Box 7.2. Definition of non-formal and informal learning

Non-formal learning is defined as education that is institutionalised, intentional and planned by an education provider. The defining characteristic of non-formal education is that it is an addition, alternative and/or complement to formal education within the lifelong learning process of individuals. It caters to people of all ages but does not necessarily apply a continuous pathway structure; it may be short in duration and/or low-intensity; and it is typically provided in the form of short courses, workshops or seminars. Non-formal education mostly leads to qualifications that are not recognised as formal or equivalent to formal qualifications by the relevant national or sub-national education authorities, or leads to no qualifications at all. Nevertheless, formal, recognised qualifications may be obtained through exclusive participation in specific, non-formal education programmes; this often happens when the non-formal programme completes competences obtained in another context.

Informal **learning** is defined as learning that is intentional or deliberate, but not institutionalised. It is consequently less organised and less structured than either formal or non-formal education. Informal learning may include learning activities that occur in the family, workplace, local community and daily life, on a self-directed, family-directed or socially directed basis.

Source: UNESCO (2012[38]), *International Standard Classification of Education ISCED 2011*, http://uis.unesco.org/en/topic/international-standard-classification-education-isced.

In Estonia, legislation defines the role and mission of universities and professional HEIs, including their responsibility to provide education services to society (Estonian Parliament, 1995[39]; Estonian Parliament, 1998[40]). The provision of continuing education for the general public is among the criteria used in institutional accreditation. Institutions are assessed on whether they define and implement objectives for continuing education training, whether this form of training is tailored to meet the needs of target groups and whether mechanisms to monitor participant satisfaction exist. There are also goals related to the provision of continuing education in performance agreements, which are tied to funding. In Estonia, 20% of funding is allocated based on performance, and one indicator pertains to revenues from study activities (i.e. funding coming from tuition fees and provision of continuing education).

In Norway, continuing education is partly funded by the government and partly by the private sector. The Strategy for Skills Policy 2017-2021 promotes the development of continuing education in vocational colleges and higher education institutions and highlights the need for further development in this area (Norwegian Ministry of Education and Research, 2017[41]). Study associations and other organisations also provide continuing education in Norway (sometimes in partnership with higher education institutions).

Centres for continuing education

Higher education institutions in a number of countries have centres for continuing education offering courses in various fields of study.

Norwegian higher education institutions provide continuing education for adults through *etterutdanning* courses, which do not have any exams or credits, and *videreutdanning* courses, which have the same admissions requirements as regular higher education programmes, involve exams and provide students with credits. Continuing education provided by higher education institutions includes corporate and business training to companies. The flexibility provided by continuing education helps Norwegians develop

Supporting entrepreneurship in higher education in the Netherlands could be further improved by making entrepreneurship education accessible to students early on in their studies as well as to alumni; recognising student engagement in entrepreneurship; enhancing entrepreneurial pedagogy; and strengthening regional entrepreneurial eco-systems and policy co-ordination for entrepreneurship and other forms of engagement.

Source: OECD/EU (2018[33]), *Supporting Entrepreneurship and Innovation in Higher Education in The Netherlands*, https://doi.org/10.1787/9789264292048-en.

Other initiatives are taking place at the international and supranational levels. For instance, Ashoka, a non-profit organisation that supports 3 500 social entrepreneurs in 93 countries, has partnered with 37 universities and colleges in the United States, including Boston College, Arizona State University, and George Mason University, to support social entrepreneurship (Florida International University, 2016[34]).

At the supranational level, the Regional Innovation Impact Assessment Framework (RI^2 system), was developed by the European Commission to assess targeted funding for universities. The RI^2 system aims to complement both the existing performance-based funding systems in EU member states and HEInnovate (Jonkers et al., 2018[35]). The RI^2 system is not meant for university self-assessments, but rather provides incentives for universities to produce convincing case studies, which should be assessed by an international panel of independent experts. The RI^2 system builds on HEInnovate in that higher education institutions that have undertaken it may be better prepared to develop case studies and perform well in the RI^2 framework assessment. The framework allows universities or regional governments to choose indicators to track university progress over time in the context of regional development levels. The RI^2 system proposes four categories that should be covered in the assessment and indicators:

- education and human capital development
- research, technological development, knowledge transfer and commercialisation
- entrepreneurship and support to enterprise development
- regional orientation, strategic development and knowledge infrastructure (Jonkers et al., 2018[35]).

7.2.2. Supporting continuing education

Higher education plays a critical role in developing and updating the skills of society. One pathway to doing this is by providing access to continuing education to individuals at different stages of their lives. Continuing education refers to education delivered by higher education institutions that is not part of a formal (typically accredited) programme; it is also distinct from the concept of informal learning that results from daily routines related to work, family or recreational activities (Box 7.2). Lifelong learning, i.e. formal learning undertaken throughout life, is addressed in Chapter 5.

Continuing education can help individuals develop or acquire new skills to improve work productivity, advance their career or change careers. Continuing education can also help stimulate personal development, provide a sense of achievement, and can improve health and general quality of life (Jamieson, 2016[36]; Souto-Otero, 2011[37]). It usually takes the form of non-credit courses on a wide range of subjects, and could have the objective of gaining new knowledge on a topic of interest or developing specific skills (e.g. information and communication technologies (ICT) or communication skills). Governments use a variety of regulatory and funding tools to promote the delivery of continuing education in higher education institutions.

- leadership and governance
- organisational capacity: funding, people and incentives
- entrepreneurial teaching and learning
- preparing and supporting entrepreneurs
- digital transformation and capability
- knowledge exchange and collaboration
- the internationalised institution
- measuring impact.

The OECD has identified a range of policies and practices that can be used to help build innovation and entrepreneurship in higher education. As part of the HEInnovate initiative, a number of country reviews have been conducted in collaboration with governments to advance change at the system level, including in the Netherlands (Box 7.1).

Box 7.1. Entrepreneurship in higher education in the Netherlands

The Netherlands provides an example of good practice in bringing innovation and entrepreneurship to the forefront of higher education. Through its "valorisation" programme (Box 7.5), the Netherlands has strengthened the business environment for start-ups, improved co-operation between higher education institutions and cities, diversified career options for higher education staff, and enabled higher education institutions to monitor and report on their engagement activities. The application of the HEInnovate framework provides insights into why the Netherlands has been successful in entrepreneurship:

1. **Leadership and governance.** Entrepreneurship is a major part of the strategy of higher education institutions, and they have a model for integrating entrepreneurial activities into the education provision. Higher education institutions support their faculties and units to act entrepreneurially.
2. **Organisational capacity.** Higher education institutions are open to engaging and recruiting individuals with entrepreneurial mind-sets; they invest in staff development and provide incentives to staff that actively support entrepreneurship education. Institutions also have access to a range of funding and investment sources to support their entrepreneurial objectives.
3. **Entrepreneurial teaching and learning**. Entrepreneurship is integrated into the education and research functions of higher education institutions. Institutions design and deliver entrepreneurial curricula in collaboration with social partners and provide a range of formal and informal learning opportunities to help students develop entrepreneurial skills.
4. **Entrepreneurship support.** Entrepreneurship support is made available to students, graduates and staff who aim to start a business; they have access to funding, mentoring and training on how to start and develop a business.
5. **Knowledge exchange and collaboration.** Higher education institutions are actively involved in collaboration and knowledge exchange with social partners. They have strong linkages to incubators and science parks; and they provide staff and students with opportunities to take part in innovative activities.
6. **Internationalisation.** Internationalisation is an integral part of the entrepreneurial agenda of higher education institutions. They support the international mobility of students and staff, recruit international staff, and embed an international dimension in teaching and research.
7. **Measuring impact.** Higher education institutions monitor and evaluate how financial and human resources are used to support their entrepreneurial agendas. They evaluate entrepreneurial teaching and learning, support for start-ups and activities to promote knowledge exchange.

education institutions (Ghent University, Artevelde University College Ghent and University College Ghent). The Ghent Entrepreneurship Ecosystem supports students in developing entrepreneurial mind-sets and engaging in entrepreneurial activities. The programme provides a variety of support activities, which are available to all students, including coaching and mentoring; counselling; support for co-operation; soft skills training; workshops; and training in sales, marketing, branding, pitching and funding. In addition, the Ecosystem supports the development of entrepreneurial skills of art students, through the ARTEpreneur project, financed by the Flemish government with the support of several business partners. Every year, up to 1 800 students participate in the project to commercialise their ideas (Melonari, 2017[31]).

