

## *7. Enhancing the Role of Tertiary Education in Research and Innovation*

### **7.1 Introduction**

This Chapter focuses on the role of tertiary education institutions (TEIs) in research and innovation. A central reason for looking at the tertiary education system in an innovation context is that in all OECD countries governments finance not only education infrastructure costs, but also a large proportion of gross expenditure on research and development (R&D), which flows to universities and other TEIs. One rationale for this sizable funding is the direct and indirect support given by the tertiary education sector to the overall innovation effort. This Chapter will therefore analyse the role(s) of tertiary education from a research and innovation perspective. It reviews the empirical evidence and analyses the governance of tertiary education research. Finally, it concludes by outlining policy options for enhancing research and innovation for countries to consider.

### **7.2 The role(s) of the tertiary education sector in the research and innovation system**

TEIs play multiple roles in the knowledge economy, and it is important not to limit the focus of any analysis of their economic roles. Moreover it should be noted that the economic functions of tertiary education – which occur essentially through the effects of human resource development, R&D and knowledge diffusion on technological innovation – are by no means the sole role of the system. Universities in particular support many fields of knowledge that have no economic role to speak of, yet an enormous social and cultural significance. Protecting and fostering such fields, especially as financing and governance systems change, is an increasingly urgent policy challenge. Beyond universities, there are usually systems of non-university institutions engaged in vocational training, often closely linked to industry, and incorporating training related to apprenticeships. The different functions of the tertiary education system in particular national innovation settings may be performed by quite different types of organisations across countries, so that both inter-country and intra-country diversity is common. Moreover, TEIs perform a variety of research (see Box 7.1).

This Chapter focuses on the tertiary education sector's support for innovation. In terms of research and innovation, many current policy frameworks see the tertiary education sector, and universities in particular, essentially as places where new scientific and technological principles are discovered. The issue then becomes, how well these discoveries are transformed into innovations. This kind of focus leads to an emphasis on commercialisation as a problem for tertiary institutions, and a policy focus on intellectual property rights, patenting, and technology transfer from tertiary institutions. However, it is important to remember that the contribution of the tertiary education sector to global knowledge resources is not limited to specific discoveries. There are at least four broad

ways in which tertiary education contributes to the use of knowledge in both economic and social life. These are:

- the building of knowledge bases (primarily through research);
- the creation of capabilities (through teaching and research training);
- the diffusion of knowledge (through interactions with knowledge users); and
- the maintenance of knowledge (inter-generational storage and transmission of knowledge through codification, libraries, databases, *etc.*).

These roles are examined in turn below.

#### **Box 7.1. Types of R&D**

R&D data are presented in various ways, one of which concerns the “type of research”. Although the statistical categories differ slightly across countries, R&D data are usually presented in terms of three main types, namely basic research, applied research and experimental development. It would be misleading to identify these with particular TEIs – that is, to think of universities as doing purely basic research, or vocational TEIs doing applied R&D. The mix tends to be more complicated. Even elite science universities perform considerable amounts of applied R&D, often in collaboration with public or private partners, and other institutions can, and do, undertake fundamental science.

The *Frascati Manual* (OECD, 2002) distinguishes three types of R&D:

**Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

**Applied research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

**Experimental development** is systematic work, drawing on knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed.

It is important to note that the *Frascati Manual* acknowledges there are many conceptual and operational problems associated with these categories because they seem to imply a sequence and a separation which rarely exist in reality. The three types of R&D may sometimes be carried out in the same centre, and there may be movement in both directions.

#### **7.2.1 Building knowledge-bases**

The tertiary sector has long been considered the primary producer of new knowledge. This is only partially true, since research institutes and government laboratories (especially related to defence), and some research-intensive companies, play important roles in basic research. Universities, however, are central to the innovation systems of OECD countries. They build knowledge bases through research and associated activities, but this does not consist simply of “breakthrough” or “blue-sky science”. The research effort also involves the patient accumulation of knowledge through incremental research, testing, improved measurement, better instrumentation or new uses of research technologies. It also involves non-scientific knowledge generation from the humanities and social sciences. University researchers led the way in the use of computers in research, for example, and this had wide impacts on industrial R&D (Colyvas *et al.*, 2002). Tertiary research may involve such activities as monitoring natural phenomena over long periods or combining existing knowledge in new ways. The research effort also links diverse areas of knowledge, creating wider and more complex multi-disciplinary

knowledge bases. Against this background, research is not only a process of discovery, it is also a process of problem-solving that may not lead to knowledge breakthroughs, but simply expands knowledge in ways that may be of great economic and social importance.

### ***7.2.2 Developing human capital***

The theory and applied analysis of human capital formation focuses in part on formal education, and in part on the creation of firm-specific human capital, via vocational or on-the-job training. Teaching has long been a – perhaps *the* – central function of TEIs. Despite the fact that teaching is often held to be closely linked to research, it is arguably quite separate from it (Nelson, 1986; Martin, 2003). From the technological point of view, education has at least two main dimensions: inculcating specific forms of knowledge or skills, via training in sciences or technology related disciplines such as chemical engineering, and developing problem-solving capabilities of a more general character. The latter is particularly important since the dynamics of knowledge imply a need for continual updating and retraining. Technologically speaking, these functions of the tertiary education system occur mainly through science and engineering training, an area that has expanded considerably since the late 19th century, and that continues to grow. However, non science and technology occupations also contribute to knowledge assets, via social sciences and humanities disciplines.

### ***7.2.3 Knowledge diffusion and use***

TEIs are not only repositories of knowledge – they are active in spreading knowledge results. The transmission of knowledge is just as significant for innovation as knowledge creation, since it is only via diffusion that new knowledge can have economic and other societal impacts. This can take several forms. First, universities and vocational TEIs publish. They have incentive structures that encourage early and timely publication, and this is a key form of diffusion since many companies monitor such publications, and companies also undertake basic R&D simply to be able to keep up with and use university-based research (Rosenberg, 1990). However they also diffuse knowledge via collaborative research programmes, via consultancies, via joint ventures, and via informal channels. The last of these can often be very important. A number of studies of engineering practice have shown that engineers often retain links with those who have taught them, and that they use these links in seeking solutions to engineering problems that they encounter (Gibbons and Johnston, 1974, was a pioneering study on this). The diffusion of knowledge is not simply a matter of spreading results since it also takes the form of assisting engineers solve problems through ideas about potentially rewarding search paths. TEIs not only spread knowledge, they spread search heuristics, or fruitful ways of searching.

### ***7.2.4 Knowledge maintenance***

Knowledge must not only be created, it must be maintained. The tertiary education sector is an important vehicle for storing and maintaining knowledge stocks. This occurs through storage and retrieval systems such as libraries, oral transmission, databases, computing resources and conferences. It should be remembered that much of the knowledge that society uses is not new. Old knowledge does not survive by itself, and it is easy for knowledge to disappear. There are spectacular examples of forms of technological knowledge that disappeared and are then laboriously rediscovered.

Maintaining knowledge can be a resource-intensive activity, and the costs of maintenance are not trivial. This can be a major burden for tertiary education budgets.

### 7.3 The tertiary education research and innovation environment: The empirical perspective

This Section uses a range of quantitative indicators to analyse research and innovation trends in TEIs. It also draws on the country background reports and country review reports to illustrate policy initiatives that have been implemented in countries taking part in the Review. The Section is structured according to the main roles of the tertiary education sector presented above, namely building knowledge bases, developing human capital and knowledge diffusion.

Before turning to these roles, it is important to note that the social sciences and humanities make an important contribution to research and innovation systems and economic growth, even though much of the current analytical focus (and data) is directed towards science, engineering and technology. The social sciences and humanities contribute towards building knowledge stocks and to training skilled graduates. These graduates make an important contribution to the economy, irrespective of the field of training. For example, understanding indigenous knowledge, national identity and similar concepts are increasingly important strategic goals for governments.<sup>11</sup> Moreover, research in the social sciences and humanities is also essential for solving “technical” problems. Nightingale and Scott (2007) point out that the justification for public funding of the biological sciences is “...largely at odds with the outcomes [because] major causes of illness, such as poverty, lack of education, and poor housing and healthcare are social and political issues that are poorly addressed by the current science-intensive research system.” Indeed, solutions to global challenges, such as environmental, health and energy issues, will need to draw on more inter and multidisciplinary research.

Furthermore, industries based on the social sciences and humanities can also be highly innovative. For example, according to recent estimates by the National Endowment for Science, Technology and the Arts (NESTA, 2006), creative industries<sup>12</sup> account for 8% of the United Kingdom’s economy, and the global market value of these industries increased from USD 831 billion in 2000 to USD 1.3 trillion in 2005.

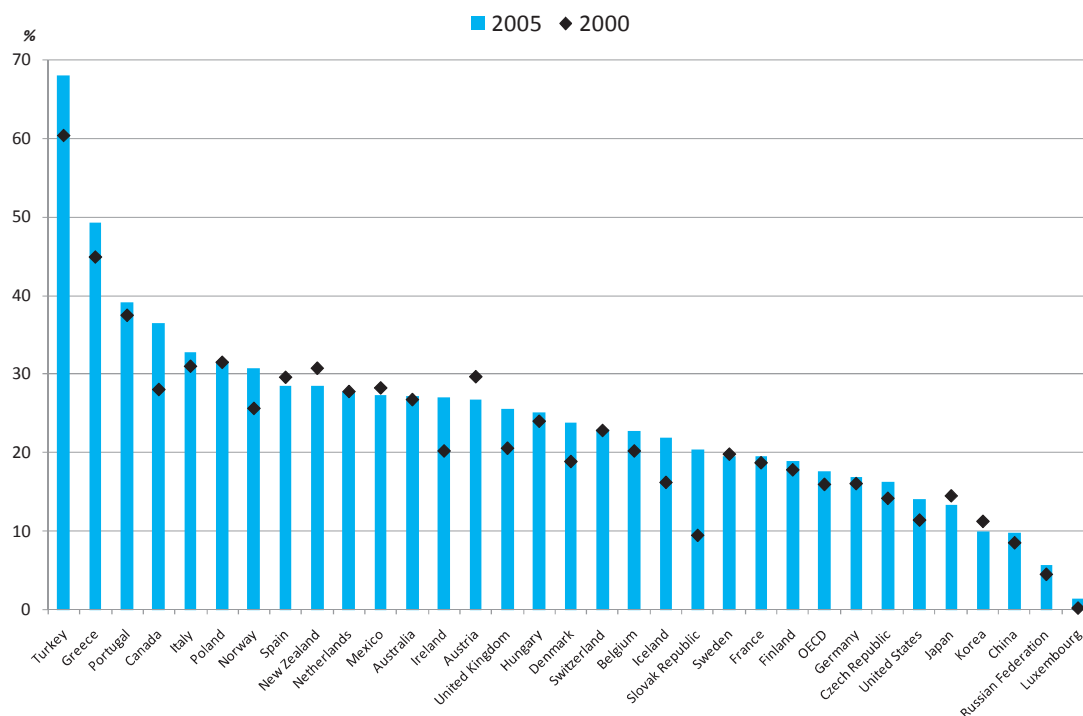
#### 7.3.1 R&D trends and scientific and technological output

Investment in R&D is an important indicator of the efforts that countries are putting into achieving scientific and technological progress. Figure 7.1 shows the higher education sector performs a large share of R&D in many countries. In 2005, the share of R&D performed in the higher education sector peaked in Turkey at 68%, followed by Greece, Portugal and Canada, which were all above 35%. Across the OECD, the average was 18%. Between 2000 and 2005 the share of R&D performed in the higher education

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11. For example, in 2002 Australia announced four National Research Priorities. One of the priorities is “safeguarding Australia”, which is tied to understanding languages, societies and cultures. In New Zealand, distinctive contributions to research, science and technology and the creative potential of traditional knowledge are increasingly being recognised (Ministry of Research, Science and Technology, New Zealand, 2006).
12. Creative industries include advertising, architecture, design, film and video, interactive leisure software (such as computer games), music, the performing arts, publishing, software and computer services, television and radio (NESTA, 2006).

sector grew in more than half of the countries represented in Figure 7.1. The largest increase was in the Slovak Republic where the share of R&D performed in the higher education sector increased by nearly 11 percentage points. The share in Canada rose from 28% to 36%, whereas across the OECD the increase was 2 percentage points.

**Figure 7.1. Percentage of gross domestic expenditure on R&D (GERD) performed by the higher education sector, 2000 and 2005**



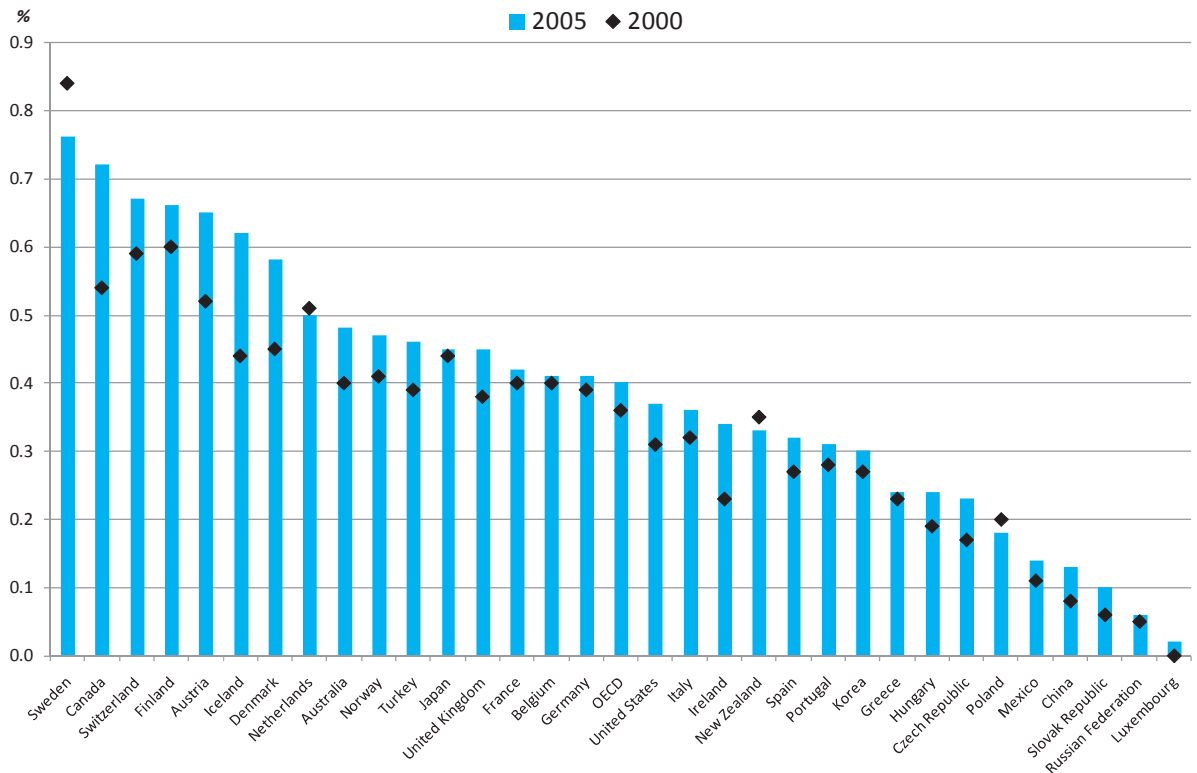
Countries are ranked in descending order of the percentage of GERD performed by the higher education sector in 2005.

Note: For '2000' data, the reference year is 1998 for Austria and 2001 for the Czech Republic, Greece, New Zealand, Norway and Sweden. For '2005' data, the reference year is 2003 for New Zealand and 2004 for Australia, Italy, the Netherlands and Switzerland.

Source: OECD, Main Science and Technology Indicators Database, 2007-1.

In GDP terms, higher education R&D expenditure has risen steadily from 0.36% to 0.40% of GDP across the OECD between 2000 and 2005 (Figure 7.2). The largest increases occurred in Austria, Canada, Denmark, Iceland and Ireland. In the Netherlands, New Zealand, Poland and Sweden R&D in higher education institutions declined as a share of GDP. The difference among OECD countries remains large. Sweden has the highest ratio of higher education R&D (HERD) to GDP in the OECD area, at 0.76%, followed by Canada (0.72%), Switzerland (0.67%) and Finland (0.66%). Most large OECD countries, including France, Germany, Italy, Japan, the United Kingdom and the United States, devote between 0.35% and 0.45% of GDP to R&D in higher education intuitions. Luxembourg had the lowest ratio because it established its first university in 2003.<sup>13</sup> Other OECD countries with low R&D spending by higher education institutions as a proportion of GDP are Mexico, Poland and the Slovak Republic.

13. However, other types of TEIs existed before 2003.

**Figure 7.2. Higher Education Research and Development (HERD) as a percentage of GDP, 2000 and 2005**

Countries are ranked in descending order of the HERD as a percentage of GDP in 2005.

Note: For '2000' data, the reference year is 1998 for Austria and 2001 for Greece, Norway and Sweden. For '2005' data, the reference year is 2003 for New Zealand and 2004 for Australia, Italy, the Netherlands, Switzerland and Turkey.

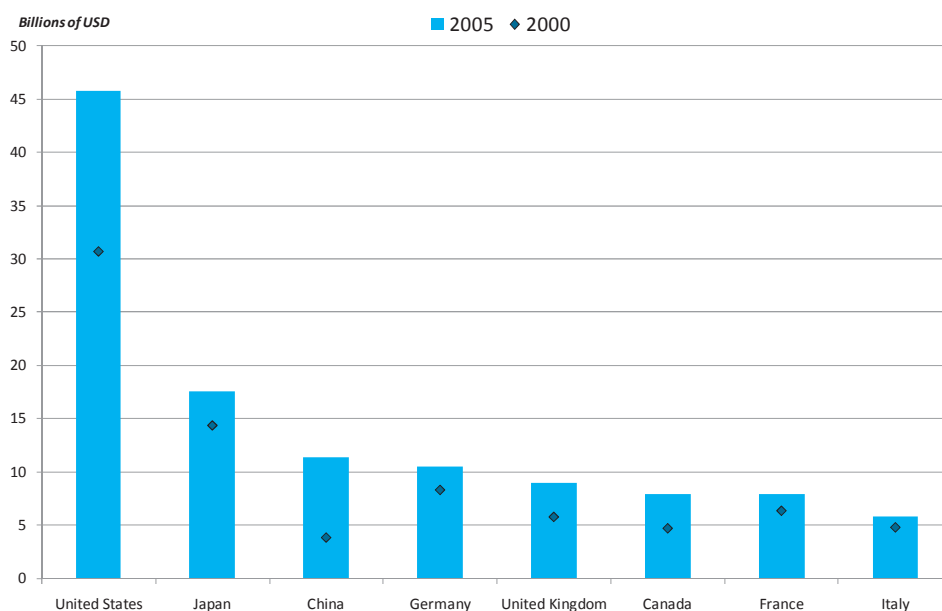
Source: OECD, Main Science and Technology Indicators Database, 2007-1.

Between 2000 and 2005, higher education R&D expenditure (in absolute terms) increased across all countries represented in Figure 7.3. China experienced the highest average annual increase over the period reaching 24%, followed by the Slovak Republic (20%) and Ireland (17%). Austria, Canada, the Czech Republic, Hungary, Iceland, Mexico, Spain and the Russian Federation saw increases of 10% or more annually during this period. Annual growth across the OECD was 7%, which was noticeably higher than the annual R&D growth rates in the business and government sectors. Across the OECD, business expenditure on R&D increased 4% annually over the period 2000 to 2005 whereas in the government sector the rate was 5% across the OECD. The larger expenditure increases in the higher education sector may reflect the growing recognition that R&D in higher education institutions is an important stimulus of economic growth and improved social outcomes.

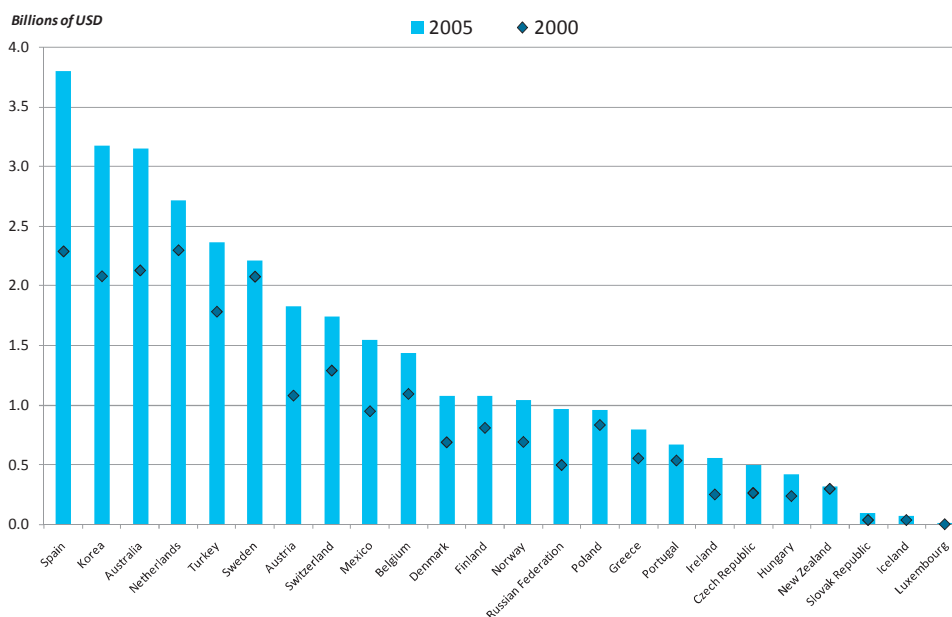
**Figure 7.3. Higher education expenditure on R&D, 2000 and 2005**

Billions of USD, current (PPP)

Expenditure above 5 billion



Expenditure below 5 billion

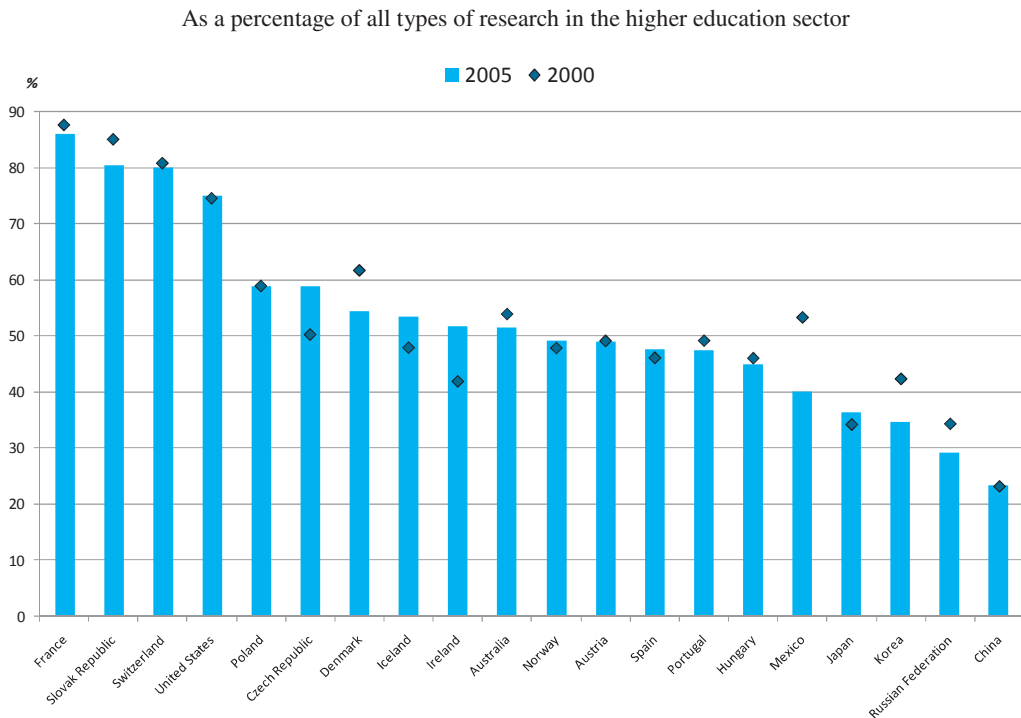


Countries are ranked in descending order of higher education expenditure on R&D in 2005.

