2. PRODUCTIVITY GROWTH AND INNOVATION IN OECD

By Dominique Guellec and Dirk Pilat
Organisation for Economic Co-operation and Development

Introduction

There has been renewed divergence of GDP per capita among OECD countries over the past decade: Whereas the relatively less advanced countries tended to catch up with the leader, the US, from the late 1940s to the late 1980s, the situation has reversed since the mid-1990s. While GDP growth was accelerating in the US, it was just slowing down in most countries of Europe and in Japan. It tended to slow down again in the 2000s in the US, but also in Europe.

GDP depends on how many workers there are, and how efficient they are: It results as the combination of two immediate factors, utilisation of labour and productivity of labour (See OECD 2008, Compendium of Productivity Indicators). Productivity matters especially in the long run; it is the key to sustainable economic growth. Innovation in turn is a central factor of productivity growth. Assessing the innovation performance of a country, and explaining it, goes a long way to understanding the dynamics of its productivity, hence its economic growth. It is what this paper will attempt to do, starting from GDP growth, going to productivity, to R&D, to innovation performance, and to the structural and institutional factors which influence innovation.

The major OECD sources of data used for this article are as follows: the Compendium of Productivity Indicators (2008) for growth and productivity figures; the Main Science and Technology Indicators (MSTI) for R&D data; the Compendium of Patents Statistics of 2007 for patent indicators; the Science, Technology and Industry Scoreboard of 2007 for most other indicators.

From GDP to productivity growth: General trends and determinants

The interest of many OECD countries in economic growth over the past years was partly linked to the strong performance of the United States over the second half of the 1990s and

---

61 This study is based on presentations made at the OECD Productivity Conference of 2005 held in Madrid (Pilat 2005) and of 2006 held in Bern (Guellec 2006). This paper reflects the views of the authors and not necessarily the views of the OECD or its member countries. The findings of this paper draw on work of many colleagues of the OECD, notably Paul Schreyer. Productivity indicators from the Compendium of Productivity Statistics have been compiled by Agnès Cimper and Julien Dupont.
the reversal of the catch-up pattern that had characterised the OECD area over the 1950s and the 1960s. During much of the early postwar period, most OECD countries grew rapidly as they recovered from the war and applied US technology and knowledge to upgrade their economies. For most OECD countries, this catch-up period came to a halt in the 1970s; average growth rates of GDP per capita over the 1973–92 period for much of the OECD area were only half that of the preceding period, and many OECD countries no longer grew faster than the United States (Maddison, 2001).

During the 1990s, a different pattern emerged. Even though the United States already had the highest level of GDP per capita in the OECD area at the beginning of the decade, it expanded its lead on many of the other major OECD countries during the second half of the 1990s. A few other OECD countries, including Australia, Canada, Finland, Greece, Ireland, Portugal, Spain and Sweden, also registered markedly stronger growth of GDP per capita over the 1995–2006 period compared with the 1980–1995 period. Some of these countries continued to catch up with the United States in the second half of the 1990s and in the 2000s. In contrast, the increase in GDP per capita in several other OECD countries, including Japan, Germany and Italy, slowed sharply over the second half of the 1990s, leading to a divergence with the United States. Most OECD countries have experienced a slowdown in GDP per capita growth in the first half of the 2000s, Japan being a major exception. However in this context the US kept the fastest growth among G7 countries except for the UK, while the largest continental European countries experienced even further significant slowdown (graph 2–1).
Even though US growth performance is no longer considered to be as exceptional as was claimed during the “new economy” hype, its strong performance over the past decade has increased interest in the analysis of economic growth and the sources of growth differentials across countries. The OECD work suggests that the divergence in growth performance in the OECD area is not due to only one cause, but that it reflects a wide range of factors.

Differences in the measurement of growth and productivity might also be contributing to the observed variation in performance. An OECD study (Ahmad, et al, 2003) suggests that such differences do play a role, but that they probably only account for a small part of the variation in growth performance. To reduce the uncertainty of empirical analysis related to the choice of data, OECD has developed its Productivity Database, which is used in this paper.

