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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Innovation and Growth

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Introduction

Innovation is a major factor of economic growth and performance in the globalised economy. Innovation brings new technologies and new products that help address global challenges such as health or the environment. New ways of producing goods and delivering services boost productivity, create jobs and can help improve citizens' quality of life.

But for innovation to provide all these benefits, it has to work. Researchers can push the frontiers of knowledge, but that in itself is not enough. We need systems to ensure that the results of that research are used to make a new piece of medical equipment, a safer lift shaft, or a more secure database – in other words, that research reaches the businesses and people that can make use of it.

And governments need to adopt policies that will encourage innovation and help ensure that it is given the best chance to develop into new products and processes.

Investment in new knowledge, notably in research and development (R&D), which provides the building blocks of innovation, is already growing in line with gross domestic product. At the same time, skilled workers, needed to help develop and implement innovation in industry and society, make up an increasing share of the labour force, notably in the services industries.

Governments are meanwhile reorienting their innovation policies away from subsidising and buying research to alternative instruments such as tax relief on R&D and reinforcing the links between industry and public research organisations to ensure that science is put to good use.

This *Policy Brief* looks at the growing role of innovation in economic and social development, and how governments can help ensure that innovation is translated into new products and techniques that can help society meet the global challenges of the 21st century. ■

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How is research funded?

Investment in knowledge is the basis of innovation and technological progress. This means investing in educating researchers and high-skilled workers, as well as in the research itself. But who is making the investment, where is it being placed and how is it funded?

One thing is clear – total spending on R&D in the OECD area is rising, whether funded by government, business or universities. In both Japan and the EU, R&D expenditure relative to GDP (known as R&D intensity) rose in 2005 to 3.3% and 1.7%. In the United States, R&D intensity slipped back from a peak of 2.7% in 2001 to 2.6% in 2006, but this was mainly owing to stronger growth in GDP than in the other main regions. In 2005, China became the third R&D spender worldwide (in purchasing power parity terms) after the United States and Japan, with growth of more than 18% a year in 2000-05.

The business sector accounts for the bulk of R&D in OECD countries in terms both of carrying out R&D (63% of the total) and of funding it (68% of the total), and its share has risen over the past few years.

Government budgets for R&D are also growing, however, and since 2000 they have grown on average by 4.3% in real terms in the OECD area. When governments are funding research, they can determine priority areas such as defence, health or the environment. The United States, for example, has the largest share of public R&D funding devoted to defence, with 57% of the total in 2005. Iceland, which devotes the largest total amount of public funding to R&D in the OECD area as a percentage of GDP, at 1.44% in 2005, spends it all on civil R&D.

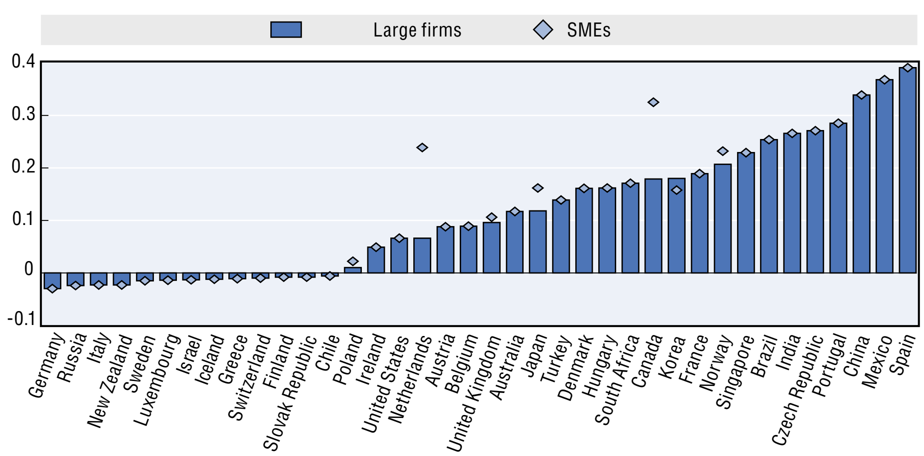
Government innovation policy is, however, shifting away from direct subsidies to tax incentives to encourage business to spend on R&D. This makes it cheaper for companies to carry out research, and gives them the freedom to decide how much research to carry out, and of what type.

