders working in the education sector were above the average level, while the share was below the average in the Netherlands. The substantial share of doctorate holders working outside of the education sector may suggest that there is a strong demand for the skills and knowledge provided by doctoral education in the wider labour market, especially given the tendency for doctorate holders to qualify in higher numbers in fields that are in high demand in the labour market. However, the relatively low rate of absorption into the education sector may also be indicative of a shortage of jobs, particularly in academia.

Figure 6.20. Doctorate holders by industry of employment (2016)



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Latvia: Data refer to 2015. Finland: Data refer to 2014. The Netherlands: Data refer to 2013.
Source: OECD Careers of Doctorate Holders survey.

StatLink https://doi.org/10.1787/888933941595

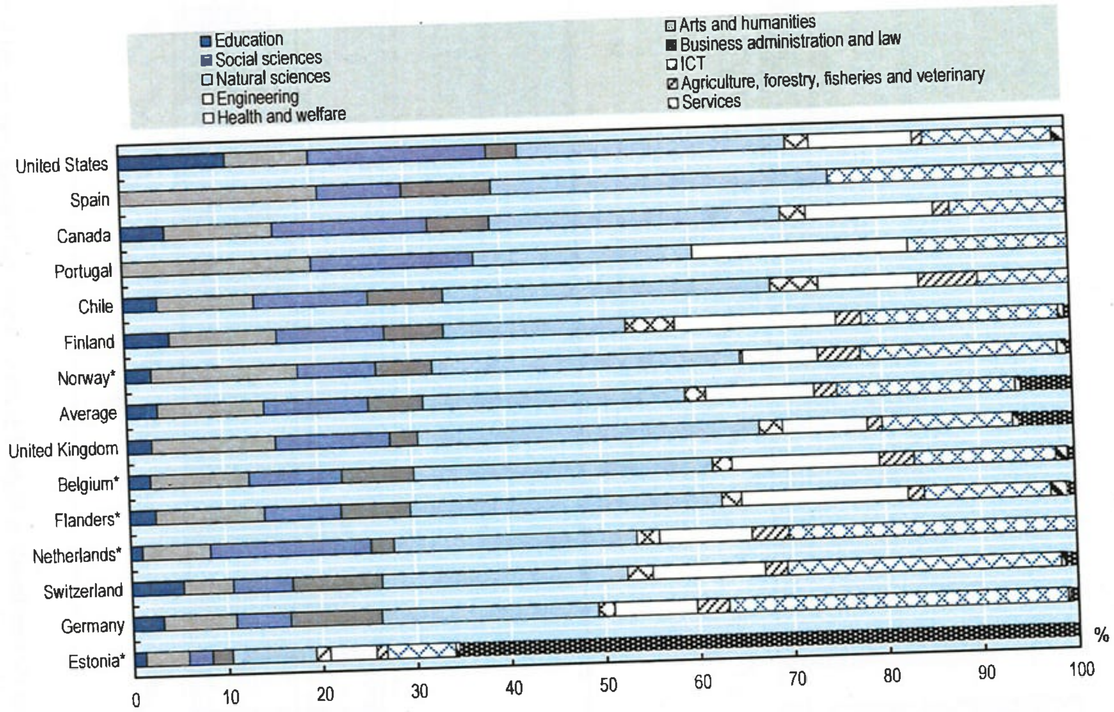
6.6. Internationalisation of research

6.6.1. International mobility

International mobility in R&D is important because it facilitates the circulation of knowledge and affects the quality of research. International mobility is also crucial to the innovation process; increasingly it is recognised that international collaboration, including the mobility of students and researchers, is likely to yield better results for innovation processes than continuously intensifying a "race for talent and investment" (OECD, 2017[25]).

International mobility is characterised in some OECD countries as a "brain circulation" where countries experience both inflows and outflows of talent. One measure of brain circulation is to examine the net flows of scientific authors, using bibliometric data available from the Scopus database, which provides data on the location of the affiliations of scientific authors over the time of their publications. These data therefore give an

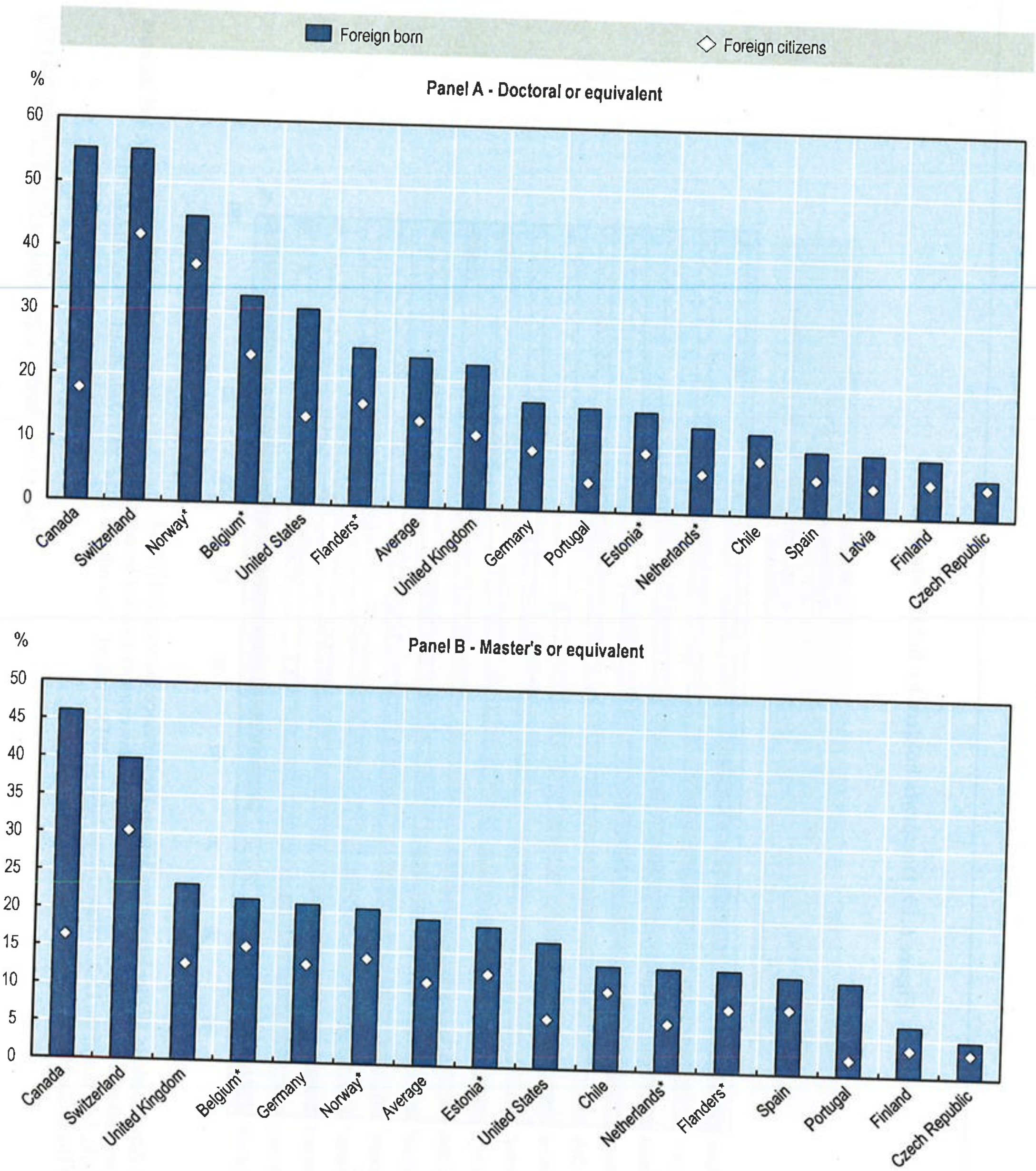
Figure 6.19. Doctorate holders by field of study (2016)



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
Countries and economies are ranked in descending order of the share of new entrants enrolled in: education; arts and humanities; social sciences; and business administration and law. Chile, Latvia and the United States: Data refer to 2015. Finland: Data refer to 2014. The Netherlands: Data refer to 2013.
Source: OECD Careers of Doctorate Holders survey.

StatLink https://doi.org/10.1787/888933941576

Figure 6.18. Advanced degree holders by country of birth and citizenship (2016)



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Chile, Latvia and the United States: Data refer to 2015. Finland: Data refer to 2014. The Netherlands: Data refer to 2013.

Source: OECD Careers of Doctorate Holders survey.

StatLink https://doi.org/10.1787/888933941557

OECD countries with available data (37%), indicating that Norway is an attractive destination for talent with advanced qualifications.

In Flanders, the share of foreign-born doctorate holders was slightly above the average across OECD countries, with 25% of doctorate holders being foreign-born. On the other hand in Estonia and the Netherlands, the share of foreign-born doctorate holders was below the average, at 16% and 14% respectively. Similarly, the share of foreign citizen doctorate holders was above the average in Flanders (16%), while it was below the average in Estonia (9%) and the Netherlands (6%).

Doctorate holders are more likely to be foreign-born or a foreign citizen than master's holders (Figure 6.18, Panel B). The shares of foreign-born individuals and foreign citizens were 4 percentage points higher among doctorate holders than master's holders, on average across OECD countries in 2016. However, this pattern does not hold equally across countries. For example, while in Flanders and Norway, the shares of foreign-born individuals and foreign citizens among doctorate holders were around double the share of master's holders, the shares of foreign citizens among doctorate holders were lower in Estonia and the same for both masters and doctorate holders the Netherlands.