GDP per capita can be broken down into two components: labour utilisation (number of hours worked per capita) and the efficiency of labour (GDP per hour worked, also labelled productivity of labour). Labour utilisation in turn results from three factors: average working time, labour force participation rate and unemployment rate.

**Improving labour utilisation remains important for many EU countries**

The first factor affecting growth differences concerns labour utilisation (graph 2–2). In the first half of the 1990s, most OECD countries, in particular many European countries were characterised by a combination of high labour productivity growth and declining labour utilisation. The high productivity growth of these EU countries may thus have been achieved by a greater use of capital or by dismissing (or not employing) low-productivity workers. In the second half of the 1990s, many European countries, improved their performance in terms of labour utilisation, as unemployment rates fell and labour participation increased. However, the growth in labour utilisation was accompanied by a sharp decline in labour productivity growth in many European countries, which was not necessarily the case elsewhere (e.g. Canada or Ireland).

Achieving a combination of labour productivity growth and growing labour utilisation requires well functioning labour markets that permit and enable reallocation of workers. This is particularly important during times of rapid technological change. Labour market institutions have to ensure that affected workers are given the support and the incentives they need to find new jobs and possibly to retrain. In many countries, institutions and regulations hinder the mobility of workers and prevent the rapid and efficient reallocation of labour resources. In most of the countries characterised by a combination of increased labour utilisation and labour productivity, reforms over the 1980s and 1990s improved the functioning of labour markets, effectively enabling more rapid growth.

Much progress in enhancing labour utilisation has been made in many OECD countries over the 1990s, but the 2000s have experienced a stagnation of labour utilisation OECD-wide, with a decline in all G7 countries except Canada. In terms of levels, for several OECD countries, notably many European countries, there is still a large scope for improvement in labour utilisation, as it accounts for the bulk of the gap in GDP per capita with the United States (The OECD Compendium of Productivity 2008 provides...
more data on labour utilisation and productivity levels across countries). The gap in labour utilisation is particularly large for Belgium and France, but also affects many other European countries.

**Labour productivity growth improved only in some OECD countries**

Together with labour utilisation, labour productivity is the other key component of GDP per capita. It is also the main determinant of the gap in income levels between the United States and most other OECD countries. After its acceleration in the second half of the 1990s in a number of countries (including Australia, Canada, Greece, Ireland and the United States), labour productivity slowed down in most countries in the 2000s, the United States and some European countries such as the United Kingdom and Sweden being the main exceptions (graph 2–3).

**The impact of human capital**

Labour productivity growth can be increased in several ways: by improving the composition of labour used in the production process, increasing the use of capital and improving its quality, and attaining higher multi factor productivity (MFP). The composition of the labour force is the first of these, and plays a key role in labour productivity growth. This is partly because in all OECD countries, educational policies have ensured that young entrants on the jobs market are better educated and trained on average than those who are retiring from it. For example, in most OECD countries, more 25–34 year olds have attained tertiary education than 45 to 54 year olds.

The available empirical evidence suggests that improvements in the composition of labour have directly contributed to labour productivity growth in virtually all OECD countries (Bassanini and Scarpetta, 2001; Jorgenson, 2003). Jorgenson (2003) points to contributions of 0.2–0.4% of labour composition to GDP growth for the G7 countries. These estimates also suggest that the contribution of labour composition to labour productivity growth has slowed in most G7 countries over the second half of the 1990s, Italy being the only exception. This is typically attributed to the large number of low-skilled workers that were integrated in the labour force in many OECD countries over the second half of the 1990s. Moreover, the contribution of labour composition may also decline over time if the gap in education levels between cohorts of new and retiring workers becomes smaller over time. Growth accounting estimates typically only take account of changes in educational attainment, however; increases in the level of post-educational skills are also important, but few hard measures are available.