Note: For '2000' data, the reference year is 1998 for Austria and 2001 for Greece, New Zealand, Norway and Sweden. For '2005' data, the reference year is 2003 for New Zealand and 2004 for Australia, Italy, the Netherlands, Switzerland and Turkey.

Source: OECD, Main Science and Technology Indicators Database, 2007-1.



*Types and fields of R&D***Figure 7.4. Share of basic research performed within the higher education sector, 2000 and 2005**

Countries are ranked in descending order of the share of basic research performed within the higher education sector in 2005.

Note: For '2000' data, the reference year is 1998 for Iceland and 1999 for Norway. For '2005' data, the reference year is 2003 for Mexico and Portugal and 2004 for Australia, Austria, Denmark, France and Switzerland.

Source: OECD, R&D database, 2007.

As mentioned above, TEIs perform three different types of R&D (see Box 7.1) and do not necessarily undertake basic research exclusively. Indeed, as shown in Figure 7.4 the share of basic research performed within higher education institutions in 2005 ranged from 86% in France to 23% in China. Figure 7.4 also shows the share of basic research undertaken in TEIs from 2000 to 2005 has fallen in 11 of the 20 countries represented. Mexico experienced the largest decrease from 53% in 2000 to 40% in 2005. Conversely, the share of basic research performed in higher education institutions grew 10 percentage points in Ireland over the same period. In some countries it is possible to look at the data over a longer time-period, which reveals that the share of basic research performed in higher education institutions has slowly decreased. For example, in Australia the share of basic R&D in higher education institutions was 67% in 1981 and 63% in 1990, and in Sweden it was 70% and 66% respectively. Conversely, in other countries the share has gradually increased. In the United States the share of basic R&D was 63% in 1980 and 66% in 1990 whereas in Japan the share grew from 30% in 1981 to 33% in 1991. These results suggest that the focus of R&D in higher education institutions is not static and may be linked to wider industrial, social or national priorities.



### R&D in vocational TEIs

Even though R&D data is collected at the institutional level it is aggregated according to the sector of performance. Therefore, it is not possible to quantify R&D expenditure across the different types of TEIs.<sup>14</sup> In some countries, some post-secondary institutions are excluded from R&D data collections. In the case of Australia, for example, only universities are surveyed because other TEIs (such as Technical and Further Education colleges) are excluded since the national statistical agency considers that “their contribution to total R&D activity would be minimal” (ABS, 2004). In the Netherlands, the vast majority of higher education R&D takes place in universities and research institutes, and in New Zealand, two universities accounted for more than 50% of the reported higher education R&D in 2004. In Estonia, research is concentrated in two universities, which account for around 70% of total R&D output. Smaller TEIs, including most professional higher education institutions, vocational education schools and private institutions in Estonia carry out very little research. In China, research and innovation is the objective of research universities and teaching and servicing regional economic development is the objective of teaching institutions. Conversely, the role of polytechnics has changed in Finland because R&D activities are now included in their formal objectives whereas previously they were viewed as teaching institutions only.

### R&D expenditures differ across countries by field of study

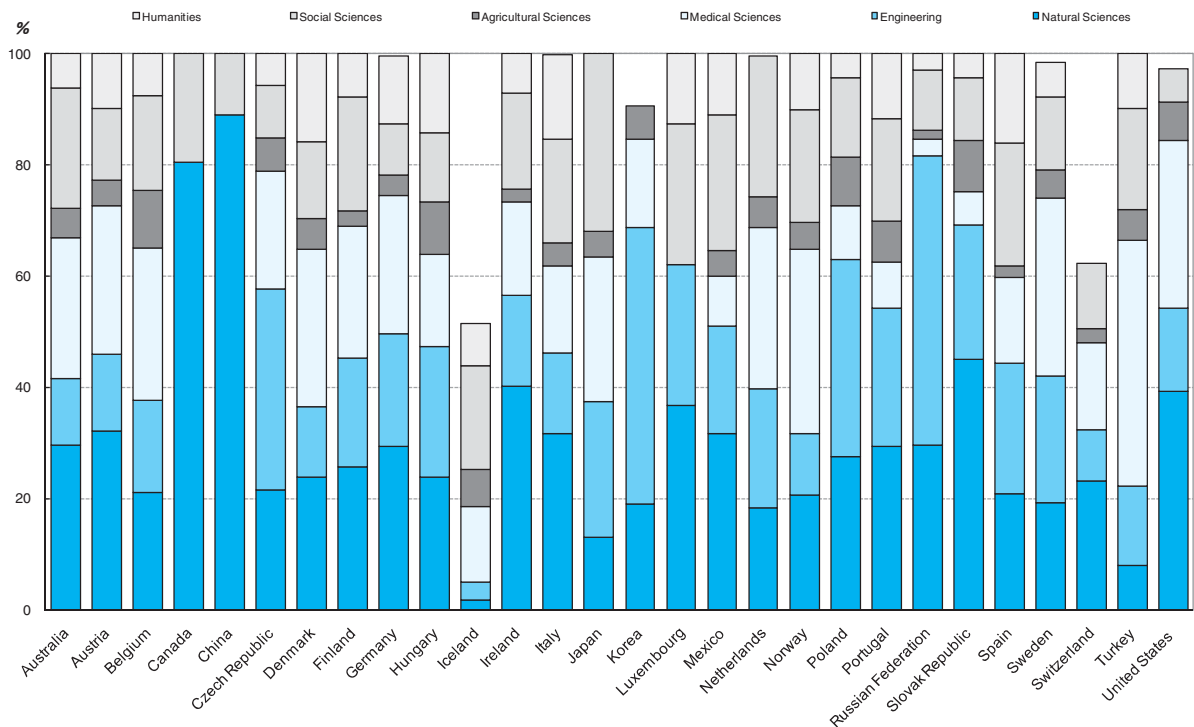
Significant differences remain in the fields of study towards which higher education R&D is directed. In the Russian Federation for example, over 85% of all research and development is carried out in natural sciences, engineering, medical sciences and agricultural sciences, with social sciences and humanities accounting for only a small share (Figure 7.5). In Luxembourg however, more than 60% of all higher education R&D is carried out in social sciences and humanities whereas in Mexico and Spain these fields account for around 35%. These differences may be linked to the specialisation of the innovation systems in each country. It is important to bear in mind that countries are often specialised in scientific or technological terms (Archibugi and Pianta, 1992), and so the types of specialisation in each country are likely to have a bearing on policy mechanisms aimed at removing demand gaps. Where gaps become more acute in the key fields and priority areas of particular countries, policy makers may have to focus on specific fields.

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14. According to the *Frascati Manual* (OECD, 2002), R&D data in the higher education sector should include all universities and other institutions of post-secondary education.

**Figure 7.5. Higher education R&D expenditure by field of study, 2005**

As a percentage of total higher education R&amp;D expenditure



*Note:* The reference year is 2001 for the United States, 2002 for the Netherlands, 2003 for Mexico and 2004 for Australia and Austria. In Canada and China sciences and engineering are combined. In Canada, China, Japan, the Netherlands and Switzerland social sciences and the humanities are combined. In Iceland, Korea, Sweden Switzerland and the United States some fields are not classified therefore the sum does not reach 100%.

*Source:* OECD R&D Database, 2007.

### *Scientific publications and patents*

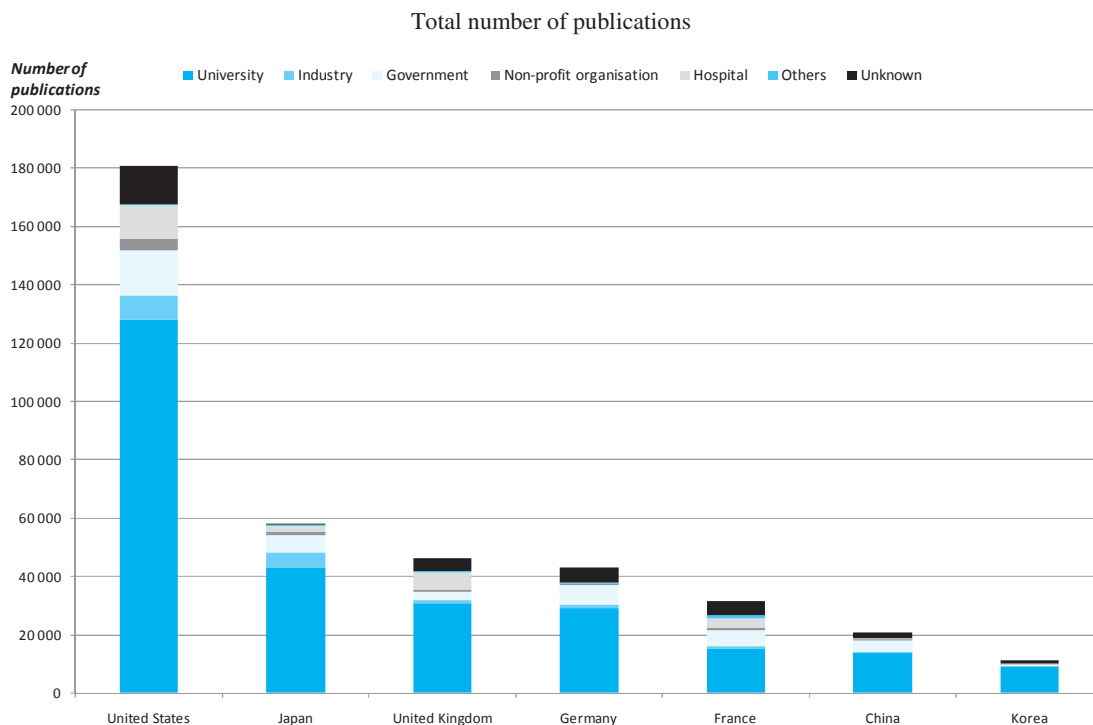
The main indicators of R&D output at the present time are the numbers of published journal articles (on the basic R&D side), and patent applications (on the applied and experimental development side). Data on publications and citations can be used to measure the quantity and impact of scientific output in the higher education sector. Even though these bibliometric indicators are imperfect,<sup>15</sup> the number of journal articles is an indicator of output and knowledge generation. As shown in Figure 7.6, universities account for the bulk of scientific publications. Apart from France, more than 65% of publications can be attributed to universities. In Japan, universities accounted for 80% of publications and in the United States this figure was 71%. In absolute terms, United States universities produce the largest number of publications by a wide margin.<sup>16</sup>

15. For example, bibliometric databases do not cover all disciplines equally well, citation practices vary by scientific field, non-English journals are less well represented and the frequency of citation is not necessarily an indication of quality.

16. It should be noted that bibliometric databases are skewed towards American scientific literature.

However, in terms of the relative prominence of scientific literature (measured by the relative citation index), the United States ranked second, behind Switzerland, in 1995 and 2003 (NSF, 2006). It should also be noted there are large discrepancies between institutions. In the Netherlands, for example, 69% of research articles are produced by scientists and scholars employed at 13 research-intensive universities. In New Zealand, a study on the academic impact of research found the relative impact of research performance<sup>17</sup> differed markedly across universities and disciplines (Ministry of Education, New Zealand, 2007).

**Figure 7.6. Scientific publications by sector, selected countries, 2001**



*Countries are ranked in descending order of the total number of publications.*

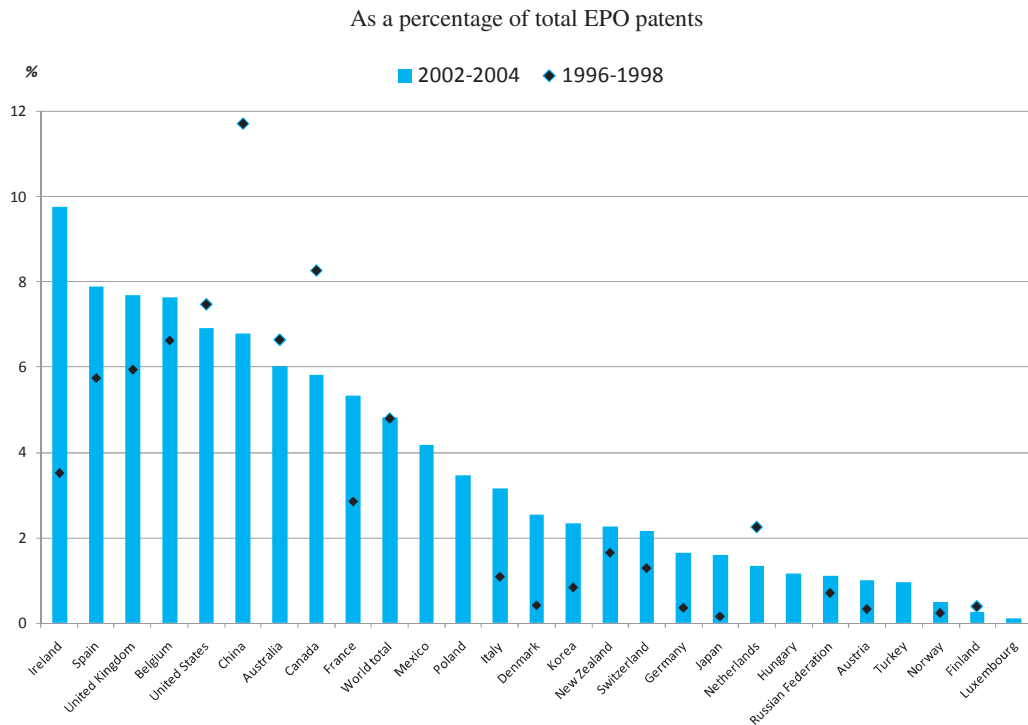
*Source: NISTEP, 2005.*

While TEIs dominate other institutional sectors in terms of scientific publication output, they account for only 4.8% of European Patent Office (EPO) world patents (Figure 7.7). The vast majority of patents are owned by companies (82% in 2002-2004). The share of patents owned by universities increased by 6.2 percentage points in Ireland over the period 1996-1998 to 2002-2004, followed by Mexico (4.2 percentage points), Poland (3.4 percentage points) and France (2.5 percentage points). Some countries experienced a drop in the share of patents owned by universities. The largest fall was in China (4.9 percentage points), followed by Canada (2.5 percentage points), the Netherlands (0.9 percentage points) and Australia and the United States (0.6 percentage points each). In some countries, like Sweden or until recently Germany or Japan,

17. The measure is calculated using the average number of citations per publication divided by the world average of citations per publication.

university professors are entitled to own patents resulting from their research, therefore these are not registered here as belonging to universities.

**Figure 7.7. Share of European Patent Office (EPO) patent applications owned by universities, 2002-2004**



*Countries are ranked in descending order of the share of patent applications owned by universities.*

*Note:* Patent counts are based on the priority date, the inventor's country of residence and fractional counts. This figure considers patent applications filed under the Patent Co-operation Treaty (PCT), at international phase, designating the European Patent Office (EPO). Only countries with more than 300 PCT filings per period are included. EPO patent applications are attributed to institutional sectors using an algorithm developed by Eurostat.

*Source:* OECD, Patent Database, using the Eurostat sector attribution algorithm, June 2007.

### 7.3.2 Human resources for science and technology

Human resources for science and technology (HRST) are critical to innovation and economic growth in two main ways. First, highly skilled people contribute to economic growth directly through their role in the creation and diffusion of innovations. Second, those with science and engineering (S&E) skills contribute in an indirect way, by maintaining society's store of knowledge, and by transmitting it to future generations. There are close links between formal education and innovation capabilities. Even though innovation requires many non-research and non-technological skills, there remains a consistently increasing demand for individuals with higher levels of education and advanced training in science and technology (S&T). Higher levels of education may also increase capabilities to use new technologies more effectively. Therefore, TEIs are a fundamental element of the research and innovation system because of the effects of human resource development and R&D capabilities on innovation and knowledge diffusion. Any economy needs a sufficient number of people with appropriate education, skills and training to support and increase its knowledge base.

HRST refers to people who are actually engaged in or have the relevant training to be engaged in the production, development, diffusion, application and maintenance of systematic scientific and technological knowledge. HRST are a central element in socio-economic development, and much work has been done in recent years to improve statistics and indicators on them. HRST are defined by the *Canberra Manual* (OECD, 1995) as people who fulfil one or other of the following conditions:

- i. Successfully completed education at the tertiary level in an S&T field of study (*i.e.* HRSTE).
- ii. Not formally qualified as above, but employed in a S&T *occupation* where the above qualifications are normally required (*i.e.* HRSTO).

It is important to clarify the differences between HRST, R&D personnel and researchers. The HRST definition is broad and covers “people actually or potentially employed in occupations requiring at least a first university degree” in S&T, where this includes all fields of science, technology and engineering study. R&D personnel, as defined by the *Frascati Manual* (OECD, 2002), are “all persons employed directly on R&D”, which includes those providing direct services such as R&D managers, administrators, and clerical staff, whereas researchers are defined as “professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems and in the management of the projects concerned.”

Table 7.1 provides a rough comparison of the size of each group in 2005 across the main OECD regions, China and the Russian Federation. By far the largest category is HRST, indicating the wide use of highly qualified people across the economy. R&D personnel stocks often include large proportions of technical support staff and administrators. Researchers are only a small subgroup of the highly skilled, but nevertheless they are crucial for R&D and innovation.

**Table 7.1. Human Resources for Science and Technology (HRST) in selected countries, 2005**

	HRST (completed education, ISCED 5A, 5B and 6)	R&D personnel (full time equivalent)	Researchers (full time equivalent)
<b>OECD</b>	191 729 858 <sup>1</sup>	Not available	<b>3 865 778</b>
<b>China</b>	70 336 000 <sup>1</sup>	1 364 799	<b>1 118 698</b>
<b>United States</b>	63 021 902 <sup>1</sup>	Not available	<b>1 394 682</b>
<b>European Union (EU-15)</b>	51 770 011 <sup>1</sup>	1 912 355 <sup>1</sup>	<b>1 088 206<sup>1</sup></b>
<b>Russian Federation</b>	42 238 000 <sup>2</sup>	919 716	<b>464 577</b>
<b>Japan</b>	<b>32 790 000<sup>1</sup></b>	<b>921 173</b>	<b>704 949</b>

Note: 1: 2004; 2: 2003.

Source: OECD Main Science and Technology Indicators database 2007/1; OECD, Education Attainment database, 2006; National sources for China.

Across the OECD, growth rates in professional occupations have outpaced employment growth overall, often by a wide margin. Employment in HRST occupations grew twice as fast as overall employment between 1996 and 2006 in most OECD countries (OECD, 2007a), and demand for skilled workers, and researchers, in particular, is expected to increase further. Real expenditure on R&D increased by around 2% annually between 2000 and 2005 across the OECD, and it is growing rapidly in non-OECD economies (for example, annual growth in China was 18%). Many OECD and non-OECD economies have policy targets to increase R&D intensity further in the coming years (see Section 7.4). While demand for HRST is increasing, it differs across scientific and technological fields. Some OECD countries have identified research priority areas where, despite variations, the broad focus is on information and communication technology (ICT), biotechnology and nanotechnology. However the extent to which these priority choices will affect HRST demand remains unclear.

Moreover, the demand for HRST is evolving, which has implications for supply-side education and training policies. Globalisation is changing firms' R&D strategies and this has a bearing on HRST and TEIs more generally. Multinational enterprises (MNEs) are altering how they innovate and this involves establishing R&D facilities around the world. In many OECD economies significant shares of domestic R&D are performed by affiliates of foreign firms, and firms headquartered in particular OECD countries are performing increasing amounts of R&D outside their home base. Firms appear to be relocating R&D to benefit from knowledge capabilities that are distributed across countries. This reflects the growing complexity of industrial and service sector knowledge bases which requires firms to build global strategies to access relevant R&D results and knowledge capabilities (for a full overview see OECD, 2006a: Chapter 4).

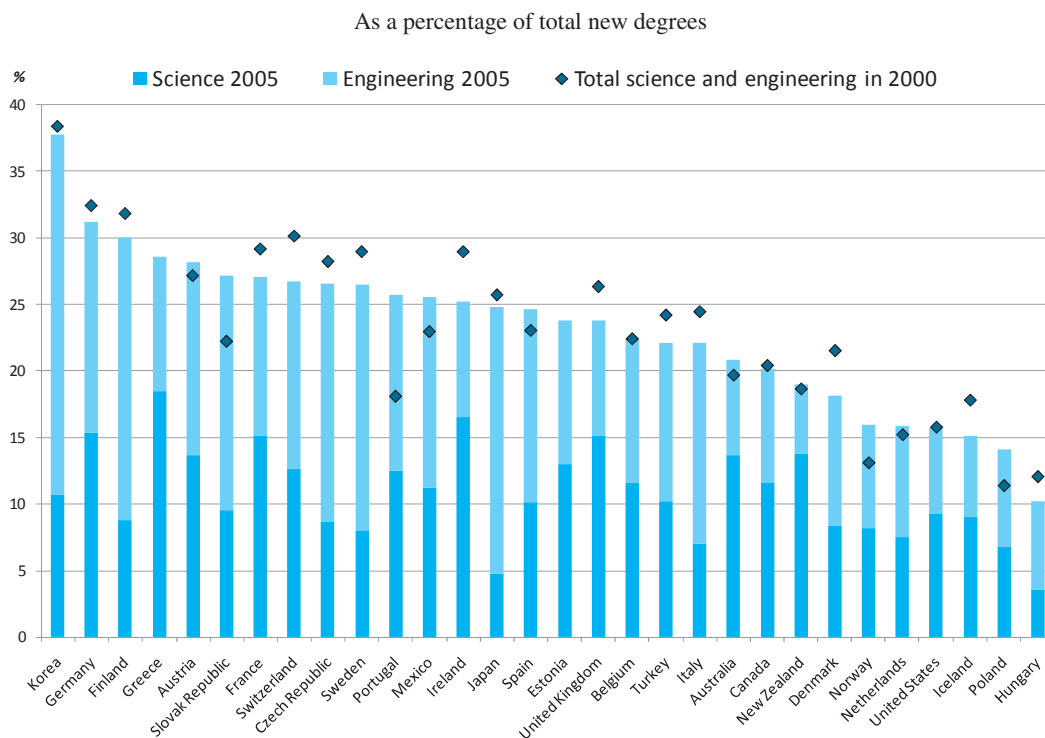
In addition, the expansion of R&D in the services sector and with it, knowledge intensive services (*e.g.* banking, financial and business services, health and education) has also changed the composition of demand for HRST. In 2004, service firms accounted for 25% of business sector R&D in the OECD, which was 11 percentage points higher than in 1995. In several countries, more than one-third of total business R&D is carried out in the services sector: Australia (47%), Norway (42%), Canada and Ireland (39% each), the Czech Republic (38%), the United States (36%) and Denmark (34%) (OECD, 2007a). An implication of change is that priority fields for education and training may be more varied than current R&D policy priorities suggest. In addition, in some of these high-demand fields the content of work is changing, so it is important to combine technical skills with “soft” skills such as problem-solving capabilities as well as communication and management skills (see Figure 7.10 for further details). Ultimately, the successful match between supply and demand for HRST depends on a flexible and rapid response from the higher education system as well as greater institutional and market incentives for mobility.

