The Innovation Imperative
Contributing to Productivity, Growth and Well-Being

Chapter 3

Fostering talent and skills for innovation

A wide range of policies affects the various drivers of innovation. Among the most important of these policies for innovation are a skilled workforce that can generate new ideas and technologies, bring them to the market, and adapt to technological changes across society. Skilled people generate knowledge that can be used to create and implement innovations, and skills are also crucial to help absorb new innovations throughout economy and society. Human capital policy for innovation must address a wide array of skills and should help create an environment that enables individuals to choose and acquire appropriate skills and that supports the optimal use of these skills at work. This includes more incentives to institutions to improve the quality and relevance of their teaching as well as support for firm-level training. Policy makers should also assess the attractiveness of careers in academic research and improve these if necessary. Moreover, barriers to women's participation in science and entrepreneurship need to be removed. Finally, policy should facilitate the development of linkages and networks among researchers across countries.

3.1. A strategic framework for innovation policies

A range of policies affects the various drivers of innovation and can help governments in shaping and strengthening the contribution that innovation makes to economic performance and social welfare. These *policies for innovation* are much broader than the policies that are often seen as "innovation policies" in a narrow sense – such as policies to support business research and development (R&D), financing for risk capital, etc. OECD analysis suggests that innovation thrives in an environment characterised by the following features, all of which are explored in detail in the next four chapters:

- A **skilled workforce** that can generate new ideas and technologies, bring them to the market, and adapt to technological changes across society (Chapter 3). Reforms to education and training systems, and to skills policies more broadly, are therefore of utmost importance to innovation. They include policies aimed at science, technology, engineering and mathematics (STEM) graduates, but must go beyond this group and cover a wider set of skills. Moreover, the international mobility of talent plays an increasingly important role in meeting emerging skills needs and supporting knowledge creation and transfer, making supportive policies of growing importance.
- A sound **business environment** that encourages investment in technology and in knowledge-based capital (KBC); that enables innovative firms to experiment with new ideas, technologies and business models; and that helps them to grow, increase their market share and reach scale (Chapter 4). The OECD's empirical analysis shows that innovation performance can be strengthened by structural reform – to product markets, encouraging competition and enabling new entry; to labour markets, enabling better resource allocation; and to financial markets, helping generate funding for risky investments. Regulations should enable rather than stifle innovation. Economies should also enhance their openness to trade, investment, knowledge flows and people, acknowledging that innovation does not recognise borders.
- A **strong and efficient system for knowledge creation and diffusion** that engages in the systematic pursuit of fundamental knowledge, and that diffuses this knowledge throughout society through a range of mechanisms, including human resources, technology transfer and the establishment of knowledge markets (Chapter 5). Strong and well-governed universities and public research institutes and mechanisms that support and facilitate the interaction among knowledge institutions and economy and society are therefore important to strengthen innovation performance. So is investment in knowledge infrastructure, notably broadband and other digital networks that are critical tools to enable co-operation and provide new platforms for innovation to occur. Again, as knowledge creation and innovation are global endeavours, policies to better connect science and innovation activities across the world are crucial to the innovation policy agenda.
- **Policies that encourage firms to engage in innovation and entrepreneurial activity** (Chapter 6) More specific innovation policies are often needed to tackle a range of

barriers to innovation. The appropriate policy mix might include tax incentives for investment in R&D; direct public support through grants, subsidies and innovation competitions; and policies to facilitate co-operation and networking, but also indirect incentives through public procurement and other so-called demand-side policies. Such policies can help to strengthen markets for innovation, and help focus it on specific challenges and opportunities, e.g. green growth. Many of these actions include policies at the regional or local level. Moreover, well-informed, dynamic engaged and skills consumers are increasingly important for innovation.

3.2. The role of human capital for innovation

Policy statements on innovation rarely fail to emphasise the importance of human capital. One reason for this is the empirically well-established positive link between human capital – the knowledge and skills embodied in workers – and incomes, productivity and growth. Since the mid-1980s, research on macroeconomic growth has gained impetus from new theoretical insights – in particular endogenous growth theory – that highlight the role of human capital. There are many reasons to expect a positive impact of human capital on growth: more education fosters technological progress and increases the ability to absorb innovations developed abroad. (Human capital is also likely to stimulate growth through non-technological routes. For instance, if education improves health, workers might be more productive and have longer working lives.) Recently, OECD (2013a) has shown that rising business investment in a range of intangible assets – from software to designs to new forms of business organisation – is important for growth and productivity in OECD economies. Such intangible assets are often a direct manifestation of human capital: for instance, software is a translation of human expertise into code. Rising business investment in intangible assets has been enabled by rising educational attainment and investment in skills.

Policy makers in some countries are also concerned that education and training systems might not be maximising the potential for progress in science, research and innovation. For instance, fears exist in some countries that too few students choose to study science and engineering.[1] Furthermore, across the OECD area, the rapid evolution of different parts of the economy – often associated with technological change – can generate skills shortages. A recent example is the reported shortfall of managers and analysts having adequate understanding of the business uses of "big data" (McKinsey & Company, 2011). Policy makers naturally wish to ensure that technology-driven skills imbalances are quickly corrected.

A further source of policy interest in human capital relates to the effects of technology on earnings inequality. Indeed, OECD analysis finds that skill-biased technological change is the single most important driver of rising inequalities in labour income (OECD, 2011a). Human capital development is clearly central to the policy response to rising income inequality.

A further consideration relates to population ageing. Other things unchanged, population ageing in OECD countries will lead to shrinkage in the scientific workforce (relative to the total population). Such shrinkage could have numerous effects and policy implications. For instance, a decline in the availability of scientific labour could affect patterns of R&D-driven offshoring. Among other things, this would have implications for education, training and immigration policies. Questions are likely to arise in many countries regarding how much spending on education and training would need to increase to keep pace with technological change and the needs for science- and innovation-related human capital. More might also need to be done to productively engage the scientific workforce, in academia and industry, beyond today's usual ages of retirement.

Overall, this subsection emphasises that human capital facilitates innovation through numerous channels, and that many disciplines and levels of skill contribute to innovation. There is no skills-related "silver bullet" for innovation. While some generic skills such as creativity and communication skills are clearly particularly important to innovation, consensus does not yet exist on how education systems should systematically develop and test them (even if education systems increasingly include such skills in their educational objectives). A number of education and training themes loom particularly large in the innovation arena, even if some are also important for other (non-innovation) reasons. These themes include the incentives for institutions to improve the quality and relevance of teaching, support for firm-level training and lifelong learning, the attractiveness of careers in academic research, ensuring that barriers to women's participation in science and entrepreneurship are removed, and facilitating the development of enduring linkages and networks among researchers across countries.