In comparison with the general trends for fields of study among the population with higher education as a whole, doctorate holders are less likely to specialise in education; arts and humanities; social sciences; and business administration and law. On average across OECD countries with available data, over half of master's holders studied these subjects, compared to one-third of doctorate holders. Less than 20% of doctorate holders completed their doctoral study in the field of health and welfare; while around 11% studied in the fields of arts and humanities, engineering and social sciences respectively (Figure 6.19).

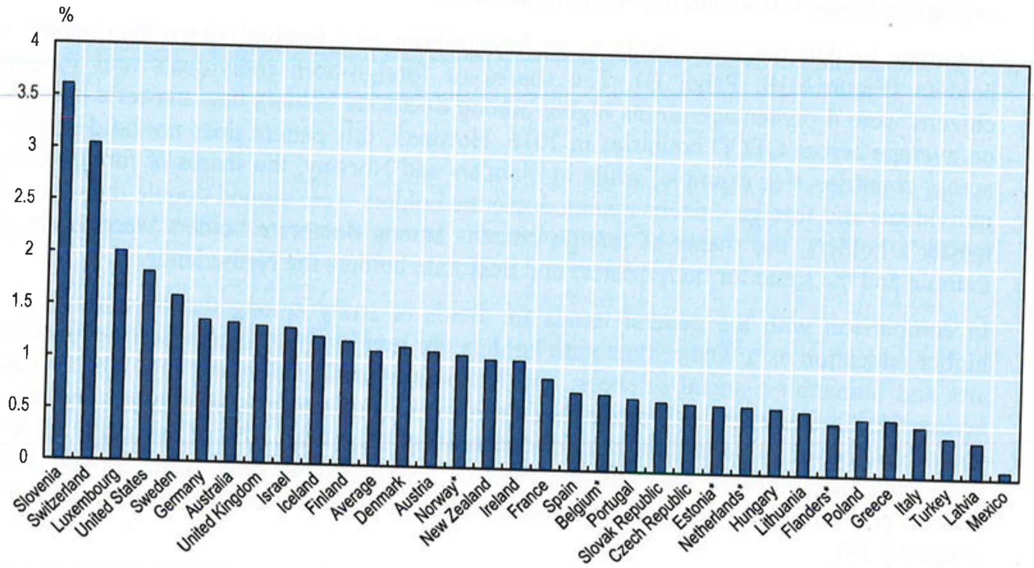
On the other hand, more than one-quarter of doctorate holders in OECD countries with available data studied natural sciences. This is a much higher proportion than the overall proportion of graduates from natural sciences programmes, where on average across the OECD, less than 7% of graduates earned a qualification in natural sciences in 2015 (OECD, 2018[32]). This highlights the prominent role that doctoral education plays within economies to provide the advanced STEM qualifications required in many areas of the labour market.

Differences in emphasis on various fields of study are also evident across the four participating jurisdictions. In the Flanders, a relatively large share of doctorate holders specialised in engineering (18% compared to the OECD average of 11%). In the Netherlands, doctorate holders who studied social sciences accounted for 17% of the total cohort, higher than the OECD average of 11%, while in Norway, 16% of doctorate holders studied arts and humanities, which is above the OECD average (also 11%).

Latvia, Mexico and Turkey to 2% or more in Luxembourg, Slovenia and Switzerland. In the participating jurisdictions, doctorate holders accounted for 1.1% of the population in Norway, similar to the OECD average, while they represented less than 0.6% of the population in Estonia, Flanders and the Netherlands.

Figure 6.17. Share of doctoral holders in the population (2017)

25-64 year-olds



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
Source: Adapted from OECD (2018[32]), *OECD Education Statistics*, http://dx.doi.org/10.1787/edu-data-en.

StatLink https://doi.org/10.1787/888933941538

6.5.1. Careers of doctorate holders

The UNESCO/OECD/Eurostat data collection on the Careers of Doctorate Holders (CDH) was initiated in 2011 in order to improve the information available about the profile and career patterns of doctorate holders in the population, given their importance in national research systems. Data are collected every two years at the aggregate level from OECD member countries, which provide the aggregates based on a range of national data sources, including labour force surveys and population registers (OECD, 2013[43]).

The 2016 version of the data collection covered 16 OECD countries, and Flanders. The CDH data shows that doctorate holders are more likely to move across borders than many other categories of the population. On average across OECD countries with available data, doctorate holders who are foreign-born accounted for nearly one-quarter of doctorate holders in 2016 (Figure 6.18, Panel A). In addition, 14% of doctorate holders were foreign citizens in 2016, on average across OECD countries.

In Norway, foreign-born doctorate holders made up 45% of the total doctorate holders in the population, the third largest share among OECD countries with available data. Norway also had the second highest share of foreign citizen doctorate holders among both individuals and higher education systems as a whole. Non-completers may experience lower employment prospects and a decrease in self-esteem, while systemically there is a loss in terms of financial resources, human resources and the loss of potential from research that will not be completed (Litalien and Guay, 2015[40]).

While there are limited studies on those who drop out of doctoral education, emerging evidence indicates that a number of personal and institutional factors can play a role in the decision to leave doctoral education. In a recent study, for example, more than one-third of doctoral students reported their intention to drop out, based on a range of factors including the difficulty of balancing doctoral studies and personal life, and problems with isolation and a lack of integration into their local academic community (Castelló et al., 2017[41]).

Evidence also suggests that doctoral completion rates can be improved through specific institutional practices, for example through ensuring academic staff are well prepared to supervise doctoral students (Box 6.4). Encouraging these practices can help to reduce costs related to non-completion.

Box 6.4. Social support and doctoral completion

Many factors play a part in doctoral non-completion. While adequate financial support is important, social support also plays a key role in improving the experience of doctoral candidates and improving completion rates. The role and approach of the doctoral supervisor is particularly vital in this regard. Professional and emotional support from an engaged doctoral advisor can help the doctoral candidate perceive stressful parts of doctoral education as less stressful (for example, writing the doctoral dissertation). Doctoral candidates are also more likely to progress in their professional development if they have a supervisor that is well connected to the relevant professional networks and wider group of scholars in the field of expertise, and when the supervisor and other faculty allocate time towards organising opportunities to discuss research questions and improve their scholarship (Jairam and Kahl, 2012[42]).

Some OECD countries are using funding mechanisms to encourage higher education institutions to increase the number of students graduating with doctoral degrees. For example, Estonia, the Flemish Community, the Netherlands and Norway take into consideration the number of defended doctoral degrees when allocating R&D funding to institutions. Estonia has also set a target to increase the number of new doctoral graduates in an academic year to 300 by 2020 (Estonian Ministry of Education and Research, 2014[12]). This figure amounted to 190 in 2012, and had increased to 253 by 2017.

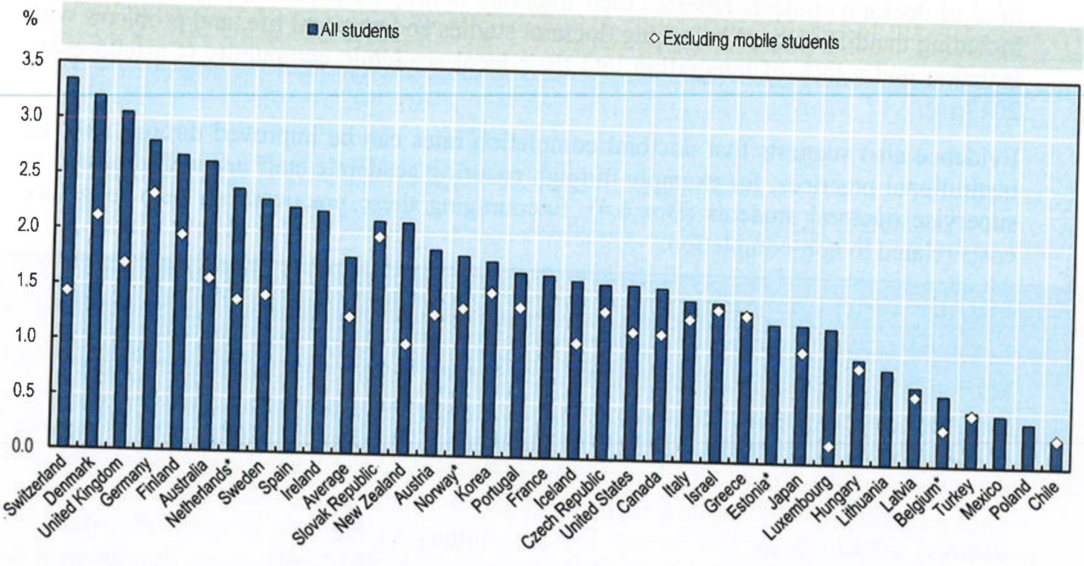
6.5. Profile of doctorate holders in the population

As the numbers of individuals with advanced research qualifications expands, it is becoming increasingly possible to identify them as a separate group and provide more detailed information on their profiles and labour market outcomes. The outcomes of doctorate holders is of particular policy interest, given the substantial government investment in doctoral education by many national research systems.

On average across OECD countries, 1.1% of the population aged 25-64 had completed a doctoral level programme in 2017 (Figure 6.17). However, the share of doctoral holders in the population varied substantially among OECD countries, from less than 0.5% in first-time graduation rate for OECD countries dropped to 1.2%. Across the OECD, around 30% of students who graduated from a doctoral programme in 2016 were international students, compared to 19% who received a master's degree, or 7% who were awarded a bachelor's degree for the first time (OECD, 2017[38]).

Figure 6.16. Graduation rates at doctoral level (2016)

Including and excluding mobile students



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
Source: Adapted from OECD (2018[32]), *OECD Education Statistics*, http://dx.doi.org/10.1787/edu-data-en.