### *The supply of S&E graduates*

Graduates in science and engineering (S&E) are an essential component of HRST, and are particularly important for science-based industries, therefore countries are keen to ensure that supply continues to grow. On average, 25% of the degrees awarded at universities in the OECD area in 2005 were granted in science-related fields (engineering, manufacturing and construction, life sciences, physical sciences and agriculture, mathematics and computing). However, the number and proportion of S&E graduates has changed markedly across countries in recent years. In absolute terms, the number of students graduating in S&E increased with the exception of Germany, where engineering

graduates fell from 38 761 in 2000 to 38 135 in 2005, Hungary (engineering fell from 5792 in 2000 to 4582 in 2005) and Spain (science graduates dropped from 21 679 in 2000 to 20 400 in 2005). However, in relative terms, the share of S&E graduates decreased in 17 of the countries shown in Figure 7.8. The largest drop in the share of S&E graduates (around 3 percentage points or more) occurred in Denmark, Iceland, Ireland, Sweden, Switzerland and the United Kingdom. The share of S&E graduates in Portugal grew from 18% in 2000 to 26% in 2005, whereas growth in Mexico, Norway, Poland and Spain was between 1.5 and 5 percentage points in 2005.

**Figure 7.8. Science and engineering degrees, 2000 and 2005**



Countries are ranked in descending order of science and engineering degrees as a percentage of total new degrees.

Source: OECD, Education database, 2007.

There are however important differences among countries in terms of the mix of S&T graduates; some countries have more engineering graduates and others have more science graduates. This generally reflects the industrial structure and historical academic traditions, but also higher education and research funding policies. In 2005, around half of the countries shown in Figure 7.8 had a larger share of engineering graduates than science graduates. In some countries, notably Belgium, Germany, the Netherlands, Norway, Poland and Portugal, the picture is more balanced with around half of graduates in each field.

#### *Vocational training and skill development for innovation*

Even though S&E graduates are a key component of HRST, persons with technical skills and vocational training are also a central part of the research and innovation system



because innovation requires a variety of skills and capabilities. Innovating firms are not necessarily engaged in the development of radical, new to the world goods, services or processes. They can be reproducing products already on the market, perhaps using off the shelf technology inputs, or making small incremental improvements to existing products. However, this is not an easy or costless process because it requires learning and adaptation within the firm. In fact, innovation involves a range of activities such as tooling up, design work, developing prototypes and testing. These activities are a key function of vocationally trained personnel (for a full overview see Toner, 2007; and Tether *et al.*, 2005).

#### Box 7.2. Engaging polytechnics in New Zealand

The **New Zealand Institutes of Technology and Polytechnics (ITP) Business Links Fund** was designed to foster greater engagement between ITPs and business. The fund provides a resource to build the capability of ITPs to establish and maintain effective working relationships with the business sector.

The most common approaches in ITPs are to develop partnerships, relationships and joint ventures with industry, and involving industry in the development of qualifications and programmes, with the latter often being achieved through advisory groups.

Allocation of the fund was intended to reflect the differences in ITPs' missions, size and stakeholders and not create excessive transaction and compliance costs for ITPs or business. In 2005 a total of NZD 5 million was available for allocation, NZD 6 million in 2006, and NZD 7 million in 2007. A half-year appropriation of NZD 3.5 million is available in 2008.

A range of projects have been funded including:

- research to support business engagement plans, particularly on skill needs analysis;
- building human capability to develop staff skills to work with industry more effectively, including staff secondments to industry;
- increasing the relevance of provision, including student placements and secondments from industry, also known as “experts in residence”;
- establishing centres, incubators or clusters for co-operative curriculum development, increasing staff knowledge, provision of work experience for students and opportunities for graduates; and
- improving advice received through programme advisory committees through improved structures, increased resources and additional activities, such as regular forums with business stakeholders and community representatives.

In 2006 the focus for investment shifted from activities designed to improve relationships with business stakeholders, to the adaptation of provision to meet the needs of local business/industry.

*Sources:* Country Background Report and Country Review Report for New Zealand; and Ministry of Education, New Zealand (2006).

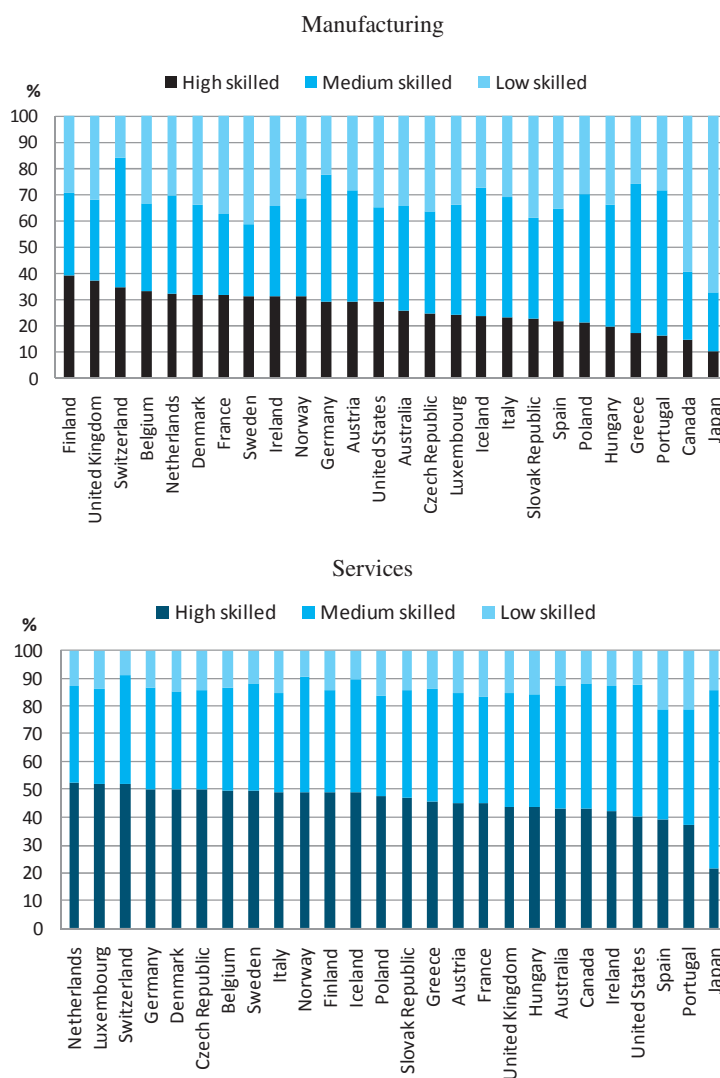
Vocational TEIs are essential for enhancing research and innovation. While many vocational TEIs are not engaged in formal R&D (see Section 7.3.1) their role, particularly in terms of training and knowledge transfer to industry is crucial. In Poland, for example, the review team noted that “the vocational tertiary institutions need to be better integrated into overall strategic thinking. In principle, vocationally and professionally oriented institutions have the potential to form a vital link between tertiary education institutions and industry.” Box 7.2 provides a policy example from New Zealand where the *Institutes of Technology and Polytechnics (ITP) Business Links Fund* is designed to strengthen linkages between polytechnics and industry.

It is also important to bear in mind that innovation is not confined to science-based or high technology industries. Low technology sectors (such as food products and beverages

manufacturing and wood product manufacturing) and service-sector firms are also highly innovative (ABS, 2006; Eurostat Community Innovation Survey Database, 2007; Statistics New Zealand, 2004). Figure 7.9 shows that in each country, service industries have a higher proportion of high-skilled employment than manufacturing. In some countries, the service sector has double the share of high-skilled employment than the manufacturing sector.

**Figure 7.9. Skill composition of employment in services and manufacturing, 2005**

As a percentage of total employees of the industry



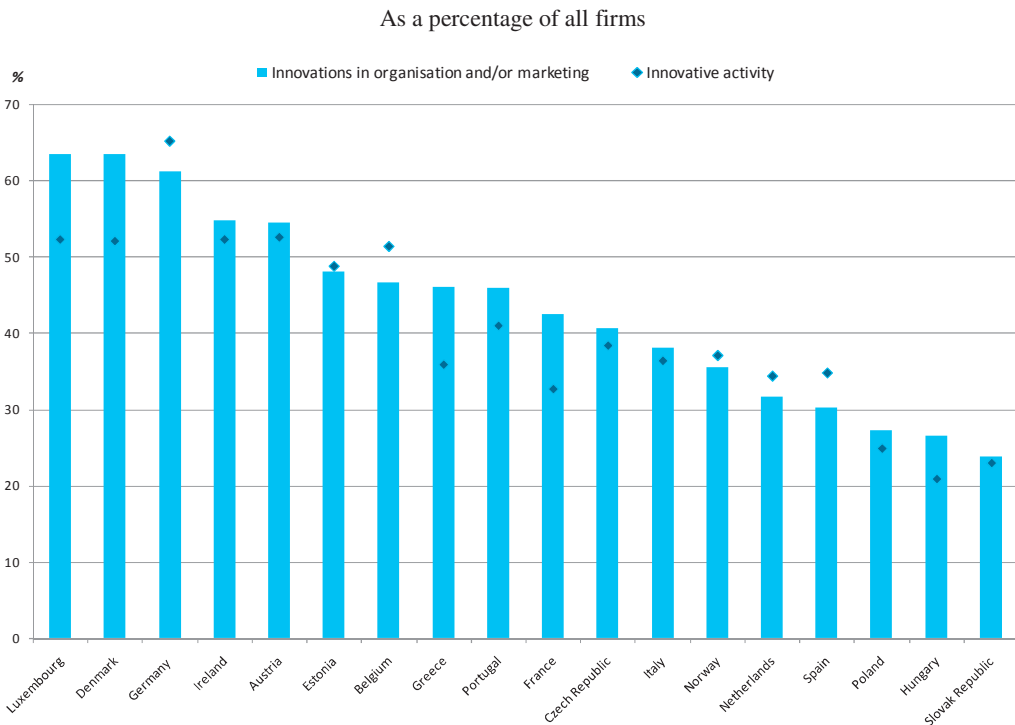
Countries are ranked in descending order of high-skilled employees as a percentage of total employees.

*Note:* Occupation (ISCO-88): ISCO 1-2-3 are considered as high skilled, ISCO 4-5-6-7 are considered as medium skilled, and ISCO 8-9 are considered as low skilled. These figures represent OECD calculations based on national estimations. The reference year for Japan is 2004. For Japan, the share of the high skilled workers seems to be underestimated because of the difficulties in converting the data from Japan Standard Occupational Classification (JSCO) towards ISCO.

*Source:* OECD, ANSKILL database, forthcoming.

But looking at the skill composition in services and manufacturing more closely reveals that manufacturing has a higher share of medium-skilled employees than the service sector in many countries (Figure 7.9). Vocational and technical skills are particularly important for innovation in the manufacturing sector because most innovation is incremental (*i.e.* the innovation is new to the firm) and requires adopting and adapting technologies developed outside of the firm.

**Figure 7.10. Firms engaged in technological and non-technological innovation, 2002-2004**



*Countries are ranked in descending order of firms engaged in innovation as a percentage of all firms.*

*Note:* Technological innovative activity refers to product (good or service) innovation, process innovation and ongoing or abandoned product and/or process innovation activities. Non-technological innovation (*i.e.* innovations in organisations and/or marketing) refers to the implementation of new or significant organisational and/or marketing changes.

*Source:* Eurostat, Community Innovation Survey Database, 2007.

In recent years measuring non-technological, or organisational innovation, has received increasing attention and it is now routinely included in national innovation surveys (OECD, 2005). As shown in Figure 7.10, the proportion of firms reporting organisational and marketing innovations (*i.e.* non-technological innovation) was higher than technological innovative activity<sup>18</sup> in 12 of the 18 countries. While the difference between these proportions was small, the data indicate that innovation is not only technological in nature. Looking at the sectoral differences reveals that the rate of non-technological innovation is similar in the manufacturing and services sectors in most

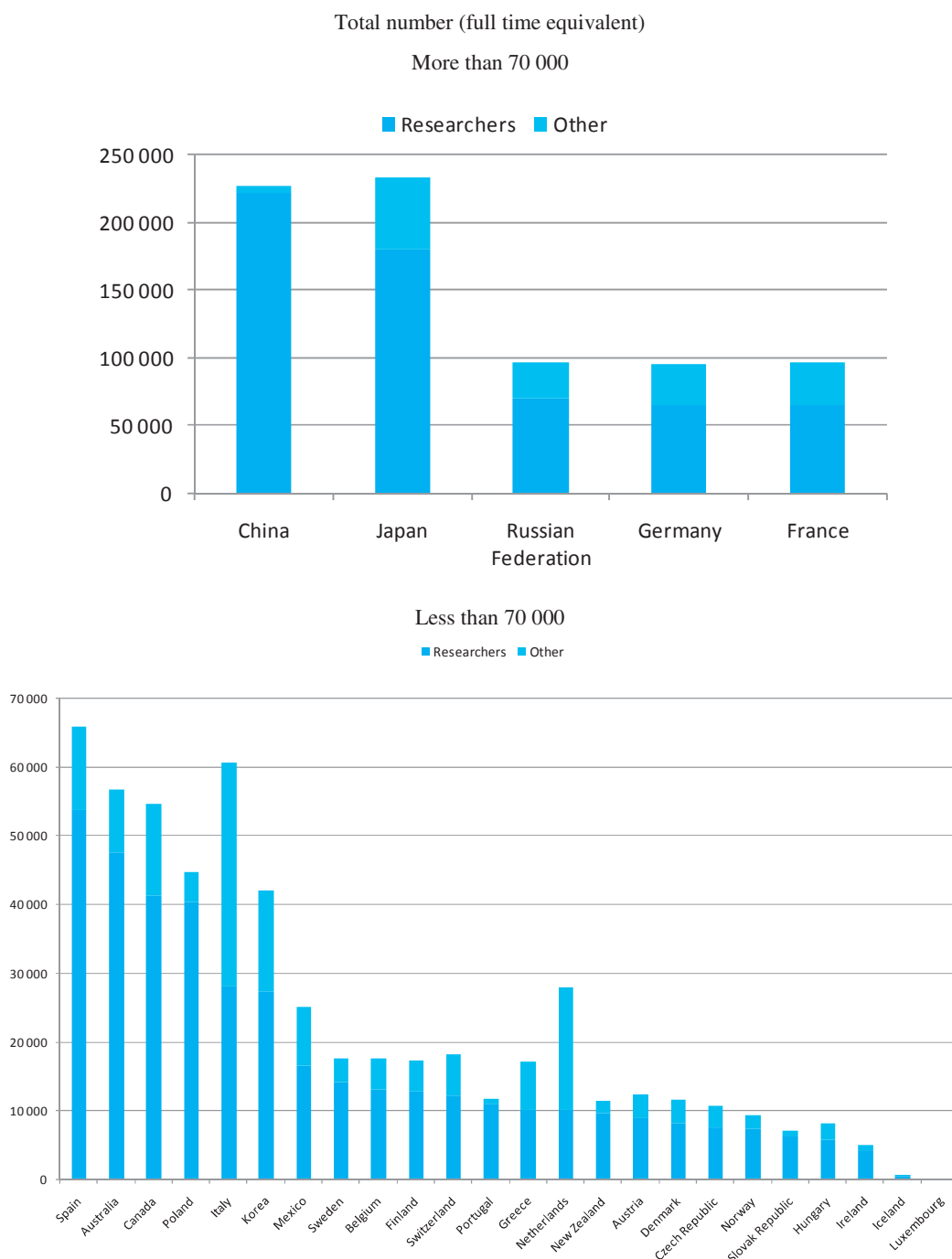
18. Innovative activity refers to product (good or service) innovation, process innovation and ongoing or abandoned product and/or process innovation activities.

countries (OECD, 2007a). This shows that organisational innovation is undertaken in both manufacturing and service firms. Innovation surveys in Australia and New Zealand have also found that around 25 to 30% of firms report non-technological innovation (ABS, 2006; and Statistics New Zealand 2007). Management, leadership, marketing, sales and distribution skills are also a central part of the innovation process. Indeed, research conducted by Statistics Canada found that a lack of specialised personnel with sales and marketing skills was a major obstacle in terms of firms commercialising their products, particularly for small and medium-sized enterprises (SMEs) (Rosa and Rose, 2006), and Australia's *Innovation Survey* found that general business skills were the most common skills and capabilities sought by innovating firms (ABS, 2007). Moreover, globalisation and the growth in outsourcing and inter-institutional collaboration has changed the way firms innovate which means employees need to develop new work methods and adapt to research and production methods that are increasingly conducted outside the firm. In fact, the most recent *Community Innovation Survey* defined one aspect of organisational innovation as "new or significant changes in your relations with other firms or public institutions, such as through alliances, partnerships, outsourcing or sub-contracting" (Eurostat, 2004). This further demonstrates that TEIs need to equip graduates with flexible and broad skill-sets to enhance innovation.

### *R&D personnel*

As discussed above, economic development and improving innovative capacity requires a well-trained and skilled workforce. An important occupational category of HRST is R&D personnel and researchers. R&D personnel are of two main types. Firstly, there are people who are directly engaged in R&D activities and secondly there are those providing management, support and ancillary services such as R&D managers, technicians and administrators. Looking at Figure 7.11 reveals the sharp differences across countries in terms of the ratio of researchers to other R&D personnel in higher education institutions. In China, Luxembourg and Portugal researchers account for more than 90% of R&D personnel whereas in Italy and the Netherlands researchers represent 47% and 36% of the share respectively. These differences may reflect the different types of R&D activities and industrial structures in each country.

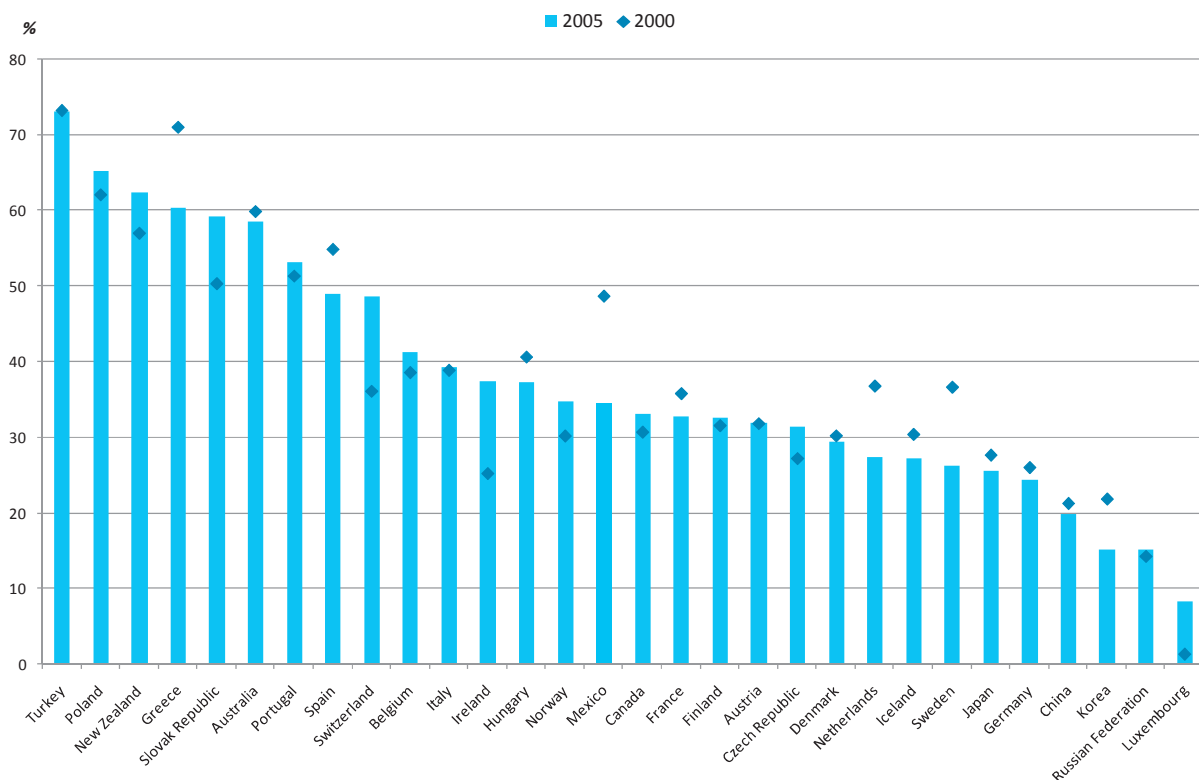
Countries differ considerably in terms of the size of their population and labour force, therefore looking at the share of higher education researchers in relation to researchers in other sectors provides an indicator of the relative size of this group. It is interesting to note that the share of researchers in the higher education sector decreased in 15 countries between 2000 and 2005 (Figure 7.12). These decreases ranged from a 14 percentage point drop in Mexico to a 0.2 percentage point fall in Turkey. This is despite the fact that R&D expenditure in the higher education sector has grown at a higher rate than in the business and government sectors (see Figure 7.3).

**Figure 7.11. Higher education R&D personnel, 2005**

Countries are ranked in descending order of the total number of researchers.

Note: The reference year is 2003 for the Netherlands and New Zealand, and 2004 for Australia, Canada, France, Italy, Switzerland and Turkey. All persons employed directly on R&D are counted as R&D personnel but they can be further classified in terms of researchers (persons engaged in the conception or creation of new knowledge) and other (persons providing direct services on R&D such as technicians, R&D managers and clerical staff) (OECD, 2002).

Source: OECD, Main Science and Technology Indicators Database, 2007-1.

**Figure 7.12. Higher education researchers as a percentage of national total of researchers, 2000 and 2005**

Countries are ranked in descending order of higher education researchers as a percentage of national total of researchers in 2005.

Note: For '2000' data, the reference year is 1998 for Austria, and 1999 for Denmark, Greece, Iceland, Mexico, New Zealand, Norway, Sweden and the United States. For '2005' data, the reference year is 2003 for the Netherlands and New Zealand, and 2004 for Australia, Canada, France, Italy, Switzerland and Turkey. In the Netherlands, 2005 data excludes doctoral trainees whereas 2000 data includes them.

Source: OECD, Main Science and Technology Indicators Database, 2007-1.

Only 5 countries experienced a fall in the absolute number of researchers in the higher education sector (Germany, Greece, the Netherlands, the Russian Federation and Sweden).<sup>19</sup> The main point here is expenditure on R&D in the higher education sector has increased markedly between 2000 and 2005, and the number of researchers has also experienced strong growth in most countries. Nevertheless, the share of researchers in higher education has dropped as a proportion of the national total in half of the countries shown in Figure 7.12. In some countries, the average annual growth rate of "other R&D personnel" was much higher than the growth of researchers. In Spain, for example, the number of researchers increased by 5% annually between 2000 and 2005 while other R&D personnel grew by 11% annually over the same period. Conversely, in other countries the reverse could be observed. In China, for example, researchers grew by 12% annually whereas other R&D personnel decreased by 14%.

19 In the case of the Netherlands, this fall may be attributed to the categorisation of doctoral trainees – in 2005 they were counted as R&D personnel whereas in 2000 they were counted as researchers.