Human capital shapes innovation in a number of ways. In particular:

- **Skilled people generate knowledge that can be used to create and implement innovations.** For instance, in American cities, a 10% increase in the share of the workforce with at least a college degree is associated with an increase in (quality adjusted) patenting per capita of about 10% (Carlino and Hunt, 2009). Locations with a high share of college graduates host more jobs that require new combinations of activities or techniques (Lin, 2009).
- **Having more skills raises the capacity to absorb innovations.** Skills that aid the adoption and adaptation of technology are beneficial across the workforce, not just within R&D teams. Innovation in firms is particularly associated with the in-house development of skills, rather than their acquisition through hiring, owing to the former's effects on absorptive capacity (Jones and Grimshaw, 2012). Educated workers also have a better foundation for further skills acquisition. And through their actions as role models, they may spur faster human capital accumulation by other workers.
- **Skills interact synergistically with other inputs to the innovation process, including capital investment.** For instance, studies show that human capital complements investment in and the use of information and communications technologies (ICT).
- **Skills enable entrepreneurship.** Entrepreneurship is often a carrier of innovation and structural change. Skills and experience are crucial to enterprise growth and survival. For example, Cressy (1999) shows that after controlling for the effects of human capital, financial capital is a relatively unimportant determinant of business longevity.
- **Skilled users and consumers of products and services often provide suppliers with valuable ideas for improvement** (Von Hippel, Ogawa and de Jong, 2011).

Human capital spurs innovation through many channels (as exemplified in the preceding paragraph). In different contexts, generic skills – such as reading, writing and problem solving – as well as technical, managerial, design and interpersonal skills, such as multicultural openness and leadership, all affect innovation. In the widest interpretation, the skills that support innovation could be any ability, proficiency or attribute that contributes to creating and implementing new products, processes, marketing methods or organisational arrangements in the workplace. Even if these skills are narrowed to only those that are teachable in the education and training system, the set remains large.

Jones and Grimshaw (2012) summarise the available assessments of how training and skills affect innovation in firms. In particular, the research shows that both tertiary and vocational education produce valuable skills, there is a positive innovation effect coming from intermediate technical skills,[2] and sectoral variation in how skills affect innovation suggests that institutions such as sector skills councils are important.

In terms of field of study, innovation policy makers often emphasise STEM. However, the importance of different fields of study varies by type of innovation and sector of activity. For example, in manufacturing, over 50% of tertiary-educated employees involved in innovation have an engineering (42.9%) or science (7.8%) degree. But in finance, the proportions are 7.0% with engineering degrees and 6.6% with science (Avvisati, Jacotin and Vincent-Lancrin, 2013).

A significant proportion of professionals with tertiary degrees from *all* fields hold highly innovative jobs. Over 45% of tertiary graduates from any field – and over 60% of science and engineering graduates – participate in at least some type of innovation. Participation varies across types of innovation. For instance, graduates in arts and engineering have the same likelihood of participating in product innovation, while engineers are significantly more likely to have a job involving technology innovation (Avvisati, Jacotin and Vincent-Lancrin, 2013).

It is useful to identify the skills that employees involved in innovation say they use in their jobs. The international REFLEX and HEGESCO surveys cover 19 European countries and Japan. These surveys show that employees who introduce innovations report using more of all types of skill in their jobs, relative to non-innovating counterparts. Among the self-reported skills used on the job that most distinguish innovative and non-innovative workers are "coming up with new ideas and solutions" (creativity), "a willingness to question ideas" (critical thinking), and "the ability to present new ideas or products to an audience" (communication) (Avvisati, Jacotin and Vincent-Lancrin, 2013).

A key principle should be the creation of an environment that enables individuals to choose and acquire appropriate skills and that supports the optimal use of these skills at work. This is the focus of the OECD Skills Strategy, the principal policy recommendations from which are set out in Box 3.1.

Educational attainment has risen; some industries have experienced large increases in workforce skills

Educational attainment, as one broad indicator of the skills available in countries, has risen steadily in OECD member countries, and around one-third of 25-34 year-olds now have a tertiary education. Graduation at the doctoral level has also grown (Box 3.2). Compared with older cohorts, young people increasingly graduate in the social sciences, business and law, and there has been a relative decline in the share of science and engineering (S&E) graduates in a number of countries. Data on wage premiums show that higher levels of study yield positive economic benefits.

Box 3.1. **Balancing the supply and demand for skills**

The OECD Skills Strategy has identified policy and institutional conditions conducive to a reasonable minimisation of skills mismatches (in any dynamic economy, such mismatches will not be eliminated entirely). The Skills Strategy has three overarching themes: developing relevant skills; activating skills supply; and putting skills to use. In a stylised manner, the key policy and institutional conditions to attain include:

- A focus on the development of strong generic skills, so that specific skills can be more easily acquired later (including through retraining).
- A focus on creating a system that is flexible, and thus responsive to economic change, rather than relying on skills forecasts as a guide to policy.
- Comprehensive information systems that allow students to understand course content, associated labour market outcomes, and the performance of education and training providers, as well as permitting employers to understand the content of qualifications.
- Arrangements allowing flexible demand-driven resource allocation across providers of education and training services, and across faculties within educational establishments. In addition, funding and financial incentives are needed that avoid distortions (for instance, inducing students to choose academic tertiary over vocational tertiary education because fees for the latter are too high) and barriers to participation (owing, for instance, to financial constraints for students from low-income backgrounds).
- The involvement of employers and other social partners in the design and delivery of skills policies. For instance, in the United Kingdom, Jaguar Land Rover has created a network from among a range of universities to deliver tailored courses in science and engineering for its staff, as part of the company's Technical Accreditation Scheme. The aim is to provide Jaguar's employees with access to "the best courses from the best sources".
- Labour market policies that help inactive workers to become active, or allow workers facing the prospect of inactivity to remain active for longer.
- Labour market policies that facilitate mobility, including mobility across local labour market areas.
- A well-developed training market for adult skills, including mechanisms that counter obstacles to training investments sometimes encountered in small and medium-sized enterprises (SMEs).
- An effective demand-driven labour migration regime. Such a regime should: identify labour market needs, considering demographic and educational changes in the non-immigrant population; establish formal recruitment channels; issue sufficient visas and process them quickly; provide efficient ways to verify residence and immigration status; and implement effective border control and workplace enforcement.
- Mechanisms to control for quality and create accountability at all levels of the system.

Source: OECD (2012a), *Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264177338-en*.

Box 3.2. **The careers of doctorate holders**

Between 2000 and 2009 there was a steady increase in the number of doctoral degrees awarded across the OECD, rising by 38% from 154 000 to 213 000. However, the association between the proportion of doctoral graduates in the labour force and a country's R&D intensity is weak.

Despite the growing supply of doctorate holders, the evidence points to a sustained labour market premium for those with a doctoral qualification. While female and younger doctorate holders fare relatively worse in terms of employment rates and earnings than their older and male counterparts, these biases are less marked for doctorate holders than for individuals with lower levels of educational attainment.