By 2006, 20 OECD countries were offering tax relief for business R&D, up from 12 in 1995, while the share of business R&D paid for directly by government fell to 7% in 2006 from 11% in 2005. Emerging economies are also following this path –

Figure 1.

RATE OF TAX SUBSIDIES FOR USD 1 OF R&D[1]

Large firms and SMEs, 2006-2007



1. Tax subsidies are calculated as 1 minus the B index. For example, in Spain, 1 unit of R&D expenditure by large firms results in 0.39 unit of tax relief. See Warda (2007) for country reviews of policy instruments.

Source: OECD (2007), STI-EAS.

Brazil, India, Singapore and South Africa all provide a generous and competitive tax environment for investment in R&D.

Unlike subsidies, tax incentives do not involve the government actually handing out any money. Nonetheless, government revenue forgone as a result of R&D tax credits can be substantial; it is estimated at around USD 5 billion in the United States, USD 1 billion in France and the United Kingdom.

Of course much research is carried out in universities, and here the challenge is to ensure that business is aware of developments and discoveries that they could use, and that universities are aware of what might interest business.

In order to stimulate technology transfer from universities to businesses, many OECD governments have encouraged universities to patent their inventions. This makes their discoveries visible to business, and also offers a source of revenue if the universities agree to sell or licence the patents to business.

Australia, Canada and the United States pioneered such policies, and the share of patents filed by universities in these countries has stabilised at about 7%. But the share of patents filed by universities in Japan and the European Union (notably France and Germany) increased markedly over the past decade, although levels generally remain modest – 1.5% in Japan, 3% in the EU, but more than 5% in France.

Business also funds an important share of R&D in the higher education and government sectors, with an OECD-area average of 4.7% in 2005. In the EU, companies financed 6.4% of total R&D in public institutions and universities, compared to only 2.7% in the United States and 2.0% in Japan.

Venture capital is also a major source of funding for new technology-based firms and a decisive determinant of entrepreneurship and innovation. It represented about 0.12% of OECD-wide GDP in 2005, up from 0.10% in 2003. It was much higher in Nordic countries (and growing rapidly), but it still remains concentrated in the United Kingdom and the United States which between them attracted half of all OECD venture capital in 2005. ■

How does research translate into innovation?

Once you have your research, it needs to be translated into innovation. Collaboration is an important part of innovation in many firms. This can involve jointly developing new products, processes or other innovations with customers and suppliers, as well as working with other enterprises or with public research bodies.

Around one in four innovating firms in Europe collaborated with a partner for their innovation activities during 2002-04. Large firms were four times more likely to collaborate than small and medium-sized enterprises (SMEs). The collaboration rate is fairly similar across countries among SMEs, generally between 10% and 20%, but it varies widely for large firms. More than half of all large firms collaborated on innovation in Belgium, Finland, Denmark, Sweden and Estonia, but less than 20% in Romania, Bulgaria, Australia and Greece.

Collaboration with public research organisations (higher-education or government research institutes) can also be a fruitful source of knowledge for innovation in firms. Here again, large firms are much more active than SMEs, and show much more cross-country variation.

In almost all countries, business collaborates more with higher education institutions than with government research centres. For large firms, co-operation with the former was most prevalent in Finland, Sweden, Estonia and Belgium (over 30%), and with the latter in Finland, Norway, Iceland and Sweden (over 20%).

Among SMEs, collaboration with both higher education and government institutions was below 10% in all countries, except Finland (with higher education).

One way of seeing how scientific institutions link with industry is to look at how much scientific literature existed around a particular topic before a patent was applied for. This can be used to map how university research is linking with industry to develop new products or processes.

An analysis of over 540 000 international patent applications (PCT) shows that in the past 15 years, patents in biotechnology, pharmaceuticals, other fine organic chemistry and ICT have a higher than average share (more than 15%) of references to previous scientific papers. This is consistent with other observed patterns of science-industry linkages in these fields such as university spin-offs, industry-university co-operation in R&D and the tendency for biotechnology companies to cluster around universities.

Similar calculations by country of inventor show higher shares of references to previous scientific papers in countries whose international patenting activity is more concentrated in these fields. For example, Indian inventors have a recent history of international patenting activity and a relatively high proportion of their applications are in biotechnology and pharmaceuticals which have closer links to science.