**The role of investment in fixed capital**

Investment in physical capital is the second factor that plays an important role in labour productivity growth. Capital deepening expands and renews the existing capital stock and enables new technologies to enter the production process. While some countries have experienced an overall increase in the contribution of capital to growth over the past decade, ICT has typically been the most dynamic area of investment. This reflects rapid technological
### Labour utilisation and productivity of labour

#### Labour utilisation

- **Italy**
- **Portugal**
- **Germany**
- **Switzerland**
- **France**
- **Netherlands**
- **EU15**
- **Austria**
- **Belgium**
- **Denmark**
- **Japan**
- **OECD**
- **Spain**
- **Canada**
- **Mexico**
- **Norway**
- **United States**
- **Australia**
- **New Zealand**
- **United Kingdom**
- **Sweden**
- **Iceland**
- **Finland**
- **Luxembourg**
- **Ireland**
- **Greece**
- **Poland**
- **Korea**
- **Czech Republic**
- **Hungary**
- **Slovak Republic**

#### Productivity of labour (GDP per hour worked)

- **Italy**
- **Portugal**
- **Germany**
- **Switzerland**
- **France**
- **Netherlands**
- **EU15**
- **Austria**
- **Belgium**
- **Denmark**
- **Japan**
- **OECD**
- **Spain**
- **Canada**
- **Mexico**
- **Norway**
- **United States**
- **Australia**
- **New Zealand**
- **United Kingdom**
- **Sweden**
- **Iceland**
- **Finland**
- **Luxembourg**
- **Ireland**
- **Greece**
- **Poland**
- **Korea**
- **Czech Republic**
- **Hungary**
- **Slovak Republic**

Source: Compendium of Productivity Statistics 2008
progress and strong competitive pressure in the production of ICT goods and services and a consequent steep decline in prices. This fall, together with the growing scope for application of ICT, has encouraged investment in ICT, at times shifting investment away from other assets (Pilat and Wölfl 2004).

While ICT investment accelerated in most OECD countries, the pace of that investment and its impact on growth differed widely across countries. For G7 countries, the use of ICT capital accounted for between 0.2 and 0.7 percentage points of growth in GDP per capita over the 2000–2005 period, with most countries around 0.4 (graph 2–4). This is significantly less than the contribution of ICT capital to growth in the 1995–2000 period. Among the G7, the US, the UK and Japan are the countries with the highest contribution of ICT, while the large continental European countries have the lowest.

The question that follows concerns the reason why the diffusion of ICT is so different across OECD countries. A number of reasons can be noted. In the first place, firms in countries with higher levels of income and productivity typically have greater incentives to invest in efficiency enhancing technologies than countries at lower levels of income, since they are typically faced with higher labour costs. Moreover, the structure of economies may affect overall investment in ICT; countries with a larger service sector or with a large average firm size are likely to have greater investment in ICT.

More specifically, the decision of a firm to adopt ICT depends on the balance of costs and benefits that may be associated with the technology. There is a large range of factors that affect this decision (OECD, 2004a). This includes the direct costs of ICT, e.g. the costs of ICT

<table>
<thead>
<tr>
<th>Contribution of ICT to GDP growth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>G 2–4</strong></td>
</tr>
</tbody>
</table>

Source: Compendium of Productivity Statistics 2008
equipment, telecommunications or the installation of an e-commerce system. Considerable differences in the costs of ICT persist across OECD countries, despite strong international trade and the liberalisation of the telecommunications industry in OECD countries. Moreover, costs and implementation barriers related to the ability of the firm to absorb new technologies are also important. This includes the availability of know-how and qualified personnel, the scope for organisational change and the capability of a firm to innovate. In addition, a competitive environment is more likely to lead a firm to invest in ICT, as a way to strengthen performance and survive, than a more sheltered environment. Moreover, excessive regulation in product and labour markets may make it difficult for firms to draw benefits from investment in ICT and may thus hold back such spending.

