OECD Science, Technology and Industry Outlook 2008 Highlights

Global dynamics in science, technology and innovation

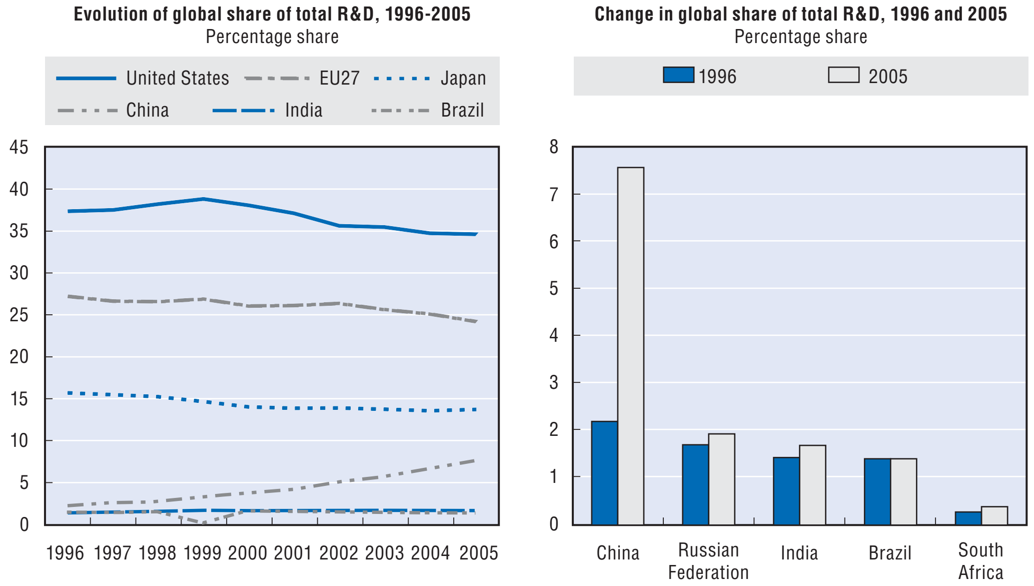
Investment in science, technology and innovation has benefited from strong economic growth

Until recently, the global context for innovation activities has been favourable. OECD investment in R&D climbed to USD 818 billion in 2006, up from USD 468 billion in 1996. Gross domestic expenditure on R&D (GERD) grew by 4.6% annually (in real terms) between 1996 and 2001, but growth slowed to less than 2.5% a year between 2001 and 2006. Future investment will depend in part on the longer-term impacts of financial market instability on business spending.

Some non-OECD economies are becoming important R&D spenders

However, the global distribution of R&D is changing. China's GERD reached USD 86.8 billion in 2006 after expanding at around 19% annually in real terms from 2001 to 2006. Investment in R&D in South Africa increased from USD 1.6 billion in 1997 to USD 3.7 billion in 2005. Russia's climbed from USD 9 billion in 1996 to USD 20 billion in 2006, and India's reached USD 23.7 billion in 2004. As a result, non-OECD economies account for a sharply growing share of the world's R&D – 18.4% in 2005, up from 11.7% in 1996. The growing weight of these countries in the global economy accounts for part of this shift, but so does the growing intensity of investment in R&D relative to GDP, notably in China. In 2005, the global shares of total R&D expenditure in the three main OECD regions were around 35% for the United States, 24% for the EU27 and 14% for Japan. While Japan has maintained its global share since 2000, the United States fell by more than 3 percentage points owing to very slow growth in business expenditure on R&D (BERD), and the EU's share fell by 2 percentage points (Figure 1).

Figure 1. **Global R&D trends in major OECD regions and selected non-member economies**



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Source: Based on data for 79 non-OECD countries (UNESCO Institute for Statistics) and 30 OECD countries (OECD Main Science and Technology Indicators database 2008/1).