The creation of new businesses and the closure of failing ones, known as “churning”, is another measure of an economy’s ability to innovate. Churning helps enhance economic growth, create jobs and raise income through increased productivity and innovation. It is commonly viewed as a measure of an economy’s ability to expand the boundaries of economic activity, to shift resources towards growing areas and away from declining ones, and to adjust the structure of production to meet consumers’ changing needs.

The available figures suggest that New Zealand, Canada, the United Kingdom and Germany are the leaders in the creation of start-ups, with more than 10% of new businesses annually. In these countries, more businesses were created than failed. The opposite occurred in Japan and the Slovak Republic. ■

How is inventive performance measured?

The number of patents granted is frequently used to assess how innovative countries or regions are, or how innovative certain sectors are at a particular time, but who owns the patents is also important.

About 53 000 international patents were filed worldwide in 2005, compared with less than 35 000 in 1995. Growth during the second half of the 1990s was at a steady 7% a year on average until 2000. The beginning of the 21st century was marked by a slowdown, with patent applications increasing by 2% a year on average.

The United States accounts for 31% of patent filings, down from 34.4% in 1995; the relative proportion originating from Europe has also tended to decrease, losing more than 4 percentage point between 1995 and 2005 to 28.4%. But Japan’s share gained almost 2 percentage points to reach nearly 29% in 2005.

Changes in country shares show a surge in innovative activities in Asia. China entered the top 15 countries in 2005, having gained 16 places since 1995. Chinese Taipei, India and Korea also rose significantly in terms of ranking.

If patents are counted relative to population, Japan has the highest per million population (119), followed by Switzerland (107). One of the largest increases between 1995 and 2005, from 7 to 65 patent families per million inhabitants, occurred in Korea. By size, China has less than 0.4 patent families per million population.

Government laboratories and universities own 7% of all international patents filed between 2002 and 2004. More than 10% of patent applications by US residents are owned by public institutions, compared to around 4% of patent applications by European residents. In Singapore, almost 40% of all international patent filings are owned either by the government or the higher education sector.

Among OECD countries, Ireland has the highest proportion of patenting by universities (9.7%), while in Australia, Belgium, China, Spain, the United Kingdom and the United States, the higher education sector accounts for 6% to 8% of all international patent applications.

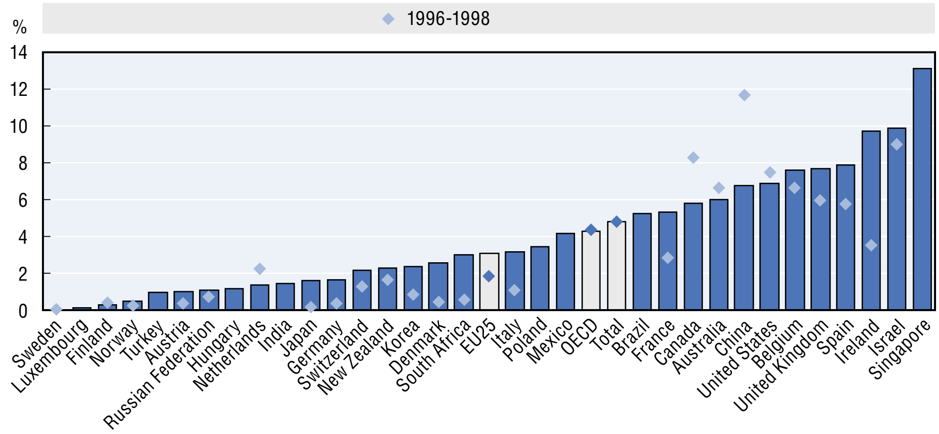
Between 1996-98 and 2002-04, the share of patents filed by universities decreased slightly in Australia, Canada and the United States but increased markedly in Japan and the European Union, notably in France and Germany. This increase results directly from policy changes in these countries in the early 2000s.

In terms of patents owned by government agencies, India and Singapore take first place, with 23.1% and 24.2%, respectively. France leads among OECD countries, with 5.5%, the largest contributor being the Commissariat à l'Énergie Atomique (CEA).

