OECD Science, Technology and Industry Scoreboard 2011
Innovation and Growth in Knowledge Economies
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Executive Summary

Today, the world's economies are facing some extraordinary challenges. While the effects of the recent economic downturn are still being felt, new pressures are stretching many governments' ability to instigate a recovery and national debt levels and unemployment remain high. The pace and scale of globalisation is unprecedented. Its distinctive features are increasing international trade, deepening economic integration, especially in emerging economies, and greater geographic fragmentation of production processes generating ever more complex global value chains. In this new geography of growth, international competition from new players is eroding the lead of more established economies. Environmental pressures challenge the sustainability of development models. Longer life expectancy is putting a greater strain on the capability of health systems to meet the needs of an ageing population.

Innovation is increasingly seen as being critical for effectively meeting these challenges. It will play a major role in lifting economies out of the downturn and finding new and sustainable sources of growth and competitiveness.

The OECD Science, Technology and Industry Scoreboard 2011 builds on 50 years of indicator development at OECD to look at major trends in knowledge and innovation in the global economy. Over 180 indicators illustrate and analyse trends in science, technology, innovation and industrial performance in OECD and major non-OECD countries (notably Brazil, the Russian Federation, India, Indonesia, the People's Republic of China and South Africa).

Chapter 1 uses traditional, new and experimental indicators to build a narrative around the features of today's landscape of knowledge and innovation. The five thematic chapters focus on five key areas of policy interest:

- *Building Knowledge* looks at the knowledge assets which many firms and governments view as their current and future strengths for long-term sustainable growth.
- *Connecting to Knowledge* considers the extent to which countries' science-innovation systems are connected, open and tap into international "brain circulation" – the mobility and interconnectedness of highly skilled labour across nations.
- *Targeting New Growth Areas* examines the direction of countries' scientific efforts and the technologies on which they build their comparative advantage.
- *Unleashing Innovation in Firms* is concerned with the dynamism of the business sector, the main types of innovation in firms and the extent to which governments create the conditions for innovation to flourish.
- *Competing in the Global Economy* examines how economies seek to build their competitive strengths.

The economic landscape and emerging players

Between 2008 and 2009, in the immediate aftermath of the crisis, the OECD as a whole suffered a net loss in employed persons of about 11 million, a 2% drop. Half of these losses occurred in the United States. For many OECD countries, significant losses in employment continued well into 2010. This occurred against the backdrop of longer-term trends characterised by greater international competition from new players. In 1990 the G7 countries accounted for two-thirds of world manufacturing value added but they now account for less than half. By 2009 China had almost caught up with the United States in manufacturing production, and the share of Brazil and India among world manufacturers is now similar to that of Korea.

The decline of manufacturing production in many OECD countries means that, on average, services now account for about 70% of OECD gross domestic product (GDP). Moreover, in many countries, the share of service activities necessary for manufacturing production has increased in recent years. In 2008, services-related employees accounted for about 35% of employees in manufacturing in the OECD area, although it varied between 17% and 52% across countries.

Increasing global interdependencies and knowledge flows…

BRIICS economies have become more integrated in the global economy. China is set to become the second largest recipient of foreign direct investment. Average outward investment flows from China increased ninefold between the early and late 2000s; those of India increased more than sevenfold. The last 15 years have seen increased trade in primary resources such as energy inputs, a more than ten-fold increase in the value of exports from China, and China's growing role as an exporter of high-end intermediates and consumer goods. Meanwhile, OECD countries' share of world exports has declined from 75% to 60%. In the BRIICS, high-technology manufacturing trade now represents about 30% of their total manufacturing trade, compared to 25% for the OECD area.

Knowledge increasingly flows across borders. The rate of patenting activities is rapidly increasing in non-OECD economies. On average, over 40% of OECD inventions are also protected in China. These technology flows mirror the strategic behaviour of firms, the location of both subsidiaries and competitors, and the attractiveness of emerging markets.

… in a world of rising specialisation

As economic activities become more global, economies increasingly rely on fewer sectors. Novel indicators show rising economic specialisation since the 1970s, with Canada the only G7 country to experience periodic bursts of diversification. In contrast, Korea reflects the development path previously travelled by G7 countries – early increasing diversification (into industry and services), peaking in the late 1980s, followed by gradual specialisation as its new comparative advantages became evident. In the G7 countries, the concentration ratio has grown over the last 30 years; the top four sectors represent on average 55% of total value added with a few broad sectors, typically "*Wholesale and retail*" and "*Business activities*", consistently among the top four.

Countries' sectoral specialisations can be taken into account when comparing widely used indicators such as R&D intensity (business R&D expenditure as a percentage of GDP). Estimating a country's total R&D intensity as if it had the same industrial structure as the OECD average provides an interesting picture. In Finland, Germany and Korea (countries with high R&D intensities), the "adjusted R&D intensity" is below the OECD average of 2.5%. Conversely, if France, Iceland and the Netherlands had an average OECD industry structure, their business R&D intensity would be higher than currently observed. For countries in southern and eastern Europe and for Mexico, an industry structure closer to the OECD average would not raise their overall R&D intensity – indicating that their business R&D is lower than average regardless of industrial specialisation.