**Strengthening MFP growth**

The final component that accounts for some of the pick-up in labour productivity growth in the 1990s in certain OECD countries is the acceleration in multi factor productivity (MFP) growth (graph 2–5). MFP growth rose particularly in Canada, Finland, France, Greece, Ireland, Portugal, Sweden and the United States. In other countries, including Germany, Italy, Japan, the United Kingdom, Belgium, Denmark, the Netherlands and Spain, MFP growth slowed down over the 1990s. In the United Kingdom, the United States, Sweden and Japan, MFP still accelerated in the 2000s, but in the large continental European countries it slowed down.
The improvement in MFP in some countries after the mid-1990s reflected a break with slow MFP growth in the 1970s and 1980s and may be due to several sources. Better skills and better technology may have caused the blend of labour and capital to produce more efficiently, organisational and managerial changes may have helped to improve operations, and innovation may have led to more valuable output being produced with a given combination of capital and labour. MFP growth is measured as a residual, however, and it is difficult to provide evidence on such factors. Some is available, though, and is discussed below.

**Innovation as a factor of productivity growth**

Among the sources of multifactor productivity growth, technological and non-technological innovation is usually recognised as the most important one in the long run. Innovation occurs when new ideas or inventions are put into use, so as to enhance efficiency of the production process or the range or quality of goods and services (see the Oslo Manual, OECD 2005). Innovation can come from R&D, a type of investment aimed at producing new knowledge; it can also result from more applied types of activities, experimentation, on-site adaptations etc. The impact of R&D on MFP growth has been established by many quantitative studies (e.g. Guellec and van Pottelsberghe 2001). In addition, much innovation is not technological but can still exercise a strong effect on productivity (new organisational systems, new ways of delivering goods and services, new types of services etc.). Innovation not only increases directly economic efficiency, but it also creates investment opportunities which translate into further economic growth via the accumulation of capital. Such opportunities created by ICT obviously played a role in the wave of physical investment in a series of countries in the second half of the 1990s.

Innovation is of particular interest to government as it is seen as an area where policy can have a significant impact. The returns from investment in new knowledge can often be appropriated only partly by the inventing firm, as competitors can take inspiration from the new technology and create their own version, which will reduce the market power of the inventor, hence her mark up on the price. Lower return for inventors means a tendency to invest in R&D less than it would be efficient from the perspective of society. Hence the importance of government in this area: to provide monetary incentives (subsidies, tax reliefs), but also, and sometimes mostly, to provide adequate institutional conditions which will give business a sufficient return on investment and adequate incentives to invest. That includes industrial property rights, competition policy, regulation etc.

**R&D performance**

R&D intensity, the ratio of R&D expenditure over GDP, is the most often used measure of effort in science and technology (graph 2–6). The OECD average was 2.25% in 2005, but there is wide cross-country variation. Nordic countries, together with Japan, Switzerland, Korea, the US and Germany feature significantly above the average. These are all countries with high GDP per capita, and most of them have had high growth over the past decade. The EU15 has been around 1.9% for years. The UK, the Netherlands, Spain and Australia are well below the average. The R&D intensity of OECD increased significantly in the late 1990s,
but it has not progressed since then, as the increase in Japan was compensated by the reduction in the US.

The business enterprise sector funds and performs the bulk of R&D (63% and 68% respectively OECD-wide; graph 2–7) and its share has been increasing consistently in most countries over the past two decades. Whereas government R&D is rather aimed at public policy objectives, such as expanding the knowledge base or responding to social needs (health, environment), business R&D is closely related to market applications, with a more direct impact on measured productivity. The share of business in total R&D is lower in the EU as compared with Japan and the US, although some countries (Nordic countries, Germany) feature high. Business R&D is the determinant factor in cross country variations in total R&D, because government R&D relative to GDP is much less dispersed across countries than business R&D is.