Institutional entrepreneurship and the HEInnovate framework

Higher education institutions themselves are also aiming to become more enterprising. Taking a more entrepreneurial approach to institutional management has long been a growing trend in higher education, with the goal of promoting efficiency of resource allocation and maximising commercial outputs (Etzkowitz et al., 2008[32]). It is therefore important that entrepreneurial skills are developed not only in students but by higher education staff within institutions as well. Entrepreneurial education emphasises organised interaction with the outside world and therefore strong partnerships with business, public sector and social economy organisations are a cornerstone of the entrepreneurial model.

In collaboration with the European Commission, the OECD has developed a framework to facilitate the development of an entrepreneurial culture in higher education institutions. HEInnovate broadens the understanding of institutional innovation and entrepreneurship beyond efficiency and maximisation of commercial outputs. The conceptual framework considers how higher education institutions build organisational capacity; how they involve external stakeholders in the leadership and governance of the institution; how they embed digital technology into their activities; how they create and nurture synergies between teaching, research and their societal engagement; and how they promote entrepreneurship through education and business start-up support, as well as knowledge exchange to enhance the innovation capacity of existing firms (HEInnovate, 2017[19]).

Some higher education institutions have a solid foundation of initiatives pioneered by individuals. Scaling these up and sustaining change at institutional and systemic levels requires supportive frameworks for resource allocations, staff incentives, continuous professional development, and the creation of strategic partnerships – locally, nationally and globally. HEInnovate provides a free online self-assessment tool that allows higher education institutions to involve a wide range of stakeholders (e.g. leadership, staff, academic and administrative staff, key partner organisations) to collectively review achievements and identify areas for improvement.

An innovative and entrepreneurial higher education institution is defined as one that is "designed to empower students and staff to demonstrate enterprise, innovation and creativity in teaching, research, and engagement with business and society. Its activities are directed to enhance learning, knowledge production and exchange in a highly complex and changing societal environment; and are dedicated to creating public value via processes of open engagement" (HEInnovate, 2017[19]).

The HEInnovate framework highlights opportunities for development within the following dimensions:

Stavanger, the University of Agder and the Norwegian University of Science and Technology (Norwegian Ministry of Education and Research, Norwegian Ministry of Local Government and Regional Development and Norwegian Ministry of Trade and Industry, 2014[27]).

Norway has also established the Centres for Excellence in Education Initiative (SFU) to improve the quality of higher education and foster more innovative learning and teaching. There are currently eight Centres for Excellence in Education based in higher education institutions across Norway, including "Engage – Centre for Engaged Education through Entrepreneurship" (Norwegian Institute of Science and Technology and Nord University) (NOKUT, 2016[28]). ENgage is a consortium consisting of the NTNU School of Entrepreneurship, Nord University Business School, NTNU Experts in Teamwork, TrollLABS and Spark NTNU. It applies a learning model that includes action-based learning, student-to-student learning, collaborative skills, rapid prototyping and student engagement. The programme provides train-the-trainer courses and activities for students in all disciplines aiming to develop entrepreneurial skills.

The 2014 Action Plan urged higher education institutions to expand and diversify their entrepreneurship education provision. As a result, a nationally funded peer-mentoring project to support the development of entrepreneurship was piloted across five Norwegian higher education institutions from 2014 to 2016. The impact of the pilot on participating programmes was positive, with students reporting increased satisfaction in course evaluations, master's graduates successfully finding employment within three months of graduation, close to 100% completion rates, and very low dropout rates. In addition, one out of three graduates established their own company. At the conclusion of the pilot, the coordinating institution, Norwegian University of Life Sciences (NBMU), was considering how the peer mentoring concept could be intensified institution-wide through its Learning Centre and integrated into other programmes. The peer learning model was also picked up by other institutions across Norway and embedded into programmes (Torp, 2014[29]).

The Research Council of Norway also finances the Student Entrepreneurship (STUD-ENT) programme through its FORNY2020 programme. The programme encourages entrepreneurship among students, promotes a stronger entrepreneurship culture in higher education institutions, and increases the number of knowledge-intensive jobs in Norway (Research Council of Norway, 2019[30]).

The Flemish Community designed an Action Plan on Entrepreneurial Education for 2015-2019, which aims to help develop entrepreneurial attitudes among students and equip them with the necessary skills and knowledge to become successful entrepreneurs. A successful practice resulting from this policy was the introduction of certificate-based business management classes in a number of higher education institutions to help students to start businesses while studying.

The Agency for Innovation and Entrepreneurship provides the *Baekeland* scholarships for doctoral students in the Flemish Community who collaborate on scientific research projects with companies (who provide part of the funding). One goal of this initiative is to encourage entrepreneurship and the commercialisation of research among doctoral students.

Additional initiatives include the Ghent Entrepreneurship Ecosystem, which is an alliance between the City of Ghent, an independent association that supports young entrepreneurs (Unizo), a government-funded institution that supports start-up projects (Imec) and higher delivery of training for teachers at all education levels, business mentors and entrepreneurs who participate actively in entrepreneurship education. The methodological framework is based on the entrepreneurship competence model as a progression model for all education levels, an extension of the EntreComp model (an entrepreneurship competence framework created by the European Commission), adjusted to the Estonian education system.

The Entrepreneurship Education Programme also entails the design and development of entrepreneurship courses that are piloted and delivered at all education levels. A network of higher education institutions, together with the Estonian Chamber of Commerce, the Estonian Employers' Confederation, the Estonian Service Industry Association, Foundation Innove, Junior Achievement Estonia, county development centres represented by the Ida-Viru Enterprise Centre, business incubators, and the Ministry of Economic Affairs and Communications, have been established to disseminate the programme activities.

In **the Netherlands** the government has supported entrepreneurship education at all levels of education since 2000, including through the TechnoPartner Programme, which started in 2004 and focused on improving the environment in which technology-based start-ups operate, particularly in higher education institutions. Funded projects are based on public-private partnerships comprised of professional higher education institutions, incubators, innovation intermediaries, and other actors, including banks and companies (OECD, 2010[22]). Subsequent initiatives include the Education and Enterprise Action Programme (*Actieprogrammema Onderwijs en Ondernemen*) from 2007 to 2011. These initiatives have helped drive the integration of entrepreneurship programmes in most Dutch higher education institutions. Institutions have also established collaborative networks such as the six regional Centres for Entrepreneurship (DutchCE), which cover eight universities and eight professional HEIs. The centres support entrepreneurship programmes for students, staff and local entrepreneurs. A 2012 evaluation and a study the same year show that the centres have helped increase student interest in entrepreneurship, build greater collaboration between institutions and firms, and encourage employers to play a greater role in the design and delivery of entrepreneurship education (Wymenga et al., 2012[25]).

In a number of higher education institutions in the Netherlands, entrepreneurship has also become a part of the human resources policy for academic staff. Lecturers, researchers and doctoral candidates can all participate in entrepreneurship training courses to enhance their knowledge of entrepreneurship and entrepreneurial skills. In addition, the government has launched a programme to support academic entrepreneurship called "Take-off," which provides grants and loans that academics can use to translate their research into a product or a service (Netherlands Organisation for Scientific Research, 2014[26]).

In **Norway**, all higher education institutions provide entrepreneurship education, either as designated study programmes or as courses or topics integrated into other programmes (Cervantes, 2017[12]). This has been a long-standing practice in Norwegian higher education. The 2014 Action Plan, *Entrepreneurship in Education and Training – from compulsory school to higher education 2009–2014*, noted that 21 state university colleges and universities in Norway reported that they offered programmes of study in entrepreneurship in 2008. These included individual courses within degree programmes in economics, education, tourism, technology and other fields. Some institutions have also created designated units to strengthen their entrepreneurship and innovation capacity, such as the Centres for Entrepreneurship at the University of Oslo, the University of entrepreneurship skills and capacities, but examples of important skills could include those listed in Table 7.2.

Table 7.2. Skills and abilities which support entrepreneurship

Business and technical skills	Social and personal skills
Planning and goal setting	Self-discipline
Decision-making	Written and oral communication
Human resource management	Innovation
Marketing	Persistence
Financial management	Leadership
Technology implementation/use	Change management
Environment monitoring	Network building
Quality control	Strategic thinking
Risk management	Negotiation
Problem solving	Interpersonal
Growth management	Ability to organise
Compliance with regulations	Creative thinking

Source: OECD (2014[23]), "Building entrepreneurship skills", in *Job Creation and Local Economic Development*, http://dx.doi.org/10.1787/9789264215009-10-en.