Although higher education is the main sector of employment for those with doctorates, demand for doctorates is apparent across knowledge-intensive sectors. Among doctorate holders, the take-up of jobs outside higher education is often in non-research occupations. Working as a researcher becomes less likely as careers progress and other competencies are acquired.

A wide range of monetary and non-pecuniary factors contribute to the reported attractiveness of research careers. Even when not in research, the jobs of doctorate holders in most cases relate to the subject of the doctoral degree, and doctoral graduates are generally satisfied with their employment situation.

A particular policy challenge faced by some small economies relates to the inability to provide suitable employment for researchers in certain specialised fields. This reflects a less diverse economic structure relative to many larger economies.

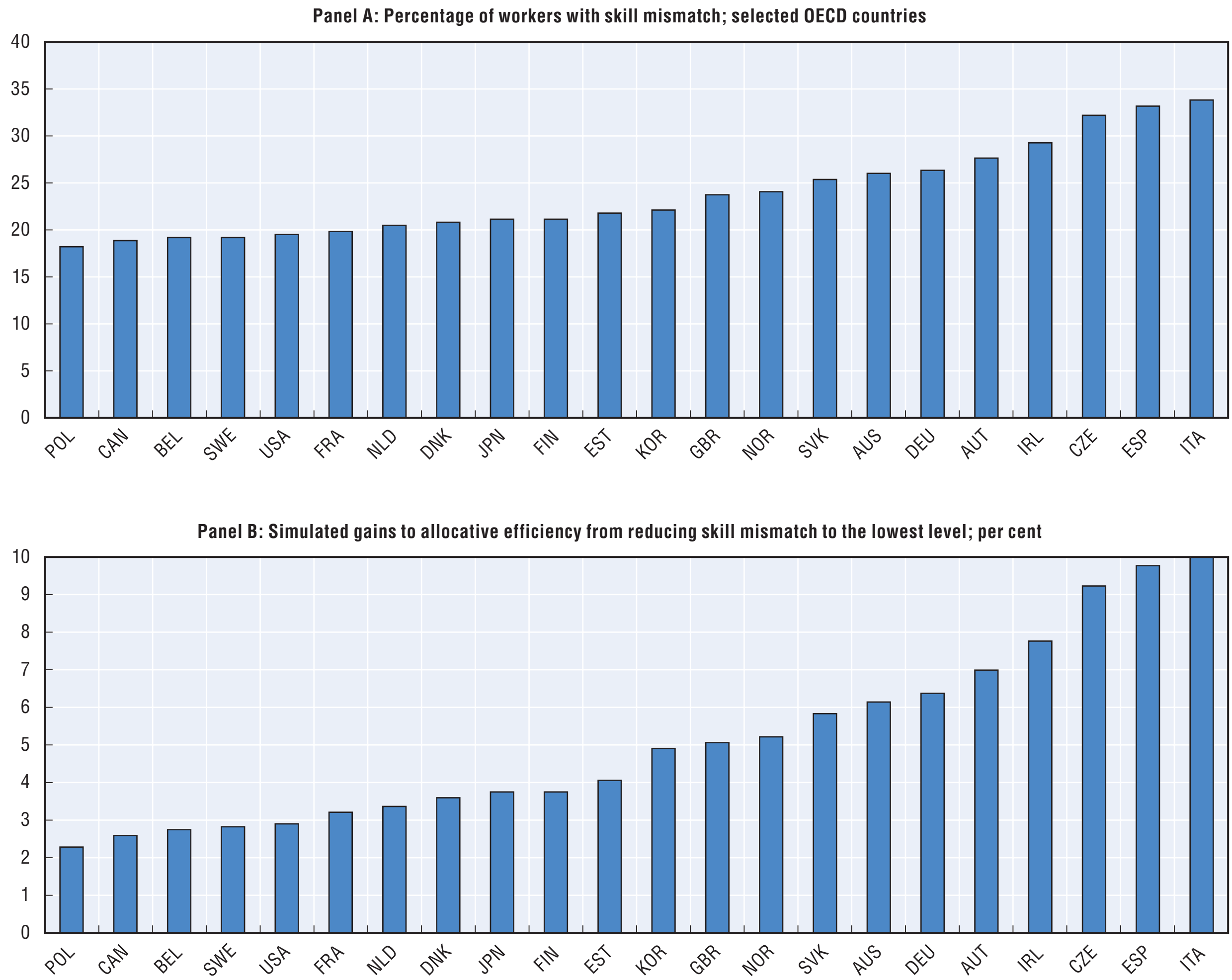
Source: OECD (2013b), *OECD (2013a), Science, Technology and Industry Scoreboard 2013*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-en*.

3.3. Reducing skill mismatch

Higher skills do not automatically translate into higher prosperity and sustained growth. Making optimal use of existing skills and preventing the waste and attrition of skills due to mismatch or lack of use is also crucial (OECD, 2012a). Indeed, there is considerable skill mismatch in many OECD countries (Figure 3.1). New OECD research highlights that potentially significant gains to labour productivity can be achieved by a more efficient matching of workers to jobs (Adalet McGowan and Andrews, 2015a). Reducing skill mismatch expands the effective pool of labour that firms can draw workers from, enabling them to innovate and grow. Put differently, by trapping resources in relatively low productivity firms, for instance when industries have a high share of overskilled workers, skills mismatch can make it more difficult for more productive firms to attract skilled labour and gain market share at the expense of less productive firms.

Beyond the specific effects of education policies, Adalet McGowan and Andrews (2015b) show that a wider range of policies can affect skill mismatch and its consequences. Well-designed framework policies are associated with lower skill mismatch. In particular, less stringent product and labour market regulations and bankruptcy legislation that do not excessively penalise business failure are all associated with lower skill mismatch. Reforming housing market policies that inhibit residential mobility may also reduce skill mismatch. Such reforms can include lower transaction costs on buying property, less strict rent controls and less stringent building regulations. A better matching of skills and jobs is also facilitated by higher participation in lifelong learning and better managerial quality.

Figure 3.1. **Skill mismatch and productivity**



Notes: Panel A: Skill mismatch refers to the percentage of workers who are either over- or underskilled for a sample of 11 market sectors. In order to abstract from differences in industrial structures across countries, the one-digit industry level mismatch indicators are aggregated using a common set of weights based on industry employment shares for the United States. Panel B: The chart shows the difference between the actual labour productivity and a counterfactual labour productivity based on lowering the skill mismatch in each country to the best-practice level. One-digit industry level mismatch indicators are aggregated using a common set of weights based on the industry employment shares for the United States. The estimated coefficient for the impact of mismatch on productivity is based on a sample of 19 countries for which both firm level productivity and mismatch data are available.

Source: Adalet McGowan and Andrews (2015a), "Labour market mismatch and labour productivity: Evidence from PIAAC data", based on OECD (2013c), *Key Findings of the OECD-KNOWINNO Project on the Careers of Doctorate Holders*, *www.oecd.org/sti/inno/CDH%20FINAL%20REPORT-.pdf*.