However it is noticeable that countries where government does or funds more R&D are also the ones where business does more R&D: notably Nordic countries, the US or Germany (graph 2–8). This illustrates the impact of public R&D on business R&D, shown in a more controlled way in various econometric studies (e.g. Guellec and van Pottelsberghe 2001b). Public R&D can open new avenues to knowledge, which are then followed by the more applied, business R&D. Public R&D also trains researchers (e.g. PhDs) which find then jobs in the business sector.

**Technological output**

What does this considerable investment on R&D result in? The most often used indicator of the output of R&D investment is patents. The statistical properties of patents as indicators of technical change have been extensively studied (OECD 2007, Compendium of Patent Statistics). The indicator used here is “triadic patent families”, which are inventions protected altogether in Europe, the US and Japan. They are not subject to the “home bias” which affects all national patent data, and they leave aside inventions with low economic value which are
2. PRODUCTIVITY GROWTH AND INNOVATION IN OECD

Percentage of GERD financed by industry

Source: Main Science and Technology Indicators (MSTI), OECD 2007

Government funded R&D as % of GDP

Source: Main Science and Technology Indicators (MSTI), OECD 2007
patented in one country only. The country of reference is the one where the inventor (not necessarily the owner, usually a company) resides. (graph 2–9).

About 53 000 triadic patent families were filed worldwide in 2005, a sharp increase from 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 families increasing by 2% a year on average. The United States, the European Union and Japan show similar trends, with a stronger deceleration in Japan after 2000. Between 2000 and 2005, the number of triadic patent families remained stable in Australia, Germany, France, Sweden and Switzerland, while those originating from Denmark, Finland and the United Kingdom decreased respectively by 2%, 6% and 1% on average (but Finland had had a sharp increase in 1995–2000). Overall the output of technological activities evolved quite in parallel with the main input of these activities, R&D, with an acceleration in the mid-1990s and a slowdown after 2000. Not only the number of patents matter, but also the technological composition is important, and in that regard some countries have been more successful than others in developing emergent technologies rather than digging deeper in older fields (see next section below).

**Openness**

Inventions made in a particular country rely not only on R&D performed in that country, but also on knowledge inputs from other countries, or “knowledge transfers”. Openness to the rest of the world is extremely important to the economic growth of any one country, due to

![Triadic patent families, compound annual growth rates](G 2–9)

Source: OECD Patent Database
several mechanisms such as increased competition (on the domestic market and on foreign markets), or the ability to specialise so as to develop comparative advantages and benefit from economies of scale, but it is all the more important in the field of technology. For all countries foreign sources of knowledge have a major impact on MFP growth. This is all the more true for smaller countries, which could not invent everything by themselves. In addition, the impact of foreign R&D on domestic productivity is higher in countries which do themselves much R&D, as own capabilities facilitate the assimilation of others’ technology. International technology transfers can be facilitated in different ways, such as research co-operation (i.e. research projects involving both domestic and foreign researchers), the creation of foreign research facilities by domestic multinational firms, or of domestic laboratories by foreign multinational firms.

International linkages can be measured with patent information, as patent filings include the address of all co-inventors of any particular invention. The world share of patents involving international co-invention among all patents increased from 4% in 1991–93 to 7% in 2001–03 (graph 2–10). This reflects the enhanced impact of globalisation on technological change (OECD 2008b). The extent of international co-operation differs significantly between small and large countries. Small and less developed economies engage more actively in international collaboration. Co-invention is particularly high in Belgium, Ireland, Switzerland and Canada. Larger countries, such as France, Germany, the United Kingdom and the United States, report international co-operation of between 12 and 23% in 2001–03. In view of its size, the UK is more opened than other comparable countries, while Japan and Korea look more insulated.