The pace of business R&D growth has slowed but remains positive

Businesses account for the majority of R&D performed in most OECD countries. This investment has grown over the past decade, although the pace of growth has slowed markedly since 2001. In the EU27, BERD intensity increased only marginally between 1996 and 2006, to 1.11% of GDP. This suggests that the EU will not be able to meet its BERD target of 2% of GDP by 2010. In the United States, business R&D intensity reached 1.84% of GDP in 2006, down from 2.05% in 2000, whereas in Japan it reached a new high of 2.62%. In China, the BERD-to-GDP ratio has increased rapidly, particularly since 2000, and has now almost caught up with the intensity of the EU27, with 1.02% of GDP by 2006.

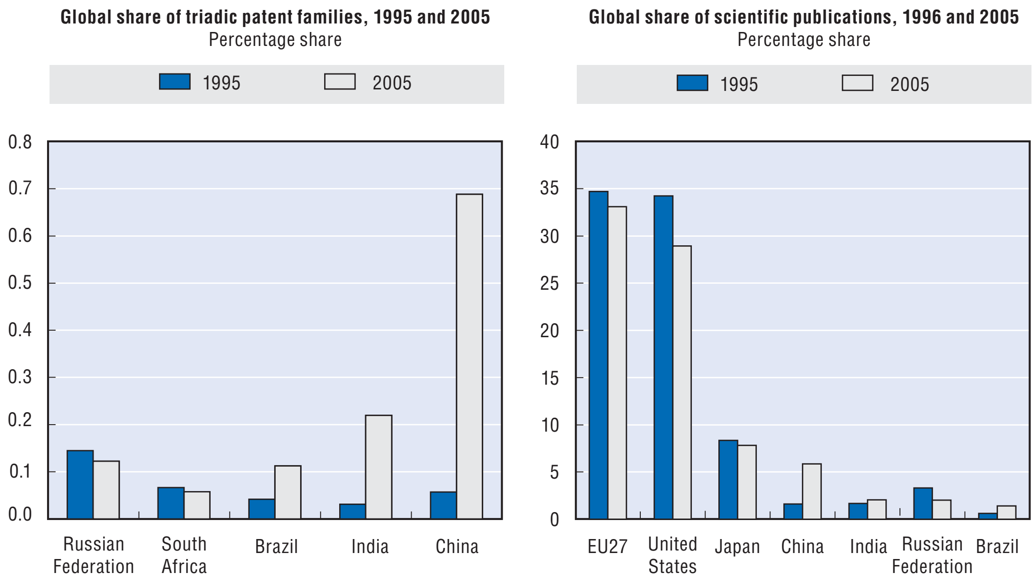
The internationalisation of R&D is spreading

An increasing share of R&D is sourced from abroad (through private business, public institutions or international organisations). In most OECD countries, the share of foreign affiliates in business R&D is growing, as foreign firms acquire local R&D-performing firms or establish new subsidiaries.

Patents and scientific publications have surged

Most countries have seen patents and scientific publishing increase in recent years. While the United States continues to account for the largest share of triadic patent families (patents filed in the United States, Japan and the EU to protect the same invention), its share has fallen, as has that of the EU25. At the same time, the share of patent families from Asian economies increased markedly between 1995 and 2005, albeit from a low level. Publication of scientific articles has also increased, but remains highly concentrated in a few countries, with the OECD area overall accounting for over 81% of global production. Nevertheless, scientific capabilities are growing strongly in some emerging economies (Figure 2).

Figure 2. **Global shares of patenting and scientific publications in major OECD regions and selected non-member economies**



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Source: OECD Patent database, 2008.

Source: National Science Foundation, *Science and Engineering Indicators 2008*.

The demand for human resources is accelerating

The growing knowledge intensity of many countries implies an increasing need for highly skilled workers. OECD-area employment in human resources in science and technology (HRST) occupations has grown faster than employment overall, often by a wide margin. Foreign talent contributes significantly to the supply of HRST personnel in many OECD countries, and the global market for the highly skilled is becoming more competitive as employment opportunities in key supply countries, such as China and India, improve. With many countries developing a range of initiatives to facilitate mobility, the internationalisation of the HRST labour market is likely to continue. At the same time, the growing international competition for talent means that countries will increasingly need to strengthen their own investment in human resources.