### 7.3.3 *Maintaining and expanding HRST capabilities*<sup>20</sup>

OECD countries face recurrent concerns about a range of HRST issues, primarily to do with recruitment to and participation in scientific careers, and the impacts of globalisation on the levels and mobility of highly skilled people. There are doubts about the ability of OECD countries to expand or even maintain the supply of workers with skills in S&E. Concerns include a decline in the share of science and engineering graduates at the tertiary level. This decline is exacerbated by potential shortages due to demographic changes and the ageing of the academic workforce in many OECD countries (see also Chapter 8). As a result attention has focused on recruitment, including the attractiveness of S&E careers, particularly at the doctorate level, enhancing women's participation in the S&E labour force, and on immigration and international mobility as potential solutions to recruitment problems. These recruitment issues have major implications for research and innovation in TEIs.

#### *The attractiveness of research careers*

In recent years the supply and demand for researchers have raised concerns about the attractiveness of research careers. A general concern in industry and academia is the issue of attracting students to research careers, particularly in S&T, because the private returns may be too low relative to other careers. Even though university graduates in S&T tend to have higher employment rates compared to university graduates in general, a research career in the public sector typically requires an advanced degree. However, increases in the number of doctoral holders have not been matched by an expansion of permanent academic positions. In many countries, access to tenure-track positions appears to be declining in favour of non-tenured temporary positions. While careers in research are often considered to be a “vocation” and not ones where monetary rewards are the main impetus, researchers seek to recoup their investments in higher education, including the opportunity costs of forgoing employment for further study. Early stage researchers appear to have more difficulty accessing longer term and stable careers in academia, which threatens the attractiveness of such careers. At the same time, the research profession is also one where non-monetary values such as independence and academic freedom are important. These non-monetary values must not be neglected in efforts to make research an attractive career (for further details see OECD, 2007b and Chapter 8 of this volume).

#### *Doctoral students*

While many researchers do not possess doctoral degrees, the supply of doctorate holders and their take-up in the labour market is of special concern. Any policy effort to increase the quality and quantity of university graduates in S&E or output from public research needs to focus on the doctorate trained population. This is because advanced research and a public-sector research career generally requires doctoral trained personnel. Even in industry the doctorate holder is relevant, especially in sectors that draw on the science base. OECD universities awarded some 6.7 million degrees in 2004, of which 179 000 were doctorates (OECD, 2007a). Among the priority issues concerning doctoral students and post-doctorates is their status as students or employees as well as their working conditions, including access to social welfare benefits. Results from the SFRI

20. Part of this Section draws on work conducted by OECD's Committee for Scientific and Technological Policy Working Group on the Steering and Funding of Research Institutions (SFRI).



work show a large variation in the average duration of doctoral programmes ranging from up to three to seven and a half years. The duration is dependent on many factors including country-specific and institutional differences such as the availability of funding for doctoral studies as well as the status/conditions of the doctoral candidate (*e.g.* employee or student). In many countries, the average duration is higher in the humanities and social sciences (for further details see OECD, 2006a and 2007b).

More research is being undertaken to advance our understanding of doctoral careers. The OECD Directorate for Science, Technology and Industry launched a project in 2004 to follow the career paths and mobility of doctorate holders. The project, the Careers of Doctorate Holders (CDH) is being jointly undertaken with Eurostat and the UNESCO Institute for Statistics, and includes data on doctoral holders' demographic and educational characteristics, their labour market situation, international mobility and scientific output. Seven countries (Argentina, Australia, Canada, Germany, Portugal, Switzerland and the United States) participated in the first data collection round in 2005. Five of the seven countries have drawn data from their census and/or labour force surveys, while two countries have dedicated surveys of doctorate holders (for a full overview see Auriol, 2007). Although the coverage of countries is currently limited, it is expected that data will be available for another 20 countries in mid 2008.

### *Women in Science*

Against a background for growing demand for HRST, policy makers have started to pay greater attention to encouraging women to pursue careers in S&E. Women have increased their numbers in higher education and the workforce, but their participation in science education and S&E careers remains low in comparison to men, especially at senior levels, and wide discrepancies exist across scientific fields. OECD countries are addressing the issue of women's participation in science to a varying degree. Most OECD countries have specific programmes in place which aim to achieve a better gender balance in science education and research. Measures range from grants to support positions for women at universities, gender-neutral performance assessment to preferential policies towards equally qualified women candidates and mentoring programmes. On the employment side, equal opportunity policies, flexible working hours, access to childcare and parental leave are used to encourage women to pursue research careers in the public and private sectors (for further details see OECD, 2006b).

### *International mobility of HRST*

Foreign talent contribute significantly to the supply of S&E personnel in many OECD countries, therefore countries are increasingly taking action to attract foreign and expatriate researchers. However, the global market for the highly skilled is becoming more competitive and opportunities in the main supply countries are improving. Countries are competing to attract staff from abroad and they are also competing to retain their best researchers, scientific talent and foreign graduates. Nevertheless, the labour market for the highly skilled, researchers and scientists has become more internationalised, and this phenomenon is likely to continue since countries are developing a range of initiatives to facilitate mobility (see also Chapter 10).

Despite increasing international flows, policy makers cannot ignore the development of human capital at the national level. International mobility is a supplement to domestic human capital creation, not a substitute for it, and policies for mobility need to be

considered against the background of the broader nationally oriented policies to build an innovative environment. Moreover, policies to expand mobility cannot simply focus on monetary incentives. Attractive environments are also important, and these include the availability and quality of the research infrastructure within which highly skilled professionals work. From this perspective, mobility cannot be separated from wider dimensions of support for science and innovation (for further details see OECD, 2008a forthcoming).

### **7.3.4 Collaboration, IPRs and commercialisation**

#### *Collaboration and linkages with TEIs*

Collaboration between TEIs and industry is vital for generating technological spillovers, knowledge diffusion and innovation. Although the literature on university-industry collaboration and linkages tends to focus on the analysis of joint R&D projects, both innovation surveys and more specific collaboration surveys have demonstrated that these linkages are much broader than R&D joint ventures, and often rest on informal relationships (OECD, 2001). Firms, including those in low-technology sectors, collaborate with TEIs to access research results, specific technical knowledge, skills and competencies (Basri, 2006). The benefits of collaboration are often mutual and include staff mobility, bi-directional knowledge flows and enhanced learning across institutions and sectors.

Moreover, collaboration and linkages between industry and TEIs may enhance a firm's absorptive capacity and the ability to access and utilise external knowledge generated outside the firm. In order to innovate, firms must be able to learn and create new knowledge. This can rest on internal R&D, but it also requires the ability to search, identify, access, absorb and apply information from external sources, and then combine this new knowledge with existing knowledge in the firm. While R&D conducted within the firm generates innovations it also develops a firm's ability to use external information: Cohen and Levinthal (1989) refer to this as absorptive capacity. Collaboration with TEIs can expand firms' capabilities and innovation potential, thus the importance of absorptive capacity is relevant not just within the firm but for the wider economy as a whole.

TEI-industry linkages occur through a number of channels and include joint research projects, consultancy and contract work, training and other interactions, such as attending meetings and conferences. Even though there are numerous methods for interaction, research has shown that these linkages are skewed since a small number of researchers are involved in a large number of interactions (Balconi *et al.*, 2004), and there are differences according to scientific discipline (D'Este and Patel, 2007).

Box 7.3 provides examples of a range of policies that promote linkages between TEIs, industry and public research organisations. In the case of Portugal, the *Partnerships for the Future* programme has an international focus that brings together research teams from around the world. In the Netherlands and Norway, the programmes promote the utilisation of public research results, and specifically address the improvement of knowledge utilisation in SMEs. The *Co-operative Research Centre* programme in Australia fosters collaborative R&D as well as producing graduates with industry skills. All of these programmes have been developed with the intention of expanding and strengthening interactions between TEIs, other public research organisations and industry.

### Box 7.3. Promoting linkages in Australia, the Netherlands, Norway and Portugal

The *Co-operative Research Centre* (CRC) programme in **Australia** was established in 1990 to strengthen the effectiveness of Australia's R&D by linking researchers with industry. A CRC is a company formed through a collaboration of businesses and researchers. This includes private sector organisations (both large and small enterprises), industry associations, universities and government research agencies such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and other end users. A selection round for new CRCs is usually held every two years. It is a competitive process with applications selected on the basis of merit.

The close interaction between researchers and the users of research is a key feature of the programme. Another feature is the industry contribution to CRC education programmes and the strong education component with a focus on producing graduates with skills relevant to industry needs. Since the start of the programme, over 3000 under-graduate, post-graduate and doctoral students of CRCs have taken up employment with industry and other end users.

The Australian Government funds CRCs for up to seven years. Since the programme began, 158 CRCs have been funded. There are currently 56 CRCs operating in 6 sectors: environment (13), agriculture and rural-based manufacturing (15), information and communication technology (5), mining and energy (7), medical science and technology (8) and manufacturing technology (8).

In the **Netherlands**, the Ministry of Economic Affairs offers a “knowledge vouchers” system. Knowledge vouchers are, in essence, a subsidy that enables SMEs to buy research services from universities and from other types of institutes including large firms, in order to improve innovation processes, products and services. This system is designed to strengthen the relation between companies and knowledge institutes, including TEIs. It is expected that these knowledge vouchers not only promote innovation but also foster other relations, such as stronger linkages between education providers and the labour market.

The value of the large “knowledge voucher” is EUR 7500, of which SMEs contribute one third themselves. As of 2006, there will also be smaller knowledge vouchers representing a value of EUR 2500 to stimulate SMEs to become acquainted with research institutes, and these are known as “sniffing vouchers”.

At the commencement of the scheme the number of vouchers was 100. Following initial demand they were increased to 6000. Knowledge vouchers have been very well received in the business community. Many employers have been using this subsidy and relations with knowledge institutes have been intensified.

The **Norwegian** VRI-programme is a new funding initiative for regional R&D and Innovation established to strengthen innovative capacity and promote new forms of cooperation within the regions of Norway. The programme is administered by the Research Council of Norway. Its aim is to generate regional mobilisation within priority areas such as the environment, tourism, the maritime sector, and the marine sector. One of the instruments implemented to increase cooperation between industry and the R&D sector is the placement of researchers into companies for a given period of time to take part in product development activities. Similarly, company employees may be deployed to work on a research project at a university, college or research institute.

In 2006, the Norwegian Research Council merged several smaller industrial R&D programmes into a larger, general programme – the Programme for User Driven Innovation Projects (BIA). The aim is to reduce administrative costs and to make it easier for the applicants to apply for R&D grants. The programme complements the Research Council's other instruments for funding industry-oriented research.

Another programme in Norway is the SkatteFUNN scheme which gives Norwegian enterprises tax credit for investments in research. All enterprises operating in Norway are eligible for a deduction in tax payable for expenses in approved R&D projects. About 50% of the companies making use of the scheme have fewer than 10 employees, and the scheme is used in all parts of the country and across many sectors. The tax credit is larger for smaller and medium sized companies than for big companies. An evaluation of the SkatteFUNN scheme found that it is most effective for small businesses, in companies where education levels among the workforce are relatively low, and in companies with low R&D intensity. The scheme also has a greater impact on businesses located in more outlying areas of the country. The likelihood that these groups will initiate R&D activity has increased since the scheme was introduced in 2002.

During 2006-2007 the **Portuguese** Government launched a *Partnerships for the Future* initiative. It is based on new international partnerships involving Portuguese and foreign universities, research institutions and companies in specific thematic areas concerning the development of post-graduate and R&D programmes. The initial partnerships were established with the:

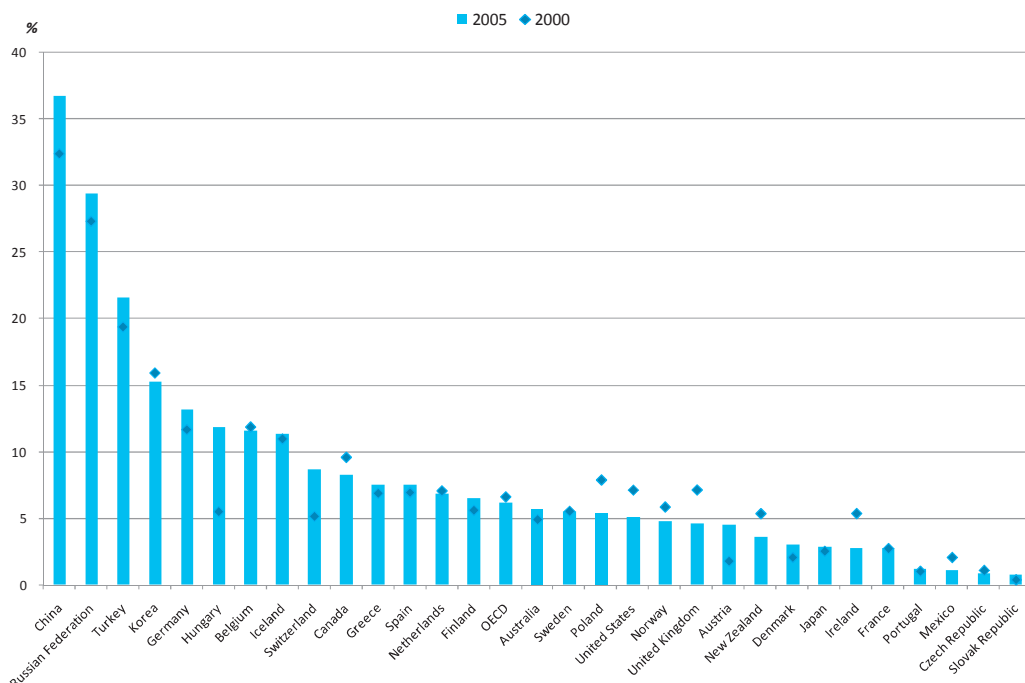
- Massachusetts Institute of Technology (MIT-Portugal Programme), focused in the areas of energy systems, transports systems, advanced manufacturing and bioengineering;
- Carnegie Mellon University (CMU-Portugal Program), in ICT;
- University of Texas at Austin (UTAustin-Portugal Program), in digital media, advanced computing, mathematics and technology commercialisation; and
- Fraunhofer Society, including the establishment of the first Fraunhofer institute outside Germany, in the area of technologies, contents and services for ambient assisted living.

The overall goals of the initiative include launching and promoting new research-based consortia at a national level together with a large number of research centres and associated laboratories as well as establishing a productive working relation between universities, research institutions and companies.

Sources: Review materials and National Programme Web sites.

The share of higher education R&D expenditure financed by industry provides an indicator of linkages between the two sectors. Figure 7.13 shows there is wide variation across countries ranging from 37% in China to 1% in the Slovak Republic in 2005. Across the OECD, industry financed R&D in higher education institutions reached 6.1% in 2005, which was slightly lower than the share in 2000 (6.6%). Nevertheless, the share across the OECD has remained fairly constant since 1990 moving between around 6% and 7%. Hungary experienced the highest growth with industry financing increasing by 6.2 percentage points between 2000 and 2005. Conversely, in Ireland, Poland, the United Kingdom and the United States the share of industry financing dropped by more than 2 percentage points in each country.

**Figure 7.13. Percentage of Higher Education R&D financed by industry, 2000 and 2005**



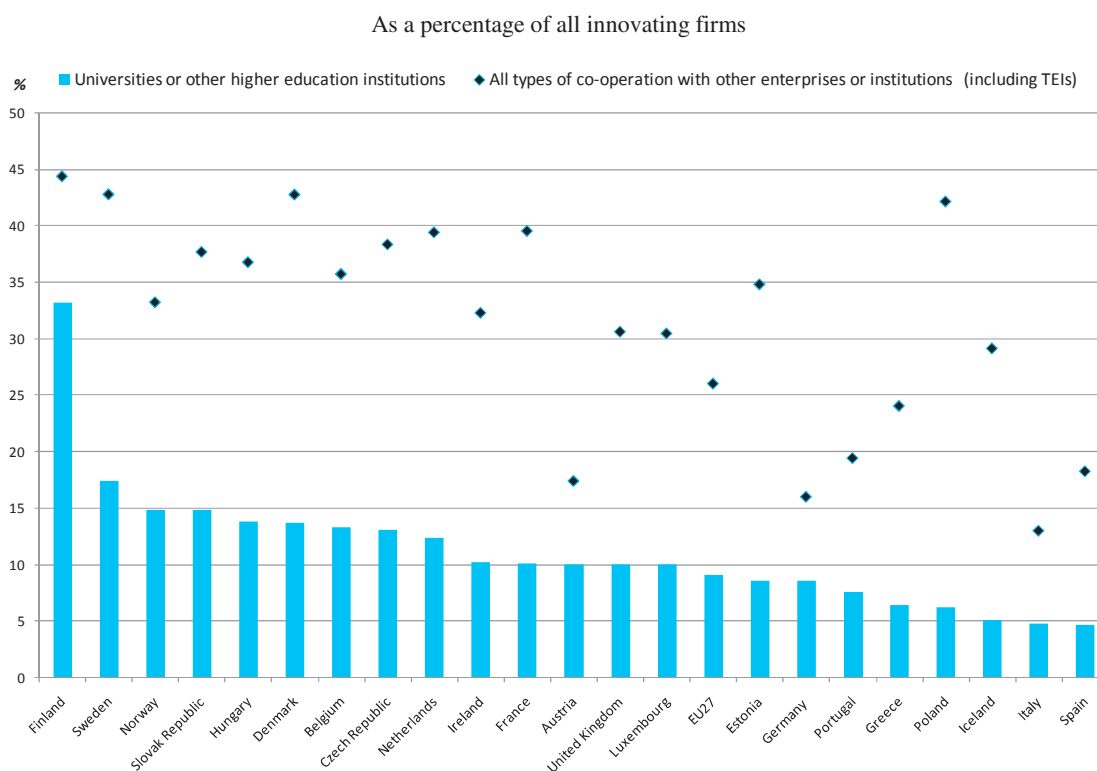
Countries are ranked in descending order of the percentage of higher education R&D financed by industry in 2005.

Note: For '2000' data, the reference year is 1998 for Austria, and 2001 for Greece, Iceland, New Zealand, Norway and Sweden. For '2005' data, the reference year is 2003 for Belgium, Greece, the Netherlands, New Zealand and Sweden, and 2004 for Australia, Denmark, France, Germany, Spain, Switzerland and Turkey.

Source: OECD, Main Science and Technology Indicators Database, 2007-1.

Results from innovation surveys are another useful data source that can be used to analyse linkages between TEIs and industry. Firms participating in the survey are asked if they have co-operated with a range of external partners during the innovation process. As shown in Figure 7.14, collaboration with enterprises or institutions is widespread among innovating firms and reaches a high of 44% in Finland. All countries report collaboration rates of 10% or more. Figure 7.14 also shows the proportion of innovating firms collaborating with universities or other higher education institutions. The results across countries vary from 33% in Finland to 5% in Spain, which reflects the different structure of innovation systems across countries. In New Zealand, 7% of businesses reported co-operative arrangements with universities or polytechnics (in the last two financial years at August 2005, Statistics New Zealand, 2007), whereas in Australia 2.3% of businesses collaborated with a university or other higher education institution (between 2004 and 2005, ABS, 2007). It has been argued that these types of collaboration results are particularly noteworthy because they indicate a strong role for TEIs in the innovation process. This is because most innovation is incremental and involves small-scale change which would not necessarily require university-type inputs. Therefore it shows that universities are not only collaborating in research-based radical innovations but are contributing to “everyday” incremental innovation as well (Basri, 2001).

**Figure 7.14. Innovating firms co-operation in innovation with other firms or non-commercial institutions (including TEIs), 2002-2004**



*Countries are ranked in descending order of co-operation with universities or other TEIs.*

*Note:* Co-operation in innovation, by innovating forms, refers to active participation in innovation activities with other firms or non-commercial institutions. Co-operation can take place with more than one partner.

*Source:* Eurostat, Community Innovation Survey Database, 2007.

Firms are also asked to identify which type of collaboration partner was most valuable for their innovation activities. Once again, differences across countries were evident. In Greece, 3.6% of firms reported that universities or other higher education institutions were the most valuable co-operation partner for innovation activities while in Slovakia the result was 0.6%. In comparison, suppliers of equipment, materials and components or software were seen as the most valuable partner in most countries, followed by clients or customers. Government or public research institutes scored lower results than other types of partners, including TEIs in almost all countries.<sup>21</sup> These results are not surprising given the different roles collaboration partners play in the innovation process.

As Figure 7.15 shows, large firms reported more collaboration with TEIs than small firms. This may reflect the higher rate of new product development in large firms as well as easier access to collaboration partners and more resources. The variation among countries is noteworthy. In Finland, nearly 70% of firms with 250 or more employees co-operated with a TEI, whereas in Greece 11.5% of large firms were co-operating with a TEI. The point to note here is that apart from Belgium, Denmark, Finland, Norway, the Slovak Republic and Sweden, co-operation between small firms and TEIs is under 10% in each country and it drops below 5% in Greece, Italy, Poland, Portugal and Spain. A similar pattern emerges in medium-sized firms with between 50 and 249 employees. In most countries, less than 20% of medium-sized firms collaborate with TEIs for innovation.

While collaboration is an important mechanism enabling the transfer of knowledge, human mobility is another way in which knowledge is spread because people hold tacit knowledge. This is because tacit knowledge is not readily transferable and has been described as “know-how”, or the skills or capability to do something. Tacit knowledge is transmitted via communication between people, or through “learning-by-doing” (Lundvall and Johnson, 1994). It also involves learning-by-using and learning-by-interacting. In comparison, codified knowledge is embedded in artefacts (books, journals, machinery, patents *etc.*) so the dissemination mechanisms are quite different. This is why mobility between the public and private sector is important: it facilitates knowledge transfer and the development of cross-sector skills. Job mobility via the placement of researchers and research students in and out of the private sector may also enhance absorptive capacity. In Europe, the Aho report proposes that “*ten per cent of the workforce in each year should be moving*” (Aho, 2006), however, the basis of advocating 10% is not apparent. In 20 of the 27 European Union countries, 6.1% of employed HRST changed jobs between 2004 and 2005, which represented nearly 3 million HRST in absolute terms. Within the EU-27, Denmark had the highest proportion of HRST job-to-job mobility in 2005 at 10.2%, and the United Kingdom followed with 9.5% (Meri, 2007). Of course inter-institutional mobility is not limited to flows between TEIs and firms because mobility within the public sector (*i.e.* between TEIs and public research organisations) is also important.