3.4. Foundation skills and innovation

Increasing students' learning outcomes in school is a key educational challenge in most countries. Every three years the OECD's Programme for International Student Assessment (PISA) tests 15-year-old students in reading, mathematics and science – as well as other domains such as problem solving and financial education. PISA gives a picture of how education systems fare in developing foundation skills.

PISA demonstrates substantial variation in learning outcomes across and within countries. Even countries that perform above the OECD average often have a long tail of poor performers. For instance, in 2012, the mathematics skills of 23% of students across

OECD countries were evaluated at Level 1 or below, suggesting that they are only able to extract relevant information from a single source and can use only basic formulae or procedures to solve problems. Eighteen per cent of students were estimated to have reading skills below the baseline level of proficiency (OECD, 2014a).

However, as already noted, some skills of particular relevance to innovation – such as creative thinking and social skills – are not traditionally tested by education systems. Education systems increasingly include such skills in their educational objectives, but there is no consensus on how to develop them. Nevertheless, a number of observations are relevant here:

- A broad curriculum exposes students to different knowledge content and ways of thinking. This could directly contribute to innovation (by enhancing the ability to make connections between different bodies of knowledge).
- Revisiting pedagogies in traditional subjects could be valuable. To take one example, in mathematics education, metacognitive pedagogies that integrate an explicit reflection about students' learning and thinking, generally by using self-questioning, have been shown to lead to better learning outcomes. Not only do students improve their mathematical reasoning, they also develop stronger skills for solving complex, unfamiliar and non-routine problems (Mevarech and Kramarski, 2014). Metacognitive pedagogies are also effective in disciplines other than mathematics.
- While countries have changed curricula to broaden the skills that they want students to acquire, many of these skills are still not explicitly assessed, at either the school or the system level. The development of new tools to assess such skills, or at least to ensure that teachers pay explicit attention to them, is critical to ensuring that students develop innovative dispositions (OECD, 2014b; Lucas, Claxton and Spencer, 2013).

As noted above, beyond subject-specific expertise, tertiary education institutions should also aim to develop students' creativity, critical thinking and communication skills. Doing so ultimately depends on pedagogy and curricula. Approaches used include problem-based learning, other pedagogical practices, and fostering inter-disciplinarity.

Problem-based learning is increasingly used to foster innovation. Problem-based learning is often characterised as the learning and teaching of theoretical material within real-world contexts. Some institutions, such as the University of Maastricht (Netherlands), integrate problem-based learning in all their educational programmes. Problem-based learning is common in medical science and increasingly in other fields such as engineering and business administration. In her review of teaching approaches in science and technology, Sagar (2014) underlines that learners often do not understand why they need to learn the specified content. Students often feel overloaded with isolated concepts that lack authentic context. A recent review of evidence on the impact of problem-based learning in higher education shows that problem-based learning fosters certain innovation-related skills compared with lecture-based forms of university instruction (Hoidn and Kärkkäinen, 2014). The literature points to benefits of problem-based learning in students' long-term retention and knowledge application as well as in social and behavioural skills such as team work. By contrast, problem-based learning appears to be inferior to traditional teaching for short-term retention of knowledge and consequently appears to have an insignificant or slightly negative impact on academic performance in tests.

Pedagogic models other than those mentioned above can also foster skills for innovation. For example, the metacognitive pedagogies presented in the previous section are also effective in higher education, even though their effect tends to be smaller than in school education (Mevarech and Kramarski, 2014). And collaborative learning, game-based learning, real-time formative assessment and the use of online laboratories have been shown to improve students' understanding, reasoning and creativity in science education (Kärkkäinen and Vincent-Lancrin, 2013). This suggests that tertiary education institutions could enhance innovation-related skills through a variety of pedagogic models.

Interdisciplinary curricula and multidisciplinary education are at the heart of the curriculum strategies by which many higher education institutions seek to train future innovators. For example, since 2006, Harvard University has integrated biological, social, behavioural and clinical sciences under its New Pathway medical programme. The Biodesign programme of Stanford University has brought together students from engineering, management, genetics, biology, medicine and business since 2003 to train medical technology innovators. And in 2014 Stanford launched a new joint programme combining computer science with either English or music. In Japan, the Shonan Fujisawa Campus of Keio University offers interdisciplinary programmes in policy management, environmental information, nursing and medical care (Hoidn and Kärkkäinen, 2013).

Recent policy reforms in higher education have often modified the governance of institutions by giving them more autonomy, increasingly opening them to the labour market and making them more accountable. Because international rankings put much emphasis on research, countries should try to give more incentives to institutions to improve the quality and relevance of their teaching.

Beyond core research competencies, researchers also need skills that apply in a broad variety of work situations. Such transferable skills include communication, business and management skills. The literature identifies several benefits that can come from formal training to develop transferable skills. PhD candidates, for example, benefit from acquiring transferable skills during their studies. These skills help in carrying out their projects and in later employment. Learning by doing in employment is of course important. However, formal skills training can add value.

Government is not typically the key player in transferable skills training for researchers (OECD, 2012b). While training activity for transferable skills is considerable, mostly through universities and research institutions, there is usually no overall national strategy. The available information does not allow detailed comparison of transferable skills training across countries, but does indicate some international differences. For instance, in certain countries the emphasis on transferable skills is relatively new (e.g. Luxembourg), while in others, activity in this area has taken place for some time (e.g. the United Kingdom).

Debate exists over the best way to learn transferable skills – whether through interaction with supervisors and peers, formal courses, or workplace-based learning (e.g. during an internship) – as well as the respective roles of governments and research institutions. There may be merit in a more systematic approach to training for transferable skills and to more thoroughly embedding such training in existing education and research structures. Making research funding conditional on transferable skills training is another possibility, notably for doctoral studies.

The attractiveness of careers in academic research

Several issues appear to reduce the attractiveness of academic research careers, including: low starting pay; limited material rewards at senior levels compared with other professions; little wage differentiation among cohorts; and difficulties in moving between institutions, and moving internationally, because of tenure arrangements, pension rights, and attitudes to movement and job changes (HLG, 2004). OECD (2007) also highlighted drawbacks linked to the use of temporary contracts, slow access to tenure and a decline in the linear career track for academics.

Developing skills for entrepreneurship

Close conceptual links exist between innovation-specific skills and entrepreneurship skills (OECD, 2014c). Moreover, as discussed in various parts of this report, entrepreneurship is a critical vehicle for the introduction of innovations. During the past decade, most OECD countries have started to promote entrepreneurship skills in all levels of education (Hytti and O'Gorman, 2004). In particular, the number of higher education institutions providing entrepreneurship support for their students, graduates, researchers and professors is growing rapidly worldwide.

Entrepreneurship support in higher education generally has two strands. One aims at developing entrepreneurial mindsets. It stresses the development of self-efficacy, creativity, risk awareness, building and managing relationships, etc. A second strand aims to build the attitudes, skills and knowledge needed to successfully launch and grow a new business.