Trends in science, technology and innovation policies

S&T policies are evolving…

Policies for research and innovation are evolving, in response to broader reforms to boost productivity and economic growth as well as to address national concerns (*e.g.* jobs, education, health) and, increasingly, global challenges such as energy security and climate change.

… in response to the globalisation of R&D and open forms of innovation

Increased globalisation of production and R&D activities and more open and networked forms of innovation are also challenging national S&T policies. Countries must build national research and innovation capacity to attract foreign investment in R&D and innovation and must foster participation in global value chains.

This requires better policy co-ordination and changes in governance structures

Such challenges are prompting countries to improve co-ordination of national policy making and implementation, including at international level, as illustrated by the creation of the European Research Area (ERA). Some countries have consolidated responsibility for research and innovation policies under a single institution as a way to improve co-ordination or to reflect the higher priority they attribute to these policies.

Public budgets for R&D continue to grow, partly in response to national R&D targets

Many OECD countries have increased public funding of R&D, despite persistent budget constraints and overall reductions in government funding in some countries. This increase is linked to national R&D targets such as those set by the EU to increase research spending to 3% of GDP by 2010. While it is unlikely that most individual EU countries will meet their national targets by 2010, such targets demonstrate a political commitment to stimulate investment in research and innovation. Several non-EU countries have also set targets to boost R&D over the next decade.

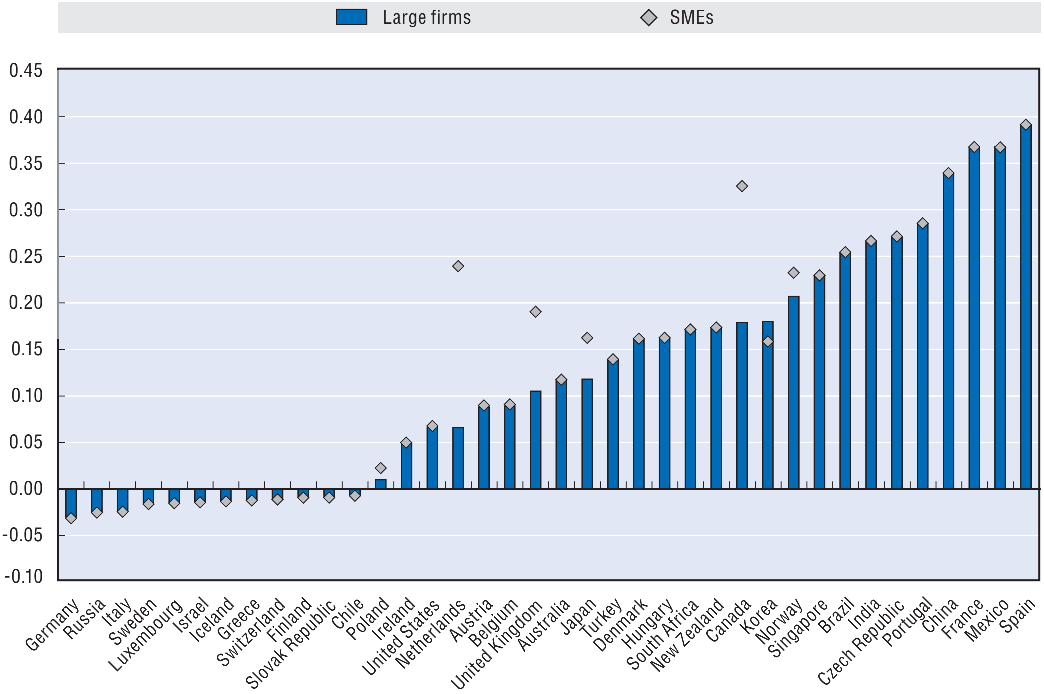
A growing number of countries offer R&D tax incentives, raising the issue of tax competition

Recent years have seen a shift from direct public funding of business R&D towards indirect funding (Figure 3). In 2005, direct government funds financed on average 7% of business R&D, down from 11% in 1995. In 2008, 21 OECD countries offered tax relief for business R&D, up from 12 in 1995, and most have tended to make it more generous over the years. The growing use of R&D tax credits is partly driven by countries' efforts to enhance their attractiveness for R&D-related foreign direct investment.