Preliminary results from the OECD’s survey of the Careers of Doctorate Holders (CDH) for a subset of countries indicate that doctorate holders in the United States are more mobile than those in Germany: 62% of doctorate holders in Germany have been

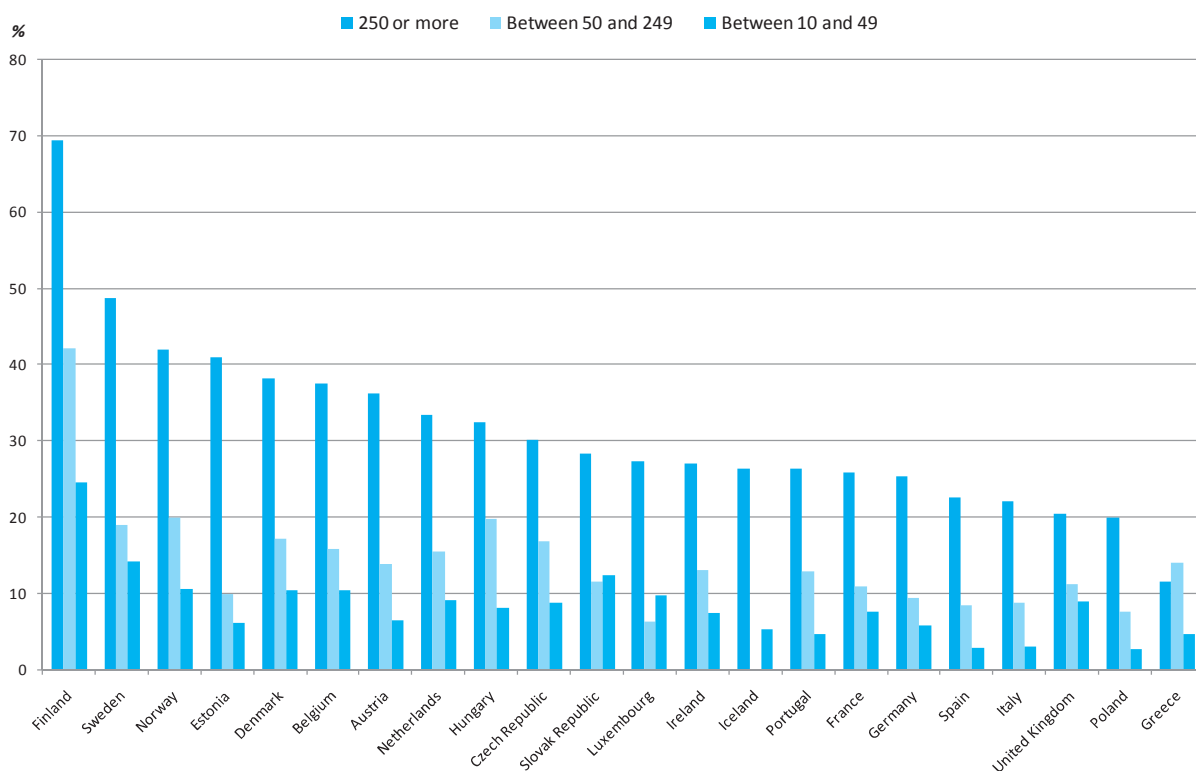
21. Other types of partners identified in the survey include enterprises within the enterprise group, competitors, consultants, commercial labs or private R&D institutes (Eurostat, 2007, Community Innovation Statistics Database).



with the same employer for at least five years compared to 55% in the United States. Mobility in the United States is lower in the higher education sector, however: 60% of United States' doctorates in academia have been with the same employer for at least five years compared to 50% in other sectors (Auriol, 2007).

**Figure 7.15. Innovating firms co-operation in innovation with universities or other tertiary education institutions by firm size, 2002-2004**

As a percentage of all innovating firms



Countries are ranked in descending order of co-operation with universities or other tertiary education institutions by innovating firms with 250 or more employees.

Source: Eurostat, Community Innovation Survey Database, 2007.

### *Knowledge transfer mechanisms: the role of IPRs and commercialisation*

A key policy focus in many OECD countries over recent years has been on enhancing the capacity of TEIs to contribute more actively to innovation and knowledge transfer through a sharper definition of intellectual property, followed by its commercialisation. In the past, commercialisation was not a priority compared with teaching and research functions. Policy mechanisms such as the Bayh-Dole Act in the United States not only made it legally possible for universities to patent results from publicly-funded research, they encouraged the idea that patenting ought to be a major function of universities. However patents have to be commercialised, and throughout the world universities have been establishing technology transfer offices (TTOs) which seek profitable links with industry through the licensing of university-produced knowledge. TTOs are meant to



increase knowledge diffusion between higher education institutions and industry. Yet the record in this area is somewhat mixed. University patenting has increased in many OECD countries, although it was already on an increasing trajectory before Bayh-Dole (Mowery and Ziedonis, 2002). In addition, the record of TTOs has not been one of great success because results have been skewed, with only a few discoveries yielding major revenue flows. Furthermore, the results are highly skewed across institutions since a small number of institutions account for the majority of patents (AUTM, 2007; NSF, 2008).

More recently, it has become clear that there are complex trade-offs between providing incentives for universities and firms to develop intellectual property rights (IPRs) versus creating incentives for diffusion of knowledge across the economy (Mowery and Sampat, 2004). Improving knowledge transfer between universities and industry is widely recognised as important, however, although commercialisation measures have been widely adopted, they are beginning to come under question. In Australia, for example, the Productivity Commission's (2006) study of the science and innovation system has been critical of the effects of commercialisation as a policy objective, and advocates a wider approach to university-industry links.

The idea that stronger IPR regimes for universities will strengthen commercialisation of university knowledge and research results has been in focus in OECD countries in recent years. Indeed, Table 7.2 shows that countries have developed national guidelines on licensing, data collection systems and strong incentive structures to promote the commercialisation of public research. More than half of the countries shown in Table 7.2 have a national policy or guidelines targeted at encouraging the commercialisation of publicly-funded R&D, which allows exclusive and/or non-exclusive licensing. The incentive structures to promote the commercialisation of public research are particularly strong. Of the 23 countries shown in Table 7.2, 19 have incentive systems for their TTO professionals, such as granting staff a proportion of licensing revenue. Likewise, 19 countries allow researchers to return to academia with the same employment conditions after a period in the private sector to create a spin-off company, although some countries have time restrictions and the decision is at the discretion of the institution. The monitoring of commercialisation in TEIs has strengthened in recent years since 11 countries regularly collect data on licensing activities and four countries plan to start collecting data in the future. Six countries (Greece, the Netherlands, New Zealand, Poland, Portugal and Sweden) do not collect data and have no plans to collect it on a regular basis in the future. However, in the Netherlands and New Zealand data on patents are collected, but not on licensing, and in New Zealand a one-off survey of all commercial activities was conducted in 2002. Given the emphasis placed on the commercialisation of TEI research it is important to collect data and monitor developments in this area.

Even though the policy issue of stronger IPR for universities is prominent, it contains a number of problems however. Firstly, the most important of these is that commercialisation requires secrecy in the interests of appropriating the benefits of knowledge, whereas universities may play a stronger role in the economy by diffusing and divulging results. It should be remembered that IPRs raise the cost of knowledge to users, while an important policy objective might be to lower the costs of knowledge use to industry. Open science, such as collaboration, informal contacts between academics and businesses, attending academic conferences and using scientific literature, can also be used to transfer knowledge from the public sector to the private sector. Moreover, industry financed R&D is usually aimed at obtaining up-to-date knowledge, solutions to

specific problems and access to students rather than specific inventions (Mansfield and Lee, 1996).

Secondly, there have been very few universities worldwide that have successfully been able to generate revenues from patents and commercialising inventions, partly because a very small proportion of research results are commercially patentable. In addition, pursuing commercial possibilities is only relevant for a select number of research fields, such as biomedical research and electronics. Other areas such as the humanities, social sciences and astronomy for example, do not engage in significant commercial activity.

Thirdly, the commercial exploitation of inventions and patents is itself a complex process requiring expertise that universities researchers seldom have, and that universities can themselves develop only by spending large sums to develop TTOs. Mowery and Shane (2002) point out that “management by universities of technology licensing activities requires a set of skills that are extremely rare within universities and in short supply more generally”. As a result, the economic benefits of university-based research are quite uncertain, and many universities that have tried to take this route have lost money. The prominent international examples where universities have contributed to commercially-valuable research have been initiated by private corporations, not by universities themselves (Bok, 2003).

The failure to commercialise public science is known as the “European paradox”, but this belief is not confined to Europe. Policy makers in Australia and Canada, for example, also share the view that their public research is of high quality but it is not commercialised (DEST, 2003; Industry Canada, 2007). In contrast, the United States is seen as the exemplar. The reasons attributed to the failure to commercialise scientific research include a lack of entrepreneurial skills, particularly among academics, a lack of experienced managers, mobility barriers between the public and private sector, and weak IPRs for TEIs inventions. Therefore, a range of policy initiatives have been developed to improve the commercialisation of public science. These include courses on entrepreneurship, subsidies for the establishment of TTOs and changes to university IPRs.

However, the empirical evidence suggests the “European Paradox” is misguided. Dosi and colleagues (2005) point out there are large differences across scientific and technological fields, but they find no evidence to support the European paradox. Research by Arundel and Bordoy (2006)<sup>22</sup> demonstrates that United States universities lead on only one commercialisation indicator, which is the number of patent grants (8.8). Nevertheless, the United Kingdom was not far behind (6.6), and it has the highest number of invention disclosures, licenses executed and start-up companies. Canada leads on the number of priority patent applications. While Europe and Australia do not lead on any particular indicator, the results are close. For example, the United Kingdom scored 3.5 on the number of start-ups, whereas the United States scored 1.1, Europe had 2.8 and Australia scored 2.1 (data were unavailable for Canada).<sup>23</sup> Furthermore, Crespi and colleagues (2006) conclude that patenting in European universities is not significantly behind American universities once the data have been corrected to account for different ownership structures between the regions.

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22. Six performance indicators are presented using results from public science commercialisation surveys in Australia, Canada, Europe, the United Kingdom and the United States.
23. The indicators are based on the number per 100 million US PPP\$ research expenditures.

Table 7.2. Commercialising public research, 2007

	Are there national policies/guidelines on licensing the results of publicly-funded research?	Is there a system to collect data on a regular basis on the licensing activities of public and/or private TEIs or research organisations to which TEIs contribute?	Incentives structures	
			Does the legal framework allow public and/or private TEIs or research organisations to which TEIs contribute to introduce incentive systems for their TTO professionals?	Does the legal framework allow researchers to return to academia with the same employment conditions after a period in the private sector to create a spin-off company?
Australia <sup>1</sup>	Yes, allowing exclusive and non-exclusive licensing at the discretion of TEIs	Yes, regular survey (biennial)	Yes, fully at the discretion of TEIs <sup>2</sup>	Yes, at the discretion of TEIs (in most cases, it involves compliance with 'conflict of interest' policies upon return, and time restrictions on the period in the spin-off company)
Belgium (Flemish Community)	Yes, allowing exclusive licensing at the discretion of TEIs	Yes, regular survey (on a continuous basis)	Yes, fully at the discretion of TEIs	Yes, with time restrictions
Chile	No	<i>m</i>	<i>m</i>	<i>m</i>
Croatia	Yes, allowing exclusive and non-exclusive licensing	Not yet, but it is planned	Yes, fully at the discretion of TEIs	Yes, with time restrictions
China	Yes, allowing exclusive and non-exclusive licensing	Yes, regular survey (annual)	Yes, fully at the discretion of TEIs	No
Czech Republic	Yes, allowing non-exclusive licensing <sup>3</sup>	Yes, regular survey (annual)	Yes, fully at the discretion of TEIs	Yes, without restrictions
Estonia	Yes, allowing exclusive and non-exclusive licensing	Yes, regular survey (annual)	Yes, following national guidelines (at the discretion TEIs)	Yes, without restrictions
Finland	Yes, allowing exclusive licensing	Not yet, but it is planned	Yes, fully at the discretion of TEIs	Yes, at the discretion of TEIs
Greece	Yes, allowing exclusive and non-exclusive licensing	No	No	No <sup>4</sup>
Iceland	Yes, allowing exclusive and non-exclusive licensing	Not yet, but it is planned	<i>m</i>	Yes, with time restrictions
Japan	Yes, allowing exclusive and non-exclusive licensing (at the discretion of TEIs)	Yes, regular survey (annual)	Yes, fully at the discretion of TEIs	Yes, without restrictions
Korea	Yes, allowing exclusive and non-exclusive licensing	Yes, regular survey (annual)	Yes, following national guidelines	Yes, with time restrictions
Mexico	No	<i>m</i>	Yes, following national guidelines	Yes, with time restrictions
Netherlands	No	No <sup>5</sup>	Yes, fully at the discretion of TEIs	Yes, without restrictions
New Zealand	Yes, allowing exclusive and non-exclusive licensing <sup>6</sup>	No <sup>7</sup>	Yes, fully at the discretion of TEIs <sup>8</sup>	Yes, at the discretion of TEIs
Norway	No <sup>9</sup>	Yes, regular survey (annual) <sup>10</sup>	No	Yes, with time restrictions (at the discretion of TEIs)
Poland	No <sup>11</sup>	No	Yes, fully at the discretion of TEIs	Yes, without restrictions
Portugal	Yes, allowing exclusive and non-exclusive licensing	No	Yes, fully at the discretion of TEIs	Yes (negotiated on a case by case basis)
Russian Federation	Yes, allowing exclusive and non-exclusive licensing <sup>12</sup>	Not yet, but it is planned	Yes, fully at the discretion of TEIs	<i>a</i> <sup>13</sup>
Spain <sup>1</sup>	No	Yes, regular survey (annual)	Yes, fully at the discretion of TEIs or regional governments	Yes, with time restrictions
Sweden	No <sup>14</sup>	No	Yes, fully at the discretion of TEIs	Yes, without restrictions
Switzerland	Yes, other <sup>15</sup>	Yes, regular survey (annual)	Yes, fully at the discretion of TEIs	Universities: yes, without restrictions Universities of applied sciences: yes, at the discretion of institutions
United Kingdom	No	Yes, regular survey (annual)	Yes, fully at the discretion of TEIs	Yes, at the discretion of TEIs <sup>16</sup>

**Definitions:** This table addresses existing national policies targeted at encouraging the commercialisation of publicly-funded R&D results achieved by public or private TEIs or research organisations to which TEIs contribute (e.g. centres of Excellence, research consortia etc.)

*Publicly-funded research* refers to research activities funded by public authorities at all levels of government (central, regional, local) and in different areas (e.g. Research, Science, Technology and Industry), or by intermediate agencies channelling public funds to TEIs and research organisations.

*Licensing the results of publicly-funded research* refers to the commercialisation of publicly-funded R&D results achieved by public or private TEIs or research organisations to which TEIs contribute through a formal contractual agreement transferring the right to use a technology from the inventor to the licensee.

*Exclusive licensing* refers to licensing conditions whereby a single entity (firm, foundation, other TEI or research institute) purchases the intellectual property rights and obtains exclusive rights to use the R&D results for a fixed period. Exclusive licensing grants monopoly rights to the purchasing entity.

*Non-exclusive licensing* refers to licensing conditions whereby all entities (firm, foundation, other TEI or research institute) willing to purchase the intellectual property rights are allowed to use the R&D results for a fixed period. Non-exclusive licensing does not grant any monopoly status to the purchasing entities.

*System to collect data on a regular basis* refers to surveys on the commercialisation of intellectual property such as the AUTM (Association of University Technology Managers) survey in the United States or the ProTon or ASTP surveys in Europe.

*TTO* stands for 'Technology Transfer Office' and refers to offices which are engaged in intellectual property management of innovations and technologies developed by public and/or private TEIs or research organisations to which TEIs contribute. TTO professionals perform intellectual property management activities such as the identification, documentation, evaluation, protection, marketing and licensing of technologies, as well as the management of intellectual property on a daily basis.

*Incentive systems* refer to schemes designed to provide TTO professionals with incentives to license research results and innovations, such as granting them a percentage of licensing revenue.

*Spin-off company* refers to firms created by academics and/or research staff on the basis of an innovation licensed from their TEI. Spin-off firms derive a significant proportion of their commercial activity from the application or use of a technology and/or know-how licensed from the TEI.

**Notes:** *a*: Information not applicable because the category does not apply; *m*: Information not available; *TEI*: Tertiary education institution

1. Information concerns universities only and does not account for the non-university sector.

2. Some publicly funded research organisations may need to seek Ministerial approval before introducing incentive schemes for TTO professionals.

3. If more than 50% of the funds come from public sources, the licence should be open to public disposal.

4. According to the legal framework, researchers are only allowed to work on a part-time basis for a spin-off company. Few TEIs have created spin-off companies.

5. The Centre for Science and Technology Studies at Leiden University collects data on patents, but not on licensing.

6. The governing legislation requires TEIs to constrain investments to the same range of low-risk investments. However, the Minister of Finance can approve investments outside the legislated 'low-risk' parameters.

7. There is no formal survey sponsored by the Ministry of Education or the Tertiary Education Commission. However, a one-off survey of all commercial activities was conducted by the Tertiary Advisory Monitoring Unit (TAMU) of the New Zealand Ministry of Education in 2002.

8. New Zealand TEIs have autonomy in employment matters. No national guidelines are known to have been developed in this area.

9. TEIs are responsible for the development of guidelines on licensing the results of research, including publicly-funded research. However, the Research Council of Norway was considering developing national licensing guidelines at the time this Table was prepared.

10. This data collection is part of the budget reporting.

11. According to the Polish Law on industrial property, the contractual relations with other entities regarding licensing R&D results are at the discretion of the TEI.

12. In practice, non-exclusive licensing and license concession are used frequently.

13. The creation of spin-off companies is not allowed in State institutions.

14. There are no rules on licensing the results of publicly-funded research conducted in public or private TEIs as the researchers have ownership of the results.

15. TEIs have ownership of the results, but inventors can obtain the intellectual property rights that have not been used.

16. It would depend on the terms and conditions of employment at the individual TEI.

**Source:** Derived from information supplied by countries participating in the project. The table should be interpreted as providing broad indications only, and not strict comparability across countries.

Tether and colleagues (2005) remind us that the public science base is funded by national taxpayers and so it is not unreasonable to expect this research to be relevant to national business interests. Indeed, these authors argue that “currently, a significant proportion of the science budget is spent on activities which contribute to a global pool of knowledge which is unlikely to be commercialised in the UK” (Tether *et al.*, 2005). However, it should be remembered that all countries have the benefit of tapping into the global pool of knowledge and utilising and commercialising knowledge developed around the world. This suggests the policy focus should also be directed towards improving access to open science. Moreover, other forms of knowledge transfer are important, and D’Este and Patel (2007) argue that government policy has been too focused on patenting and spin-off activity, and this can obscure “other types of university-industry interactions that have a much less visible economic pay-off, but can be equally (or even more) important, both in terms of frequency and economic impact.”

## 7.4 The governance of TEI research: Systems in transition

With respect to research performance, the reform of TEI governance methods has focused on four broad actions across OECD countries in recent years. These actions are, firstly, attempts to focus research efforts around explicitly chosen priority areas; secondly, changes in funding mechanisms aimed at raising research quality; thirdly, a stronger emphasis on research evaluation; and fourthly, building critical mass. In some countries these shifts have been accompanied by efforts to widen the channels of funding, with attempts to increase the links between universities and industry, and to make universities more responsive to industrial needs by making them more dependent on business funding of research. These changes have multiple sources and objectives, but a central motivation has been the aim of increasing the innovation effectiveness of TEIs’ R&D.

### 7.4.1 The research and innovation policy framework

Across the OECD and non-member economies national governments continue to develop national strategies, plans and frameworks for planning, co-ordinating and implementing science, technology and innovation policies to increase the efficiency of their research and innovation system. This is important for TEIs because national S&T plans provide an overarching framework in terms of funding commitments and future orientations, and they are used to identify research priorities. There appears to be a trend towards a more integrated and strategic approach to policy with respect to innovation. National strategies now often involve inter-ministerial councils, often at a very high political level, suggesting a degree of policy coherence. Moreover, these plans are increasingly involving institutions at the sub-ministry level such as research bodies, funding agencies and universities, since they are required to undertake their own strategic planning exercises and monitor progress. TEIs are also linked to regional development strategies in some countries (Box 7.4).

#### Box 7.4. The role of TEIs in regional innovation

TEIs play an important role in regional research and innovation systems along four main dimensions. As discussed above, TEIs contribute to innovation through the creation of knowledge-bases, developing human capital, knowledge diffusion and use and knowledge maintenance. However, regions have distinct local capabilities and so this means the knowledge infrastructure can be regionally specific. In some cases, regional clusters of firms and local innovation networks develop (see OECD, 2007c). Innovation involves interactions and knowledge flows between actors, so geographical proximity can be an important part of the innovation process. Technology transfer and collaborative relationships between local firms and local TEIs fosters interactive learning and knowledge diffusion. Regions also have specific training requirements, particularly at the vocational level.

Many OECD governments have sought to improve regional economies innovation capacity by integrating TEIs within regional development strategies. Some countries have developed initiatives aimed at strengthening the linkages between TEIs and regional employers (e.g. the **Czech Republic**) while others have focused on creating virtual clusters to enable small regional institutes to play an active role in research at the European level (e.g. **Belgium**). In **Norway**, some TEIs have been involved in setting up science parks in their vicinity, while in **Iceland** an initiative to foster regional entrepreneurship was a scheme to encourage graduates to found their own firms. **Chile** has a programme that develops closer associations between TEIs, firms and the productive sectors in the regions. It focuses on providing high-quality and regionally relevant technical training – *Chile Education and Permanent Training Qualifies* programme. The programme promotes the formation of regional networks of institutions that have been designed to link technical training with priorities for the region.

**The Russian Federation's Innovation Education Programme** was implemented in 2006 under the aegis of the President. The programme develops students' competencies and skills in a number of areas including capabilities for research-based activities and the practical use of results from fundamental and applied studies. The programme is competitively based and 57 TEIs (around 10% of all TEIs in the Russian Federation) have received funding. Most of these are leading regional TEIs, and it is expected that they will become the basis for innovation clusters in regions through the development of partnerships with other regional TEIs as well as with other regional stakeholders. The TEIs participating in this programme have established small-sized science and research institutions, centres and laboratories that focus on inter-disciplinary research and new scientific pathways. They have also raised project-based funding on a competitive basis. These new structural divisions integrate different TEI stakeholders such as students, Doctoral students, teachers and researchers into an innovation-based economy.

In some countries, direct support for regional TEIs is provided by Education Ministries. In **Korea**, for example, Divisions of Industry/University Cooperation (DIUC) have been established to build relations with companies or groups of companies to target development and training needs, and universities designated as a regional hub receive subsidies over 5 years. Cluster programmes have been introduced in some countries to improve linkages and economic development. The **Finnish** Centres of Expertise focus on key industries in many different sectors including culture, media and digital content. In **Japan**, the Knowledge Cluster Programme of MEXT (Ministry of Education, Culture, Sports, Science and Technology) aims to create a "concentration of knowledge and talent" (i.e. a Knowledge Cluster) for internationally competitive technological innovation, cooperating with the Industrial Cluster programme of METI (Ministry of Economy, Trade and Industry). For further details about these programmes see OECD (2007c).

Despite these initiatives, an issue emerging from the country reviews was the lack of co-ordination and collaboration between ministries responsible for regional issues, and institutions at the regional level. In **Iceland**, for instance, it was noted that a greater degree of coherence was needed across different Ministries with oversight for the regional dimension.