StatLink https://doi.org/10.1787/888933941519

Among the participating jurisdictions, first-time graduation rates exceed the OECD average in the Netherlands, where 2.4% of young people are expected to graduate at the doctoral level. Norway is just below the average and Estonia and Belgium fall below the average with 1.3% and 0.6% first-time graduation rates at the doctoral level, respectively. When excluding international students, first-time graduation rates drop by as much as 50% in Belgium (from 0.6% to 0.3%) and by 40% in the Netherlands (from 2.4% to 1.4%).

In the Netherlands, graduation rates are considerably higher than entry rates for all students, excluding mobile students. This may reflect the fact that doctoral researchers do not register initially as doctoral students and are thus excluded from the entry rates statistics. It would also explain why entry rates in the Netherlands are well below the OECD average, whereas graduation rates are well above the OECD average for all students and in line with the average when excluding mobile students.

Comparing the rates in Figure 6.14 and Figure 6.16 may suggest that entry rates are growing, but also could indicate that many candidates do not complete doctoral education. Internationally comparable data on completion rates in doctoral programs is not currently available, but evidence from individual country studies indicates that they are relatively low across the OECD. Non-completion rates have been estimated to be as high as 50% in many countries (Van Der Haert et al., 2013[39]). This represents a cost for research work and a subsequent defence of the work before an academic committee (Box 6.3).

Box 6.3 Assessment practices for awarding a doctoral degree

In **Estonia**, doctoral studies are carried out on the basis of an individual work plan, the progress of which is periodically assessed by an attestation committee. Participation in international scientific conferences, international doctoral courses, study activities organised by doctoral schools, and training in laboratories abroad may count towards the fulfilment of such work plan (Eurydice, 2016[34]). Independent research in the form of a thesis, a series of publications accompanied by a summary article or a published monograph can be recognised as a doctoral thesis. The degree of 'doctor' is awarded after the completion and public defence of the thesis.

In the **Flemish Community**, the degree of 'doctor' is awarded after a period of scientific research and the public defence of a doctoral thesis involving a university panel of academics. At most universities, the doctoral fellows have followed training organised by doctoral schools before defending the doctoral thesis (Eurydice, 2014[35]).

In the **Netherlands**, the progress of a doctoral candidate is evaluated on an individual basis, usually through an arrangement made between the candidate and the supervisor. The status of the supervisor remains provisional until their official appointment shortly before the doctoral defence. The doctoral dissertation of the candidate is first approved by the supervisor and then provided to a panel of at least three academics to decide whether the dissertation satisfies the standard required for a doctorate (Eurydice, 2014[35]).

In **Norway**, at least three senior academics sit on the committee that evaluates a candidate's doctoral thesis, and at least one of them must come from another institution in Norway or from abroad (Eurydice, 2011[36]). The doctoral degree is awarded after a public thesis defence. The traditional doctorate leads to a degree of 'doctor of philosophy', which must be based on high level research.

Another major model of doctoral assessment is in place in the United States, where it is common for doctoral candidates to receive more formative assessment throughout the process and first defend their progress in front of a committee, then only prepare the dissertation after this successful examination (Barnett et al., 2017[37]).

Expected graduation rates from doctoral education can give an indication of the relative success of OECD countries in producing young research talent. Based on patterns of graduation for 2016, approximately 1.8% of young people across the OECD are expected to graduate from a doctoral programme in their lifetime, compared to 18% who are expected to graduate with a master's degree and 38% with a bachelor's degree (OECD, 2018[31]).

In 2016, first-time graduation rates at the doctoral level exceeded 3% in only three countries: Denmark, Switzerland, and the United Kingdom (Figure 6.16). These countries also have some of the highest first-time entry rates and the largest share of international students in doctoral education in the OECD. When excluding international students, the on average when they first start a doctoral programme, whereas in Portugal the average age of entry is 35 years old (OECD, 2018[31]). This could be a function of the age at which students graduate from lower levels of higher education, the flexibility of the higher education system, or cultural expectations (such as a preference for having work experience before entering a doctorate programme).

Overall, approximately 59% of new entrants to doctoral education across the OECD are below the age of 30. While in some countries, such as the Czech Republic and France, more than 75% of new entrants to doctoral programmes are below the age of 30; in others, such as Israel and Portugal, less than 40% of new entrants are below this age (Figure 6.15).

The Netherlands is the country with the largest proportion of younger entrants to doctoral education among OECD countries, with 87% of new entrants to a doctoral programme below the age of 30 in 2016. In Estonia, 67% of new entrants were under 30 in 2016 while less than half (46%) of entrants were under this age in Norway.

While starting ages are different, it is clear that in most OECD countries, doctoral students are most likely to be going through their studies while in their 30s. Insecurity about career prospects and limited financial resources often associated with early-stage careers in research (and in some countries, the accumulation of debt over this period) can be at odds with other sectors which may offer greater job security and benefits for similar levels of skills and experience within the age cohort. This also means that doctoral graduates tend to enter the labour market at a later stage compared to peers choosing other career paths. Furthermore, the employment prospects for doctoral graduates can vary; while overall unemployment rates for doctoral graduates are very low, the higher education sector appears to only absorb about one-third of doctoral graduates, which may mean that many young researchers are not able to follow their preference for an academic career (Section 6.5).

Figure 6.15 also shows the share of female new entrants to research careers, based on 2016 data. On average, close to 49% of new entrants to doctoral education in OECD countries were women in 2016, reflecting the progress that has been made in this area in recent years in closing the gender gap in higher education enrolments at all levels. The lowest proportions of women entering doctoral programmes were in Japan (about 30%), Chile, Korea, Luxembourg and Turkey (around 40%), while the proportion was more than 50% in a group of countries including Finland, Iceland and Poland. However, other sorts of gender gaps remain in research (see Box 6.2).

Women accounted for around 50% of the population of new entrants to doctoral education in the Netherlands, and Norway in 2016, which is just above the OECD average. In Estonia, over 52% of new entrants to doctoral education were women.

6.4.2. Completion of doctoral programmes

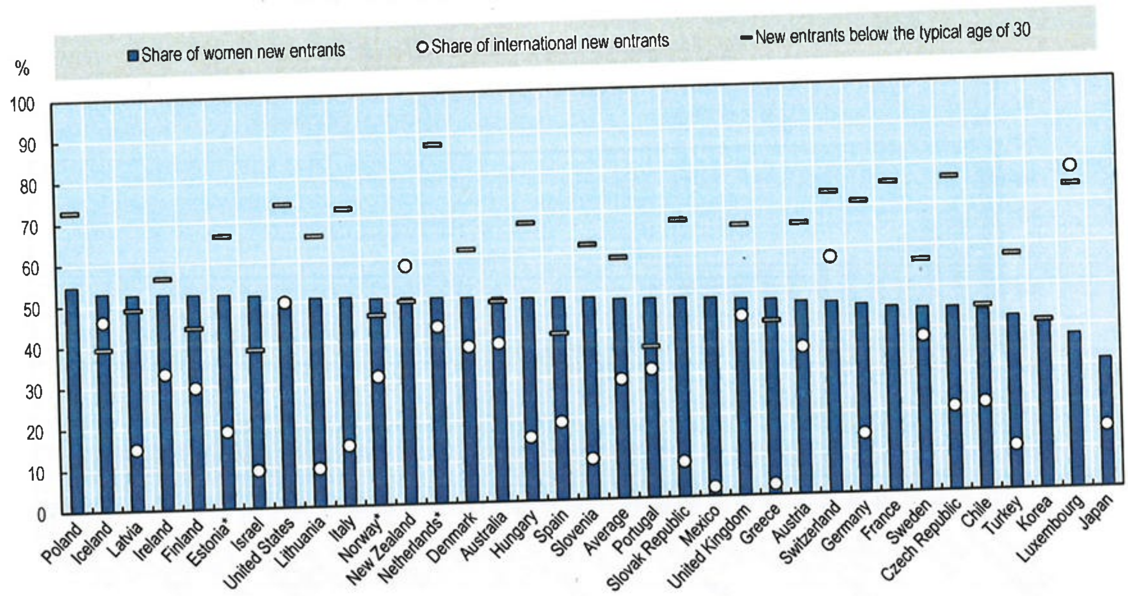
Doctorates are awarded following the achievement of a set of requirements which aim to show the standard has been met to achieve the award. Doctoral degrees can be awarded based on the public defence of a thesis, by publishing a minimum amount of material, or by other means, such as completing a combined programme of teaching and research, or other practice-related milestones in the case of professional doctorates. Though differences in assessment exist across countries, most processes in European countries, including the participating jurisdictions, entail the preparation of a substantive body of than one out of four new entrants to doctoral education is an international student, compared to one out of five at the master's level and one out of ten at the bachelor's level (OECD, 2016[33]). Luxembourg had the highest proportion (78%) of international new entrants at the doctoral level among OECD countries in 2016; and around one in two new entrants in New Zealand, Switzerland and the United States were international students in the same year. In some countries, such as Greece and Mexico, international students accounted for less than 5% of all new entrants at the doctoral level (Figure 6.14).

When excluding international students, first-time entry rates at the doctoral level in 2016 decreased from 2.4% to 1.7% on average in OECD countries and by more than half in Switzerland (from 4.7% to 2.0%) and New Zealand (from 3.2% to 1.3%) (Figure 6.14).

Within the participating jurisdictions with available data, Estonia and the Netherlands had entry rates at the doctoral level below the OECD average in 2016 with first-time entry rates of 2% and 1.5% respectively, while Norway was marginally above the OECD average with a first-time entry rate of 2.7%. International entrants represented 43% of new entrants to doctoral education in the Netherlands, which was 14 percentage points above the OECD average. In Norway and Estonia, international entrants accounted for 31% and 19% of new entrants respectively (Figure 6.15).