Policies to support cluster, network and innovation eco-systems are evolving

Networking and cluster initiatives continue to emerge while various tools (*e.g.* tax credits) are being used at the same time to promote collaboration between industry and research. With globalisation, support for clusters is also evolving with a view to creating world-class "nodes" to link to global innovation value chains rather than geographically bound

Figure 3. **Rate of tax subsidies for USD 1 of R&D, 2008**[1]



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1. Tax subsidy to R&D calculated as 1 minus the b-index, defined as the present value of before tax income necessary to cover the initial cost of R&D investment and to pay corporate income tax.

Source: Warda, 2008, based on national sources.

clusters. Linkages and co-operation between regions both within and across countries are becoming more important.

Most policies remain focused on science and technological innovation

A key policy challenge for OECD countries is to develop and implement policies that support innovation in a broader sense (*e.g.* including organisational and non-technological innovation) and to include sectors that do not undertake much R&D (*e.g.* resource-based and traditional sectors) as well as services. Indeed, many government initiatives targeting innovation remain focused on technological or science-based innovation where the rationale for public intervention is generally well defined and operational.

Lack of markets for innovative products and services shift focus to demand-side policies

Policies to encourage demand for innovation, such as the development of lead markets, innovation-friendly procurement and the development of standards, are also receiving greater emphasis. These policies reflect awareness that poor innovation performance may be linked to the lack of markets for innovative products and services.

Impact assessment has become a cornerstone of innovation policy

Assessing the socio-economic impacts of public policy has become important…

The changing role and position of government has resulted in a growing demand for evidence-based policies. Moreover, with the growing emphasis in many countries on policies to foster innovation, governments need to justify how much they invest in innovation, where they invest and how much the public gets in return. Assessing the socio-economic impacts of public R&D is crucial in order to evaluate the efficiency of public spending, assess its contribution to achieving social and economic objectives and enhance public accountability.

… but assessing the socio-economic impacts of public R&D is not easy

It is difficult to determine and measure the various benefits of investment in R&D for society. R&D spillovers and unintended effects are likely, many key scientific discoveries are made unintentionally, and applications of scientific research are often in areas far removed from the original goal of the R&D. Moreover, the time required to reap the full benefits of R&D may be quite long.

New practices have been developed to overcome challenges…

A number of techniques to assess the impacts of public R&D have emerged in the past years. Most have focused on analysing the economic impacts, even though a substantial share of the results of public R&D go beyond economic gains and increase the well-being of citizens. National security, environmental protection, improved health or social cohesion are examples of non-economic impacts.

International co-operation is needed to improve practices and comparability

Because current efforts to assess the impacts of public R&D still fail to capture the full range of the impacts of public R&D on society, continued international co-operation is needed to improve impact assessment practices and develop comparable indicators and analytical techniques.

Microeconomic analysis of innovation performance offers new insights

Simple indicators from innovation surveys are of limited use for policy making

Indicators based on innovation surveys are an important source of information for measuring innovation activities in firms and innovation performance across countries. However, their usefulness for guiding policy has been somewhat limited by their extensive use as average pointers for benchmarking purposes. Simple averages hide the great heterogeneity of innovation patterns across firms, sectors and locations.

Innovation indicators based on "microdata" can inform policy making

More sophisticated indicators based on innovation microdata (*i.e.* at firm level) can be used to assess the individual characteristics of firms according to firm size, industry sector and "mode" of innovation. Understanding and measuring different forms of innovation can help to improve policy design and implementation. The OECD Innovation Microdata project is the first large-scale cross-country attempt to exploit firm-level data from innovation surveys for economic analysis and the development of new indicators.