Several countries have established new organisations or consolidated existing government organisations to centralise or streamline policy development. For example, in Switzerland, a new constitutional framework for the education system was passed in 2006 which enables better co-ordination among the cantons as well as between the cantons and the federal government. In Poland, the National Centre for Research and Development was established in 2007. It is a central government agency responsible for implementing R&D and innovation policy, managing strategic R&D programmes, facilitating technology transfer, enhancing scientists' career development including supporting the involvement of young scientists in the implementation of research programmes and



international mobility. In England, the Department for Innovation, Universities and Skills was formed in 2007 by bringing together functions from two former departments – the Higher Education, Further Education and Skills Directorates from the former Department of Education and Skills and the Science and Innovation Directorates of the former Department of Trade and Industry. Similarly, in 2007 the Australian Government, with the goal of promoting national leadership in innovation, formed the Department of Innovation, Industry, Science and Research. In Finland, a new Ministry of Employment and the Economy was launched on the 1<sup>st</sup> of January 2008 by merging the previous Ministry of Trade and Industry, the Ministry of Labour and the Regional Development Department from the Ministry of the Interior. A National Innovation Strategy – the first of its kind – was prepared in early 2008. France has launched a series of reforms to strengthen the quality of higher education and research as well as to support innovation. Two major legislative acts in research and higher education have followed; the *Loi de programme pour la recherche* of 2006 which created a new framework for research funding, notably for project-based funding, and reformed Ministerial structures to bring more coherence to national research policy making and focus research in key areas such health, ICTs and nanotechnology; and the 2007 *Loi sur les libertés et responsabilités des universités* which grants universities greater autonomy on administrative, financial and human resources matters. In addition, responsibility for higher education and research has been placed under the autonomous Ministry for Higher Education and Research, independent from the Ministry of Education. The government established a new advisory body, the High-Level Council for Science and Technology (*Haut Conseil de la Science et de la Technologie*) reporting to the President of the Republic. (For a comprehensive overview of policy reforms and initiatives see OECD, 2006a; and OECD, 2008b, forthcoming.)

A number of countries have quantitative targets for R&D spending, and have substantially increased public funding for R&D. The EU Lisbon Agenda objective is to increase R&D expenditures to 3% of GDP by 2010 (with 2% in the private sector and 1% in the public sector), and both EU and non-EU countries have established their own goals in this respect. For example, Finland has an R&D target of 4% of GDP by 2011, whereas OECD countries such as Japan and Korea have directed their national targets for R&D spending towards the public sector. Japan's objective is to increase government R&D investment to 1% of GDP by 2010 and Korea plans to raise the ratio of government R&D investment in GDP from 0.86% in 2006 to 1% in 2012. In non-OECD countries R&D spending objectives are similar: China's target is to reach 2.5% of GDP by 2020 and the Russian Federation's objective is to reach 2% of GDP by 2010.

The European Commission has launched an integrated action plan to upgrade the conditions of research and innovation in the member States. Measures include regulatory reform, increasing funding for research and innovation, strengthening IPRs, and improving HRST mobility (European Commission, 2006). The European Research Council (ERC) was launched in February 2007 to support frontier research. According to its mission statement, the ERC approach “allows researchers to identify new opportunities and directions for research, rather than being led by priorities set by politicians. This approach ensures that funds are channelled into new and promising areas of research with a greater degree of flexibility” (European Research Council, 2007).

National innovation policy frameworks have an important impact on the governance of TEIs, since TEIs are often integrated into specific policy initiatives that can be used by governments to affect overall TEI management and direction. Innovation policies are now

characterised by new organising concepts, new agencies for implementation, and wider rationales. The main areas of innovation policy development relevant to TEIs include:

- Education and training (specifically related to innovation – skills acquisition, distance learning, lifelong learning, *etc.*);
- Mobility of students, teachers and researchers (through international mobility programmes, which are having large effects in some countries);
- Raising public awareness of science and innovation (including entrepreneurship);
- Management of innovation (“watch” capabilities and foresight activities which keep institutions abreast of design and production trends, organisational change, commercial and management consultancy and science developments);
- Innovation and the public sector (infrastructure, public procurement, monitoring and analysis, statistics and indicators, innovation in the public sector, policy capabilities); and
- Promotion of clustering and collaboration (regional initiatives, cluster-wide services and regional TEI capabilities).

Despite the development of national innovation strategies and policy frameworks, there is still a need for improved policy coherence among different policy arenas. In terms of HRST, a relatively well-known coherence problem for some countries has taken the form of difficulties in integrating such areas as science policy, TEI funding and HRST mobility into immigration policy. As a result of more stringent visa and immigration conditions for students and researchers in recent years, United States universities experienced falls in foreign student enrolments, with implications for TEI funding, course viability and longer term labour shortages in the science and engineering workforce. This has led to debate between universities and the federal government, with easing of visa restrictions and a recovery in numbers in 2007 (Open Doors, 2007 and NSF, 2008). Coherence issues of this type can be found throughout TEI research and innovation policies: for example, between objectives to enhance research quality using publication metrics, and efforts to increase the involvement of TEI researchers in industrial applications through collaboration with industry, the protection of IPRs through patenting and/or the commercialisation of TEI research. The establishment of R&D targets and research priorities provide further examples of policy coherence issues. Boosting R&D spending requires a substantial increase in R&D personnel but it can take many years to educate and train new R&D personnel, particularly researchers. Moreover, the introduction of research priorities may lead to HRST shortages in certain fields.

#### **7.4.2 Priority setting**

Many countries are implementing research priority setting measures to enhance outcomes by focusing efforts within their research and innovation systems. These priority-setting exercises face two challenges. First, “a major problem inherent of every priority setting process is to find a feasible methodology for the identification, selection and definition of thematic priorities or specific technologies” (Gassler *et al.*, 2007). Second, there is the implementation problem of linking the activities of the system effectively with the priorities that have been chosen.



Very few countries appear to have a systematic method for analysing and selecting priorities. One of the striking features of R&D priority setting across the OECD is the persistent focus on the knowledge bases underlying three technology fields: ICT, biotechnology and nanotechnology. At the present time the formal priority setting exercises of OECD countries appear to have little connection with actual patterns of technological specialisation, but it should also be said that in many countries the actual pattern of allocation of public R&D resources does not necessarily correspond to the formal R&D priorities. A recent development in monitoring priorities is the EU's ERAWATCH system, which is dedicated to monitoring the implementation of the European Research Area policy (European Commission, 2007). ERAWATCH contains detailed information on R&D policy across all of the EU's member States and associated countries, plus such countries as Brazil, China and India, and major OECD members such as Japan, Korea and the United States. At a broad policy level, the information suggests that countries do not have differentiated policy goals, but rather they have a common set of priority S&T fields that recur regularly. These are biotechnology and life sciences, ICT, and nanotechnology (Box 7.5). Given that OECD countries have differences in industrial structure, this uniformity across priority fields may suggest a lack of specificity in priority setting across countries.

#### Box 7.5. Examples of national R&D priorities

**Australia** – Research priorities focus on “frontier technologies”, meaning ICT, biotechnology and nanotechnology, as well as environmental sustainability, promoting and maintaining good health and safeguarding Australia.

**Japan** – The Third Basic Science and Technology Plan has identified four priority areas for R&D: life science, ICT, environment and nanotechnology.

**Korea** – The 2004 Science and Technology Plan priorities include IT technology, biotechnology, alternative energy technology, technology for high value-added industries, and technology for national safety.

**Norway** – Thematic priority areas are energy and environment, oceans, food and health. ICT, biotechnology, new materials and nanotechnology are prioritised technologies, and there is an increased focus on natural sciences and mathematics.

**Portugal** – The *Commitment towards Science* initiative, launched in 2006, while covering the whole spectrum of scientific fields (including the social sciences), comprises priorities around thematic R&D activities, such as ICT, nanotechnology, bioengineering, energy systems, transport systems and engineering design.

#### 7.4.3 Funding of research

A central element of governance is funding, namely the methods for allocating resources among competing needs within research systems. There is some evidence that although the array of methods remains generally unchanged, the balance among them has been changing across the OECD. There are three main government allocation mechanisms that are used to fund research activities in TEIs:

- **Research core funding**: a fixed block grant that is provided periodically (e.g. annually);
- **Research centre funding**: funds are allocated to specific research centres (e.g. centres of excellence); and
- **Project-based funding**: funds are granted to an individual researcher or group of researchers to carry out a specific research project on the basis of a project application.

These three allocation mechanisms are subject to further allocation criteria including historical trends, political decisions, negotiations with funding authorities, research funding formulas (which are performance-oriented in most cases), and competitive processes. Table 7.3 provides an overview of the mechanisms used in each country to allocate public funds to TEIs for research activities.<sup>24</sup> It shows a combination of allocation mechanisms are used, but project-based funding is now prevalent and is used in all countries.<sup>25</sup> In the majority of countries private institutions are eligible for public funds, and the allocation mechanisms are mostly similar to those utilised in the public sector. However, some countries have different allocation mechanisms for private institutions depending on the type of allocation. For instance, in Croatia and Mexico, private institutions are not eligible for public “research core funding” and there are some restrictions in terms of project-based funding. In New Zealand private institutions are eligible for public research core funding, but they are not entitled to public research centre funding or project based funding from the education budget. They can however access project-based funding from the government's allocation for “public-good” research, science and technology. The funding of research capital expenditure differs across countries, but tends to be either partially or fully included in the allocation methods described above. In Sweden, TEIs are entitled to borrow money from the State for research capital expenditure.

In addition, Table 7.3 shows that Australia, the Czech Republic, Estonia, Finland, Korea, the Netherlands, New Zealand, Norway, Poland, Portugal, and the United Kingdom use a funding formula to determine allocations, but in most cases it applies to research core funding. The performance measures attached to funding formulas include the number of post-graduate students, the number of research degrees awarded, the number of scientific publications, the number of patents and licences issued, the number of spinoffs, research contracts with companies and external research income. The allocation of research funds is made by an intermediate agency (such as a Research Council or Science Foundation) in more than half of the countries shown in Table 7.3.

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24. Research funding is also addressed by Table 4.3 in Chapter 4 (funding of teaching and learning activities) insofar the block grant for teaching and learning activities also includes research funding. That is, Table 7.3 does not provide the full picture of research funding allocation mechanisms.
25. While Table 7.3 highlights the research block funding scheme administered at the Government Departmental level in Australia, it should also be noted that project-based funding is rewarded in Australia through agencies such as the Australian Research Council and the National Health and Medical Research Council.

Table 7.3. Mechanisms to allocate public funds to tertiary education institutions for research activities, 2007

	Allocation mechanisms used by government authorities and/or intermediate agencies to primarily fund TEIs' research activities		Are private institutions eligible for public funds under each mechanism?		Is funding for research capital expenditure included?		Who is responsible for the allocation of funds?		Bases for allocation		Criteria used in funding formulas	
	Research core funding	Research centre funding	Yes, in a way similar to public institutions	Yes, in a way similar to public institutions	Yes, partially	No	Government authorities	Funding formula	Number of full-time equivalent student load, research degrees awarded, scientific publications, external research income, Australian Competitive Grants Research Income			
Australia <sup>a</sup>			Yes, in a way similar to public institutions	Yes, in a way similar to public institutions	Yes, partially	No	Intermediate agency (Australian Research Council)	Competitive basis (based on a quality evaluation by a peer review panel)	Competitive basis (based on a quality evaluation by a peer review panel)	Number of full-time equivalent student load, research degrees awarded, scientific publications, external research income, Australian Competitive Grants Research Income		a
Belgium (Flemish Community)			Yes, but with some restrictions (only private TEIs under public responsibility) <sup>2</sup>	Yes, partially (medium-sized equipment under a single scheme aimed at encouraging collaborative development of infrastructure)	Yes, partially (includes budget for equipment)		Government authority	Government authority	Competitive basis (based on a quality evaluation by a peer review panel)	Number of: master's degrees awarded, doctoral degrees awarded, scientific publications, citations, patents, spinoffs, research contracts with companies		a
Chile			Yes, but with some restrictions (only private TEIs under public responsibility) <sup>2</sup>	Yes, fully	Yes, partially (includes budget for equipment)		Intermediate agency (Research councils)	Competitive basis	Competitive basis		a	
			Yes, in a way similar to public institutions	Yes, fully	Yes, fully		Intermediate agencies (National Commission for Scientific and Technological Research; National Agency for Economic Development)	Competitive basis	Competitive basis		a	
			Yes, in a way similar to public institutions	Yes, fully	Yes, fully		Government authorities/intermediate agencies (National Commission for Scientific and Technological Research; Millennium Initiative-Ministry of Planning)	Competitive basis	Competitive basis		a	
China			Yes, in a way similar to public institutions	Yes, fully (public institutions)	Yes, partially (private institutions)		Government authorities/intermediate agency (National Foundation of Natural Sciences)	Competitive basis	Competitive basis		a	
			No	No, integrated in another budget item			Government authorities/intermediate agency (Research Council)	Historical trends (based on the number of staff)	Historical trends (based on the number of staff)		a	
Croatia			Yes, in a way similar to public institutions	No, integrated in another budget item (separate proposals)			Government authorities/intermediate agencies (Research Council, Technology Council, The National Foundation for Science, Higher Education and Technological Development)	Competitive basis	Competitive basis		a	
			Yes, in a way similar to public institutions	Yes, partially	Yes, partially		Government authorities	No competition (assessment of applications)	No competition (assessment of applications)		a	
Czech Republic			No	No, integrated in another budget item			Government authorities	Funding formula	Funding formula	Number of: doctoral students, master's degrees awarded; level of qualifications of academic staff; volume of external research income		a
			Yes, in a way similar to public institutions	Yes, partially	Yes, partially		Government authorities/intermediate agencies (Czech Science Foundation; Academy of Sciences)	Competitive basis	Competitive basis		a	
			Yes, in a way similar to public institutions	Yes, in a way similar to public institutions	Yes, partially		Intermediate agencies (Research Competency Council; Estonian Science Foundation)	Competitive basis (based on a quality evaluation by a peer review panel)	Competitive basis (based on a quality evaluation by a peer review panel)		a	
Estonia			Yes, in a way similar to public institutions	Yes, in a way similar to public institutions	No		Government authority	Funding formula	Funding formula	Number of research articles and patents; financial volume of research projects for industry; doctoral degrees awarded; volume of research in areas of national importance		a
			a		Yes, partially		Government authorities	Funding formula	Funding formula	Research degrees awarded; research income; number of: research fees awarded; scientific publications, study places in graduate schools		a
Finland			a		Yes, partially		Intermediate agency (Academy of Finland)	Competitive basis	Competitive basis		a	
			Yes, in a way similar to public institutions	Yes, partially	Yes, partially		Government authorities (public institutions), intermediate agencies (Academy of Finland; Finnish Funding Agency for Technology and Innovation)	Competitive basis	Competitive basis		a	
			No	No	Yes, partially		Government authorities	No competition (assessment of applications)	No competition (assessment of applications)		a	
Greece			No	No	Yes, fully		Government authorities	Competitive basis	Competitive basis		a	

Table 7.3. Mechanisms to allocate public funds to tertiary education institutions for research activities, 2007 (continued)

Allocation mechanisms used by government authorities and/or intermediate agencies to primary fund TEIs' research activities		Are private institutions eligible for public funds under each mechanism?		Who is responsible for the allocation of funds?		Basis for allocation		Criteria used in funding formulas	
Research core funding	Yes, in a way similar to public institutions	Yes, fully	Is funding for research capital expenditure included?	Government authorities	Negotiations with government authorities <sup>3</sup>	Negotiations with government authorities <sup>3</sup>			
Iceland	Research centre funding Project-based funding	Yes, in a way similar to public institutions Yes, in a way similar to public institutions	Yes, fully No	Government authorities Intermediate agency (Research council)	Negotiations with government authorities <sup>3</sup> Competitive basis	Negotiations with government authorities <sup>3</sup> Competitive basis			a a
Japan	Project-based funding	Yes, in a way similar to public institutions	Yes, partially	Government authorities/intermediate agencies (Japan Society for the Promotion of Science, Japan Science and Technology Agency)	Competitive basis	Competitive basis	(based on the number of post-graduate students, research degrees awarded, scientific publications, patents and licences issued)		a
Korea	Research centre funding	Yes, in a way similar to public institutions	Yes, partially	Government authorities	Competitive basis	Competitive basis	(based on scientific publications, patents and licences issued and research plan)		a
Mexico	Research centre funding (includes teaching and learning at the ISCED level 6) Project-based funding	Yes, in a way similar to public institutions No Yes, but with some restrictions (only in the context of certain governments projects/programmes)	Yes, fully Yes, fully	Government authorities Government authorities Intermediate agency (National Council for Science and Technology)	Historical trends; Funding formula Competitive basis	Historical trends; Funding formula Competitive basis			a a
Netherlands	Research centre funding Project-based funding	Yes, but with some restrictions (only publicly-subsidised private TEIs) Yes, but with some restrictions (only publicly-subsidised private TEIs)	Yes, fully Yes, fully	Government authorities Intermediate agency (Research Council NWO)	Historical trends; Funding formula Competitive basis	Historical trends; Funding formula Competitive basis	(based on number of scientific publications issued and licences issued and quality evaluation by a peer review panel)	Number of: post-graduate students, doctoral degrees awarded	a a
New Zealand	Research centre funding Project-based funding	Yes, in a similar way to public institutions No	Yes, fully Yes, partially (only strategic research assets except buildings)	Government authorities Government authorities Government authorities	Negotiations with government authorities Funding formula Competitive basis	Negotiations with government authorities Funding formula Competitive basis			a a a
Norway	Research centre funding Project-based funding	Yes, in a similar way to public institutions Yes, in a similar way to public institutions	Yes, fully Yes, partially	Government authorities Government authorities Intermediate agency (Research Council of Norway)	Historical trends; Funding formula Competitive basis	Historical trends; Funding formula Competitive basis	(based on themes of collaboration, excellence and relevance)	Number of: doctoral degrees awarded, scientific publications; volume of external research income	a a
Poland	Research core funding Research centre funding Project-based funding	Yes, in a way similar to public institutions Yes, in a way similar to public institutions Yes, in a way similar to public institutions	Yes, fully No Yes, partially	Government authorities Government authorities Government authorities Intermediate agency (Foundation for Science and Technology)	Funding formula Competitive basis Competitive basis	Funding formula Competitive basis Competitive basis			a a a
Portugal	Project-based funding	Yes, in a way similar to public institutions	No, integrated in another budget	Intermediate agency (Foundation for Science and Technology)	Competitive basis	Competitive basis	(followed by funding formula)	Quality evaluation by a peer review panel; number of researchers with a doctorate	a

Table 7.3. Mechanisms to allocate public funds to tertiary education institutions for research activities, 2007 (continued)

Allocation mechanisms used by government authorities and/or intermediate agencies to primarily fund TEIs' research activities	Are private institutions eligible for public funds under each mechanism?	Is funding for research capital expenditure included?	Who is responsible for the allocation of funds?	Bases for allocation	Criteria used in funding formulas	
Russian Federation	Research core funding (minor)	Yes, but with some restrictions (only in the context of certain government's projects/programmes)	No, integrated in another budget item	Government authorities	Historical trends; Negotiations with government authorities and/or intermediate agencies	a
	Research centre funding	Yes, in a way similar to public institutions	Yes, partially	Government authorities/intermediate agency (Federal Agency on Science and Innovations)	Competitive basis	a
Spain <sup>1</sup>	Project-based funding	Yes, in a way similar to public institutions	Yes, fully	Government authorities (national and regional)	Competitive basis	a
	Research core funding (including teaching and learning at ISCED level 6)	Yes, in a way similar to public institutions	Yes, partially (entitled to borrow money from the State)	Government authorities	Historical trends; Political decisions	a
Sweden	Research centre funding (for research centres) (including teaching and learning at ISCED level 6)	a	Yes, partially (entitled to borrow money from the State)	Government authorities	Historical trends; Political decisions	a
	Research centre funding (for Centres of Excellence) (including teaching and learning at ISCED level 6)	Yes, in a way similar to public institutions	Yes, partially (entitled to borrow money from the State)	Intermediate agencies (research councils and other national agencies)	Competitive basis (competitions open to TEIs)	a
Switzerland	Project-based funding (including teaching and learning at ISCED level 6)	Yes, in a way similar to public institutions	Yes, partially (entitled to borrow money from the State)	Intermediate agencies (research councils and other national agencies)	Competitive basis	a
	Research core funding (for universities and universities of applied sciences)	No	No, integrated in another budget item	Government authorities	Funding formula	Universities of applied sciences: knowledge transfer from R&D to teaching (share of lecturers employed); volume of external research income
United Kingdom <sup>4</sup>	Project-based funding (for universities and universities of applied sciences)	No	Yes, partially	Intermediate agencies (Swiss National Science Foundation for universities and Commission for Technology and Innovation for universities and universities of applied sciences)	Competitive basis	a
	Research core funding	Yes, but with some restrictions (only publicly-subsidised TEIs)	No, integrated in another budget item	Intermediate agencies <sup>2</sup> (Research Councils)	Funding formula	Results of a periodic Research Assessment Exercise <sup>3</sup> ; number of research-active academic staff; subject cost-weightings
	Project-based funding	Yes, but with some restrictions (only publicly-subsidised private TEIs)	No, integrated in another budget item	Intermediate agencies (Research Councils)	Competitive basis	a

**Definitions:** This table deals with the allocation mechanisms used by government authorities and/or intermediate agencies to fund primarily 'research activities' (i.e. training of researchers, basic and applied research) at the institutional level. It might include the funding of teaching and learning activities at ISCED level 6 only. Note that research funding is also considered in Table A3 (Chapter 4) insofar it is included in the allocation mechanisms primarily dedicated to fund teaching and learning activities at ISCED levels 5 and 6 (or ISCED level 5 exclusively). For the countries where this occurs, this is signalled in Column 1 of Table 4.3.

**Research core funding and research centre funding:** These terms refer to funding for research activities that are not subject to public procurement procedures. They are usually channelled through intermediate agencies. Allocation mechanisms refer to or public funds to allocate public funds to TEIs to conduct their activities. Both public and private institutions are covered in this table (Column 2 assesses the differences between these two types of institutions regarding the allocation of public funds).

**Research core funding:** refers to a fixed block grant provided periodically (e.g. Centres of Excellence, research consortia etc.).

**Research centre funding:** refers to a fixed block grant provided periodically (e.g. annual) by government authorities and/or intermediate agencies to TEIs for research activities.

**Research core funding:** refers to funding allocated by government authorities and/or intermediate agencies to specific research centres. Such research centres focus on a specific research/scientific area and can be part of a TEI, associated to a TEI or involve researchers from several TEIs and other research organisations.

**Project-based funding:** refers to funds conferred by government authorities and/or intermediate agencies to an individual researcher or group of researchers to carry out a specific research project. It is granted on the basis of a project application (i.e. an application is required in order to obtain funding).

**Research capital expenditure:** refers to spending on fixed capital assets for use in R&D activities. Capital expenditures are composed of expenditures on: (1) Land acquired for R&D (e.g. testing grounds and pilot plants) and buildings constructed or purchased (including improvements); (2) Major instruments and equipment; and (3) Computer and networking equipment. Small tools and instruments and minor improvements to existing buildings will normally be excluded in measuring capital expenditures. Most systems these items are usually carried on current cost accounts.

**Competitive basis:** refers to a process by which a TEI (a researcher or a group of researchers) is selected from among two or more contestants for the allocation of limited resources. If the granting of project-based funding results from the assessment of individual applications from institutions/researchers/group of researchers (i.e. the decision of whether or not to grant funding on the basis of an application is unrelated to applications by other institutions/researchers), then the basis for allocation is considered 'No competition'.

**Notes:** a - Information not applicable because the category does not apply; TEI: Tertiary education institution

- Information concerns universities only and does not account for the non-university sector.
- Private TEIs that are not under public responsibility are not eligible for public funds but can offer accredited master's courses.
- Research core funding and research centre funding are allocated through performance contracts, which are negotiated with the government authority. The performance contract is based on national priorities, work with other research institutions, tender for international funding and management of research quality.
- 4th in Northern Ireland, funding is made directly to TEIs by the Department for Employment and Learning, and not via an intermediate agency.
- 5th in Northern Ireland, funding is made directly to TEIs by the Department for Employment and Learning, and not via an intermediate agency.
- Research evaluation is carried out through the UK-wide Research Assessment Exercise. It is intended to introduce a more metrics-based approach after 2008. The publicly available reports consist of ratings/quality profiles.