Figure 6.15. Profile of first-time new entrants to doctoral studies (2016)

Percentage of total



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
Source: Adapted from OECD (2018[32]), *OECD Education Statistics*, http://dx.doi.org/10.1787/edu-data-en.

StatLink https://doi.org/10.1787/888933941500

The profile of doctoral candidates

Based on 2016 evidence for OECD countries, students are on average 31 years-old when they first enter a doctoral programme. But the age at which students first start doctoral studies varies across countries. For example, in the Netherlands, students are 26 years old to some employee benefits such as parental leave and pension credits. In 2012, the position of junior researcher was created to encourage doctoral candidates to continue working in the research field after obtaining a doctoral degree. This means that doctoral students can work in parallel as junior researchers and receive a salary in addition to their study allowance.

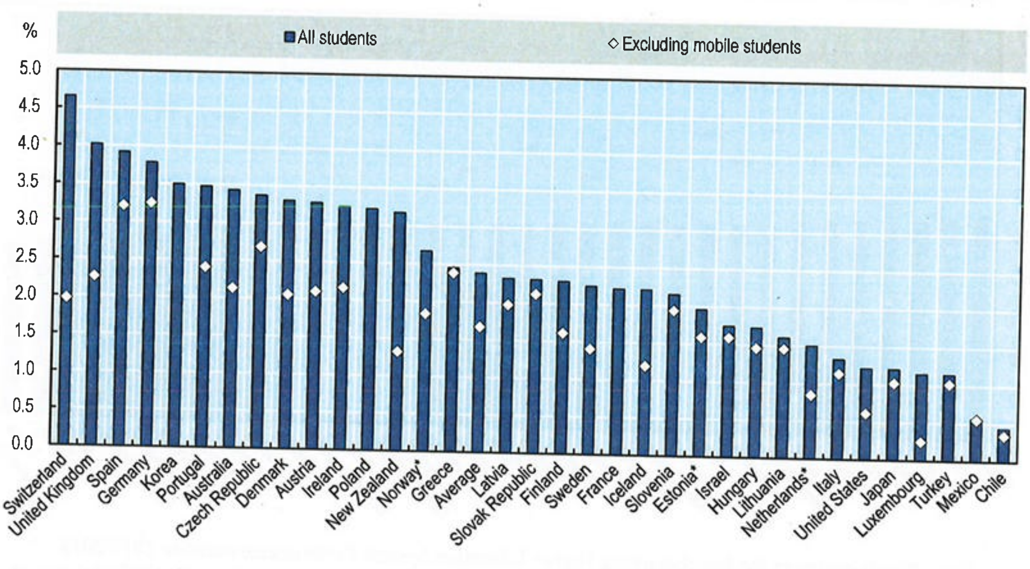
There are also funding schemes in the participating jurisdictions that support prospective students employed in other sectors outside of academia. For example, in Norway, public sector organisations and businesses that allow their employees to complete a doctorate in their area of work are entitled to financial support from the Research Council of Norway (Research Council of Norway, 2019[30]).

Entering doctoral studies

Numbers of doctoral students have been increasing in recent years across the OECD, and based on patterns of entry for 2016, 2.4% of young people are expected to enter a doctoral programme or equivalent in their lifetime on average across the OECD. By comparison, lower levels of higher education first-time entry rates equal 58% for bachelor's programmes and 24% for master's programmes (OECD, 2018[31]). This overall rate masks substantial inter-country differences, however. Entry rates surpass 4% in Switzerland and the United Kingdom but are less than 0.5% in Chile (Figure 6.14)

Figure 6.14. Entry rates at doctoral level (2016)

Including and excluding international students



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Data on doctoral students exclude those who are employed outside of higher education.
Source: Adapted from OECD (2018[32]), *OECD Education Statistics*, http://dx.doi.org/10.1787/edu-data-en.

StatLink https://doi.org/10.1787/888933941481

Doctoral education is characterised by a relatively high level of internationalisation reflecting policy efforts to increase international mobility in the scientific community and among highly skilled individuals (OECD, 2017[13]). On average across the OECD, more

Table 6.3. Characteristics of doctoral education in the participating jurisdictions

	Estonia	The Flemish Community	The Netherlands	Norway
Providers of doctoral education	Universities	Universities	Universities	Universities and some university colleges
Admissions requirements	Master's degree or equivalent (required); other admission requirements set by institutions may apply	Master's degree (exceptions apply); other admission requirements set by institutions may apply	Master's degree (exceptions apply); other admission requirements set by institutions may apply	Master's degree (at ISCED-7); other admission requirements set by institutions may apply
Duration of doctoral studies	3-4 years FTE (typical duration 4 years)	4 years (intended duration, but on average candidates take about 5 years to complete)	3 years FTE (minimum duration) but most doctoral candidates working at universities are appointed for 4 years	3 years FTE (minimum duration). Doctoral candidates are normally hired based on a 4-year contract (1/4 of the time dedicated to teaching and other duties at the HEI). Candidates financed through other sources are on 3-year contracts
Status of doctoral candidates	Students	Students but in addition they can be considered employees of the university where they study, or of a foundation that provides scholarships for doctoral education	Most doctoral candidates are employees of the university where they study; there are also external doctoral candidates	Employees of the higher education institution where they study, of a company, or a public employer; there are also external doctoral candidates

Source: Adapted from Eurydice (2018[28]), *National Education Systems*, https://eacea.ec.europa.eu/national-policies/eurydice/home_en; information provided by the participating jurisdictions. See the reader's guide for further information.

In most European countries, including Estonia and the Flemish Community, the primary status of a doctoral candidate is a student status (Eurydice, 2017[29]). In the Flemish Community, students may also be considered employees of the university where they study or of a foundation that provides scholarships for doctoral studies. Around 13% of doctoral candidates in the Flemish Community have both student and employee status (Eurydice, 2017[29]).

In contrast, in the Netherlands and Norway, the primary status of a doctoral candidate is an employee of the educational institution, usually for a period of four years (Eurydice, 2017[29]). This applies to most doctoral candidates in Norway and around half of candidates in the Netherlands. In these jurisdictions, some doctoral candidates are also hired as employees of another public or private employer. In the Netherlands, around 45% of doctoral candidates are considered 'external candidates'. These individuals generally work outside the academic sector (Eurydice, 2017[29]). A small number of doctorate students can also study on the basis of a scholarship, through a scheme introduced in 2015 to attract more talented students to doctoral education. Many of the students benefiting from this scholarship are international students.

In Estonia, doctoral candidates are classed as students and are entitled to social benefits on the same grounds as bachelor's and master's students. However, they are also entitled doctoral programmes, students participate in graduate-level coursework and doctoral seminars and colloquia. Students may then be required to pass a qualifying examination in the second or third year of study to be admitted to the research part of the doctoral programme. Students take between six and nine years to complete a doctorate in the United States depending on the subject and the institution.

In Australia, the usual prerequisite for prospective students is the completion of a bachelor's programme with an honours component (class I or IIA). Alternatively, students may be accepted on the basis of completion of a master's through research or course work. Doctoral programmes typically take three to four years to complete.

The most common type of qualification obtained from research doctoral studies is the Doctor of Philosophy (PhD), though professional doctoral education has seen significant growth in many countries. Professional or discipline-specific doctorates are most often obtained by undertaking a combined period of study based at a higher education institution (which can comprise taught programmes, research or both) and professional practice, and are oriented more towards applying the skills obtained in professional practice than a career as a researcher. While some OECD countries, such as the UK and the USA, offer increasing numbers of professional doctoral programs, other countries, such as Canada, have instead opted to add more professionally focused elements to the traditional PhD program (Chiteng Kot and Hendel, 2012[26]).

Accessing and funding doctoral education in the participating jurisdictions

In all of the participating jurisdictions, admission to doctoral studies is generally on the basis of a master's degree or an equivalent qualification, with a minimum duration of around three years FTE, though typically completion takes at least four years (Table 6.3). Higher education institutions may have additional requirements for admission, such as interviews, the submission of a research plan, additional examinations, etc. In the Flemish Community and the Netherlands, candidates without a master's degree may be admitted to a doctoral programme, but only in exceptional cases, and applicants may need to undergo a competence assessment to show their ability to conduct research and write a doctoral thesis.

In Estonia, the Flemish Community and the Netherlands, doctoral studies are carried out only in universities. In Norway, the majority of state institutions and some private institutions also provide doctoral education. In the Netherlands, all doctoral candidates are either part of a graduate school or a research school. Research schools are partnerships between multiple research universities and research institutes, while graduate schools are organised within universities.

The level and type of financial supports for doctoral students are important predictor variables for the completion of doctoral education, with assistantship-type support (where a student receives a stipend in return for the performance of specific research or teaching-related duties) strongly associated with increased completion (Ampaw et al., 2012[27]). All four participating jurisdictions have a range of mechanisms in place to provide financial stability for doctoral students.

6.4. Accessing a career in research

Doctoral education represents the key entry point into a career in academia. Most career paths in higher education research require a doctorate as the minimum standard before researchers can progress to the next career level, for example as a post-doctoral researcher, junior lecturer or associate professor (see Chapter 4).

On a global level, the role of doctoral students and graduates within the broader research system could be considered to be at crossroads. Many countries have been actively encouraging increasing numbers of doctorate holders in the population, and there have been large increases in the numbers of new doctorates worldwide over the last decades (OECD, 2016[3]). However, the increased numbers alone may not be necessarily be meeting the needs of the research and development sector. For example, there have been some indications of a slowdown in STEM doctorate graduates in recent years, particularly in the largest doctoral education systems, which could lead to a future shortage of researchers in these fields. At the same time, in some cases, doctoral graduates are facing uncertain and insecure career paths within public research systems. Many doctoral graduates and increasingly, post-doctoral researchers, are leaving the research profession (OECD, 2016[3]).