---

**International co-inventions**

(Share of patents with co-inventors residing in a different country)  

<table>
<thead>
<tr>
<th>Country</th>
<th>1990–92</th>
<th>2000–02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>35%</td>
<td>30%</td>
</tr>
<tr>
<td>Ireland</td>
<td>30%</td>
<td>25%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>25%</td>
<td>20%</td>
</tr>
<tr>
<td>Canada</td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td>Austria</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>Spain</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>Denmark</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Australia</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Sweden</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>France</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Finland</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>United States</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Germany</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Italy</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>EU15</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>European Union</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>OECD</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Japan</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

The development of new activities

For countries which are at the technological frontier—the case of most OECD countries and a few others—their ability to nurture new technical fields is an important component of growth performance. Not only such fields are growing more rapidly and are at the root of tomorrow’s industries, but they generate spillovers which benefit to other fields. Three technical fields are of particular interest in that regard nowadays: ICT, biotechnology and nanotechnology. In terms of the impact on productivity, we’ve seen how important ICT use has been, and it is expected that biotechnology and nanotechnology, as they are getting more mature and are applied at a large scale, will have significant impact on productivity in the future. In terms of economic conditions, all these technologies are initially developed mainly by new firms, start-ups, created just for developing and implementing such inventions. Many of these start-ups were born out of research conducted in universities. Hence, the performance of a country in new, emerging technical fields is a reflection of its ability to encourage entrepreneurship and to generate high quality academic research with industrial applications. A country’s relative focus on these fields can be measured by the share of these fields in total patents taken on inventions coming from the country, relative to the same share in other countries – this is an indicator of comparative advantage (graph 2–11).

In that regard, the US seems to have a significant comparative advantage in biotechnology and in nanotechnology, whereas it is in the average for ICT. Japan has an advantage in ICT and nano, but is weak in biotechnology. As for the EU as a whole, it is weak in all three fields, in accordance with a tendency to keep to established technical fields. The latter statement does not apply to all countries, as the UK, Denmark and Belgium have an advantage in biotechnology,
France in nanotechnology, Finland and the Netherlands have an advantage in ICT; the strong advantage of Australia and Canada in biotechnology is also noticeable.

The emergence and expansion of new industries depends notably on:

1) The availability of the needed factors, mainly skilled labour, knowledge (science), and capital;

2) The incentives and institutions that will drive these factors into new industries rather than keeping them in established activities. That includes competition and openness of product markets and of the labour market, as well as adequate incentives for capital to go into risky areas and incentives for universities to transfer new knowledge to industry.

**The availability of human capital**

Innovation in general requires skilled labour, both for its generation and for its diffusion. In addition, emerging fields usually require new skills, which are brought by new graduates rather than older cohorts. Hence the ability of a country to nurture emerging fields should be related to the flow rather than the stock of human capital, provided that new fields would have a higher share in current flows than in older ones. The number of new university graduates is an indicator of this flow (graph 2–12). In 2004, OECD universities awarded about 6.7 million degrees, of which 179 000 doctorates. At the typical age of graduation, 35% of the population completed a university degree and 1.3% a doctoral degree. Nordic countries, with Switzerland, the United Kingdom, Germany and Austria have the highest graduation rates at doctoral level in science and engineering.

**Graduation rates at doctoral level, 2004**

(% of doctorates in the relevant age cohort)
The availability of basic knowledge

Technological innovation, especially in emerging fields, is very close to science. New artefacts are invented in connection with new discoveries, more than it is the case in mature technical fields. It is not by accident that clusters of innovative start-ups usually blossom in the neighbourhood of the most advanced research universities. Hence a country willing to nurture emerging technical fields should make particular efforts in basic scientific research. Counts of scientific journals articles are used as indicators of the performance of scientists, scientific institutions and of countries.

In 2003, some 699 000 new articles in science and engineering (S&E) were reported worldwide, most of which resulted from research carried out by the academic sector. They remain highly concentrated in a few countries. In 2003, almost 84% of world scientific articles were from the OECD area, nearly two-thirds of them in G7 countries. The United States leads with over 210 000.

In order to assess the performance of countries, the number of articles has to be standardised by the population (graph 2–13). The geographical distribution of publications is very similar to that of R&D expenditure, with more S&E articles produced in countries with higher R&D intensity. For instance, in Switzerland and Sweden, output exceeded 1100 articles per million population in 2003. The level of scientific publications is low in Korea and Japan, compared to their R&D efforts, but a statistical bias in publication counts towards English-speaking countries may be part of the reason.