Findings from the analysis show that there are at least three modes of innovation…

At least three innovation patterns are common to the countries analysed. A set of activities which tend to be grouped and implemented together by the same firms is called a "mode of innovation". One involves some form of new-to-market innovation linked to own generation of technology (in-house R&D and patenting). The second involves process modernising and includes the use of embedded technologies (acquisitions of machinery, equipment and software), alongside training of staff. The third is wider innovating, which clusters organisational and marketing-related innovation strategies.

…. but there is no "single" mode of innovation across countries

Even if common innovation patterns have been identified, there is no "single" mode of innovation, and there appear to be major national differences in patterns of competitive and comparative advantage. The analysis also demonstrates that innovation in firms goes considerably beyond technological innovation and own generation of technology; policies to foster innovation will need to account for this diversity.

Improving our knowledge of innovation in firms is crucial for designing innovation policies

Innovation surveys can be exploited further, for example by matching innovation survey data with other firm-level data and administrative records, such as balance sheets, R&D surveys, etc. This would allow for a better understanding of innovation performance and the policies that affect innovation.

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SPAIN

Despite strong economic growth over the past decade, labour productivity growth has been modest. GDP per hour worked expanded by 0.9% a year between 2001 and 2006, compared to the OECD average of 1.8%. The government's National Reform Programme aims to boost productivity and sustainable growth through reforms in product and labour markets, higher education and human capital, investment in infrastructure and research and innovation.

Spain spent 1.2% of GDP on R&D in 2006, significantly below the EU27 (1.76%) and OECD (2.26%) averages. However, this is a substantial increase from the levels of the mid-1990s. The business sector finances 47% of gross domestic expenditure on R&D; the government finances 42.5%, 5.9% is financed from abroad and 4.5% from other national sources. Boosting R&D and innovation in the business sector is a challenge as most industries are relatively low-technology and most firms are small or medium-sized.

The regional governments are increasingly important players in innovation and have developed their own R&D and innovation policies, although regional R&D efforts remain concentrated in Madrid and Catalonia, which account for half of total R&D.

A 2007 OECD report identified several challenges for Spain's innovation system: dispersed public research funding, low impact of scientific output, low innovativeness of firms, lack of researcher mobility, and weak co-ordination of innovation policy. Since 2004, however, Spain has increased its budget for R&D and innovation programmes, which reached EUR 8.1 billion in 2007. Research capacity is also being lifted by the strong growth in R&D personnel (7.8% a year on average between 2000 and 2006).

A major policy package to boost innovation, Ingenio 2010, was approved in 2005. It includes public-private partnerships (CENIT) for innovation, venture funds, and programmes to increase research capacity (CONSLIDER and CIBER). While Spain has a generous R&D tax credit, uptake has been weak. The government has therefore reduced the R&D tax credit (by making the rate proportional to the general corporate tax level) until it is phased out by 2011, subject to government evaluation, and it created a new scheme that offsets 40% of the labour and social charges of R&D workers.

The government recently approved its Sixth National Plan for Research, Development and Innovation (2008-11) which sets out the policy instruments for reaching the objectives of the longer-term National Strategy on Science and Technology (2008-15), approved jointly by the national and regional governments. It gives high priority to leveraging R&D and innovation for the benefit of society and industrial competitiveness and the creation of new knowledge.

The 2007 *Act on the Reform of the Universities* aims to increase the administrative, academic and financial autonomy of universities so as to enhance research quality, foster researcher mobility and improve the conditions for technology transfer and academic start-ups. The government has also transformed the CSIC, the largest public research centre, into a research agency and strengthened its autonomy and accountability through performance contracts.