While countries "specialise", newly matched enterprise and patent data reveal the benefits of a broad industrial base for the development of key enabling technologies. Chemical firms, for example, contribute to the advancement of pharmaceuticals and biotechnologies, and to a lesser extent also to nanotechnologies. Research and development service providers are also essential to these fields, as are institutions such as universities. New information and communication technologies are concentrated in a set of computer and communications industries, while environmental technologies are shaped by the patenting activity of specialised machinery manufacturers and certain technical and engineering service activities.

Science and innovation build on local strengths…

Many countries are building centres of excellence to create the optimum conditions for raising research quality and impact. Non-OECD economies account for a growing share of the world's R&D, measured in terms of both number of researchers and R&D expenditures. Worldwide, the 50 universities with the highest impact – measured by normalised citations to academic publications across all disciplines – are concentrated in a handful of countries. Overall, 40 of the top 50 are located in the United States, and the rest in Europe. A more diverse picture emerges on a subject-by-subject basis. There is evidence that some universities in Asia are emerging as leading research institutions. Many of the leading firms in knowledge-intensive industries – such as ICT and the life sciences – have emerged in a limited number of regions in the world.

… but collaboration and a multidisciplinary approach are key

The production of scientific knowledge is shifting from individuals to groups, from single to multiple institutions, and from a national to an international scope. Comparisons of certain indicators across countries suggest a positive relationship between measures of research collaboration and scientific impact.

New technologies often draw on a broad base of scientific knowledge. Focussing on "clean" energy technologies, a new indicator based on citations to scientific publications reveals that material science makes the single largest contribution to clean energy, followed by chemistry and physics; energy and environmental science only account for 10% and 1.7% respectively. The diversity of scientific sources highlights the difficulty of identifying a single major scientific contributor to innovation in this area.

Collaboration is part of innovation processes whether firms perform R&D or not. In all countries R&D-active firms tend to collaborate more frequently on innovation (usually twice as much) than non-R&D-active firms. In the United Kingdom, collaboration is embedded in the innovation processes of over 50% of non-R&D-active firms.

Innovation is broader than R&D and a key source of growth…

New indicators based on trademarks point to large numbers of incremental and marketing innovations and confirm that firms perform both technological and non-R&D-based innovation. Analysis of firm-level data on innovation shows that firms follow various innovation strategies and that these are not always based on formal R&D. However, product innovation is often associated with R&D. Indeed, in most countries, more than half of all product-innovating firms also engage in R&D. Remarkably, more than two-thirds of product innovators are not engaged in R&D in New Zealand and the United States and more than 90% in Chile and Brazil.

Broader innovation is essential for economic growth and social advancement. Innovation entails investment in a range of complementary assets beyond R&D such as software, human capital and new organisational structures. Investment in these *intangible assets* is rising and even exceeds investment in physical capital (machinery and transport equipment) in Finland, Sweden, the United Kingdom and the United States. Encouragingly, in some countries, recent estimates of intangible assets explain a significant portion of multi-factor productivity growth.

… as is a dynamic and innovative business sector

The presence of young firms among patent applicants underlines the inventive dynamics of firms early in their development and their desire to develop new activities and products – crucial to their survival and relative growth. During 2007-09 firms less than five years old filing at least one patent application represented on average 25% of all patenting firms, and generated 10% of patent applications. The share of young patenting firms varies considerably across countries, led by Ireland (42%) and followed by the Nordic economies.

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Mapping knowledge and innovation flows is a complex endeavour; it requires a data infrastructure that allows linkages between actors, outputs and outcomes. Large datasets have been linked together to develop new indicators for the 2011 edition of the *STI Scoreboard*, such as those that look at the fields of science that new technologies draw upon or the demographic characteristics of innovative firms. By exploiting OECD's "harmonised" Input-Output tables and bilateral trade data, world production value chains have been investigated and international transfers of "embodied" CO_2 emissions revealed.

Several "traditional" indicators have been re-engineered to change the perspective of international comparisons, *e.g.* business R&D intensities adjusted by industry structure or new indicators of the impact of scientific output based on counts of citations received. Finally, some experimental indicators are proposed such as quantitative estimates of R&D tax incentives and indicators of public funding "modes" (institutional *versus* project funding). While international comparisons based on these indicators need to be interpreted with caution, they are a step towards new insights into areas of policy interest.

From:

OECD Science, Technology and Industry Scoreboard 2011

Access the complete publication at:

https://doi.org/10.1787/sti_scoreboard-2011-en

Please cite this chapter as:

OECD (2011), “Executive Summary”, in *OECD Science, Technology and Industry Scoreboard 2011*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/sti_scoreboard-2011-4-en

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