Programmes that help develop supportive skills for entrepreneurship usually include the following:

- Learning to understand entrepreneurship: education *about* enterprise involves creating awareness and increasing a theoretical understanding of entrepreneurship.
- Learning to become entrepreneurial: education *in* enterprises deals mainly with management training for established entrepreneurs and employees.
- Learning to become an entrepreneur: education *for* enterprise involves education that aims to cultivate the skills necessary for setting up and running a business (OECD, 2014[23]).

Governments can play a critical role in developing entrepreneurship in higher education in all fields of study, not just in business or related fields, by driving the development and diffusion of entrepreneurship education across a wide range of educational programmes and institutions. Alongside international initiatives such as HEInnovate (HEInnovate, 2017[19]), various national policies to support entrepreneurship have been put in place across the OECD in the context of the growth of the entrepreneurial university model (Clark, 1998[16]), including in the participating jurisdictions.

In **Estonia**, entrepreneurship is recognised as a key competence for lifelong learning. One of the key goals of *Estonian Lifelong Learning Strategy 2020* is to implement a new approach to learning that supports personal development and the acquisition of creativity and entrepreneurial skills at all levels and in all types of education (Estonian Ministry of Education and Research, 2014[24]). The Entrepreneurship Education Programme which was launched in 2015 aims to embed the development of entrepreneurial skills in general, vocational and higher education. The programme supports the development of an entrepreneurship competencies framework and pedagogical materials, as well as the

7.2. Engagement to build human capital

Effective development and use of human capital is essential for economic and social progress (OECD, 2012[20]). Higher education, through its education, research and engagement functions, facilitates the development of critical skills needed for employment, innovation, active citizenship and social cohesion. As well as basic cognitive skills, students in higher education can also develop a range of technical, professional and discipline-specific skills through their study programmes, which support their successful integration into the labour market.

However, a much broader set of skills is required to ensure that individuals and societies are resilient to challenges created by economic and social upheaval, and to support the innovations necessary for continued social progress. Higher education study can help to strengthen transversal skills, such as cognitive and information processing skills, and can also provide the opportunity to develop further skills (such as innovation, leadership and risk management), which have a strong potential to enhance the benefits of education and research to the wider society.

This section describes two distinct ways in which higher education institutions and systems can work to build human capital through engagement activities. First, higher education systems can develop and implement policies to support entrepreneurship– through direct educational programmes and by creating an entrepreneurial mind-set and enterprising environment for students and academics. Second, higher education systems also provide opportunities to develop skills and competencies in a more informal way through continuing education.

7.2.1. Building capacity for entrepreneurship

Entrepreneurship, including social entrepreneurship, is one key channel through which the benefits of higher education can be transformed into products and services that provide societal value. Higher education institutions are in a great position to mobilise students to enhance their entrepreneurial skills, to provide support for their business start-ups and to develop their career as entrepreneurs in all fields of study. For example, it is accepted that higher education has a role to play in social entrepreneurship by identifying, training and supporting individuals who have the potential to create profound social change (Nicholls, 2006[21]). Student entrepreneurship can also support business creation, as well as urban and regional economic development (OECD, 2010[22]).

Embedding education for entrepreneurship across higher education

As noted in the OECD Skills Strategy, entrepreneurs are made, not born (OECD, 2012[20]). Capabilities and competences to support entrepreneurship are increasingly being targeted for development through the higher education system. Higher education institutions can help their students to develop the knowledge, skills and attitudes necessary to become entrepreneurs. This includes generic workplace skills such as communication, teamwork, planning and organisational skills.

Additionally, to become successful entrepreneurs, students need to know how to identify opportunities, turn them into successful ventures, and recognise and respond to difficulties and obstacles they may encounter. They therefore also need to develop a range of business, technical, social and personal skills, the ability to manage risk, think strategically, exploit personal networks, and motivate others. There is no single set of

Table 7.1. Engagement in education: Key concepts and definitions

Title	Definition
	Types of engagement
Public engagement	Public engagement entails the many approaches adopted by higher education institutions, their staff and students while connecting with the public. Such connections are a two-way process and lead to the sharing of knowledge, expertise and skills. Public engagement is mutually beneficial, building trust, understanding and further collaboration, and increasing the relevance and impact of higher education on civil society (National Co-ordinating Center for Public Engagement, 2017[4]).
Community engagement	Community engagement encompasses interactions and collaborations between higher education institutions and their communities at different levels (local, regional, national, global) to promote inclusivity, mutuality, partnership and reciprocity in their exchange of resources and knowledge (Driscoll, 2008[6]).
Third mission	The term third mission refers to higher education institutions' expanded efforts to engage with industry and society in recent decades. The activities which form the third mission (often comprised of technology transfer and innovation, continuing education and social engagement) are often defined as supplementary to teaching and research, and therefore become known as such in higher education (E3M, 2010[7]).
Responsible research and innovation	Responsible research and innovation (RRI) is an approach where researchers, citizens, policy makers, business, third sector organisations, etc. work together throughout the research and innovation process to better align the process and its outcomes with the values, needs and expectations of society, with the aim of fostering inclusive and sustainable research and innovation (European Commission, 2017[8]).
Valorisation	Valorisation is a term used to address efforts related to maximising access to and impact of academic research, expanding its value beyond academia. It often entails concepts such as increased accessibility (i.e. open access), and the development of research and science with non-traditional groups (Benneworth and Jongbloed, 2010[9]).
	Models of collaboration for innovation
Triple helix	The triple helix is a model that describes the interaction between government, industry and higher education institutions in a knowledge-based economy to foster innovation. This model highlights the interdependence and importance of policy interaction in innovation systems (Etzkowitz and Leydesdorff, 1995[10]).
Quadruple helix	Building on the triple helix, this model adds civil society as the fourth helix to encourage a more citizen- or user-centred approach to innovation, including co-creation of knowledge and entrepreneurial discovery processes (Cavallini et al., 2016[11]).
Knowledge triangle	The knowledge triangle is a conceptual tool for understanding knowledge building as a multifactorial and systemic process, depending on the interaction between education, research and innovation. The knowledge triangle framework highlights the need for an integrated approach to research, innovation and education policy. The term originated as part of the European Union's Lisbon Strategy (Cervantes, 2017[12]; Soriano and Mulatero, 2010[13]).
Technology transfer	Technology transfer involves the transfer of ideas, practices, knowledge, intellectual property, discoveries and inventions that results from research conducted in higher education institutions (in co-operation with external partners or not) into a non-academic environment where they can lead to social and commercial benefits at local, regional, national or global levels (E3M, 2012[2]).
Smart specialisation	Smart specialisation is a policy approach to knowledge-based investment that aligns industrial, education and innovation policies with a focus on those areas of comparative advantage in a city, region or country. The approach is based on entrepreneurship; multi-governance mechanisms of interaction; mapping and benchmarking of cluster and key players; evidence-based monitoring; and evaluation systems (OECD, 2013[14]). In EU countries, it has been implemented as a strategic place-based approach to economic development through targeted support for research and innovation (European Commission, 2017[15]).
	Concepts related to higher education institutions
Entrepreneurial university	The entrepreneurial university describes higher education institutions that are organised and managed like enterprises. The entrepreneurial model is both a process and an outcome; it is associated with the commercialisation of knowledge and research outputs, the development of entrepreneurship and entrepreneurial skills, and a more enterprising approach to institutional management in higher education (Clark, 1998[16]; Etzkowitz, 1983[17]; Foss and Gibson, 2015[18]).
Civic university	A civic university has a clear sense of purpose and place; it takes a holistic approach to engagement by developing institution-wide collaborations with impact that goes beyond academia; it uses innovative methodologies to be actively engaged with the world and the community where it is based; and it is transparent and accountable to both stakeholders and the public (Goddard et al., 2016[3]).
HEInnovate	A framework, developed by the European Commission and the OECD, for higher education institutions to self-assess how they manage resources, build organisational capacity, collaborate with external stakeholders, create and nurture synergies between their core functions, embed digital technology, promote entrepreneurship and support knowledge exchange with the wider world (HEInnovate, 2017[19]).

7.1. Introduction

Engagement with the wider world is recognised as one of the three main functions of higher education, but it typically takes a backseat to education and research. The term "engagement" denotes the interaction between higher education and wider society, reflecting the responsibility of higher education to provide social benefits beyond the academic realm (Benneworth, 2017[1]; E3M, 2012[2]; Goddard et al., 2016[3]). It is often referred to as the "third mission" of higher education, though in reality all three functions tend to be broadly intertwined and mutually sustaining.

Engagement is "by definition a two-way process, involving interaction and listening, with the goal of generating mutual benefit" (National Co-ordinating Center for Public Engagement, 2017[4]). This implies a reciprocal relationship between higher education and society. Active engagement between higher education institutions and communities, industry and others ensures higher education is more responsive to the needs of society, and enhances the relevance of both education and research activities.