In recent years, the frequent use of business plans to teach entrepreneurship courses has been complemented by greater involvement of entrepreneurs in the teaching process, as well as an increasing use of social media and massive open online courses. It is increasingly common to find classrooms in which students are challenged to identify and use a wider range of knowledge sources to find novel solutions (Box 3.3).

Today, more than ever, universities are expected to respond to the social and economic needs of society, such as facilitating graduate employability, contributing to economic growth and local development, assisting innovation, and stimulating the birth of new enterprises. In this connection, HEInnovate (*www.heinnovate.eu*) – a joint initiative of the OECD and the European Commission – is a tool to help higher education institutions identify and act on opportunities for capacity development, including in teaching and research to enhance innovation and entrepreneurship.

Skills development beyond initial education

Lifelong learning is an essential part of both reacting to and fostering innovation. Learning and replenishing skills is necessary to respond to economic and technological change. For those who leave formal education with relatively poor skills, formal and informal learning in adulthood provides an opportunity to enhance their skills and increase their ability to contribute to innovation.

Giving companies and individuals sufficient incentives to participate in work-related or other kinds of training over their life span is a key challenge for any lifelong learning policy. Across OECD countries more than 40% of adults are estimated to participate in job-related and other training in a given year, though patterns vary substantially by country. Training is more common among younger workers and those with higher educational attainment.

Box 3.3. **Curricula-embedded entrepreneurship learning**

The University of Twente (UT) is located in Enschede, a town with approximately 170 000 inhabitants in eastern Netherlands. Established in 1961, with the aim to enhance and revive the regional economy after a major collapse of the regional textile industry, performing research that is useful for society has been UT's main goal from the beginning. All UT students should acquire entrepreneurship competencies by the end of their studies. The educational model has an emphasis on project-based and active learning, with a core emphasis on challenging students to identify and use many sources of knowledge to find novel solutions. A new interdisciplinary programme – the Academy of Technology and Liberal Arts & Sciences (ATLAS) – was recently launched for students who want to combine social and technical perspectives in engineering studies. During the three-year programme, students make use of the latest technologies in areas such as nano-robotics, tracers for personal safety, 3D printing and renewable energy. The curriculum includes a "personal pursuit" element in which students focus on their personal interests in music, sports or a second language.

Founded in 1971, the Munich University of Applied Sciences is the second-largest university of applied sciences in Germany. In 2011 a new course format was developed, building a triangle among entrepreneurship education, knowledge exchange and start-up support. REAL (Responsibility, Entrepreneurship, Action- and Leadership-Based) projects involve teams of five to six students in a one-semester project. Each REAL project course has multiple teams working on different aspects or solutions of a central innovation challenge. The course is team-taught, by a professor and an expert on entrepreneurship. Professors and students work together to define the specific challenge. One of the first REAL project courses, on urban farming, involved four faculties (mechanotronics, architecture, design and business administration). Students developed ideas related to crop production, food processing, transportation and logistics. Linking REAL project courses to topics of global relevance (e.g. sustainability, mobility, energy and space) has proved successful for attracting external partners.

Source: OECD HEInnovate case studies, online available at *www.heinnovate.eu*.

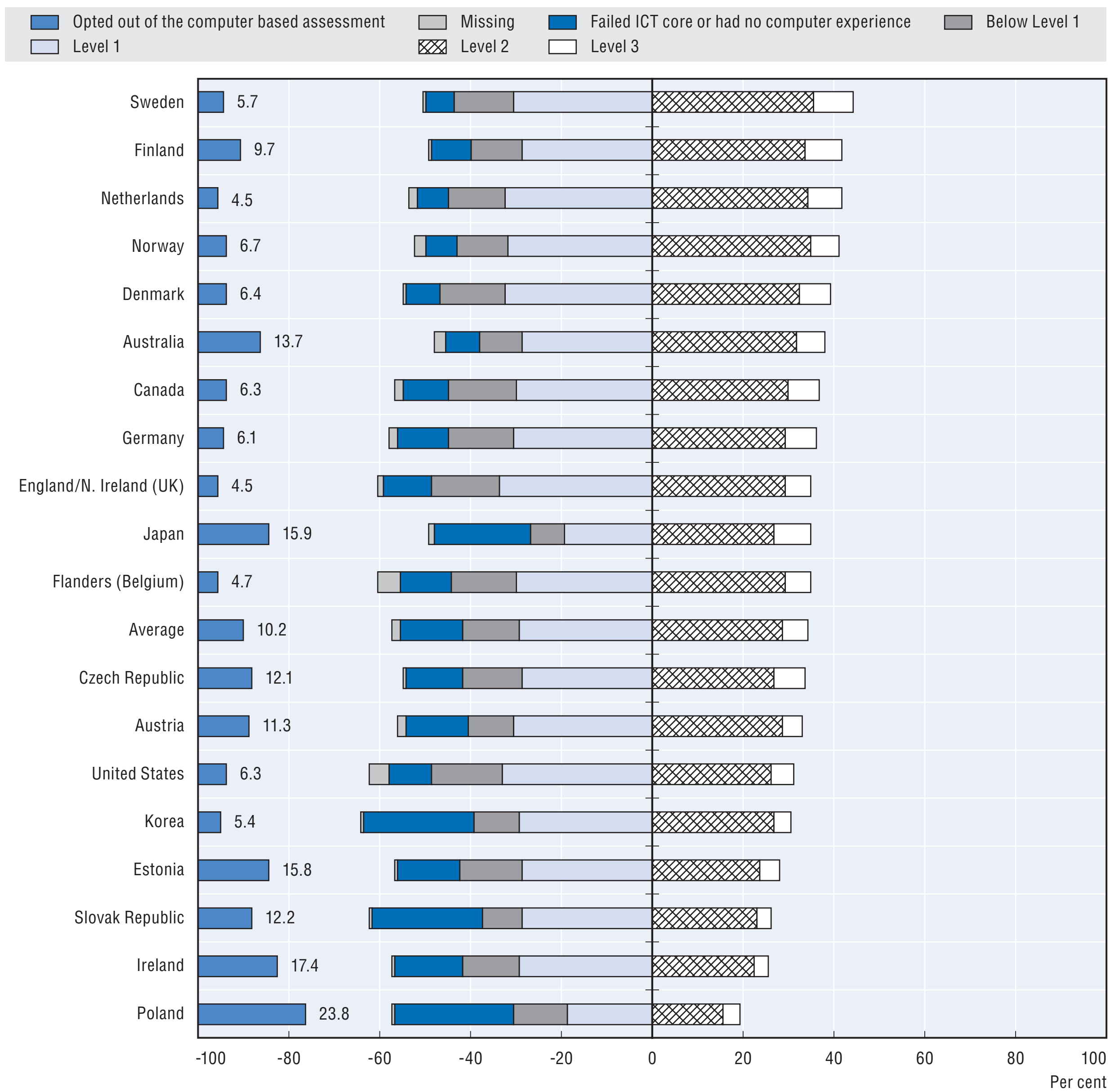
Using European data, Hansson (2008) estimates that employer-provided training is the most important source of further education and training once individuals enter the labour market. A substantial portion of these human capital investments are financed by firms. Hansson found that individuals captured between 20% and 50% of the returns to such training, with the rest accruing to firms. Mismatches in the structure of firm-level and wider economic returns to training may lead to an undersupply of training.