Scientific publications per million population, 2003 and 1993

Source: STI Scoreboard, OECD 2007
Universities and government laboratories (public research organisations: PROs), are a unique source of knowledge for industry: To what extent does this potentially essential role materialise across countries? Knowledge transfers from PROs to industry can take several channels. Over the past 25 years, starting in the US and then coming to other OECD countries, PROs have patented more and more of their inventions, with the objective to encouraging their downstream exploitation, notably by the creation of spin-offs and licensing out to start-up companies. The justification is that most enterprises will not engage in costly downstream investment if they are not guaranteed some exclusive rights on the product they are developing on the basis of fundamental knowledge provided by universities. It is then interesting to look at the number of patents taken by PROs across countries (graph 2–14). It shows notably that the EU (led by Belgium, the UK and France) is ahead of the US in that regard, while Nordic countries are far behind Nordic countries are putting more emphasis on other mechanisms of technology transfer.

This is not the whole story however, as another channel for knowledge transfers between PROs (notably universities) and industry is to conduct joint research projects, where the business part provides often the funding while the research is done by university staff. This mechanism is reflected in the share of public research funded by business (graph 2–15). From that perspective, the ranking of countries is quite different: If Canada and Belgium are highly ranked in both indicators, we see Germany, Switzerland or the Netherlands (and Finland and Sweden to a lesser extent) featuring better for funding than for patenting, while the UK and France lag behind. This could show that PROs follow different models across countries in their

---

**Patent applications filed by Public Research Organisations as % of total patents**

(EPO, priority year 2001–2003)

---

<table>
<thead>
<tr>
<th>Country</th>
<th>Patent Applications %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>14</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>12</td>
</tr>
<tr>
<td>Belgium</td>
<td>10</td>
</tr>
<tr>
<td>Canada</td>
<td>8</td>
</tr>
<tr>
<td>France</td>
<td>8</td>
</tr>
<tr>
<td>EU15</td>
<td>6</td>
</tr>
<tr>
<td>United States</td>
<td>4</td>
</tr>
<tr>
<td>Spain</td>
<td>4</td>
</tr>
<tr>
<td>OECD</td>
<td>2</td>
</tr>
<tr>
<td>Denmark</td>
<td>2</td>
</tr>
<tr>
<td>Italy</td>
<td>2</td>
</tr>
<tr>
<td>Korea</td>
<td>2</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2</td>
</tr>
<tr>
<td>Japan</td>
<td>2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2</td>
</tr>
<tr>
<td>Germany</td>
<td>1</td>
</tr>
<tr>
<td>Austria</td>
<td>1</td>
</tr>
<tr>
<td>Finland</td>
<td>1</td>
</tr>
<tr>
<td>Sweden</td>
<td>1</td>
</tr>
</tbody>
</table>

attempt to transfer technology to industry. For instance, in Sweden and in Germany (until a law passed in 2003) patents from collaborative research could be taken by the researchers themselves or by the industry partner, rarely by the university itself. However, the upward time trends in both indicators indicate clearly that in all countries technology transfers are getting more significant.

**Venture capital**

The standard mechanisms for allocating capital across economic activities, within company planning, capital markets and banks, are not well equipped to address emerging technologies and in particular start-ups. Large, established firms will tend to fund new activities which are in line with their current business, not those which might disrupt it or cannibalise it. Banks are ill-equipped for managing the specific risk patterns of emerging industries, and they are limited by strict prudential regulations. Capital markets are characterised by arm-length relationships between investors and the firms, which limit the quantity of information that can be passed to investors. It is therefore not expected that entirely new activities are started by large, established firms or funded by markets or banks. In fact, capital is allocated to emerging activities mainly through venture capital (VC). Emerging activities are typically developed by new firms, with high risk and high reward. VC has permitted the creation of nearly all successful companies in new industries since World War 2, including Intel, Microsoft, Chiron etc. All prominent internet or biotech start ups have started with VC funding. Biotechnology was developed, starting in the 1980s, by start ups, which would then
(when being successful) possibly be acquired by big pharmaceutical companies as a way for these companies to access biotech knowledge and implement it in their mainstream activities (developing new drugs, tests etc.).