The transfer and exchange of knowledge and resources lie at the core of all engagement activity. However, higher education institutions take different approaches to engagement depending on their missions, locations and other factors. As a result, there is no 'one-size-fits-all' approach to engagement in higher education. It includes interactions with social partners to improve the relevance of higher education and to drive innovation. It also involves participation in a wide range of activities at local, regional and national levels to contribute to the social, economic, cultural and environmental development of communities and regions (OECD, 2007[5]).

Table 7.1 illustrates the diversity of engagement activities across higher education systems with a list of some of the key concepts and definitions that are used to characterise engagement. Different concepts have originated in different contexts and have often become more comprehensive with time; for instance, the concept of the "triple helix" has developed into the "quadruple helix", reflecting an increased importance of the role of civil society in higher education.

Participating jurisdictions in the 2017-18 round of the benchmarking project requested a deeper analysis of the engagement function of higher education, focusing on continuing education and broader civic and social engagement. This chapter will therefore explore the ways that engagement builds human capital for greater social impact; contributes to innovation; and supports wider social, economic, cultural and environmental development.

Comparable metric data on different forms of engagement are not yet widely available. Much of the internationally comparable data are based on engagement between higher education and business. The chapter presents an overview of the available indicators of engagement, including measures of collaboration between higher education and enterprises, and business contribution to higher education expenditure on research and development (R&D). To support peer learning, it also outlines some policies and practices for developing effective engagement activities that have been recently initiated across the OECD.

Chapter 7. Engagement with the wider world

This chapter focuses on one of the three main functions of higher education – engagement with society. Engagement in higher education encompasses various roles and functions and involves a wide range of stakeholders, including business and industry, the public sector, the social economy and civil society. This chapter discusses how higher education engagement activities can work to build human capital, contribute to innovation and support wider social, economic, cultural and environmental development.

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

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Notes

[1] In some countries, there is no material difference between the policies or funding systems in the higher education and government sectors. For example, in Estonia, the same rules of funding apply for government, higher education and private non-profit sectors, independent of their legal status.

[2] It should be noted that these data cover all sectors of R&D and are not specifically tailored to higher education. However, as researchers in higher education have the most incentive to publish their work in indexed publications, it could be expected that the measures are at least of this magnitude in higher education.

[3] As indicated by the SCImago Journal Rank, a measure of scientific influence of scholarly journals that accounts for both the number of citations received by a journal and the importance or prestige of the journals where the citations are made (OECD, 2017[13]).

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- In addition to the metric data presented in this chapter, a number of national policies and practices in the participating jurisdictions are motivated by improving various aspects of the research function in higher education. A summary of some of the initiatives presented in this chapter is given in Table 6.4.

Table 6.4. Selected higher education policies from the participating jurisdictions (2017)

	Motivation	Policies
Estonia	Increasing the internationalisation of research	• The Dora Plus and Mobilitas Plus programmes have been established 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 provide 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 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. • Estonia also participates actively in many international research projects and initiatives, including the European Molecular Biology Conference (EMBC), European Space Agency (ESA), European Spallation Source (ESS) and the European Organization for Nuclear Research (CERN). • Estonia has relatively high Horizon 2020 funding as a percentage of GDP among the jurisdictions.
The Flemish Community	Improving and streamlining investment in R&D	• The Flemish Community has brought investment in R&D to a level of 2.5% of GDP, with the target of reaching 3% by 2020. • Funding mechanisms include 'Special Research Funds' (BOF), which are awarded based on the number of master's and doctoral degrees awarded, gender diversity, and research productivity and impact. Institutions can also benefit from 'Industrial Research Funds' (IOF) if they engage in technology transfer activities, such as licensing, patenting and spin-offs. • The Flemish Community is among the jurisdictions most successful at attracting funding from Horizon 2020.
The Netherlands	Creating world-class, high-impact research	• The Gravitation Programme supports the formation of consortia of universities that have the potential to conduct ground-breaking scientific research of international importance, preferably leading to some breakthrough of global significance. • Standard evaluation protocols (SEP) are used to monitor the quality of research.
Norway	Developing flexible ways to access a career in research	• State institutions and private institutions carry out doctoral research. • Researchers are treated as employees and receive social benefits. • 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. • Norway participates in international joint doctoral supervision projects (*cotutelle*).

Source: Adapted from information provided by the participating jurisdictions. See the reader's guide for further information.

selection procedure is conducted by Netherlands Organisation for Scientific Research (NWO) (Dutch Ministry of Education, Culture and Science, 2014[8]).

- In **Estonia**, the programme of the Centres of Excellence in Research (CoE) was introduced in 2001. A Centre of Excellence in Estonia consists of one or more internationally high-level research teams that have a clear set of common research objectives and work under the same management, with the aim of strengthening the international competitiveness and the quality of research, improving performance, ensuring future generations of researchers, intensifying national and international research co-operation between institutions and increasing the international impact of Estonian research (Estonian Ministry of Education and Research, 2017[73]).

6.8. Concluding remarks

This chapter provided a discussion of the available metric data related to the inputs, processes, outputs and outcomes of higher education research and development, as well as a more in-depth analysis of relevant policies and practices in the four participating jurisdictions. In this section, key messages of this chapter are outlined, along with an overview of areas where additional data would provide benefits for assessing the performance of the research function in higher education.

- The key justification for investment in research and development is that it underpins the creation of new knowledge that is needed to develop future innovations. With that in mind, OECD governments are aiming to increase the level of investment in research as a proportion of GDP, as well as broaden the range of sources for R&D investment. As discussed in Chapters 3 and 4, a clearer delineation between the resources (human and financial) invested in education and research would allow for a more robust analysis of the efficiency and cost-effectiveness of the research and development activities of higher education systems.
- Ensuring access to a rewarding career in research is a core requirement for building and sustaining a high-performing research and development system. More comprehensive and reliable data on the different types of researchers within the higher education system and in the private sector, their socio-demographic characteristics and the different stages of their careers would provide a greater understanding of how government policy could support the needs of R&D systems for high-quality human resources, through, for example, identifying mismatches between field of studies and sector of employment, understanding employment conditions in research oriented occupations within and outside academia, and monitoring transition paths in and out of academia.
- Bibliometric data is currently the only means by which to conduct comparative metric analysis across countries of the quality and impact of research. It is also the best available data source for inferring information about the flow of researchers between jurisdictions, and the effect that this has on research quality. However, there are a number of conceptual and methodological challenges associated with using bibliometric data. While there is no obvious alternative at present, it is likely, given the growth in research activity in recent years across the OECD, that there will be increasing interest in developing a broader and more reliable range of indicators to measure research impact.

and various biases (Bowman and Bastedo, 2011[69]). Rankings of individual institutions are sensitive to changes in indicators or weightings used, which limits their utility for students and policymakers and may result in sub-optimal choices if used as a basis for making decisions (Saisana and Saltelli, 2010[70]).

Despite concerns about the reliability of the rankings, the high weight attached to research impacts in these rankings, either through bibliometric indicators, the numbers of staff that have been awarded international prizes (Nobel Prize and Fields medal) for breakthrough research, or even indirectly through research reputation, helps to explain the increasing investment in higher education research in recent years by institutions, and a growing policy focus on research excellence.

In this competitive environment, research excellence initiatives have become commonplace across OECD countries and other countries that are heavily investing in producing research output and quality, such as China and the Russian Federation. A 2013 OECD survey of government ministries, to which 20 countries responded, identified 28 funding initiatives from 18 of the countries that met the criteria to be considered a Research Excellence Initiative (OECD, 2014[71]) .

Research excellence initiatives have been defined by the OECD as instruments that are designed to encourage outstanding research by providing large-scale, long-term funding to designated research units (often termed centres of excellence or CoEs). Many benefits of research excellence initiatives have been identified, including the enhanced ability of CoEs to attract and concentrate highly talented researchers in well-equipped environments, and providing security for carrying out broad and complex research agendas, especially for projects involving transdisciplinary research (OECD, 2014[71]) .