Suggested policy avenues to support firm-level training include improving information about training opportunities, setting appropriate legal frameworks so that private parties can organise and finance their training (e.g. through contracts), and helping to support the portability of skills by improving information about the competencies and skills gained through various learning channels. Tax incentives to promote training and education might be a supplementary measure. Other policy suggestions include reinforcing public funding of vocational education and training (VET) to complement firms' training investments if these are insufficient, and helping small firms to provide training. Value might also be had in ensuring high levels of skills among the staffs of organisations that bridge the gap between young and small firms and the science base (such as science parks and business incubators). These staff members can help to identify skills needs in client firms.

Evidence from the OECD Survey of Adult Skills (PIAAC) suggests that a relatively large fraction of the adult working population may lack some of the skills that facilitate innovation. Levels of literacy and numeracy among workers vary across countries, and this variation is strongly correlated with the PISA results mentioned above (OECD, 2013c). Around half of all adults in the OECD area have low capabilities in "problem solving in a technology-rich environment" (Level 1 or below), an indicator that reflects both computer literacy and problem solving skills (Figure 3.2). Evidence from PIAAC also shows that adults with advanced skills in problem solving in a technology-rich environment are much more likely to receive job-related training than other workers.

Figure 3.2. **Proficiency in problem-solving in technology-rich environments among adults, 2008-13**

Percentage of 16-65 year-olds scoring at each proficiency level



Notes: Countries are ranked in descending order of the combined percentage of adults scoring at Levels 2 and 3. Adults included in the missing category were not able to provide enough background information to impute proficiency scores.

Source: OECD (2013d), *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills http://dx.doi.org/10.1787/888932900612.*

Policy should enable firms to adopt forms of work organisation that support innovation

Making the most of available skills for innovation depends in part on how the workplace is organised. For instance, Toyota's entrenched process of continuous incremental innovation reflects forms of workplace organisation that enable the collection and implementation of ideas from across its workforce (and this organisational asset has proven hard for competitors to copy). The OECD's PIAAC study shows a positive link between labour productivity and reading at work, even after controlling for average proficiency scores in literacy and numeracy. Indeed, once such adjustment is made, the average use of reading skills at work is found to explain 37% of the variation in labour productivity across countries (OECD, 2013c). In academia and industry, concepts such as employee engagement, high-performance working and the learning organisation are being widely studied. The evidence shows a link between management of human resources and innovation, although causality may run in both directions.

New OECD research indicates that different models of work organisation adopted by SMEs are associated with differences in their innovation performance. The effect is likely to operate through the impact of work organisation on the opportunities for the independent and creative use of employees' knowledge and problem solving abilities (OECD, forthcoming). Although causality cannot be confirmed, the evidence suggests that SMEs that adopt "learning organisation" or "discretionary learning" models – which are associated with teamwork, performance incentives and greater employee discretion in the planning and execution of tasks – have greater levels of product and process innovation and greater inter-organisational co-operation and knowledge exchange (relative to more traditional and hierarchically organised SMEs). Furthermore, the share of "learning organisation" SMEs varies substantially across countries. Micro-econometric analysis at the level of the firm, across 29 countries, shows a positive relationship between the national share of "learning organisation" SMEs and national innovation rates among SMEs (OECD, forthcoming).

While many decisions about human resources are the subject of practices internal to the firm, governments do have some scope to shape these decisions. Labour market policies that allow mobility and enable organisational change, while also supporting training, may help firms to adopt forms of work organisation that support innovation. Competitive markets – and the effective enforcement of competition policy – are also important in encouraging firms to innovate in terms of business organisation.

3.5. The participation of women in science and entrepreneurship

The participation of women in science may require particular policy attention. There are concerns that the skills of some highly trained women are underutilised and that the associated social and individual investments in education are at risk of being lost. Female scientists are concentrated in certain fields, such as biology. And the proportion of female scientists tends to fall as seniority rises. While participation is a result of personal choices, certain barriers to female participation may persist. These barriers include gender stereotypes, non-transparent nomination and appointment procedures, inadequate facilities for childcare, and insufficiently family-friendly workplace practices.

A variety of policies has been implemented to address gender issues in science. Countries have introduced equal opportunity legislation, units for women within science ministries, targets and quotas, networks and mentoring programmes, and policies on maternity and paternity leave. However, policies mainly aim at universities and public research institutions, not the private sector – although the Nordic and other countries have mandated quotas for female representation on the boards of publicly listed companies. Most of the relevant policies have also not been well evaluated.

OECD (2012c) shows that across the OECD area there are more male than female entrepreneurs, and the share of women who choose to run a business has not increased substantially in most countries. If women's intentions to engage in entrepreneurship are constrained by gender-specific conditions, society and the economy will fail to maximise entrepreneurial potential. Currently, more women than men become business owners out of necessity. On average, female-owned businesses register lower profits and labour productivity than male-owned businesses. These disparities can mostly be explained by differences in the size and capital intensity of female- and male-owned firms. Female entrepreneurs rely substantially less than men on external loans, but it is not clear if this is because women are less inclined to use external finance or because women experience discriminatory treatment in capital markets (or both). Female-owned firms do differ from male-owned firms in terms of innovation outcomes. But lower levels of product and process innovation in enterprises founded by women can be explained by the sectoral, investment and size characteristics of their firms, as well as by women's entrepreneurial experience prior to start-up.

Making the most of the available talent pool is also about ensuring that women have equal opportunities to contribute to innovation. Analysis of "gendered innovation" shows that removing gender biases can improve research and innovation and open up new market opportunities (European Commission, 2013). Examples included in the EU report note, "In engineering, for example, assuming a male default can produce errors in machine translation. In basic research, failing to use appropriate samples of male and female cells, tissues, and animals yields faulty results. In medicine, not recognising osteoporosis as a male disease delays diagnosis and treatment in men. In city planning, not collecting data on caregiving work leads to inefficient transportation systems." Taking better account of gender differences is therefore of great importance for science and innovation.

3.6. Competition and collaboration in the global market for internationally mobile talent

Increasingly, the international mobility of highly skilled individuals is a defining feature of the global innovation landscape. A range of innovation activities cannot be conceived without taking into account their global nature and the role played by mobile talent. This is particularly apparent in science, where progress relies on the circulation of knowledge, interaction between scientists, and the exchange of diverse views and evidence. Furthermore, businesses and academia often seek foreign staff for their specific knowledge and abilities. For talented individuals, mobility provides a means to exploit opportunities abroad, further develop their human capital, fulfil vocations and improve their livelihoods.