Nonetheless, a steady supply of skilled knowledge-based capital will be needed to spur the innovations of the future and maximise the potential for future economic progress (OECD, 2015[2]). Furthermore, to actively participate in international innovation networks, countries will need to not only ensure that they have a pool of capable researchers, but that they have the skills to collaborate effectively across institutions and countries, and that the research they do is relevant to the international market (OECD, 2017[25]).

Therefore, the policy focus is beginning to broaden in many countries from increasing the volume of doctoral graduates to also ensuring rewarding careers in R&D, addressing systemic and individual challenges that can arise throughout a career in research, and helping doctoral graduates to develop the types of transferable skills that are in demand across the economy. This section looks into how doctoral education is organised (with a particular focus on the participating jurisdictions) and the flows of students in and out of doctoral studies. The data presented can give an indication of how successful systemic policies and practices are in attracting doctoral students, and providing rewarding conditions which encourage them to complete their studies and progress.

6.4.1. Entering doctoral studies

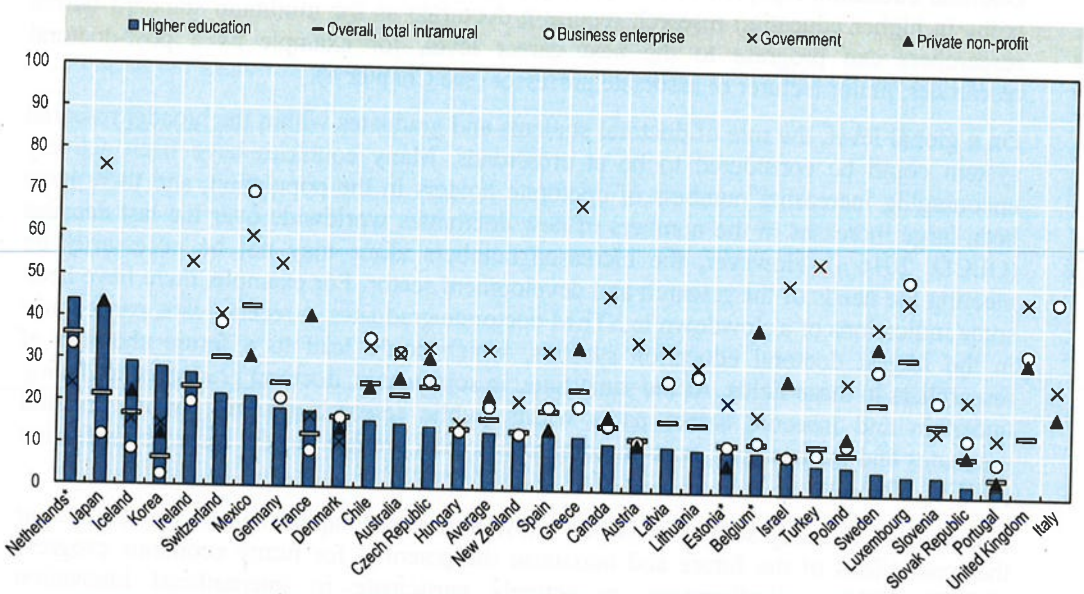
Across OECD countries, doctoral education is organised in diverse ways, and there are substantial differences in the number and profiles of those who are pursuing doctoral studies. The entry requirements for a doctorate also vary across OECD countries.

Since the introduction of the three-cycle system as part of the Bologna Process in Europe, a master's qualification is generally the basis for admission to doctoral studies throughout the European Higher Education Area (EHEA). The duration of doctoral studies within the EHEA is typically three to four years. The Canadian doctoral programme is also similar to European approaches, with most students entering on the basis of a master's degree, though the average time for completion of the doctorate is around six years.

By contrast, in the United States, the majority of students can enter doctoral programmes following the completion of a bachelor's degree. However, during the first two years of

Figure 6.13. Other support staff to researchers (2016)

FTE other support staff per 100 researchers, overall and by sector of employment



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Data refer to 2016 or most recently available year.

Source: Adapted from OECD (2018[16]), *OECD Science, Technology and R&D Statistics*, https://doi.org/10.1787/strd-data-en.

StatLink https://doi.org/10.1787/888933941462

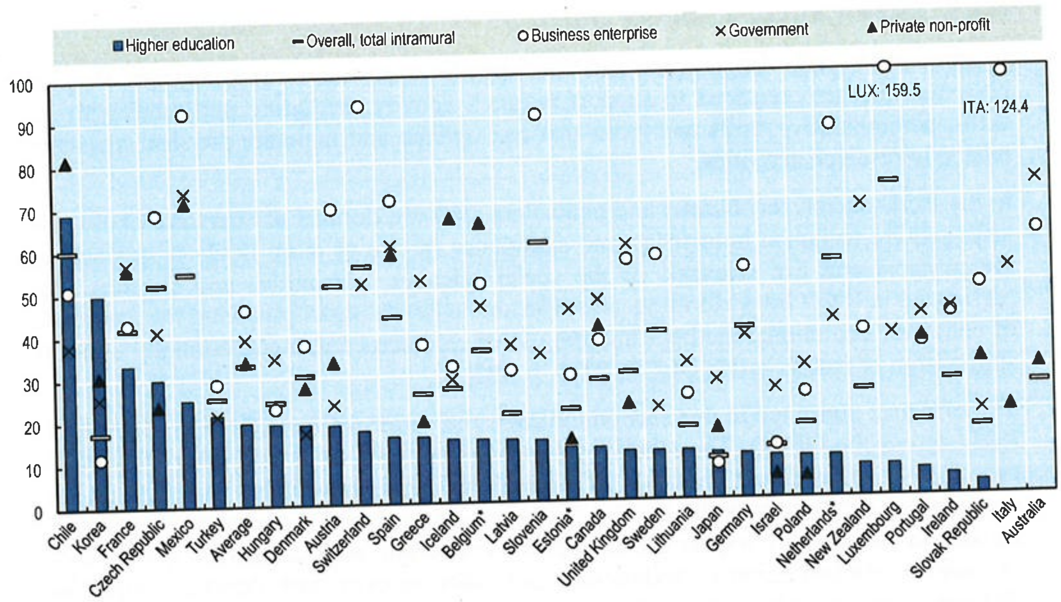
Estonia and Belgium both have just under 10 higher education support staff to 100 researchers, below the OECD average for the higher education sector. Proportions of support staff are also well below the average for the government sector, at around 20 researchers per 100 technicians in each of the two jurisdictions. The Netherlands is one of only a few countries with greater proportions of support staff working in the higher education sector (44 per 100 researchers) than in the government sector (24 per 100 researchers). This could partly be explained by the national emphasis on maximising the "valorisation" of research and the additional resources devoted to this priority in the Netherlands (see Chapter 7).

While Norway does not have separate data for technicians and supporting staff, aggregate data for the two categories are available. In Norway, there are around 40 technicians and other supporting staff per 100 researchers. This number is somewhat higher for the government sector, but markedly lower for the higher education sector at only 27. These values are below the OECD average of 51 overall and 69 for the government sector, and relatively in line with the average of 29 for the higher education sector. However, Norway has a very high number of researchers relative to its population. This may indicate that in Norway researchers perform the tasks that are performed by technicians and other supporting staff in other countries, and this may explain the apparent relative under-resourcing in these personnel categories.

researchers in the government sector, and 15 in higher education, though their most recently available data refer to 2011.

Figure 6.12. Technicians to researchers (2016)

FTE technicians per 100 researchers, overall and by sector of employment



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
Data refer to 2016 or most recently available year.
Source: Adapted from OECD (2018[16]), *OECD Science, Technology and R&D Statistics*, https://doi.org/10.1787/strd-data-en.

StatLink https://doi.org/10.1787/888933941443

Other support staff include "skilled and unskilled craftsmen, and administrative, secretarial and clerical staff participating in R&D projects or directly associated with such projects" (OECD, 2015, p. 164[1]). According to 2016 data, the average ratio of other support staff in OECD countries with available data was 17 support staff to 100 researchers. As is the case with research technicians, this ratio is higher in the government sector (33 per 100 researchers), and slightly lower in the higher education sector (14 per 100 researchers), with marked differences between countries (Figure 6.13).

The ratio of other support staff to 100 researchers in higher education is more than 40 in Japan and the Netherlands, while the category appears to be almost non-existent in the United Kingdom, although the category does exist in other R&D sectors. The ratio of other support staff to 100 researchers in the government sector is over 50 in Germany, Greece, Ireland, Japan, Mexico and Turkey, with Mexico in particular having a very large proportion of both other support staff and technicians in the government sector (60 other support staff and 74 technicians per 100 researchers).

In Belgium, on the other hand, the largest share of government researchers (40%) is in engineering and technology, a difference of almost 25 percentage points from the OECD average. And while social sciences is one of the fields that is least represented among government researchers in general across the OECD, it attracts the largest share of government researchers in Norway (25%).

6.3.5. Technicians and support staff

In addition to staff with research and field-specific expertise, other categories of skilled personnel are also required to support research activity, including personnel with ICT skills, administrative skills and those that can operate and maintain physical machinery related to research activities.

In the R&D sector, technicians and equivalent staff are defined as "persons whose main tasks require technical knowledge and experience in one or more fields of engineering, the physical and life sciences, or the social sciences, humanities and the arts. They participate in R&D by performing scientific and technical tasks involving the application of concepts, operational methods and the use of research equipment, normally under the supervision of researchers" (OECD, 2015, p. 163[1]).