In the participating jurisdictions, many research excellence initiatives have been implemented:

- The development of excellent academic communities is one of three core pillars in the **Norwegian** Long-term Plan for Research and Higher Education. The Research Council of Norway's Centres for Excellence and Centres for Research-based Innovation are key mechanisms through which Norway supports higher education research excellence. Through these programmes, large tranches of funding are awarded to research clusters on a competitive basis, based on selection criteria which focuses on scientific quality and high international standards (OECD, 2017[72]).
- **The Flemish Community's** "VIS-scheme" (Flemish Cooperative Innovation Networks) has been responsible since 2001 for the creation of centres of excellence in the Flemish Community. Since 2009, many of these centres have been streamlined, consolidated or scaled up to become strategic research centres. More recently, the VIS-scheme has supported the development of Innovation Platforms, which provide a platform for the co-operation of various actors engaged in research in a particular industry. Many of the innovation initiatives are in the process of being updated following a new policy which focuses on strategic clustering of research actors (Flemish Department of Economy, Science and Innovation, 2017[6]).
- **The Netherlands** promotes excellent research through the Gravitation Programme, which supports the formation of consortia of universities that have the potential to conduct ground-breaking scientific research of international importance, preferably leading to some breakthrough of global significance. The

In the Netherlands, there were 3.5 published applications for patents per 100 higher education researchers between 2010 and 2016, above the OECD average. In Belgium, there were 2.4 published applications per 100 researchers, slightly below the average; while Norway and Estonia were further below the average at close to 1.7 patents per 100 researchers each. The number of published patent applications for the government sector is also relatively high in Belgium and the Netherlands (around 3 per 100 researchers). On the other hand, the government sector in Estonia and Norway publishes relatively few patents, which could be related to the missions of public research institutes in these jurisdictions. For example, in Estonia, government research institutes that have remained outside the higher education sector tend to have other functions in addition to conducting research.

Despite the fact that Figure 6.29 indicates that the rate of patent applications from the higher education sector is relatively low overall, higher education research and development outputs may indirectly have a larger impact than it appears. For example, due to the legal situation in some countries, patents may be assigned to actors outside the higher education sector. Thus, the quantity of patent applications with higher education institutions as the origin but not the applicant remains largely unknown. In other cases, the higher education sector might create the knowledge which spurs patent applications. This influence is difficult to capture with existing metrics, although efforts have been made to identify relevant indicators, such as the number of patent applications filed by other sectors that cite academic papers. (The EUMIDA Consortium, 2010[67]).

Research and development in higher education also impacts more broadly on innovative processes through a number of other pathways as well as through patents. Through increased engagement-related activity, higher education institutions and systems are aiming to further enhance the social impact of research carried out in the higher education system. Chapter 7 explores some of the ways that higher education systems have been seeking to improve collaboration and create a more favourable environment for innovative processes.

6.7.4. Fostering research excellence in higher education

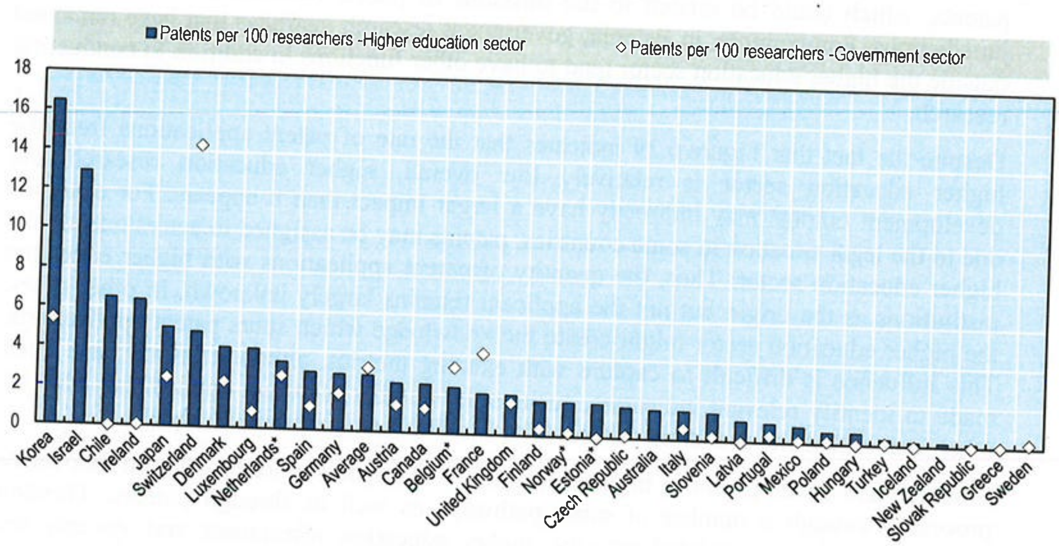
As discussed in previous sections, the quality of research can be assessed by considering the impact of research output on the work of other researchers, or by examining how well the research can be turned into innovative products, services and technologies. While the discussion in the previous sections focuses on systemic performance, in reality, the highest impact research is concentrated not only within certain countries, but in a subset of institutions within those countries. In terms of vertical differentiation, high impact research is often most associated with the more elite research universities, and high research performance is essential for universities to achieve the "world-class" status of being ranked among the top universities globally.

The initial publication of the Academic Ranking of World Universities (ARWU) in 2003 by Shanghai Jiao Tong, followed closely by the Times QS World University Ranking in 2004 led to an almost immediate general acceptance of these metrics throughout the global higher education sector and sparked waves of policy initiatives at institutional, national and supranational level aimed at increasing standing in the rankings (Hazelkorn, 2009[68]).

Concern has been expressed about the narrow range of metrics used in the international institutional ranking, and the methodology used to compute them. For example, reputation surveys are a key input (see Chapter 2), which can be subject to manipulation in Chile and Portugal, where the share of researchers in higher education in these countries is relatively high. On the other hand, the proportion of patents filed by the higher education sector is close to zero in Iceland and Sweden.

Figure 6.29. PCT published applications by higher education and government researchers (2010-2016)

Number per 100 researchers



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Data include all Patent Co-operation Treaty applications which were published between 2010 and 2016. WIPO uses published applications for confidentiality reasons. Government and PROs are not calculated separately, they are aggregated into the same group.
Source: World Intellectual Property Organization (2010-2016[66]), *PCT Yearly Review: The International Patent System*, http://www.wipo.int/pct/en/activity/index.html.

StatLink https://doi.org/10.1787/888933941766

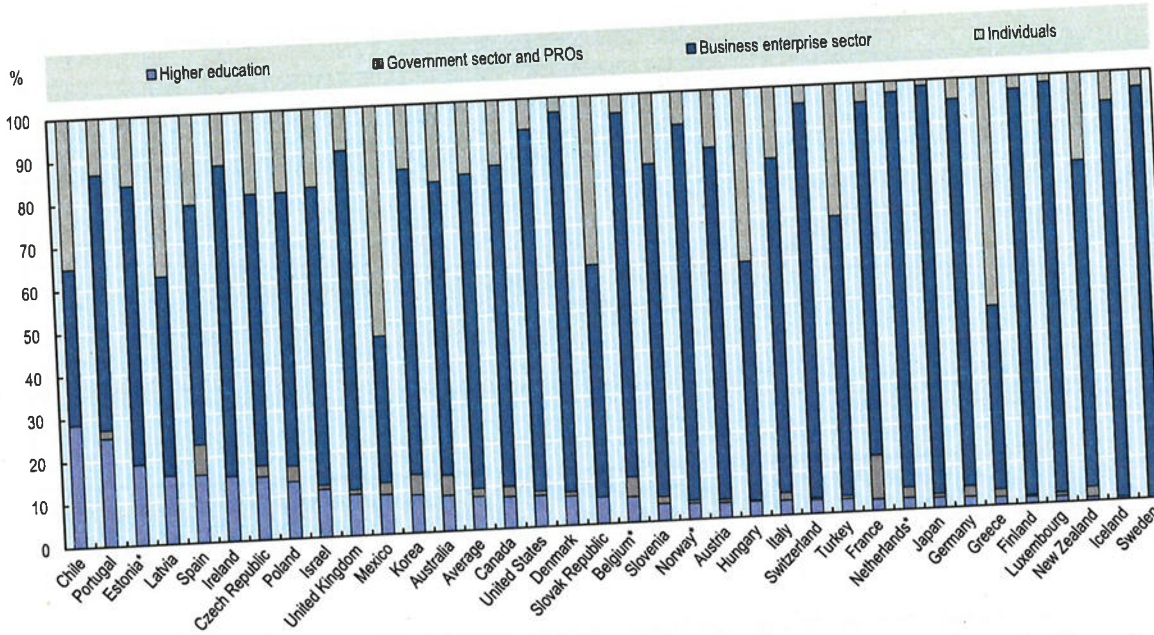
In addition to the variability across countries, there are significant differences between the government and higher education sectors. In general, the average number of published patent applications by government researchers in OECD countries is larger than the number of published patent applications by higher education researchers. A notable example is Switzerland, with over 14 published applications per 100 government researchers between 2010 and 2016, compared to 5 per 100 higher education researchers (Figure 6.29). This may be explained by the fact that almost all R&D undertaken by the government sector in Switzerland is dedicated to applied research (OECD, 2017[13]).