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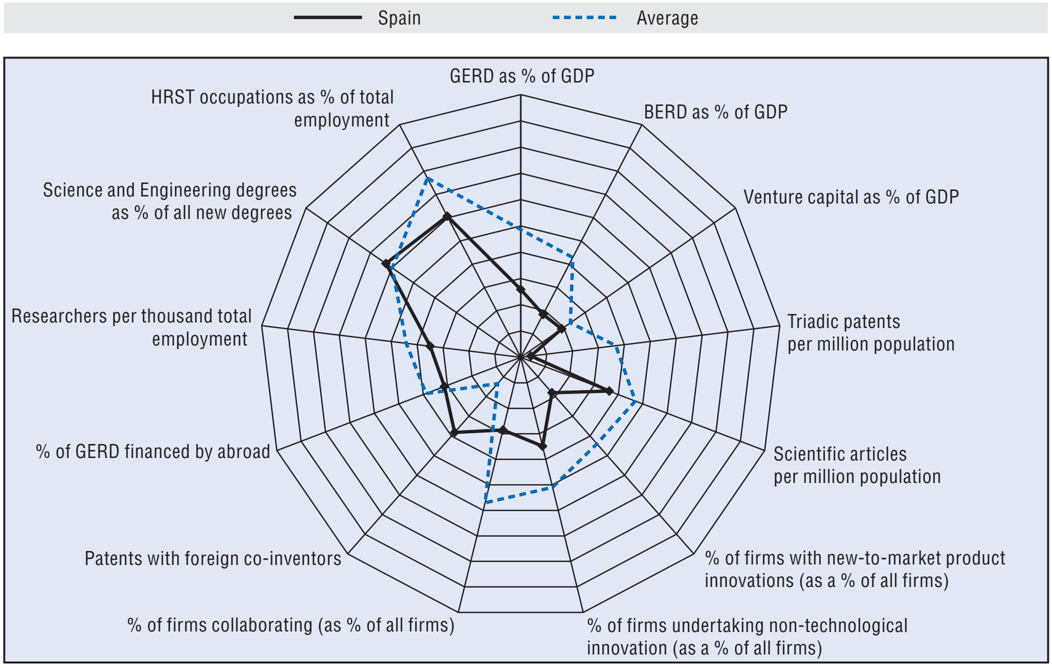
Science and innovation profile of Spain



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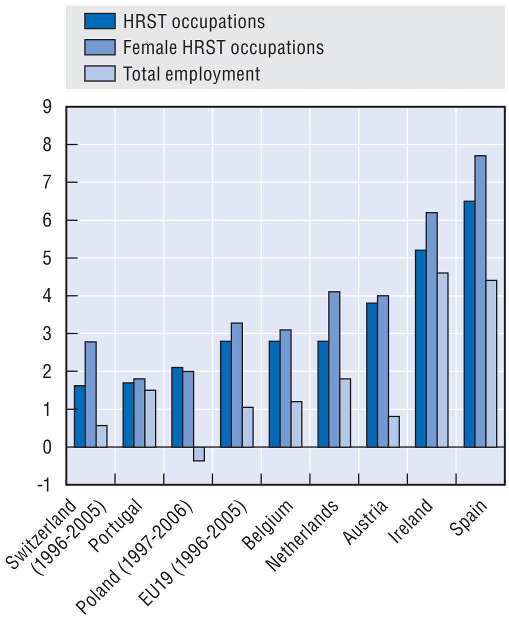
Growth in occupations for human resources in science and technology, 1996-2006

Average annual growth (%)



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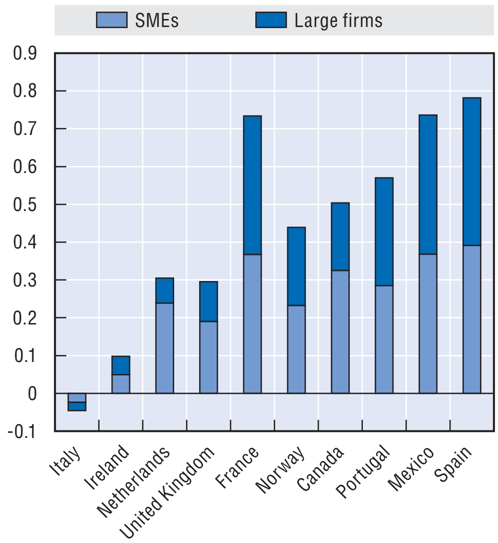
Rate of tax subsidies for USD 1 of R&D, large and small and medium-sized firms, 2008

Percentage



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