Looking at patents by region can measure the concentration of innovative activities within countries. California (United States) and Tokyo (Japan) are leading regions in terms of the number of patent applications in information and

Figure 2.

SHARE OF PATENTS FILED UNDER PCT[1] OWNED BY UNIVERSITIES,[2] 2002-04



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

Source: OECD, Patent Database, April 2007.

communication technology (ICT) and biotechnology. In Europe, Noord-Braband (Netherlands) produces the largest number of ICT patent applications and Düsseldorf (Germany) is the largest source of biotechnology patents.

Patenting by industry provides valuable information on industries' technological strengths. The breakdown of countries' patent portfolio by industry shows the emergence of new producers of high technology. Singapore, India, China, Korea and Israel report the highest share of patenting activity in technologies associated with high-technology industries, notably office, accounting and computing machinery, radio, television and communication equipment, and pharmaceuticals. In OECD and EU economies overall, patenting in high and medium-high technology industries grew faster than in other industries during 1997-2003 (annual growth of over 3.5%).

There is a positive association between R&D investment and patenting. High R&D-intensive industries, such as pharmaceuticals or medical, precision and optical instruments, are among those that patent the most. Inversely, weaker technological activity, in terms both of R&D and patenting, is frequently found in textiles, leather and wood and paper-related industries.

The importance of patents for protecting knowledge does not depend solely on the level of R&D investments. Differences among industries in terms of the risk of imitation and the extent to which patents enhance competitive advantages in markets also affect the use of patents by companies. ■

How do companies innovate?

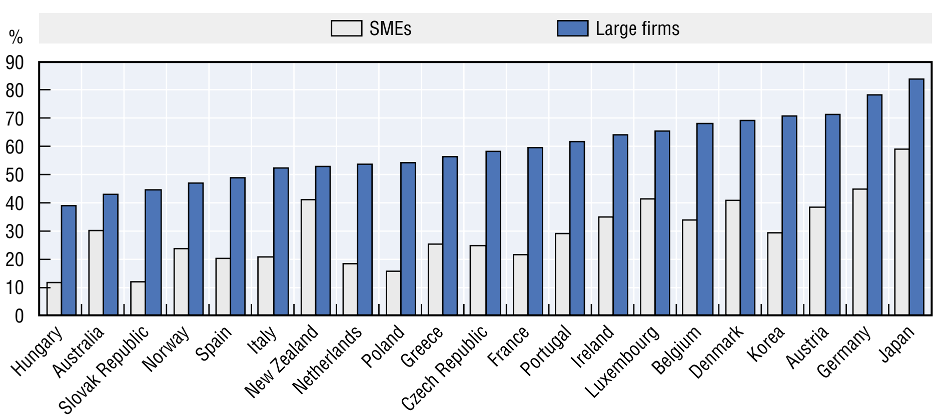
There are essentially four types of innovation identified in the Oslo Manual for measuring innovation: product innovation; process innovation; marketing innovation and organisational innovation.

Product innovation involves a good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.

Figure 3.

NON-TECHNOLOGICAL INNOVATORS[1] BY SIZE

As a percentage of all firms,[2] 2002-04[3]



1. Includes firms that introduced an organisational or a marketing innovation (or both).
2. SMEs: 10-249 employees for European countries, Australia and Japan (persons employed); 10-99 for New Zealand, 10-299 for Korea.
3. Or nearest available years.

Source: Eurostat, CIS-4 (New Cronos, May 2007), National data sources.

Process innovation involves a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

Marketing innovation involves a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

Organisational innovation involves introducing a new organisational method in the firm's business practices, workplace organisation or external relations.

The first two types are traditionally more closely related to technological innovation. In the sense of innovation surveys following the Oslo Manual, firms are considered innovative if they have implemented an innovation during the previous two to three years.

To understand how diffusion of new technologies takes place, and to produce a more complete picture of how innovative a firm is, innovation surveys collect data on whether the innovation was developed within or outside the firm, and to what extent the firm interacted with other parties during the process.

Data on innovations mainly developed within a firm (so-called "in-house innovators") show that small and medium-sized enterprises (SMEs) tend to be "adapters" of existing products – "new to the firm" innovation – more frequently than large firms.