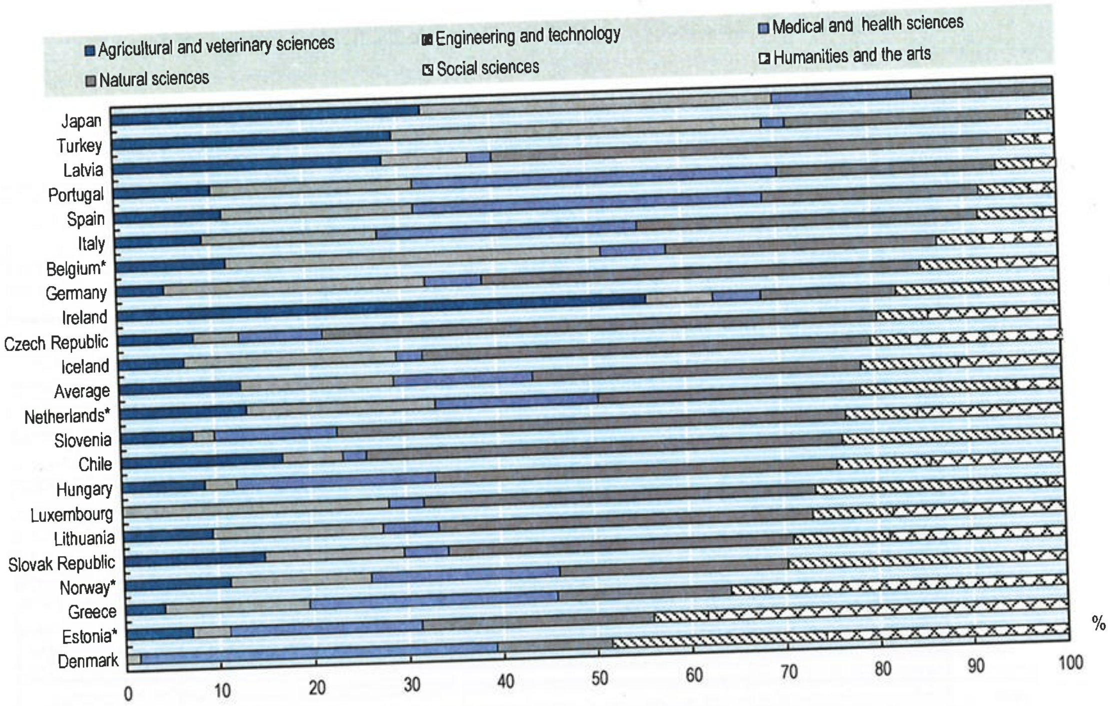
The evidence presented in this section indicates the variety of human resource patterns in R&D across the OECD. The relative proportions of technicians and other support staff can depend on different methods of apportioning research-related tasks in different countries, or differences in the amount of applied research and experimental development carried out, which may require greater numbers of certain staff categories. Differences in the relative concentration of technicians and other support staff therefore reflect very different ways in which research is organised, as well as the variety of roles and responsibilities undertaken by staff working in research and development in different countries.

In the OECD countries with available data for 2016, there are on average 33 technicians for every 100 researchers. The ratio of technicians to researchers tends to be higher than average in the government sector (39 technicians per researcher) and lower than average in the higher education sector (19 technicians per researcher). Across countries, the ratio of technicians to researchers in higher education can range from less than 5 in the Slovak Republic and Ireland to as high as 69 in Chile (Figure 6.12).

Lower ratios of technicians working in higher education, compared with other sectors, is not unexpected given the fact that higher education performs a relatively high proportion of basic research in most countries. Applied research and experimental development are likely to require a higher ratio of technicians to researchers to perform the necessary tasks. However, with many higher education systems aiming to expand the volume of applied research, as well as an increasing use of physical infrastructures even for basic research (Section 6.2.3), the demand for research technicians and other associated staff in higher education is likely to increase in the future.

In Estonia, there was an overall ratio of 22 technicians to 100 researchers in 2016, though the ratio is higher in the government sector (45 per 100 researchers) and much lower in the higher education sector (13 per 100 researchers). The difference between the government and higher education sector was even higher in the Netherlands, with 42 technicians per 100 researchers in the government sector, and around 10 in the higher education sector, partly due to the presence of public research institutes (Box 6.1). Belgium also has a similar pattern to the Netherlands, with 46 technicians per 100 engineering and technology; medical and health sciences; and natural sciences are also the three most represented fields among government researchers in OECD countries with available data, the majority of which are in the natural sciences. But compared to the higher education sector, a smaller proportion of government researchers across the OECD are in the social sciences (11%); while a higher proportion (13%) are in agricultural and veterinary sciences, although differences between countries are substantial. In Ireland, for example, more than half of government researchers are in agricultural and veterinary sciences, while in Norway, one-quarter of government researchers are in the social sciences. (Figure 6.11).

Figure 6.11. Researchers in the government sector by field of science (2016)



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
Data refer to 2016 or most recently available year.
Source: Adapted from OECD (2018[16]), *OECD Science, Technology and R&D Statistics*, https://doi.org/10.1787/strd-data-en.

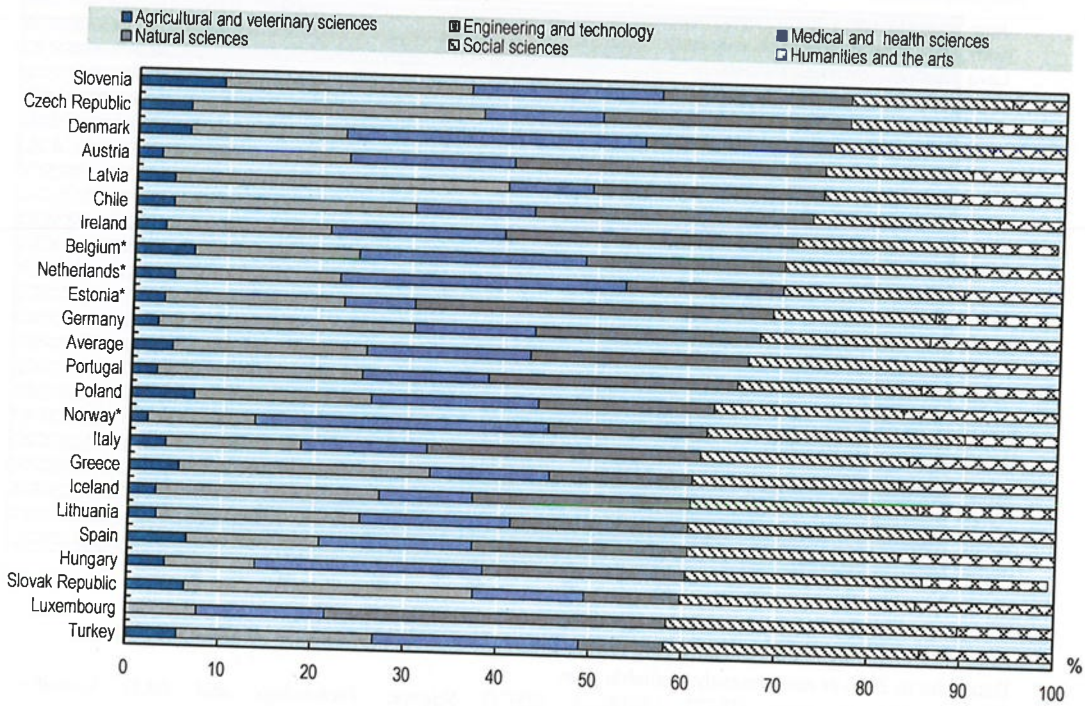
StatLink https://doi.org/10.1787/888933941424

Estonia has one of the largest shares of government researchers in the humanities and the arts (38%). While engineering and technology is the second most represented field of science among higher education researchers in Estonia, it is the least represented field among government researchers. This reflects a historical division of roles between different sectors; following Estonian independence, many government research institutions merged with universities, whereas those institutions that carry out other functions in addition to research and development activities (e.g. the Estonian Literary Museum and the Institute of the Estonian Language) have tended to remain in the government sector.

While a variety of patterns can be observed across countries, at least 50% of researchers in each country are working in STEM-related fields of natural sciences, engineering and technology, medical and health sciences, and agricultural and veterinary sciences. Estonia has the largest share of higher education researchers in natural sciences among OECD countries with available data, making up 39% of researchers, while on the other end of the scale, less than 10% of researchers in Turkey are working in areas related to natural sciences.

In Belgium, the distribution of higher education researchers across fields of science is similar to that of the OECD average. In the Netherlands and Norway, there is a particularly high proportion (more than 30%) of higher education researchers working in medical and health sciences.

Figure 6.10. Researchers in higher education by field of science (2016)



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Data refer to 2016 or most recently available year.
Source: Adapted from OECD (2018[16]), *OECD Science, Technology and R&D Statistics*, https://doi.org/10.1787/strd-data-en.

StatLink https://doi.org/10.1787/888933941405

Differences between concentrations of researchers in different fields of science can relate to government policy goals or country specialisation in different sectors. In many countries, including the participating jurisdictions, governments have identified "key sectors" in which to focus R&D activity (Section 6.7).

Differences can also relate to the ways in which public research is distributed between the higher education sector and the government sector. As with higher education researchers, Norway's proportion of researchers in higher education was approaching parity in 2016, with 47% of women researchers. Estonia and Flanders were also above the OECD average on this measure, with 44% of higher education female researchers. The Netherlands was slightly below the OECD average, with 40% of female researchers in higher education (Figure 6.9).

As discussed in Chapter 4, many countries have introduced policies aimed at increasing the participation of women in research careers. While there have undoubtedly been some advances in terms of increased participation, persistent challenges remain to be overcome before gender equity in research and development can become a reality (Box 6.2).