Global flows of highly qualified individuals, students, scientists and engineers have increased steadily over the past two decades (Docquier and Rapoport, 2012). Economic and cultural factors have contributed to making international mobility more affordable. For example, the cost of international flights is only a fraction of what it was in the early 1970s. And English as a working and teaching language is now widespread. Policies to attract talent and promote its circulation also appear to have been important.

Migration is increasingly skill-based. The number of highly skilled migrants increased by 70% during the past decade (Arslan et al., 2014).

Students – particularly tertiary-level students – are at the forefront of the increased international mobility of talent. During the period 2000-12 the number of foreign tertiary students enrolled worldwide more than doubled, with average annual growth of almost 7% (OECD, 2014a). Europe is the leading destination for tertiary-level students enrolled outside their country of origin, hosting 48% of these students, followed by North America and Asia.

Factors driving the increase in international student mobility range from the rapidly expanding demand for higher education worldwide and the perceived value of studying abroad, to government support for students in fields that are growing rapidly in the country of origin. In addition, some countries and institutions actively seek to attract foreign students (OECD, 2014a).

Internationalisation is even more marked in the upper tier of post-secondary education. International students account for nearly a quarter of all students in advanced research programmes such as doctorates (OECD, 2014e). Data from a recent OECD/UNESCO/Eurostat study on doctorate holders show that, on average, 14% of national citizens with a doctorate degree have had at least one experience of international mobility of three months or longer over the previous ten years. Individuals with doctorates who have already experienced international mobility are more likely to report an intention to move abroad, mainly for the purpose of knowledge acquisition. The data also show some significant differences across countries in the relationship between international mobility and earnings. International mobility can be associated with lower earnings in a number of countries, which suggests rigidities in the labour market for the highly skilled (Auriol, Misu and Freeman, 2013; OECD, 2013b).

Global databases on key actors in science and innovation systems, such as scientists and inventors, help to gauge the extent of brain circulation. For example, patents filed under the Patent Cooperation Treaty contain information on both the residence and the nationality of inventors. These data suggest that, in 2005, 10% of inventors worldwide had an experience of migration (Miguélez and Fink, 2013). An indicator developed for the *OECD Science, Technology and Industry Scoreboard 2013* tracks changes in the institutional affiliation of authors who published in scientific journals over the period 1996-2011. Large differences are seen to exist in scientist mobility: nearly 20% of authors based in Switzerland have had a previous affiliation abroad. However, in Japan, Brazil and the People's Republic of China (hereafter "China"), researcher mobility stands at less than 5%.

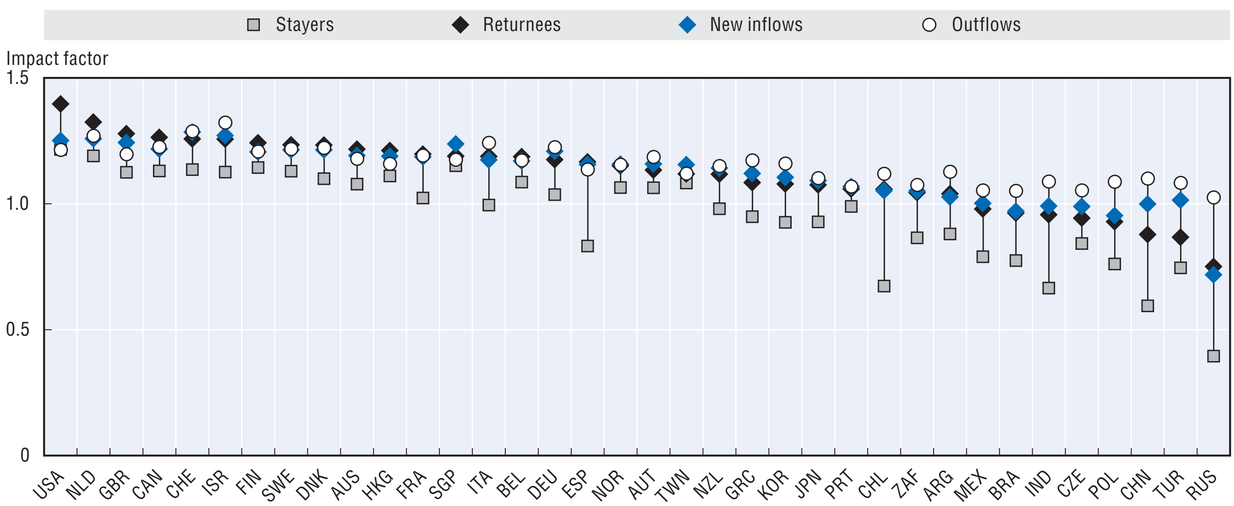
On average, the research impact of scientists who change university (or research centre) affiliation across national boundaries is 20% higher than those who never move abroad (Figure 3.3). If the performance of "stayers" could be raised to the level of internationally mobile researchers, many economies would catch up with leading research nations. Of course, causality in this relationship could go in both directions, as high-impact researchers may well have more opportunities to move internationally. But a lack of mobility and exposure to leading scientists and their institutions is likely to be a drag on the scientific performance of an institution or of a country as a whole, and could ultimately affect a country's innovation capacity.

There is new and compelling evidence that geographic, cultural, economic and scientific distance measures are good statistical predictors of mobility among scientists (Appelt et al., 2015) and among inventors (Miguélez and Fink, 2013). The analysis of bilateral flows of scientists also provides evidence of two mechanisms by which home countries can benefit from mobility. First, mobility is closely related to scientific collaboration. Economies that have higher rates of international collaboration tend to have higher average citation rates, and top-cited publications are more likely to involve scientific collaboration across institutions (especially internationally) than "average" publications (OECD, 2013b).

Secondly, the mobility of scientists is strongly related to student flows in the opposite direction. These findings lend support to a "knowledge circulation" perspective on scientist mobility, rather than a more traditional zero-sum view in which some countries win talent at the expense of others. Mobility among scientists appears to occur in the context of wider and more complex networks of mobile, highly educated and skilled individuals. The analysis also shows that mobility can be positively influenced by convergence in economic conditions and resources dedicated to R&D, as well as reduced visa-related restrictions.

Figure 3.3. **The impact of scientific authors, by category of mobility, 1996-2011**

Based on the median source-normalised impact per paper (SNIP)



Note: This is an experimental indicator.

Source: OECD (2013b), *OECD Science, Technology and Industry Scoreboard 2013*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/888932891549*. OECD calculations based on Scopus Custom Data, Elsevier, version 5.2012 and *SNIP2 Database*, *www.journalmetrics.com*.