Korea and Israel have the highest numbers of patents per 100 researchers from the higher education sector. The high productivity of researchers in Korea may be related to the fact that the majority of expenditure on R&D in higher education goes into applied research and experimental development. However, other factors may also be related to productivity, as for example while Israel also has a relatively high number of patents per 100 researchers, only about one-third of R&D funding in higher education is spent on applied research and experimental development (Figure 6.6).

across society can be converted into impactful innovations (OECD/Eurostat, 2018[65]). In experimental development, the primary intention is to develop innovative processes or products, though other research and development activities can also strengthen individual or organisational capacities for innovation, even where innovation is not the primary objective of the research (OECD/Eurostat, 2018[65]).

Figure 6.28. PCT published applications by sector (2010-2016)

Percentage by sector and individuals



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. Data include all Patent Co-operation Treaty applications which were published between 2010 and 2016. WIPO uses published applications for confidentiality reasons. Government and PROs are not calculated separately, they are aggregated into the same group.

Source: World Intellectual Property Organization (2010-2016[66]), *PCT Yearly Review: The International Patent System*, http://www.wipo.int/pct/en/activity/index.html.

StatLink https://doi.org/10.1787/888933941747

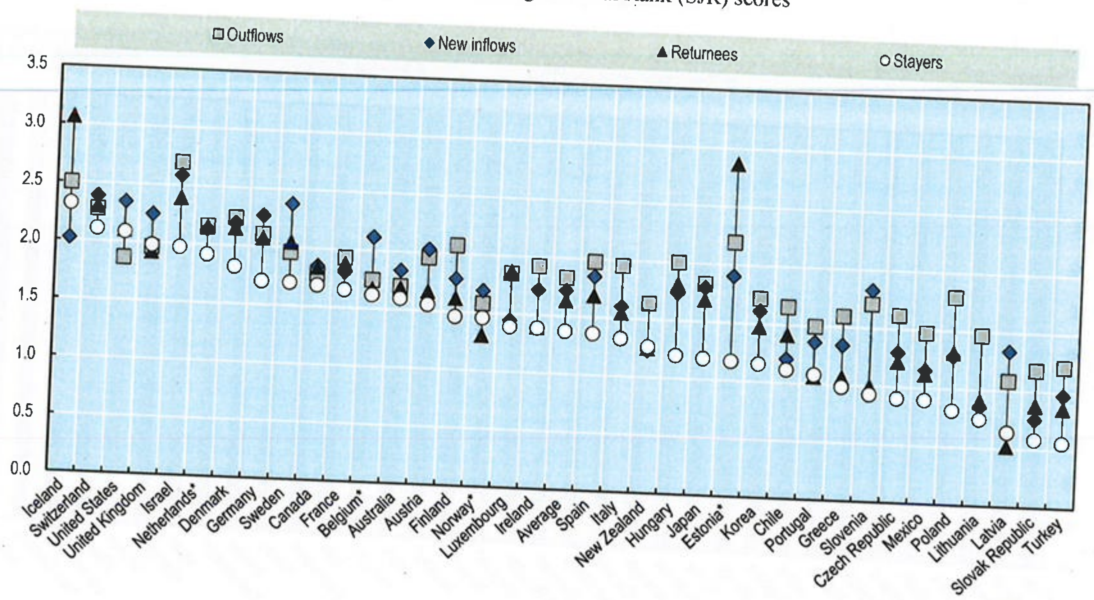
When an organisation or research team develops an innovative idea, it is possible to legally protect their resulting intellectual property rights in various ways, including through patents and trademarks. Therefore, data on patent applications are often used as a proxy means of analysing innovative output. Data in Figure 6.28 cover all Patent Co-operation Treaty (PCT) patent applications which were published between 2010 and 2016 by sector and individuals. The vast majority of published applications originate in the business enterprise sector, followed by individuals; higher education, government and public research organisations generate smaller proportions of patents.

Patents can give an indication of how well expenditure on higher education research and development can be turned into innovative output. On average for OECD countries, fewer than 8% of patents are filed by the higher education sector, but the figures vary. For example, higher education accounts for more than one-quarter of published applications

The United States in somewhat exceptional in this regard; researchers who moved into the country ("new inflows") had higher journal scores in 2016 than those who have stayed in the country throughout their career. However, United States-based authors who left the country and moved abroad had lower journal scores, as measured by the SCImago journal rank (Figure 6.27).

Figure 6.27. Expected citation impact of scientific authors, by mobility profile (2016)

Average 2015 SCImago Journal Rank (SJR) scores



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018. OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 SCImago Journal Rank from the Scopus journal title list (accessed June 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/10.1787/888933941728

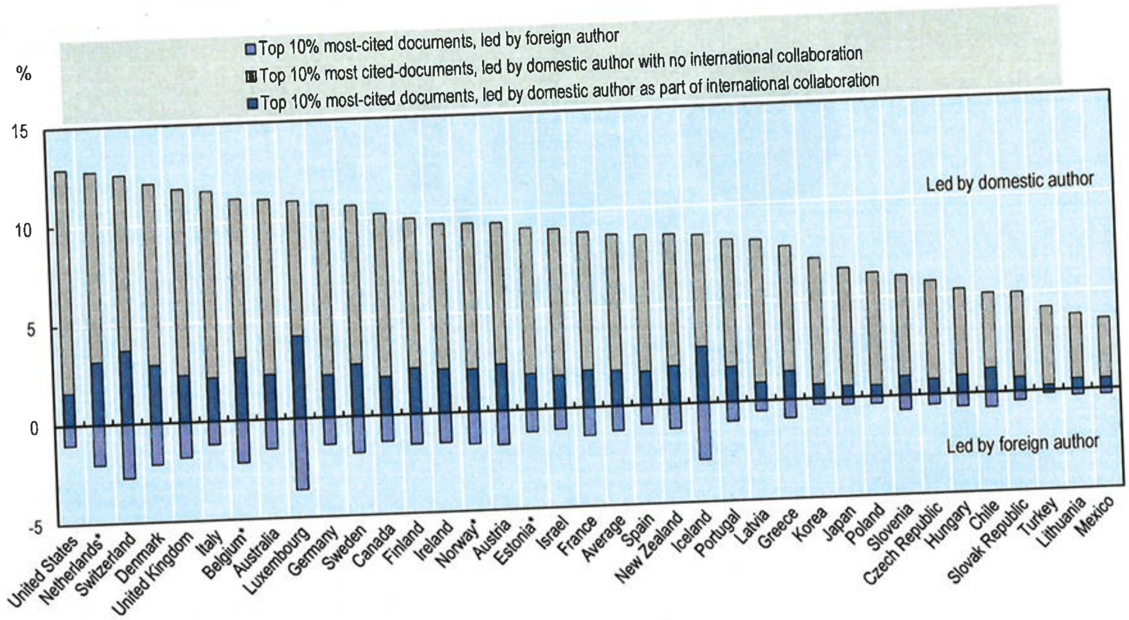
In the Netherlands, there was almost no difference between returnee, outflow or new inflow authors in 2016 in terms of the ranking of the journals where they publish (as measured by the SCImago journal rank score), although stayers had a lower journal score. On the other hand, in Norway returnees tended to publish in lower-ranked journals than the other groups of authors. In Belgium new inflows were the group who were able to publish most frequently in higher-ranked journals in 2016. Estonia had the widest range of scores between groups, and the largest difference between the expected citation impact of returnees and stayers (although these effects may also be due to the statistical variability produced by the smaller size of the research community in the country).

6.7.3. Turning research into innovation

Innovations can come about in a number of different ways, including as a result of research and development activities. The results of research projects can lead to knowledge that generates new ideas or inventions, which when implemented or diffused performance in both citation impact and international collaboration, while Estonia is near the median values for both measures.

Figure 6.26. Top 10% most-cited documents and patterns of international collaboration (2015)

Domestic and foreign-led top cited, as a percentage of all 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; and 2015 SCImago Journal Rank from the Scopus journal title list (accessed June 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.