Box 6.2. Persistent barriers to gender equity related to research and development

A recent OECD and G20 review of the evidence base covering the position of women in the modern digital economy and society found that large inequalities still exist between men and women across many areas relevant to research and innovation. Findings include:

- There is a systematic underrepresentation of women in ICT jobs, and top management positions in business and academia. For example, only 17% of scientists making a salary of more than USD 105 000 are women.
- Women still account for only one-fifth of graduates in STEM subjects, and only make up 20% of corresponding authors on STEM publications.
- Around 90% of innovative start-ups seeking venture capital funding are run by men. When women-owned start-ups do seek funding, they receive on average 23% less funding. Evidence indicates that this ratio can be improved when women are included in the management structure of venture capital firms.
- While progress has been made in the number of patents filed by teams with at least one woman, overall 80% of patents filed at key intellectual property offices worldwide are filed by all-male teams.

Source: Borgonovi et al. (2018[23]), *Empowering Women in the Digital Age; Where Do We Stand?*, https://www.oecd.org/social/empowering-women-in-the-digital-age-brochure.pdf.

6.3.4. Researchers in higher education by field of science

Researchers in OECD countries work across a broad range of fields of science, though many countries tend to specialise more heavily in particular fields. Broad fields of science in this section are defined according to the ISCED 2011 classification (OECD/Eurostat/UNESCO Institute for Statistics, 2015[24]), though at a more granular level, new fields are constantly emerging as communities of researchers grow, new technologies develop and science becomes more specialised.

According to 2016 data, around one-quarter of higher education researchers across OECD countries with available data work in natural sciences (24%), while just over 20% of researchers work in engineering and technology and another 20% on social sciences. The medical and health sciences sector has 18% of researchers, while 12% are working in humanities and the arts, and just over 4% of researchers across the OECD area are in agricultural and veterinary sciences (Figure 6.10).

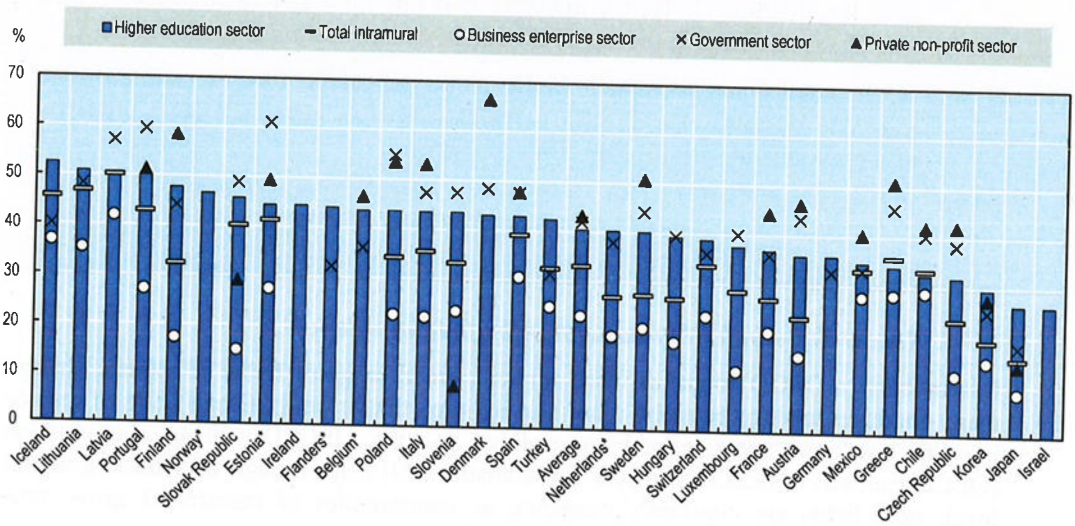
6.3.3. Gender equality in the research and development workforce

Women now outnumber men in terms of enrolment at the bachelor's and master's levels, on average across the OECD, and gender parity in enrolment in doctoral education has almost been achieved, as overall women now make up 48% of new entrants to doctoral education (Section 6.4). However, some countries are lagging behind on gender equity in the research and development workforce, and women remain less represented in doctoral education in some fields of research, including engineering and science (OECD, 2015[17]). Other forms of gender inequality persist that are specific to the research and development sector; for example in higher education, women are also less likely to hold a senior academic position, be corresponding authors in research publications or manage a higher education institution (OECD, 2015[17]).

On average in OECD countries with available data, women account for around 40% of the total of full-time equivalent researchers in the government, higher education and private non-profit sectors. While this shows that gender parity has not yet been achieved in higher education, progress is more advanced than in the business enterprise sector, where overall in 2016 only around 23% of researchers were women. In Iceland, Latvia, Lithuania and Portugal, parity of male and female researchers in higher education has been achieved, while in the government sectors in Estonia, Poland, Portugal and Latvia there is now a larger proportion of female than male researchers. In Japan and Korea, while higher education has a larger female representation than other R&D sectors, still in 2016 less than 30% of higher education researchers were female (Figure 6.9).

Figure 6.9. Women researchers, overall and by sector of employment (2016)

As a percentage of total full-time equivalent researchers



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Data refer to 2016 or most recently available year.

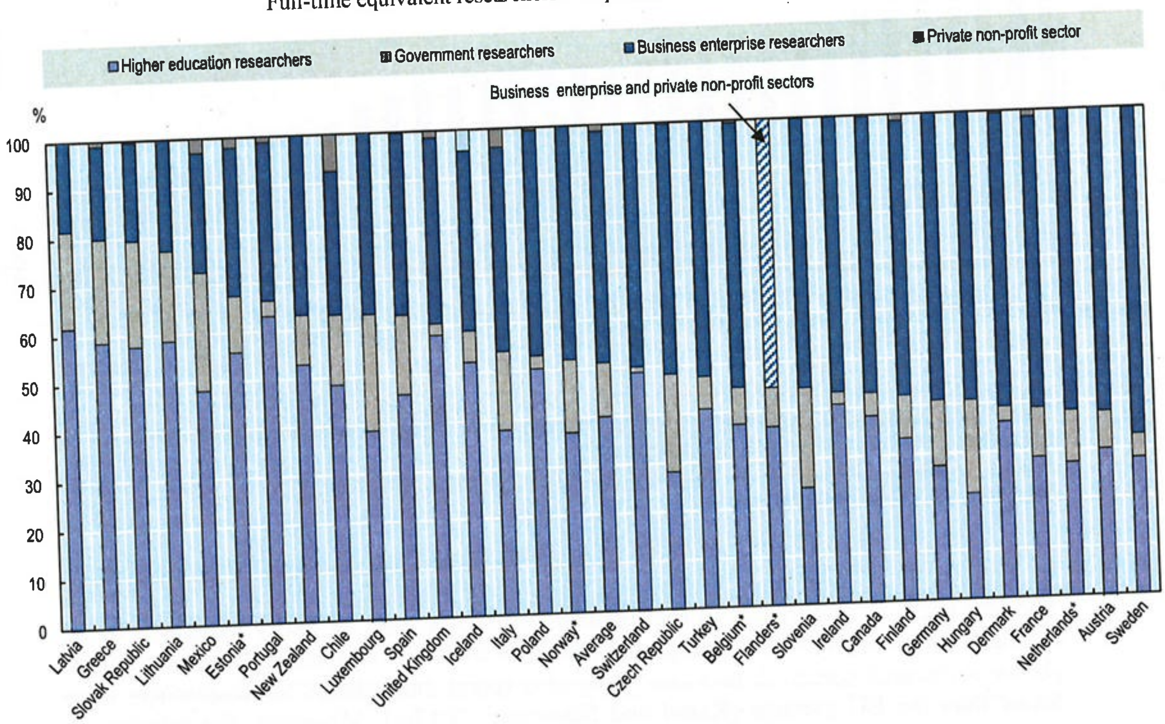
Source: Adapted from OECD (2018[16]), *OECD Science, Technology and R&D Statistics*, https://doi.org/10.1787/strd-data-en.

StatLink https://doi.org/10.1787/888933941386

education in 2016, and 11% in the government sector, though there are marked differences between countries (Figure 6.8). Higher education and government researchers combined account for less than 20% of total FTE researchers in Korea; while in Greece, Latvia and the Slovak Republic, higher education and government researchers combined represent at least 80% of the overall numbers.

Figure 6.8. Researchers by sector of employment (2016)

Full-time equivalent researchers as a percentage of national totals



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
Data refer to 2016 or most recently available year.
Source: Adapted from OECD (2018[16]), *OECD Science, Technology and R&D Statistics*, https://doi.org/10.1787/strd-data-en.

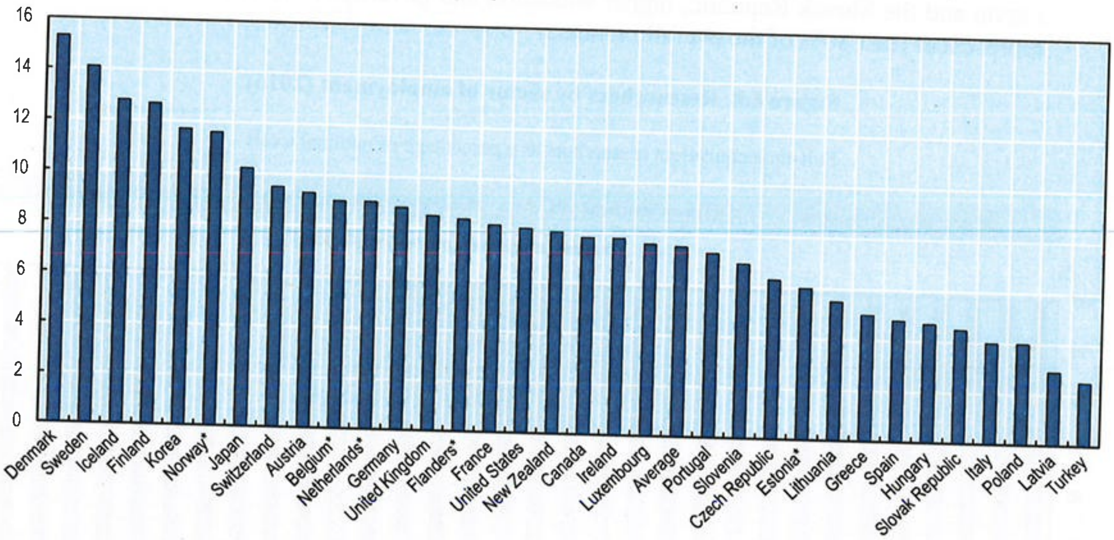
StatLink https://doi.org/10.1787/888933941367

Higher education researchers make up over half of all FTE researchers in Estonia, while the proportions are lower in the other participating jurisdictions; around 37% in Flanders and Norway and 28% in the Netherlands. The proportion of government researchers is also lower than average in Flanders at around 8%, while they are closer to the average (around 12%) in Estonia and the Netherlands, and make up 15% of researchers working in Norway.