**Source:** Derived from information supplied by countries participating in the project. The table should be interpreted as providing broad indications only, and not strict comparability across countries.

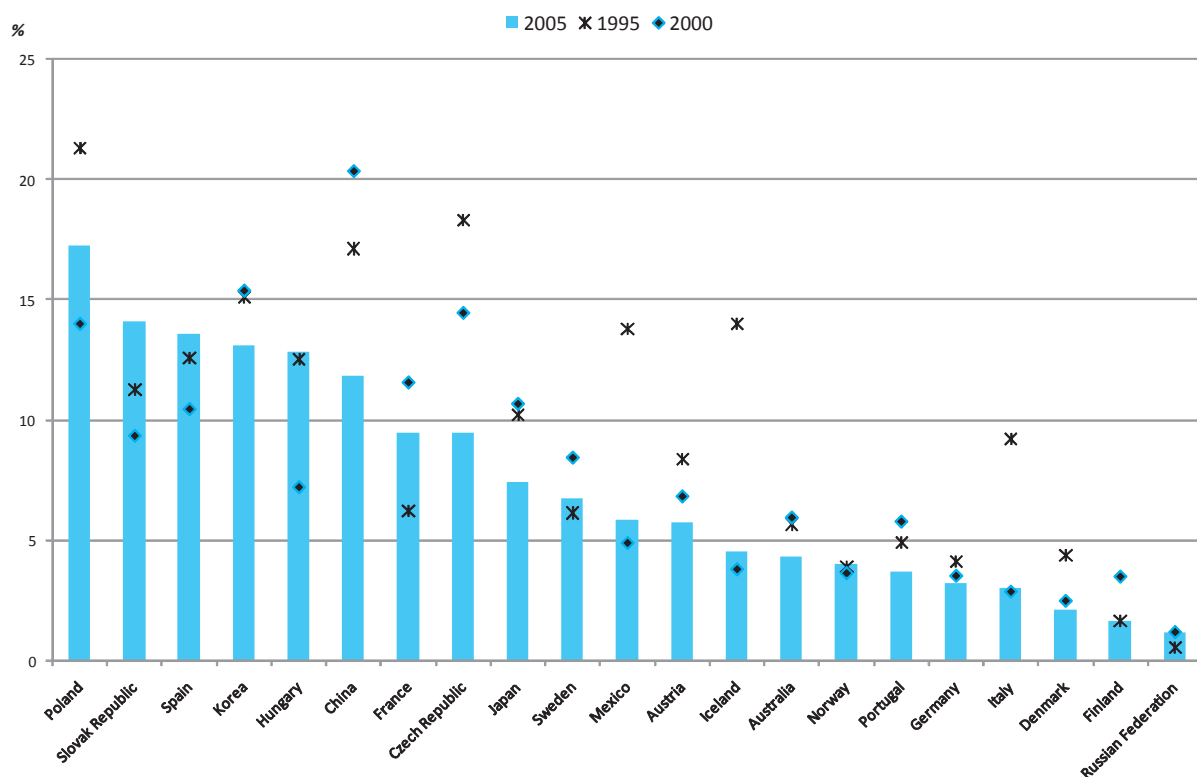
The shift to project-based research funding in TEIs raises a number of issues that need to be considered in relation to the long-term development of the research and innovation system. Competitive funding may promote more *ad hoc* and short-term research in cases where evaluation mechanisms and incentive structures focus on quantifiable and “immediate outputs”. As a result, researchers may be reluctant to engage in research that will not produce results that can be demonstrated over short time-spans. In addition, precisely because project-based funding is competitive, sustained funding is not guaranteed, which may impede the autonomy of researchers working in controversial fields. If project-based funding has a short duration, it may also mean that researchers need to spend time preparing applications to secure funding on a more frequent basis. Atkinson (2007) remarks that young faculty in particular spend an excessive amount of time preparing project proposals. Liefner (2003) found that competitive or performance-based funding could have an impact on the type and field of research because some academics avoided research with riskier outcomes. Likewise, Geuna (2001) notes that short-term research and less risky research may reduce the likelihood of “scientific novelty”. Furthermore, Geuna and Martin (2003) argue that research may become “homogenised” because “safer” research is rewarded. Morris and Rip (2006) point out that the stage of a researcher’s career needs to be considered in relation to the type of research undertaken. Some of the questions raised are: “does the researcher need quick results to bolster his or her next job application? Is he or she senior enough to get a five-year rather than a three-year grant?” (Morris and Rip, 2006), and these questions are pertinent in the context of project-based funding.

There may be a trend towards diminishing infrastructure funding at the present time. It is difficult to quantify precisely whether trends toward project-based funding have had an impact on investment in research infrastructure, but there are indications that investment is falling in TEIs. Figure 7.16 shows expenditure on major instruments and equipment acquired for use in the performance of R&D as a proportion of all types of R&D costs in higher education institutions. In 14 of the countries shown in Figure 7.16, the share of expenditure towards instruments and equipment decreased over the period 1995 to 2005. In China, the Czech Republic, Iceland, Italy and Mexico the share fell by more than 5 percentage points over the 10 year period. It is interesting to note that the share of expenditure increased slightly in Iceland and Mexico between 2000 and 2005. These decreases may represent a fall in the cost of instruments and equipment relative to other costs such as salaries for R&D personnel, other current costs (*e.g.* water, electricity, subscriptions to libraries, administrative costs) and land and buildings. Equally, there may simply be decreasing real expenditure on instruments and equipment. Without more detailed investigation, these results are inconclusive, although changing funding practices may have a bearing on investment in equipment and should be taken into account. For example, a comparative study of large-scale research equipment purchase and use in United Kingdom and United States universities found that limited funding and purchase delays could impede international competitiveness (Flanagan *et al.*, 2002). The authors of the report suggest problems were more pronounced in the United Kingdom because funding research infrastructure was largely piecemeal and involved submitting independent and successive research grant applications. In addition to the costs of purchasing equipment, support costs (*e.g.* maintenance, support personnel) were excluded, and uncertain and short-term funding exacerbated these issues.



**Figure 7.16. Expenditure on R&D instruments and equipment in the higher education sector, 1995, 2000 and 2005**

As a percentage of all types of R&amp;D costs



Countries are ranked in descending order of the expenditure on R&D instruments and equipment in the higher education sector in 2005.

Note: For '1995' data, the reference year is 1998 for China, 1997 for Sweden, 1996 for Korea and the Slovak Republic, 1993 for Austria, and 1992 for Italy. For '2000' data, the reference year is 2001 for Sweden, and 1998 for Austria. For '2005' data, the reference year is 2003 for Mexico, Portugal and Sweden, and 2004 for Australia, Austria, Denmark, France, Germany, Italy and Spain.

Source: OECD, R&D database, 2007.

There may also be impacts of project-based funding on the training of researchers. It was noted above that one of the key functions of the TEI system is competence building and research training. No major studies have yet been undertaken on the effects of governance reforms on such training. However, research in Australia has shown that the introduction of performance indicators can have an impact on teaching. For example, Taylor (2001) found that some academics encouraged their research students to undertake "easier projects" to ensure the research could be completed in a short period of time.

Some countries combine project-based funding with core research funding and research centre funding, which provides TEIs with a stable funding stream as well. For example, in Japan, MEXT (Ministry of Education, Culture, Sports, Science and Technology) has shifted public R&D expenditures away from recurring funding awarded to institutions on a formula basis towards funds that are awarded on a competitive basis. These have taken the form of *Grants-in-Aid for Scientific Research*, the *21st Century Centers of Excellence* programme (the 21<sup>st</sup> COE) and the *Global Centers of Excellence*



programme (the Global COE). Taken together these programmes have provided a foundation of peer-reviewed, competitive funding for university-based research. In Portugal, the share of competitive and semi-competitive funding was to increase from 26% in 2006 to 37% in 2007 as a part of the increased public funding of S&T. Liefner (2003) notes that while the competitive allocation of resources can provide positive incentives, such as increased scholarly activity, it can also have unintended consequences, such as the avoidance of risky projects. Therefore, Liefner (2003) argues that one of the positive aspects of stable core funding is it enables researchers to “follow new ideas and concentrate on pure research”. A combination of funding mechanisms can be used to ameliorate the negative effects of one type of funding.

It should be remembered, however, that the allocation of core research funding and research centre funding can also be competitively-based. The archetype of competitively based core funding is the United Kingdom’s Research Assessment Exercise (RAE), which is a periodic national exercise that assesses the quality of research and is used to inform the distribution of public funds for research.<sup>26</sup> The RAE has inspired other models based on similar principles because it attempts to raise the quality and visibility of research universities. Hong Kong (China) and New Zealand have adopted RAE evaluation principles.<sup>27</sup> In Australia, the Research Quality Framework (RQF) was cancelled by the new Australian Government on 21 December 2007. The Government has since announced a new system called the Excellence in Research for Australia (ERA) initiative. The initiative will be developed by the Australian Research Council (ARC) during 2008 and will assess research quality using a combination of metrics and expert reviews by committees comprising experienced, internationally-recognised experts. The RAE may be seen to have had positive effects in terms of directing funds selectively to the most highly rated, raising the profile of research and stimulating the development of supporting infrastructure, and consequently improving the quality of research. On the other hand, negative effects have included: unintended and inappropriate uses made of results as a guide to under-graduate education; reducing the status of teaching among academics; raising concerns about inhibiting industry and community links; concerns about the treatment of applied and interdisciplinary research; concerns about treatment of women and new entrants to the profession; the emergence of a transfer market for academics as universities seek to buy in leading researchers to enhance their profiles; hostility to the exercise from industry and other users who see it drawing research away from their interests and towards purely academic issues; and it places an undue administrative burden on the sector.

#### ***7.4.4 Evaluation and the quality assessment of research***

In recent years public support for R&D and innovation activities have been undertaken not simply as supports for the science system, but have been seen as instruments towards wider objectives related to growth, employment, competitiveness and welfare. These wider objectives have made governments more conscious of the need for impact assessments. Enhanced attention has therefore been given to evaluation

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26. For example, the RAE “informs the main allocation (90%) of research funds by the Funding Councils... In England, nine universities out of over 130 institutions receive about one half of the total funding allocated on the basis of research quality” (Country Background Report for the United Kingdom).
27. It should be noted that the systems in each country have developed progressively, which has enabled the countries to learn about unintended impacts.

activities that seek to explore the relations between funding inputs and a wide range of possible outcomes. Evaluation has become a basic element of the management of public research funding. The main aim has been to help governments assess the appropriateness, efficiency and effectiveness of public funding, as well as their joint effects (which may be intended or unintended). However the increased emphasis on evaluation has raised a number of important conceptual and methodological challenges.

Changes in the governance and financing of TEIs have led to increasing attention to commercialisation of research results, and to the use of IPRs by TEIs. These shifts in some ways simplify evaluation tasks, because they permit a greater focus on outcome evaluation. But changes of a less tangible kind remain difficult to evaluate, and research conducted in TEIs continues to pose important methodological challenges for evaluators. Four basic problems arise when assessing the impact of research activities (OECD, 2006a):

- i. *timing*: the effects of research often emerge long after the research has been completed;
- ii. *attribution*: a given innovation may draw upon many research projects and a given research project may affect many innovations;
- iii. *appropriability*: because the beneficiaries of research may not be the people or organisations that perform the research, it may not be obvious where to look for effects; and
- iv. *inequality*: in a given project portfolio the distribution of impacts is typically highly skewed, as a small number of “blockbuster” projects may account for most effects, while around half often only advance knowledge in a general way.

Table 7.4 shows the variety of mechanisms used to measure the quality of research conducted in TEIs. Most countries report evaluations are periodic, but there is wide variation in terms of the frequency. For example, in the Czech Republic the whole R&D system is evaluated every year whereas in Estonia, evaluations are conducted every 8 years. In Finland research evaluation is carried out on an *ad hoc* basis. There is also wide variation regarding the unit of evaluation which ranges from an evaluation of the whole R&D system, to the institutional level (the department, faculty or research group) and to the research field. In Finland, Mexico, New Zealand, the Russian Federation and Spain, individual academic staff are evaluated.

Table 7.4 also shows there is greater consistency across countries in terms of the indicators used to assess research quality. The use of publication data is prevalent. With the exception of New Zealand and Norway, publications contribute to the evaluation process. Patents and patent citations, and the relevance of research to business, including securing external research income, are common indicators as well. Peer reviews, awards and prizes, academic staff data and research student data also play a role in some countries. A less frequent indicator used to assess research quality is the alignment of research with national strategic priorities. In all countries apart from Spain, reports of the quality monitoring process are publicly available. However in the Czech Republic and the Russian Federation, this is at the discretion of the TEI, whereas in Mexico positive evaluations are publicly available.

Table 7.4. Evaluation of research quality, 2007

	Is general research evaluation carried out?	Unit of the evaluation	Types of evidence used to assess research quality	Are reports of the quality monitoring process publicly available?
Australia <sup>1</sup>	No <sup>2</sup>	a	a	a
Belgium (Flemish Community)	No	a	a	a
Chile	No	a	a	a
China	Yes, periodic evaluation (every 5-8 years)	Department or faculty	Research students' data, publication data, relevance of research to business and internal efficiency of TEI	Yes, in all cases
Croatia	Yes, periodic evaluation (every year for research plans)	Research field	Publication data and patents citation	Yes, in all cases
Czech Republic	Yes, periodic evaluation (every year for the whole R&D system)	The whole R&D system	Publication data and patents citation	Yes, in all cases
	Yes, periodic evaluation (every 2-3 years for research plans)	Research group	Academic staff data, publication data, patents citation and peer reviews	At the discretion of the TEI
Estonia	Yes, periodic evaluation (every 8 years)	Research group; research field	Academic staff data, research students' data, publications, patents, previous peer-reviews, infrastructure, cooperation with industry and participation in research programmes (such as centres of excellence)	Yes, in all cases
Finland	Yes, on an <i>ad hoc</i> basis	Individual academic staff; research group; department or faculty; TEI; and discipline	Academic staff data, research students' data, publication data, peer reviews, awards and prizes, relevance of research to business, alignment of research with national strategic priorities and internal efficiency of TEI	Yes, in all cases
Greece	No <sup>3</sup>	a	a	a
Iceland	Yes, periodic evaluation (every 3 years)	Department or faculty; field of study	Research students' data, publication data, relevance of research to business and internal efficiency of TEI	Yes, in all cases
Japan	National universities, public universities, public university corporations, private institutions: Yes, periodic evaluation (every 7 years)	TEI	At the discretion of intermediate agencies	Yes, in all cases
	National universities: Yes, periodic evaluation (every 6 years)	Department or faculty; TEI	At the discretion of TEIs (in most cases: publication data, patents citation, peer reviews, awards and prizes, relevance of research to business and alignment of research with national strategic priorities)	Yes, in all cases
Korea	Yes, periodic evaluation (every 5 years) <sup>4</sup>	TEI	Academic staff data, research students' data, publication data, relevance of research to business and internal efficiency of TEI	Yes, in all cases
Mexico	Yes, periodic evaluation (every 3-5 years)	Individual academic staff	Research student's data, publication data, relevance of research to business, supervision of post-graduate students and internal efficiency of TEI	Yes, for positive evaluations
Netherlands	Yes, periodic evaluation (every 6 years)	Department or faculty; research programme	Academic staff data, publication data, peer reviews, relevance, productivity, quality and feasibility	Yes, in all cases
New Zealand	Yes, periodic evaluation (every 6 years)	Individual academic staff; TEI	Individual academic staff: quality of research outputs, peer esteem and contribution to the research environment TEI: relevance of research to business (external research income) and research students' data (number of post-graduate research degree completions)	Yes, in all cases
Norway	Yes, on an <i>ad hoc</i> basis	Research group; department or faculty; research field/discipline	Peer reviews	Yes, in all cases
Poland	Yes, periodic evaluation (every 4 years)	Faculty (or other organisational unit of the TEI)	Academic staff data (e.g. number of staff, staff qualifications), publication data, patents citation, licenses and practical application of research	Yes, in all cases
Portugal	Yes, periodic evaluation (every 3 years for research centres and every 5 years for associate labs)	Research centres; associate labs	Academic staff data, research students' data, publication data, patents citation, peer reviews, awards and prizes, relevance of research to business, alignment of research with national strategic priorities, internal efficiency of TEI and international reference criteria	Yes, in all cases
Russian Federation <sup>5</sup>	Yes, periodic evaluation (every 5 years by accreditation expert teams)	Individual academic staff; TEI	Academic staff data, research students' data, publication data, relevance of research to business	At the discretion of the TEI <sup>6</sup>
Spain <sup>1</sup>	Yes, periodic evaluation (every 6 years)	Individual academic staff	Publication data and patents citation	No
Sweden	No <sup>7</sup>	a	a	a
Switzerland <sup>8</sup>	Yes, on an <i>ad hoc</i> basis	TEI	Universities: No standardised criteria at the national level Universities of applied sciences: academic staff data, publication data and peer reviews	At the discretion of the TEI
United Kingdom	Yes, periodic evaluation (every 5-7 years)	Department or faculty	Peer review, sample of publications (including patents citations), academic staff data, research students' data, research income, research environment and esteem (including awards and prizes)	Yes, in all cases <sup>9</sup>

**Definition:** The table addresses the mechanisms used to measure the quality of research conducted in TEIs. Only formal external evaluations are considered.

*Research* refers to publicly-funded research conducted by public or private TEIs and includes both research activities and the training of researchers.

*General research evaluation* refers to the existence of a national framework for the external evaluation of the research capacity of units assessed and their ongoing and/or completed research. General research evaluation also includes the evaluation of institutional research plans in countries where such plans exist. However general research evaluation excludes both 'project-based evaluation of research' (i.e. evaluation of a research project proposal) and 'internal evaluation' (i.e. self-evaluation carried out within TEIs without the involvement of an external panel).

**Notes:** a: Information not applicable because the category does not apply; TEI: Tertiary education institution

1. Information concerns universities only and does not account for the non-university sector.

2. The Australian Government is developing a new system called the Excellence in Research for Australia (ERA) Scheme. The scheme will use leading researchers to evaluate research activity progressively in each of the six ARC (Australian Research Council) discipline clusters and several clusters covering health and medical research that will be informed by experts from the National Health and Medical Research Council (NHMRC). It is expected that each cluster report will detail by institution and by discipline those areas that are internationally competitive together with emerging areas where there are opportunities for development and further investment.

3. A general research evaluation is planned. It will be carried out at least every 4 years. The unit of the evaluation will be TEIs, departments and research programmes and the report on quality monitoring process will be publicly available.

4. Evaluation cycles vary according to research projects. However for most multi-year research projects, external evaluation is conducted every year.

5. Research evaluation is part of accreditation procedures, but a systemic and comprehensive system of research evaluation was under elaboration at the time this Table was prepared.

6. The reports of the quality monitoring process are available to accreditation expert teams as well as to assessed TEIs. TEIs can make these reports publicly available at their own discretion.

7. Although there is no national framework for the external evaluation of research, research funding agencies evaluate most subjects on a regular basis (usually every 10 years).

8. Research is also evaluated through the accreditation process. Please see Table 5.2 (Chapter 5) for more information.

9. Reports of the quality monitoring process are not publicly available in Northern Ireland.

**Source:** Derived from information supplied by countries participating in the project. The table should be interpreted as providing broad indications only, and not strict comparability across countries.

However, linking output to funding may have unintended impacts on research quality. For example, Butler (2002 and 2003) found that Australian universities' share of publications in the Science Citation Index increased when funding agencies started to link the allocation of research funds to the number of publications. Moreover, the strongest growth was in journals with a below-median impact, and this pattern was found across the social sciences, humanities and sciences. Other studies have found that publication practices have changed. Data collected from nine upper tier American universities by researchers at the National Science Foundation<sup>28</sup> found that respondents reported it was now easier to publish because the volume of scientific articles had increased, though it was also noted that standards for publishing in high impact journals had risen as well (Bell *et al.*, 2007). Nevertheless, given the adjustments required to make publications a valid measure of scientific impact all respondents concluded that this was not a viable mechanism to evaluate a faculty. The same study also found that competitively obtained external research funding was viewed as the most relevant quantitative measure of research activity (Bell *et al.*, 2007). However, this assumes that external funding is readily obtainable across all disciplines.

Another common output indicator is patenting, but it is not a reliable general indicator of the impact of scientific output on innovation. Patenting behaviour is highly skewed towards particular fields, relatively few inventions actually make it into innovations, and the majority of patent revenue comes from a few successful innovations. Moreover, the growth of university patents has had an impact on the quality of patents. For example, research has found that “the relative importance and generality of university patents has fallen at the same time as the sheer number of university patents has increased. This decrease appears to be largely the result of a very rapid increase in the number of ‘low quality’ patents being granted to universities” (Henderson *et al.*, 1998).

Butler (2007) argues that “any research assessment process, particularly one with significant funding consequences, will affect the way people behave.” Despite the difficulties associated with evaluating the impact of research in TEIs, it is necessary to ensure the system is efficient and effective. Butler (2007) suggests that perverse outcomes can be minimised if assessment exercises combine peer review with a range of indicators. Nevertheless, policy makers need to be mindful of the complexities, unintended side-effects and long-term impacts on the research and innovation system. These problems suggest continuing and unresolved challenges for evaluation methodologies.

#### **7.4.5 Creating critical mass – centres of excellence**

Centres of excellence have been established as a means of creating critical mass and excellence in specific research areas, promoting interdisciplinary research and encouraging public-private collaboration. Under this system, public funding is increasingly concentrated in a limited number of institutes or centres. While the concept of centres of excellence is used and interpreted in many ways, the term implies performing measurable world standard research. According to the European Commission (2002), some of the key features of a centre of excellence are:

- a “critical mass” of high level scientists and/or technology developers;
- a well-identified structure;

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28. It should be noted that this study focused on science and engineering disciplines.

- capable of integrating connected fields and to associate complementary skills;
- capable of maintaining a high rate of exchange of qualified human resources;
- a dynamic role in the surrounding innovation system (adding value to knowledge);
- high levels of international visibility and scientific and/or industrial connectivity;
- a reasonable stability of funding and operating conditions over time; and
- sources of finance which are not dependent over time on public funding.

The notion of critical mass continues to play a strong role in tertiary education R&D in many countries, and it is clearly linked to the funding and evaluation mechanisms discussed above. This concept contains a number of problems, however, that remain unresolved at the present time. The most important point is actually identifying what critical mass means across different fields. It is unclear, for example, how many researchers need to be brought together to create a critical mass, do they need to be co-located or can the mass be created through virtual contact, networks and collaboration? Is a critical mass in astronomy the same as a critical mass in computer sciences or economics? These unanswered questions suggest further research is required to inform policy development.

### 7.5 Pointers for future policy development

The policy suggestions that follow are drawn from the experiences reported in the Country Background Reports, the analyses of external review teams, and the wider research literature. Not all of the policy implications apply equally to all reviewed countries. In a number of cases many or most of the policy suggestions are already in place, while for other countries they may have less relevance because of different social, economic, research and educational structures and traditions. The implications also need to be treated cautiously because in some instances there is not a strong enough research base across a sufficient number of countries to be confident about successful implementation. The discussion attempts to distil potentially useful ideas and lessons from the experiences of countries that have been searching for better ways to enhance the role of tertiary education in research and innovation.