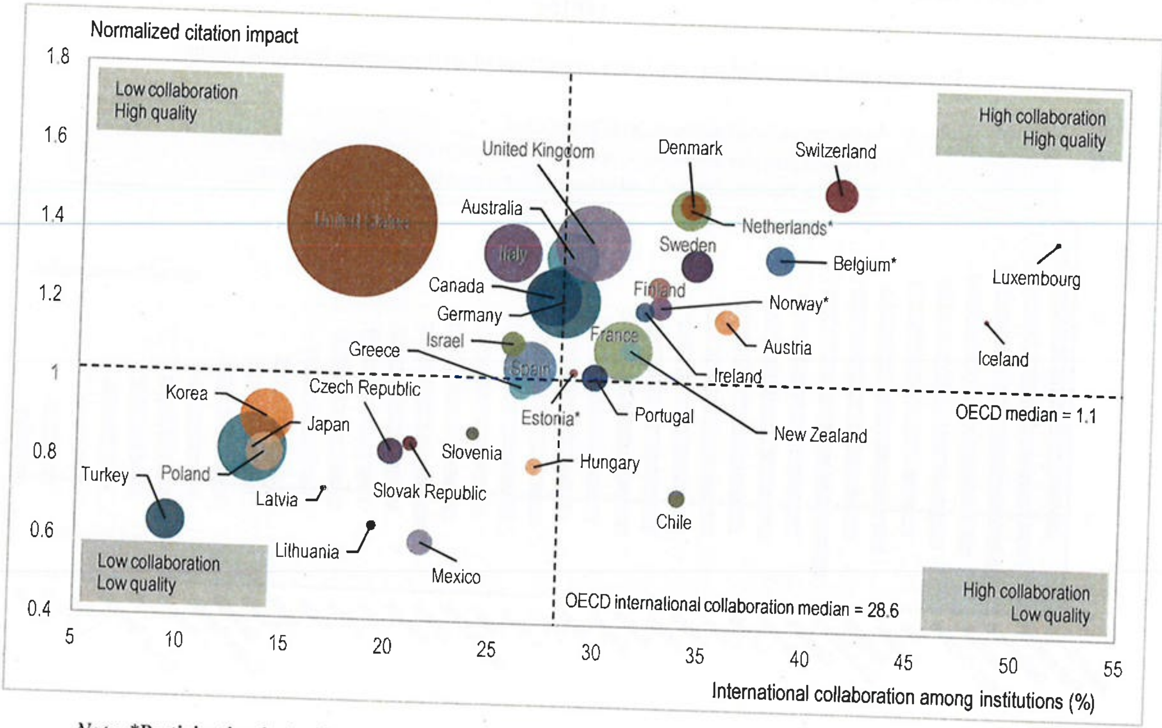
StatLink https://doi.org/10.1787/888933941709

The strength of the research performance of the Netherlands is further confirmed by the fact that it is only second to the United States in the percentage of top 10% most-cited documents led by a domestic author in 2015, either with or without international collaboration (Figure 6.26). Belgium had a similar percentage of top 10% most-cited documents led by a domestic author with international collaboration to the Netherlands (just over 3% in both countries), but had a smaller share of top cited publications with no international collaboration (8% compared to almost 10% in the Netherlands). Norway and Estonia had similar shares of most-cited documents led by a domestic author with and without international collaboration, both just above the OECD average levels.

Bilateral flows of researchers can help to further increase the impact of research. As discussed in Section 6.6, evidence suggests that authors who undertake research abroad and return to the economy ("returnees" in Figure 6.27) in which they first published contribute to raising the overall impact of domestic research. Authors who move abroad ("outflows") tend to be associated with higher rated publications than their counterparts who remain in the country or return later. Authors who do not move abroad ("stayers") are generally more likely to publish in lower ranked journals (OECD, 2017[13]).

Figure 6.25. The citation impact of scientific production and the extent of international collaboration (2012-2016)

As an index and percentage of all citable documents, based on fractional counts



Note: *Participating in the Benchmarking Higher Education System Performance exercise 2017/2018.
The size of the bubble indicates the relative volume of publications (using fractional counts). The normalised citation impact measure is derived as the ratio between the average number of citations received by documents published by authors affiliated with an institution in a given economy and the world average of citations, over the same time period, by document type and subject area.
OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017.
Source: Adapted from OECD (2017[113]), *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation*, http://dx.doi.org/10.1787/9789264268821-en.

StatLink https://doi.org/10.1787/888933941690

When comparing the data in Figure 6.22 and Figure 6.23 on international mobility and collaboration of researchers and Figure 6.24, a link between internationalisation and research performance could be inferred. The countries that perform the best in terms of the scientific quality of their research, as measured by field-normalised citation impact, tend to be those with higher levels of international collaboration.

Figure 6.25 also reinforces this point. Denmark, the Netherlands and Switzerland are among the top performers in OECD countries in terms of citation impact, with a normalised impact at least 30% higher than the OECD median for all indexed publications between 2012 and 2016. These countries were also among the OECD countries with relatively high levels of international collaboration between 2012 and 2016 (between 34% and 41% of all publications involved international collaboration). Belgium and Norway are also in the top right quadrant of Figure 6.25, indicating above average

Box 6.6 Connecting R&D funding to bibliometric data

To improve the quantity and quality of their scientific output, participating jurisdictions have incorporated bibliometric information into R&D funding decisions.

In **Estonia**, around one-third of base funding is based on the number of publications in internationally recognised journals, the number of high level research monographs and the number of registered patents and patent applications (Jonkers and Zacharewicz, 2016[18]). The remainder of the funding in based on qualitative evaluations.

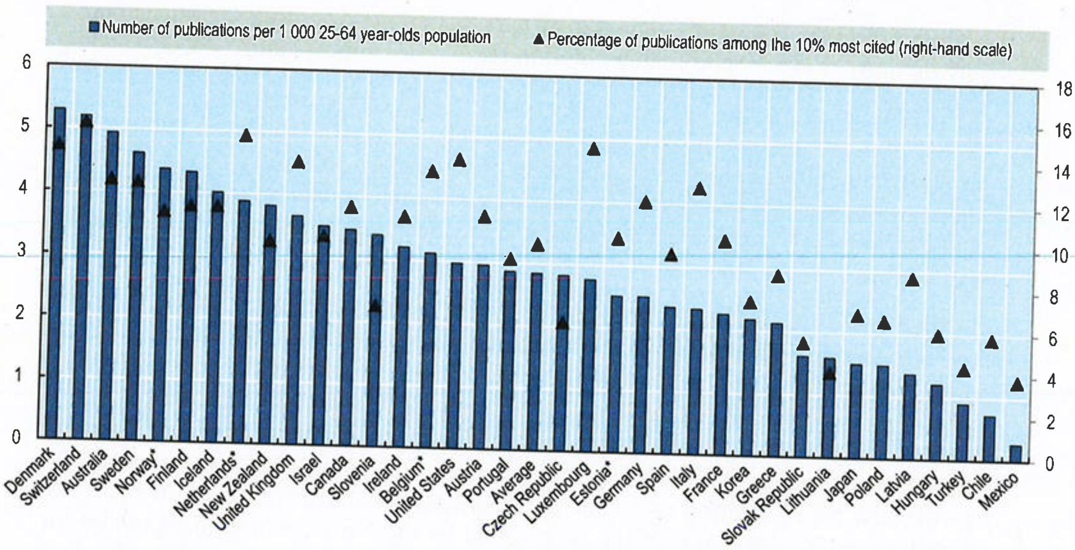
In **the Flemish Community**, around 40% of the 'Special Research Funds' provided to Flemish universities are based on research output and scientific impact (Jonkers and Zacharewicz, 2016[18]). Among the bibliometric information considered when allocating funding are publications in the Web of Science (WoS), a repository of academic articles, and citations and publications in the Flemish Academic Database for the Social Sciences and Humanities (VVAB). The latter was created in response to the low representation of social sciences and humanities journals in the WoS (Jonkers and Zacharewicz, 2016[18]). Inspired by the Norwegian funding model for research, the Flemish Government modified the bibliometric part of the funding model in 2008 to give prominence to all areas of research and make field-specific publications comparable across fields. Publications in the VVAB were included in the funding model in 2010, and their relative weight has increased since 2012.

Norway introduced incentives for publications in the higher education funding model in 2004. The funding model for research was designed in a way that offers a complete representation of verifiable bibliographical records in all areas of research and makes field-specific output comparable across research fields (Sivertsen, 2016[64]). Comprehensive bibliometric information is verified or provided by research organisations, through an integrated national research information system (CRISTIN), covering all public research organisations in Norway, including universities, university colleges, university hospitals and independent research institutes. Higher weight is given to publications in the most selective international journals and book publishers. Evidence suggests that this has not led to higher citation impact at the country level, but it did increase the absolute number of publications in high-level publication channels (Sivertsen, 2016[64]).