In almost half of the 24 countries surveyed, 40% or more of all large firms had developed an in-house product innovation. Among SMEs, the share developing in-house product innovations exceeded 20% in only around one third of the countries.

The pattern is similar for in-house process innovations. The highest rates were for large firms (over 45%), in Canada, Ireland, Greece, Belgium, Luxembourg and Australia. The same countries plus New Zealand had rates above 21% for SMEs.

In terms of sectors, manufacturing firms tend to undertake more in-house innovation than services firms, both for products and processes. In the services sector, organisational innovation is more common than technological innovation. ■

How does innovation boost economic performance?

Innovations have different degrees of novelty. Introducing an innovation developed elsewhere can have a significant impact on the firm's performance, but adopting an innovation is different from developing one in-house.

Large firms tend to introduce more "novel" innovations than SMEs. For product innovation, this ranges from more than 50% of all large firms having introduced a new-to-market innovation in Iceland, Austria and Luxembourg, to less than 20% in Australia, Germany and some of the recent EU member countries.

Within Europe, SMEs in Iceland, Luxembourg, Sweden, and Austria had a significantly higher propensity to introduce new-to-market product innovations than those in Spain and Hungary.

The share of turnover from new-to-market product innovations can be used as indicator of the impact of innovation at the firm level. In most countries differences between SMEs and large firms in this respect are not very significant. However, Germany and Poland, the share of turnover from such innovations was on average three times higher for large firms than for SMEs.

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Innovation has both technological and non-technological aspects. Non-technological innovation, such as marketing innovation (*e.g.* redesigning a line of furniture) or organisational innovation (*e.g.* introducing work teams) is an important dimension of many firms' innovation activities and is particularly relevant for many services firms.

Non-technological innovation is significantly more prevalent among large firms than among SMEs, although the gap is less pronounced in countries such as New Zealand, Australia and Japan. ■

For further information

For more information about the OECD's work on innovation, please contact:
Maria Pluvia Zunigalara, tel.: + 33 1 45 24 80 04,
e-mail: Maria-Pluvia.Zunigalara@oecd.org,
or Dominique Guellec, e-mail: Dominique.Guellec@oecd.org, tel.: + 33 1 45 24 94 39.

For further reading

OECD (2007), **OECD Science, Technology and Industry Scoreboard**, ISBN 978-92-64-03788-5, € 60, 228 pages.

OECD (2006), **OECD Science, Technology and Industry Outlook**, ISBN 978-92-64-02848-7, € 80, 248 pages.

OECD (2007) **Main Science and Technology Indicators** (MSTI): 2007/1, SUB-94013P1, subscription, 2 issues per year, € 106.

Or visit: *ww.oecd.org/sti/innovation*.

Where to contact us?

OECD HEADQUARTERS
2, rue André-Pascal
75775 PARIS Cedex 16
Tel.: (33) 01 45 24 81 67
Fax: (33) 01 45 24 19 50
E-mail: sales@oecd.org
Internet: *www.oecd.org*

GERMANY
OECD Berlin Centre
Schumannstrasse 10
D-10117 BERLIN
Tel.: (49-30) 288 8353
Fax: (49-30) 288 83545
E-mail:
berlin.contact@oecd.org
Internet:
www.oecd.org/deutschland

JAPAN
OECD Tokyo Centre
Nippon Press Center Bldg
2-2-1 Uchisaiwaicho,
Chiyoda-ku
TOKYO 100-0011
Tel.: (81-3) 5532 0021
Fax: (81-3) 5532 0035
E-mail: center@oecdtokyo.org
Internet: *www.oecdtokyo.org*

MEXICO
OECD Mexico Centre
Av. Presidente Mazaryk 526
Colonia: Polanco
C.P. 11560 MEXICO, D.F.
Tel.: (00.52.55) 9138 6233
Fax: (00.52.55) 5280 0480
E-mail:
mexico.contact@oecd.org
Internet:
www.oecd.org/centrodemexico

UNITED STATES
OECD Washington Center
2001 L Street N.W., Suite 650
WASHINGTON DC. 20036-4922
Tel.: (1-202) 785 6323
Fax: (1-202) 785 0350
E-mail:
washington.contact@oecd.org
Internet: *www.oecdwash.org*
Toll free: (1-800) 456 6323

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