The knowledge embodied in people is the object of strong global competition. But policy makers also need to be aware of the potential for different countries to simultaneously benefit from this knowledge. Policies should not be based on the idea that international mobility entails zero-sum competition. The recommendation in the 2010 OECD Innovation Strategy (OECD, 2010) that policy on mobility should support knowledge flows and enduring networks across countries thus appears to be validated by more recent evidence.

Educational accreditation standards and information are important in helping individuals demonstrate competences acquired elsewhere, thus removing major barriers for mobility and improving the efficiency of the global market for advanced skills. While countries sometimes enter into bilateral arrangements, international mobility is also promoted through multilateral programmes. For example, international co-operation in standardisation and grade recognition, and academic exchange among signatory countries, is part of the Bologna Process in the European Union, which also has initiatives to share information on funding opportunities and job vacancies for researchers in Europe (EURAXESS) (OECD, 2014e). UNESCO and the OECD have jointly developed guidelines for quality provision in cross-border higher education (OECD, 2005). These guidelines aim to facilitate the recognition of foreign degrees, ensure consumer protection for students and other stakeholders, and guarantee quality in the international mobility of students, researchers, educational programmes and institutions. Monitoring of the guidelines shows they have largely been implemented, but that some gaps remain in terms of information, transparency and consumer protection (Vincent-Lancrin and Pfotenhauer, 2012; Vincent-Lancrin, Fisher and Pfotenhauer, forthcoming).

Higher education policies focused on student mobility provide an opportunity to concentrate limited resources on educational programmes with potential economies of scale. And for host countries, *enrolling international students* can help raise revenues from higher education, and be part of a broader strategy to recruit highly skilled immigrants.

Some recruitment practices in the publicly controlled research system can have adverse effects on mobility. Evidence of an earnings penalty for international mobility paid by researchers in some countries may be a sign of dysfunctional personnel policies. If by moving abroad to acquire competences individuals find themselves in a worse position to take jobs in their home institutions, relative to those who stay, this may negatively affect mobility and research excellence. Some institutions address this problem by recruiting in international labour markets, precluding the hiring of incumbent students, or requiring mobility as a qualification for hiring, accompanied by relevant support incentives.

Restrictive immigration and visa policies appear to have negative effects on inflows of skilled workers. Even generic visa restrictions on short-term visits appear to hinder the most basic forms of collaboration. Immigration policies in several countries favour inflows of highly skilled individuals above other population groups. Barriers to the cross-country provision of some specialised services can also hinder certain forms of mobility among the skilled workforce. Policy makers should consider whether perceived shortages are best addressed by removing barriers to mobility or whether problems have other causes.

Financial assistance for mobility and support for the development of absorptive capacity are major policy approaches. Most OECD countries operate programmes to support the short-term outward mobility of students and researchers. These programmes differ with respect to the conditions and expectations placed on individuals upon their return. A major issue for policy makers is to develop coherent approaches for creating value from investments in acquiring skills abroad. This need not involve the creation of academic positions. Promoting the development of absorptive capacity in the business sector is a complementary option. Several countries offer schemes to attract the return of nationals working abroad or encourage the inward mobility of foreign-born individuals, even to a point where such measures become a central part of science and innovation strategies (OECD, 2014e).

Some countries provide tax relief for key foreign employees to help companies attract international expertise to their domestic operations. This is sometimes justified on the basis that short-term stayers do not get to fully benefit from local social welfare and pension systems. Such schemes have become increasingly popular in OECD countries. However, the schemes can become complex, imposing substantial compliance and administrative costs relative to the potential gains in employment or innovation (OECD, 2011b).

Main policy messages: Fostering talent and skills for innovation

Human capital policy for innovation must address a wide array of skills. A key principle should be the creation of an environment that enables individuals to choose and acquire appropriate skills and that supports the optimal use of these skills at work (the OECD's Skills Strategy sets out a comprehensive assessment of good practice in this area). An innovative economy and society requires the development, activation and use of skills in many disciplines and at many levels. There is no skills-related silver bullet for innovation.

Because international rankings often emphasise research, countries should give more incentives to institutions to improve the quality and relevance of their teaching. Broad curricula, updated pedagogical practices and the development of tools to assess innovation-related skills are all important in initial education. Beyond subject-specific expertise, tertiary education should also develop students' creativity, critical thinking and communication skills. Doing so ultimately depends on pedagogical approaches and the design of curricula.

Support for firm-level training requires a variety of steps. Possible policy avenues include improving information about training opportunities, setting legal frameworks so that private parties can organise and finance their training (e.g. through contracts), and increasing the portability of skills by improving information on the competencies and skills that are gained through various learning channels. Tax incentives to promote training might be a supplementary measure. Other policy suggestions include reinforcing public funding of VET to complement firms' training investments if these are insufficient, and helping small firms to provide training.

Individuals should have access to sufficient information – and be given incentives – to participate in work-related or other kinds of training over their life span.

Policy makers should assess the attractiveness of careers in academic research and improve these if necessary. Low starting pay, limited material rewards at senior levels, temporary contracts, and difficulties in moving institutionally and internationally because of tenure arrangements and pension rights lower interest in academic research careers.

At **a minimum, policy should ensure that barriers to women's participation in science and entrepreneurship are removed.** Gender stereotypes and non-transparent nomination and appointment procedures can all hinder female involvement in science. Shortages in regard to female experience of entrepreneurship should be addressed (for instance through innovations in the design and delivery of training programmes and support for networks of women entrepreneurs at multiple levels). Awareness programmes showcasing successful women in science and technology, and in high-growth firms, can provide useful role models for young women who may not otherwise consider such fields.

Policy should facilitate the development of enduring linkages and networks among researchers across countries. The knowledge embodied in people is the object of strong global competition. But policies should not be based on a view that international mobility entails zero-sum competition. Collaboration between countries often results in better outcomes. A key consideration is that migration regimes for the highly skilled should be efficient, transparent and simple, enabling movement on a short-term basis. Another consideration is the importance of facilitating the mutual recognition of skills, so as to allow efficient matching of mobile workers and jobs. Policy can also encourage inward and outward mobility. For example, for researchers, scientists and engineers, countries offer a range of economic incentives for inflows, including fellowships, grants and project funds, scholarships and tax benefits (although fewer options exist for those seeking to do research abroad). Individual institutions such as universities can also contribute. Their practices towards travel grants and support for mobile researchers can complement policies at national level. And recruitment practices in publicly controlled research systems should not create earnings penalties for internationally mobile researchers. Such practices may negatively affect both mobility and research excellence.

Notes

1. See for instance the speech given by US Federal Reserve Chairman Ben Bernanke to the conference on New Building Blocks for Jobs and Economic Growth. Available at: *www.federalreserve.gov/newsevents/speech/bernanke20110516a.htm*.
2. Intermediate technical skills are technical skills that are typically bounded at the lower limit by unskilled labourers and at the upper limit by university or polytechnic graduates engaged in management, research, design or production (Steedman, Mason and Wagner, 1991). Such intermediate technical skills are often developed through a mix of school- or workplace-based vocational education and training.

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