The Netherlands uses a Standard Evaluation Protocol (SEP) to monitor the quality of research. The SEP is periodically evaluated by the association of universities, the Research Council and the Royal Academy of Arts and Sciences. The SEP planned for 2015-2021 has moved from a high emphasis on research output to research quality. All research universities and research institutes are subject to assessment according to the guidelines outlined in the SEP. In 2014, the Netherlands released a White Paper announcing its vision for science and research for 2025. It envisages conducting world-class research, maximising research impact through stronger links to industry and society, and developing talent (OECD, 2016[49]).

Figure 6.24. Quantity and impact of scientific production (2015)

Number of documents and percentage among the world's 10% most cited publications, 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; and 2015 SCImago Journal Rank from the Scopus journal title list (accessed June 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/10.1787/888933941671

Belgium also performs highly according to this measure, with around 13% of publications among the most cited globally, higher than the OECD average level of just under 10%. There are no disaggregated statistics for the regions of Belgium, but the normalised score for most-cited publications from the European Regional Innovation Scoreboard shows the highest performance for Flanders (0.77), followed by the Brussels Region (0.72) and Wallonia (0.69) (European Commission, 2017[62]). Norway (11%) and Estonia (10%) both have levels of top cited publications slightly higher than the OECD average, and Estonia in particular has shown a considerable improvement in this indicator from 2005 to 2015 (OECD, 2017[13]).

The number of top-cited publications has been used widely as a proxy measure of the quality of research output, though it may be more accurately considered as a measure of its impact, as certain papers such as broad reviews of literature tend to attract more citations regardless of quality, certain fields of study tend to have higher citation counts, and authors may also cite a paper when criticising it (Tahamtan, Safipour Afshar and Ahamdzadeh, 2016[63]). Despite some shortcomings in the measurement process, the use and acceptance of bibliometric data to measure performance is growing across the OECD. In many countries, such the participating jurisdictions, they are now part of the decision-making process for R&D funding (Box 6.6).

6.7.2. Volume and impact of research output

Metrics used for assessing the performance of research in higher education at the systemic level include the volume of output, measured quantity of scholarly output per FTE researcher; and the impact of output, often measured by citation counts per FTE researcher. These values are often normalised by fields of study, due to the differences in the levels of citations between different fields. Another measure used to assess quality of research is the number of scholarly output per FTE in high-impact journals, i.e. those journals whose publications traditionally attract more citations from the scientific community (Box 6.5).

Figure 6.24 presents some information on the overall quantity and impact of scientific production in different economies, by measuring the volume of scientific publications and the relative numbers of citations they attract.

In terms of volume of publications, the most productive countries in 2015 with around 5 publications per 1 000 25-64 year-olds in the population were Australia, Denmark and Switzerland. On the other hand, Chile, Mexico and Turkey had the lowest volume of publications, at less than one publication per 1 000 of population.

Norway and the Netherlands produced publications at a level higher than the OECD average in 2015, with around 4 publications per 1 000 of 25-64 year-olds, compared to the OECD average level of 3 publications. In the same year, Belgium produced 3 publications and Estonia 2.5 publications respectively for every 1 000 25-64 year-olds.

The percentage of documents from each country in the global 10% most-cited publications allows a comparison of the scientific impact of publications at the system level, as a proxy for the quality of output of research systems. In 2015 Switzerland had the largest share of domestic scientific documents within the top 10% most-cited publication (15%), closely followed by the Netherlands and Luxembourg. On the other hand, only about 4% of publications in Lithuania, Mexico and Turkey appeared among the world's most-cited publications (Figure 6.24).

fully cover research activity, given that there is no one central repository of all scientific publications, and there are variations in methodologies between different repositories of indexed scientific publications on how such metrics are calculated (OECD, 2017[13]). However, because of the volume of information available, they have become widely adopted as the best available measures of research performance.

Despite the increasing access to metric performance data, qualitative evaluation through peer review remains the backbone of quality assurance in scientific production, both for reviewing individual research outputs and determining which research project proposals should be funded. Peer review of research proposals can help to increase the probability of the highest quality research being supported financially. However, the peer review process for journal publications has also attracted criticism due to the delays it introduces in communicating scientific results; and as evidence emerges demonstrating various types of bias, a lack of reliability and predictability in review processes (Bornmann, 2013[56]). While no alternative has arisen to challenge peer review, it is likely that future measures of research performance will increasingly attempt to combine both qualitative and quantitative elements, to provide a more multidimensional view of performance and increase confidence in the process (OECD, 2016[46]).

However, while peer review and bibliometric data can give some information on aspects of quality, there are other quality issues related to research publications for which solutions must be found in the research community. A major quality challenge relates to reproducibility of research; an increasing number of studies across various fields show that a large proportion of research claims and results cannot be replicated either by the original researchers or another team (Ioannidis, 2017[57]). Various obstacles to reproducibility present themselves at all stages of the research process, including not controlling for bias at the design stage, p-hacking (generating hypotheses and making analytical decisions which fit the structure of the observed data), failing to properly outline the experimental conditions under which the results were obtained and results which meet the standard of being statistically significant but with small effect sizes (Munafò et al., 2017[58]).

A number of initiatives aim to improve the ability to replicate important research results and strengthen the knowledge base which is used to underpin many decision processes and inform further research. For example, in some fields such as medicine, pre-registration of studies and specification of their protocols in advance of conducting the research have become standardised (Munafò et al., 2017[58]) and many high-impact journals have introduced more stringent requirements for authors to describe the conditions under which experiments were carried out (McNutt, 2014[59]).

Other policy actions which can improve the reliability of research include open science movements such as the European Commission's European Open Science Cloud, which has a goal of ensuring that all scientific publications are FAIR (Free, Accessible, Interoperable and Reusable). One of the key drivers of the requirement for FAIRness is the recognised need for research to be more reproducible, and evidence suggesting that implementing FAIR principles systemically is likely to bring considerable return on investment in terms of research quality, transparency and discoverability (European Commission, 2018[60]). Governments can also play a role in improving research quality, for example by funding research which aims to replicate existing results and requiring pre-registration of study hypotheses as a condition for awarding funding (KNAW, 2018[61]).

experiment involving performance contracts (OECD, 2016[45]). The *Long-term Plan for Research and Higher Education 2019–2028* serves as the key guiding policy framework for higher education and R&D in Norway. It outlines five priority areas which reflect a mixture of social and economic goals: oceans; climate, environment and clean energy; public sector innovation for better and more efficient services; enabling and industrial technologies; civic protection and social cohesion in a globalised world research (Norwegian Ministry of Education and Research, 2018[7]). In 2016, Norway also introduced stricter requirements for institutional accreditation in order to improve the quality of research and education in higher education institutions (OECD, 2016[45]). Among other factors, these requirements consider the relevance of research to the regional business community and the nature and size of doctoral provision (OECD, 2016[45]).

6.7.1. Monitoring research productivity and quality

In tandem with the increase in the volume of research activity and growing investment in research, there has been an expansion of measures which aim to provide an indication of research and development performance and impact. Pressure at the political level to demonstrate the effectiveness of public spending, the growth of bibliometric analysis and increasing volumes of both quantitative and qualitative information about research output has led to a research-related "metric tide" (Wilsdon et al., 2015[51]). These metrics can relate to the output of individual researchers, or can be aggregated to provide measures of quality and performance for journals, institutions and national systems (Box 6.5).

Box 6.5 Key terms related to research productivity and quality

Most measures of research quality and productivity are based on bibliometrics, such as the number of scientific publications and number of citations (the number of times an individual published paper is referenced in the work of other scientific authors). Key relevant bibliometrics which have grown in popularity and use in recent years include:

Citation count: The number of times a paper has been cited in other publications.

H Index: Designed to measure both productivity and quality at the individual level, the H index is defined as the highest number of publications an author has that have been cited at least an equal number of times (Hirsch, 2005[52]). For example, an H Index of 10 implies that the author has 10 papers that have been cited at least 10 times.

Impact factor: The impact factor measures how often on average each article in a journal is cited in a given year (Glänzel and Moed, 2002[53]). High-impact journals can be defined as those that have the highest levels of citations within their particular journal category or specialty (Garfield, 2003[54]).

Scientific production (of a country): The total amount of publications by authors affiliated with institutions in that country in a given year (OECD and SCImago Research Group, 2016[55]).

Altmetrics: Alternative measures of impact, such as the number of times a publication is mentioned on social media, discussed in blogs or mentioned in news sites.

Quantitative measures of research productivity and quality are still recognised as being experimental in nature and questions remain about how well such measures are able to