Between 2005 and 2015, the share of researchers in higher education increased in Belgium and Estonia and remained unchanged in Norway. The Netherlands experienced a decrease in the proportion of higher education researchers by around 8 percentage points over the same time period. The smaller share of higher education researchers in the Netherlands may partly be explained by the presence of public research institutes, including applied research (TO2) institutes (Box 6.1).

Figure 6.7. Researchers in the labour force (2016)

Full-time equivalent researchers per 1 000 people in the labour force



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Data refer to 2016 or most recently available year.

Source: Adapted from OECD (2018[16]), *OECD Science, Technology and R&D Statistics*, https://doi.org/10.1787/strd-data-en.

StatLink https://doi.org/10.1787/888933941348

The low share of researchers in the Estonian workforce may be partly explained by an ageing population and outward migration, but also by a lack of funding and incentives to pursue a research career. A previous study also found that salaries for researchers were lower than the EU average (Kattel and Stamenov, 2017[4]). Moreover, the reliance on short-term, project-based funding may lead to precarious conditions for researchers. To address these challenges, Estonia is making use of European structural funds to develop research capacity (Kattel and Stamenov, 2017[4]). In addition, the government has been working to make funding for R&D more sustainable by increasing the share of recurrent funding to institutions so that the proportion of such funding to competitive research grants would be 50:50 (Jonkers and Zacharewicz, 2016[18]).

Well-designed human resources policies can play an important role in attracting talented human capital to the research profession. Adopting internationally agreed human resource principles into local policies can also act as an important signal to potential talent. For example, in the Flemish Community, almost all universities and other R&D institutions have obtained a 'Human Resources Excellence in Research' designation, or are close to obtaining this recognition. This designation indicates that the human resources policy for researchers in this jurisdiction is in line with the human resources strategy and principles of the European Charter and Code for Researchers (see Chapter 4).

6.3.2. Researchers by sector of employment

On average, around one-half of FTE researchers in OECD countries work in the higher education and government sectors, with 40% of all researchers working in higher

Many countries have set targets to increase expenditure on applied research in recent years, including in the participating jurisdictions. In line with the target to increase investment in R&D to 3% of GDP by 2020, the Flemish Community aims to increase funding for fundamental, basic and applied research at higher education institutions. For 2019, the Flemish Government has a budget increase of EUR 128 million for R&D. In 2015, Estonia established a new instrument to support the development of applied research in areas of smart specialisation. Approximately EUR 27 million will be allocated to support the development of business R&D and co-operation between higher education institutions and business (Kattel and Stamenov, 2017[4]).

However, it is important to ensure that the growth in applied research does not come at the expense of basic research, and that an appropriate balance of basic and applied research is maintained (OECD, 2008[21]). With the shift in emphasis in public research away from public research institutes and towards universities (OECD, 2016[3]), the higher education sector will continue to play the core role in ensuring that fields of knowledge that may hold social and cultural value, though not necessarily immediate economic value, are protected. At the same time, research universities face an increasing pressure to commercialise knowledge and earn income from sources other than public funds, which creates conflict with the traditional view that knowledge production and dissemination is a public good, and threatens to erode the position of basic research (Altbach, Reisberg and Rumbley, 2009[22]).

6.3. Profile of research and development personnel

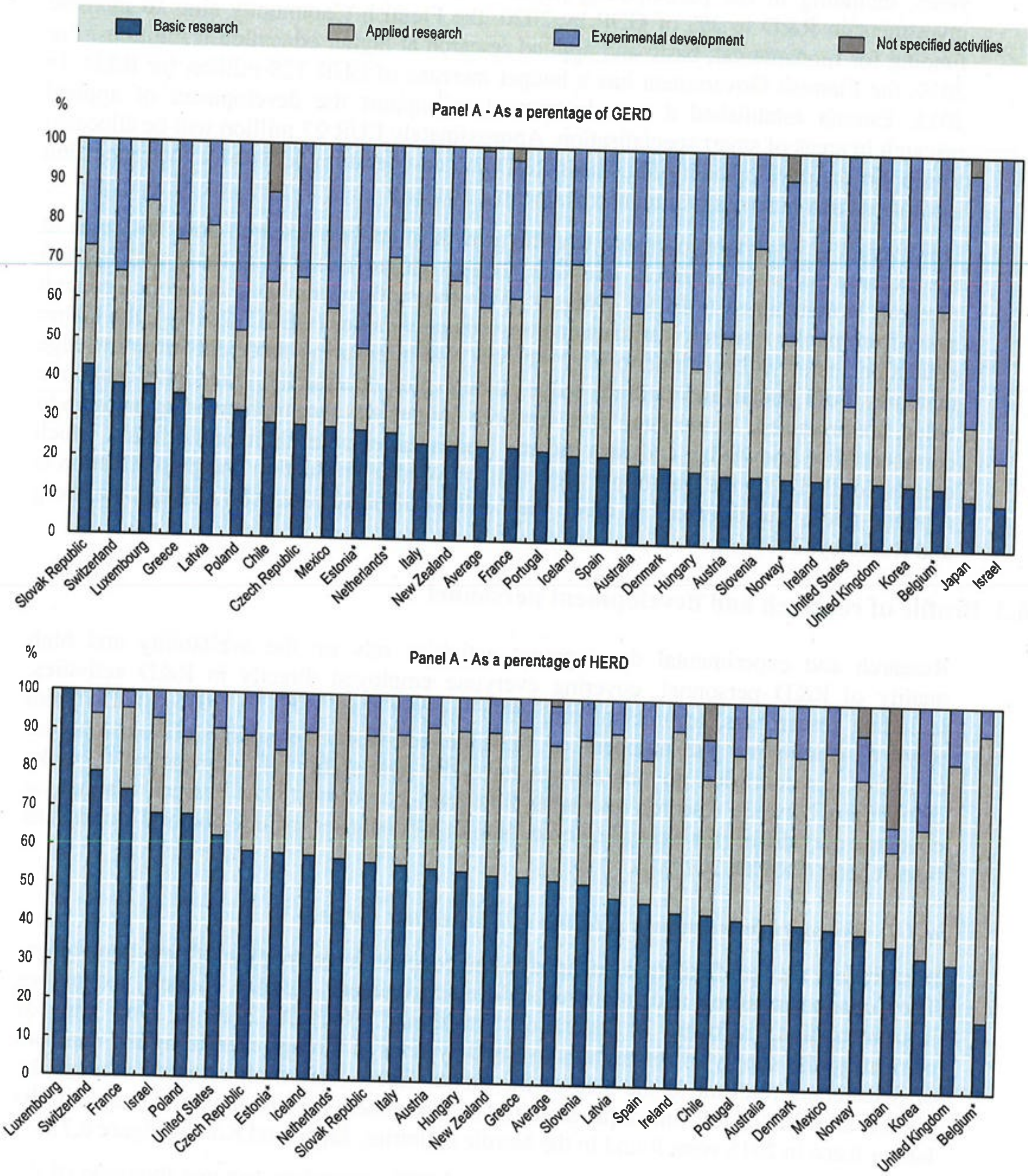
Research and experimental development activities rely on the availability and high quality of R&D personnel, covering everyone employed directly in R&D activities, including researchers, technicians and other support staff (OECD, 2015[17]). Different ways of calculating the numbers of full-time equivalent research staff exist across countries, as countries do not always have the availability of information to make distinctions between research and other functions, according to the Frascati manual, or coverage may differ (for example, some, but not all countries include doctoral students as researchers) (OECD, 2017[13]).

6.3.1. Researcher numbers relative to the labour force

Researchers are "professionals engaged in the conception or creation of new knowledge. They conduct research and improve or develop concepts, theories, models, techniques instrumentation, software or operational methods" (OECD, 2015[1]). One way of comparing the supply of researchers to R&D systems is through measuring the numbers of researchers relevant to the size of the labour force. Across all research sectors, the highest numbers of full-time equivalent (FTE) researchers per one thousand people in the labour force in 2016 were found in the Nordic countries, Japan and Korea (Figure 6.7).

For the participating jurisdictions, the share of FTE researchers per one thousand of the working age population was slightly above the OECD average in Flanders (8) and the Netherlands (9) in 2016. Norway had one of the higher concentrations of FTE researchers in the same year, with 12 per one thousand people in the labour force. On the other hand, Estonia had 6 researchers per one thousand people in the labour force, lower than the OECD average.

Figure 6.6. Expenditure on R&D by type of R&D activity (2015)



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Data refer to 2015 or the latest available year.

Source: Adapted from OECD (2018[16]), *OECD Science, Technology and R&D Statistics*, https://doi.org/10.1787/strd-data-en.

StatLink https://doi.org/10.1787/888933941329