#### *Improve knowledge diffusion rather than strengthening commercialisation via stronger IPRs*

There has been, in recent years, a stronger policy emphasis on the commercialisation of university R&D results. This has been implemented via such measures as the Bayh-Dole Act in the United States and its equivalents in other countries, and via the very frequent establishment of university technology transfer offices (TTOs). While patenting and other commercialisation activities may provide revenue for TEIs it is important to remember that the results are highly skewed. This suggests that the ongoing existence of TTOs in many TEIs should be assessed. Moreover, a common criticism of commercialisation is it takes at best a restricted view of the nature of innovation, and of the role of universities in innovation processes. In essence, such measures assume that innovation is the outcome of a discovery process that is then commercialised, and that R&D is the initiating phase of innovation. However it is widely held among innovation analysts that innovation often has wider origins in the development of new product



concepts by firms, and that R&D is a problem-solving activity along the “innovation journey” rather than a point of departure for it (van der Ven *et al.*, 1999). This latter approach suggests that the diffusion capabilities and interactive support activities of TEIs may be at least as important as discovery processes. Methods and instruments for such support deserve closer policy consideration at present.

*Improve and widen channels of interaction and encourage inter-institutional collaboration*

Linkages and collaboration between the tertiary education sector and other actors in the research and innovation system, such as firms and public research organisations, need to be further developed, with the aim of improving knowledge diffusion. Linkages range from formal strategic alliances to informal interactions and partnerships. Informal interactions, personal contacts and networks between TEIs and other organisations are critical, but tend to be outside the policy scope because these relationships are based on trust and other social mechanisms. Nevertheless, the tertiary education sector, including non vocational TEIs, should be flexible and responsive to industry needs in terms of co-operative projects. Policy needs to ensure that small and medium-sized enterprises (SMEs) and firms from all technological sectors are considered when programmes are designed. This is particularly important given the results presented above which showed that small and medium-sized firms reported considerably less co-operation with TEIs. Moreover, some existing linkage programmes are largely suited to longer-term arrangements, and this may hinder participation by some firms, particularly SMEs. While most partnerships with industry tend to have a research or innovation focus, they can be broadened to include industry representation on boards of management or the development of co-operative education programmes (for example industry can play an advisory role in curriculum design).

*Foster mobility across the research and innovation system*

Inter-sectoral mobility is one of the main carriers of knowledge diffusion. Mobility between firms, TEIs and public research organisations should be more actively encouraged. Staff mobility enhances tacit knowledge flows and stimulates the circulation of ideas and the development of new capabilities. Each individual’s skills and expertise can improve as a result of even short-term moves, thus increasing the global stock of skills. Moreover, human capital could be used more efficiently, resulting in an increase in the global production of research results and more innovation. Policy makers need to provide incentives to facilitate mobility, and ensure that barriers are removed such as inflexible pension schemes and restrictive leave of absence policies in TEIs.

*Develop policies for both international as well as intra-national mobility*

An increasing number of countries are focusing on international mobility, rather than intra-national mobility. Many countries are implementing policy measures to attract foreign students and foreign researchers and to facilitate their access to the labour market. However, competition for students and skilled workers is increasing, and policy makers need to be concerned with measures both to attract students and researchers and to retain them. Although policy has less influence on cultural and structural barriers, it can focus on improving visa regulations and other immigration conditions, housing policies, and education access for children.

Despite increasing international flows, policy makers cannot ignore the development of human capital at the national level, and its mobility between domestic sectors. The global market for the highly skilled is becoming more competitive and opportunities in the main supply countries are improving. However it should be remembered that international mobility is largely a supplement to domestic human capital creation, not a substitute for it, even in economies with relatively high levels of immigration. Therefore, policy also needs to focus on building attractive research environments in TEIs, which includes the availability and quality of research infrastructure.

#### *Improve research career prospects*

While there is, at least in aggregate, an increasing supply of HRST graduates, there is no concomitant expansion of tertiary education career opportunities, and there has been a significant increase in part-time work, temporary employment, and time-limited contracts in tertiary institutions across the OECD. In addition, during review visits, some academic staff expressed that professional expectations and demands have been rising. In order to maintain current levels of research staff, attract young researchers, and attenuate the effects of an ageing workforce, the attractiveness of research careers in TEIs must be improved. Policy issues include addressing the impacts of insecurity on the attractiveness of research careers, improving the flexibility of public sector employment policies, and ensuring that salaries remain commensurate with other professions.

#### *Monitor the supply and demand of human resources*

The nature of demand for human resources in research and innovation is evolving in both the public and private sectors, which has implications for supply-side education and training policies. Ultimately, the successful match between supply and demand for HRST depends on a flexible and rapid response from TEIs as well as greater institutional and market incentives for mobility. An important policy challenge is improving information on supply and demand mismatches, and overall labour market trends. Although the data situation has improved, there is still considerable scope for improving policy-relevant data on HRST, and this should be an important common priority across countries in the near future.

#### *Ensure a variety of skills for innovation*

Innovation is a complex phenomenon that requires a broad mix of skills and competencies. While S&E graduates are a key component of HRST and crucial for R&D activities, persons with technical skills and vocational training are also a central part of the research and innovation system. Innovating firms are not necessarily engaged in the development of radical, new to the world goods, services or processes, therefore many innovation activities are a key function of vocationally trained personnel. Moreover, the content of research work is changing. Globalisation and the growth in outsourcing and inter-institutional collaboration has changed the way firms innovate which means employees need to develop new work methods and adapt to research and production methods that are increasingly conducted outside the firm. It is important to combine technical skills with “soft” skills such as problem-solving capabilities and communication and management skills. The education of S&E graduates should prepare them for careers outside the traditional research path, and all TEIs, including non-research institutions should focus on providing their students with flexible and transferable skills and competencies.



*Maintain adequate research infrastructure*

Research infrastructure, instruments and equipment need to be maintained and updated regularly. This has two dimensions. On the one hand there is the basic fabric and resources of the tertiary education system with respect to its teaching, routine research and knowledge storage functions. On the other, there is the more specialised area of large scientific facilities. The replacement of large infrastructures must be carefully planned both nationally and in individual institutions. However, this is not simply a national matter because large science facilities are increasingly transnational in funding and operation, and this imposes a need for collaborative policies across countries. It is helpful to see this against the background of the increasing internationalisation of R&D.

*Use the tertiary education sector to foster the internationalisation of R&D*

Until recently, R&D policy has largely been national in scope, often supporting the development of critical knowledge bases and technologies or particular national specialisations. However, the internationalisation of R&D is now a key dimension of globalisation, with important implications for economic development and public policy. Multinational enterprises (MNEs) play a major role in this process since they account for the major share of global business R&D. While corporate R&D activities still maintain a home-country bias – in the sense that firms continue to carry out R&D predominately where their head offices are located – MNEs are changing how they innovate and this involves building global distributed R&D networks. MNEs are increasingly establishing R&D facilities at many locations worldwide. These changes have important implications on tertiary education policies because innovation and research networks span national boundaries. A key policy problem is how to integrate essentially national measures and instruments – such as education and training policies and infrastructure policies – and companies' globalised knowledge strategies.

*Improve methods for priority selection*

Many countries, facing the reality of resource constraints, argue a need for setting research priorities and building centres of excellence. These often consist of specific scientific and/or technological fields. However, it is common for countries to select the same areas – usually biotechnology, ICT and nanotechnology – and relatively rare for them to select priorities that relate clearly to their actual areas of technological specialisation. Few countries have a systematic approach to priority selection. Given that the OECD as a whole exhibits considerable diversity in industrial structures and technological fields, this may be an important issue for future work. Moreover, once priorities are selected the activities need to be linked to the research and innovation system.

Many countries in the Review are striving to create world-class centres of excellence – *i.e.* sufficiently concentrated research capacity to ensure that graduate student training and scientific activities are carried out at the highest international levels, and to attract international researchers. This needs to be approached with some caution. While it is important to ensure that resources are used efficiently and research funding is effectively targeted at the national level, and resources are not distributed too thinly, many countries – as noted above – are concentrating on similar priorities. Therefore, creating a world class international centre of excellence is a very difficult challenge for an individual country in the global research context. Policy makers need to ensure that the

tertiary education sector retains sufficient diversity so it can respond to future needs in the innovation system. The bias towards “frontier research” or “cutting-edge science” might be evaluated, in view of the fact that most innovation is incremental in character, and it involves non-scientific and non-R&D based knowledge such as design, marketing and tooling-up. In addition, a balance needs to be achieved between supporting basic and applied research. Policy needs to take account of non-technological, or organisational innovation by ensuring that the social sciences and humanities are not neglected. The establishment and maintenance of centres of excellence should be linked to national strengths and align with national industry priorities, as well as retaining enough flexibility to support emerging areas.

*Broaden the criteria used in research assessments*

A variety of indicators are used to measure the quality of research conducted in TEIs, but these indicators are problematic. Linking funding to quantifiable output measures, such as publications and patents, has had unintended impacts on the quality of research. This suggests a broad range of robust performance indicators should be developed and used to ensure the quality of TEI research is maintained and enhanced. Indicators can also be supplemented with other evaluation mechanisms such as peer review. Particular care needs to be taken to ensure that research assessments capture the wide differences across disciplines and significant time lags.

*Ensure the shift towards project-based funding is monitored and provide a mix of funding mechanisms*

The shift to competitive and project-based funding in TEIs needs to be examined in relation to the long-term development of the research and innovation system. Investment in equipment and instruments and the share of basic research conducted in TEIs is declining in many countries. The type of research undertaken seems to be shifting towards shorter and safer projects, and this is also linked to performance measures. It is unclear if project-based funding is having an impact on the training of researchers. These issues should be carefully monitored over the coming years. In the meantime, a mix of competitive and non-competitive mechanisms can be used to balance undesired effects.

*Provide a long-term perspective to research and innovation policies*

Knowledge production is a cumulative process that often involves very long time-lags between discovery and application. Therefore, it is essential that research and innovation policies take a long-term perspective to ensure the system is capable of contributing to future economic growth, technological progress and sustainable development. In particular, TEIs have an important role to play in terms of understanding and developing solutions to global challenges such as environmental, health and energy issues. Moreover, TEIs play multiple roles in knowledge economies. This means the governance of TEIs cannot focus on one-dimensional or short-term needs.

*Evaluate and co-ordinate policy instruments across the research and innovation system*

The policy instruments that have an impact on the development of the research and innovation system are diverse and multi-faceted. The governance structures related to policy making cut across administrative, judicial, regulatory and ministerial boundaries. Furthermore the decentralised nature of tertiary education policy in many countries limits

the scope and coverage of national policy measures. Such a policy landscape makes it extremely difficult to assess the effectiveness of individual policies and measures, many of which take place at the grass-roots or institution level and whose impact (or lack of) may depend on the success of other measures at different levels and under the competence of different actors (e.g. schools, local governments, national education ministries, research funding agencies) and require time to be evaluated. The tertiary education sector is an integral part of the science and innovation system. Different policies interact and influence wider performance so policies need to be coherent and co-ordinated across government, and evaluated across the entire innovation system.

### References

- Aho, E. (2006), *Creating an Innovative Europe: Report from the Independent Expert Group on R&D and Innovation appointed following the Hampton Court Summit*, January.
- Archibugi, D. and M. Pianta (1992), *The Technological Specialisations of the Advanced Countries*, Kluwer, Dordrecht.
- Arundel, A. and C. Bordoy (2006), “Developing internationally comparable indicators for the commercialization of publicly-funded research”, paper presented at the OECD Blue Sky II Conference, September 26-28, Ottawa, Canada.
- Atkinson, R. (2007), “Research Universities: Core of the US Science and Technology System”, Center for Studies in Higher Education, University of California, Berkeley, Paper CSHE5’07.
- Auriol, L. (2007), “Labour Market Characteristics and International Mobility of Doctorate Holders: Results for Seven Countries”, *STI Working Paper 2007/2*, OECD, Paris.
- ABS (Australian Bureau of Statistics) (2004), *Research and Experimental Development: Higher Education Organisations*, Cat. No. 8111.0, Australian Bureau of Statistics, Canberra.
- ABS (Australian Bureau of Statistics) (2006), *Patterns of Innovation in Australian Businesses*, Cat. No. 8163.0, Australian Bureau of Statistics, Canberra.
- ABS (Australian Bureau of Statistics) (2007), *Innovation in Australian Business 2005*, Cat. No. 8158.0, Australian Bureau of Statistics, Canberra.
- AUTM (The Association of University Technology Managers) (2007), *AUTM U.S. Licensing Activity Survey FY2006*, [www.autm.net/surveys/index.cfm](http://www.autm.net/surveys/index.cfm), accessed 22 January 2008.
- Balconi, M., S. Breschi and F. Lissoni (2004), “Networks of inventors and the role of academia: An exploration of Italian patent data”, *Research Policy*, 33, pp. 127-145.

- Basri, E. (2001), “Inter-firm technological collaboration in Australia in an international context: Implications for innovation performance and public policy”, *Innovative Networks: Cooperation in National Innovation Systems*, OECD, Paris, pp. 143-168.
- Basri, E. (2006), *Technological Collaboration and the Innovation Activities of Australian Firms*, PhD Thesis, Australian National University.
- Bell, R., D. Hill and R. Lehming (2007), “The Changing Research and Publication Environment in American Research Universities”, *Working Paper SRS 07-204*, National Science Foundation [NSF], Arlington.
- Bok, D. (2003), *Universities in the Marketplace*, Princeton University Press, Princeton.
- Butler, L. (2002), “A list of published papers is no measure of value”, *Nature*, 419, p. 877, 31 October 2002.
- Butler, L. (2003), “Explaining Australia’s increased share of ISI publications – the effects of a funding formula based on publication counts”, *Research Policy*, 32, pp. 143-155.
- Butler, L. (2007), “Assessing university research: a plea for a balanced approach”, *Science and Public Policy*, 34(8), pp. 565-574.
- Cohen, W. and D. Levinthal (1989), “Innovation and Learning: the two faces of R&D”, *The Economic Journal*, 99, pp. 569-596.
- Colyvas, J., M. Crow, A. Gelijns, R. Mazzoleni, R. Nelson, N. Rosenberg and B. Sampat (2002), “How do university inventions get into practice?”, *Management Science*, 48 (1), pp. 61-72.
- Crespi, G., A. Geuna and B. Verspagen (2006), “University IPRs and Knowledge Transfer. Is the IPR Ownership Model More Efficient?”, *SPRU working paper series*, No. 154.
- DEST (Department of Education, Science and Training) (2003), *Mapping Australian Science and Innovation*, Commonwealth of Australia, Canberra.
- D’Este, P. and P. Patel (2007), “University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry?”, *Research Policy*, 36, pp. 1295-1313.
- Dosi, G., P. Llerena and M. Sylos Labini (2005), “Science-technology-industry links and the ‘European Paradox’: Some notes on the dynamics of scientific and technological research in Europe”, *LEM Working Paper Series*, 2005/02, Italy.
- European Commission (2002), *Action for “centres of excellence” with a European Dimension*. <http://ec.europa.eu/research/era/pdf/centres.pdf>, accessed 30 July 2007.
- European Commission (2006), *Putting Knowledge into Practice: A Broad-based Innovation Strategy for the EU*, Brussels.
- European Commission (2007), <http://cordis.europa.eu/erawatch/index.cfm>, accessed 30 July 2007.
- European Research Council (2007), Mission of the ERC, accessed 30 July 2007 <http://erc.europa.eu/index.cfm?fuseaction=page.display&topicID=12>
- Eurostat (2004), *The Fourth Community Innovation Survey (CIS) Harmonised Survey Questionnaire*, Eurostat.

- Flanagan, K., K. Malik, P. Halfpenny and L. Georghiou (2002), *A Comparative Study of the Purchase, Management and Use of Large-scale Research Equipment in UK and US Universities*, PREST and CASR, The University of Manchester.
- Gassler, H., W. Polt and C. Rammer (2007), “Priority Setting in Research and Technology Policy – Historical Developments and Recent Trends”, *InTeReg Working Paper No. 36-2007*, Joanneum Research Institute of Technology and Regional Policy, Austria.
- Geuna, A. (2001), “The Changing rationale for European university research funding: Are there negative unintended consequences”, *Journal of Economic Issues*, 35(3), pp. 607-632.
- Geuna, A. and B. Martin (2003), “University research evaluation and funding: an international comparison”, *Minerva*, 41, pp. 277-304.
- Gibbons, M. and R. Johnston (1974), “The role(s) of science in technological innovation”, *Research Policy*, 3 (3), pp. 220-242.
- Henderson, R., A. Jaffe and M. Trajtenberg (1998), “Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965-1988”, *Review of Economics and Statistics*, 80, pp. 119-127.
- Industry Canada (2007), *Mobilizing Science and Technology to Canada’s Advantage*, Public Works and Government Services, Canada.
- Liefner, I. (2003), “Funding, resource allocation, and performance in higher education systems”, *Higher Education*, 46, pp. 469-489.
- Lundvall B.-A. and B. Johnson (1994), “The learning economy”, *Journal of Industry Studies*, 1 (2), pp. 23-42.
- Mansfield, E. and J-Y Lee (1996), “The modern university: contributor to industrial innovation and recipient of industrial R&D support”, *Research Policy*, 25, pp. 1047-1058.
- Martin, B. (2003), “The changing social contract for science and the evolution of the university”, in Geuna, A., A. Salter and E. Steinmueller (eds.), *Science and Innovation: Rethinking the Rationales for Funding and Governance*, Edward Elgar, Cheltenham, pp. 7-29.
- Meri, T. (2007), “How Mobile are Highly Qualified Human Resources in Science and Technology?”, *Statistics in Focus, Science and Technology*, 75/2007, Eurostat.
- Ministry of Education, New Zealand (2006), *The System in Change: Monitoring Report 2005 – Tertiary Education Strategy 2002/07*, Ministry of Education, Wellington.
- Ministry of Education, New Zealand (2007), *Comparing the Academic Impact of Research by New Zealand and Australian universities 1981-2005*, Ministry of Education, Wellington.
- Ministry of Research, Science and Technology, New Zealand (2006), *Vision Mātauranga: Unlocking the Innovation Potential of Māori Knowledge, Resources and People*, Advisory Group to the Ministry of Research, Science and Technology, Wellington.



- Morris, N. and A. Rip (2006), “Scientists’ coping strategies in an evolving research system: the case of life scientists in the UK”, *Science and Public Policy*, 33 (4), pp. 253-263.
- Mowery, D. and B. Sampat (2004), “Universities in national innovation systems”, in Fagerberg, J., D. Mowery and R. Nelson (eds.), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford.
- Mowery, D. and S. Shane (2002), “Introduction to the special issue on university entrepreneurship and technology transfer”, *Management Science*, Vol. 48 (1), pp. v-ix.
- Mowery, D. and A. Ziedonis (2002), “Academic patent quality and quantity before and after the Bayh-Dole Act in the US”, *Research Policy*, 31 (3), pp. 399-418.
- Nelson, R. (1986), “Institutions supporting technical advance in industry”, *American Economic Review*, 76 (2), pp. 186-194.
- NESTA (National Endowment for Science, Technology and the Arts) (2006), “Creative Industries Report”, *NESTA Research Report*, April. [www.nesta.org.uk](http://www.nesta.org.uk), accessed 22 January 2008.
- Nightingale, P. and A. Scott (2007), “Peer review and the relevance gap: ten suggestions for policy-makers”, *Science and Public Policy*, 34(8), pp. 543-553.
- NISTEP (National Institute of Science and Technology Policy) (2005), “Study for evaluating the achievements of the S&T Basic Plan in Japan: Quantitative and qualitative evaluation of outputs of scientific and technological research”, *NISTEP Report No. 88*.
- NSF (National Science Foundation) (2006), *Science and Engineering Indicators 2008*, National Science Foundation, Arlington.
- NSF (National Science Foundation) (2008), *Science and Engineering Indicators 2006*, National Science Foundation, Arlington.
- OECD (1995), *The Measurement of Human Resources Devoted to Science and Technology – Canberra Manual: The Measurement of Scientific and Technological Activities*, OECD, Paris.
- OECD (2001), *Innovative Networks: Cooperation in National Innovation Systems*, OECD, Paris.
- OECD (2002), *Proposed Standard Practice for Surveys of Research and Experimental Development – Frascati Manual*, OECD, Paris.
- OECD (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, OECD, Paris.
- OECD (2006a), *Science, Technology and Industry Outlook 2006*, OECD, Paris.
- OECD (2006b), *Women in Scientific Careers: Unleashing the Potential*, OECD, Paris.
- OECD (2007a), *Science and Technology Scoreboard*, OECD, Paris.
- OECD (2007b), “Research Careers for the 21<sup>st</sup> Century”, Summary Report of the Joint OECD-Spanish Ministry of Education and Science Workshop, OECD, Paris. [www.oecd.org/dataoecd/39/58/39946722.pdf](http://www.oecd.org/dataoecd/39/58/39946722.pdf), accessed 23 January 2008.
- OECD (2007c), *Higher Education and Regions: Globally competitive, Locally Engaged*, OECD, Paris.

- OECD (2008a forthcoming), *Adjusting to the Global Competition for Talent*, OECD, Paris.
- OECD (2008b forthcoming), *Science, Technology and Industry Outlook 2008*, OECD, Paris.
- Open Doors (2007), *International Students 2007*, Institute of International Education, United States.
- Productivity Commission (2006), *Public Support for Science and Innovation*, Draft Research Report, Productivity Commission, Canberra.
- Rosa, J. and A. Rose (2006), “Report on Interviews on the Commercialization of Innovation”, *Working Paper, Science, Innovation and Electronic Information Division*, Statistics Canada.
- Rosenberg, N. (1990), “Why do firms do basic research? (with their own money)”, *Research Policy*, 19, pp. 165-174.
- Statistics New Zealand (2004), *Innovation in New Zealand, 2003*, Statistics New Zealand, Wellington.
- Statistics New Zealand (2007), *Innovation in New Zealand, 2005*, Statistics New Zealand, Wellington.
- Taylor, J. (2001), “The impact of performance indicators on the work of university academics: Evidence from Australian Universities”, *Higher Education Quarterly*, 55 (1), pp. 42-61.
- Tether, B., A. Mina, D. Consoli and D. Gagliardi (2005), *A Literature Review on skills and Innovation. How Does Successful Innovation Impact on the Demand for Skills and How Do Skills Drive Innovation?*, ESRC Centre for Research on Innovation and Competition, University of Manchester.
- Toner, P. (2007), *Skills and Innovation – Putting Ideas to Work*, NSW Department of Education and Training, Sydney.
- Ven, A. van der, D. Polley, R. Garud and S. Venkataraman (1999), *The Innovation Journey*, Oxford University Press, Oxford.



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**From:**  
**Tertiary Education for the Knowledge Society**  
Volume 1 and Volume 2

**Access the complete publication at:**  
<https://doi.org/10.1787/9789264046535-en>

**Please cite this chapter as:**

OECD (2008), “Enhancing the Role of Tertiary Education in Research and Innovation”, in *Tertiary Education for the Knowledge Society: Volume 1 and Volume 2*, OECD Publishing, Paris.

DOI: <https://doi.org/10.1787/9789264046535-10-en>

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