The share of investment allocated by VC funds in proportion of GDP varies significantly across countries (graph 2–16). It is higher in Nordic countries, the UK, Korea, and the US, while continental Europe and Japan lag behind. Actually the correlation between the share of nanotechnology and biotechnology in total patents and the ratio of VC over GDP across OECD (as reported in graphs 2–11 and 2–16 respectively), is higher than 0.5, showing the close association of emerging technologies and venture capital.

The weak development of VC in certain countries is probably one factor which explains the difficulty of nurturing new industrial activities. The degree of development of venture capital in a particular country is related to both supply side and demand side factors. On the supply side are financial regulations (e.g. easiness for institutional investors to channel capital into VC funds; easiness to free the capital back when the investment has succeeded, by an Initial Public Offering). Demand for VC depends on entrepreneurship, and it is affected by the broader conditions of entrepreneurship, such as bankruptcy laws (which influence the distribution of risk between entrepreneurs and fund providers), market openness to new entrants (competition law, public procurement etc.), and by labour market regulation (which command the possibility and cost for new firms to attract and lay off staff). Nordic countries, the UK, Korea and the US seem better positioned in that regard.

**Venture Capital investment as a percentage of GDP, 2005**

Source: OECD Venture capital database. STI Scoreboard 2007
Conclusion

Starting from an analysis of productivity growth across OECD countries, we’ve seen the contribution of technical change and focused on the key role of emerging technical fields, based on the ability of countries to generate new scientific knowledge and to encourage venture capital and entrepreneurship. Although the complete picture is of course more complex (notably with a catching up component for certain countries like Ireland or Korea), countries with the highest growth performance, including the US and Nordic countries, are the ones which displayed the highest ability to nurture emerging technical fields – ICT, biotechnology and nanotechnology. It is the countries were conditions for entrepreneurship are the most favourable, allowing them to capture the gains generated by emerging fields. The quality of the higher education system, of the public research system, of the financial regulation, the adequate regulation of product and labour market has encouraged, in various ways, the reallocation of resources to new fields, generating productivity gains which are at the core of economic growth.
References


OECD (2005) Oslo manual


OECD (2008), Compendium of Productivity Indicators.


# TABLE OF CONTENTS

**Introduction**  
7

**1. OECD Workshops on Productivity Analysis and Measurement:**  
Conclusions and Future Directions; *Erwin Dievert*  
13

## PART 1: PRODUCTIVITY GROWTH IN SPAIN AND IN SWITZERLAND

2. Productivity Growth and Innovation in OECD; *Dominique Guellec and Dirk Pilat*  
41

3. The Role of ICT on the Spanish Productivity Slowdown;  
*Matilde Mas and Javier Quesada*  
61

4. Multi-factor Productivity Measurement: from Data Pitfalls to Problem Solving – the Swiss Way; *Gregory Rais and Pierre Sollberger*  
81

5. Innovation and Labour Productivity Growth in Switzerland:  
An Analysis Based on Firm Level Data; *Spyros Arvanitis and Jan-Egbert Sturm*  
101

## PART 2: THE MEASURE OF LABOUR INPUT

6. On the Importance of Using Comparable Labour Input to Make International Comparison of Productivity Levels: Canada-U.S., A Case Study; *Jean-Pierre Maynard*  
115

7. Labour Productivity Based on Integrated Labour Accounts – Does It Make Any Difference?; *Kamilla Heurlén and Henrik Sejerbo Sørensen*  
145

8. Are Those Who Bring Work Home Really Working Longer Hours? Implications for BLS Productivity Measures; *Lucy P. Eldridge and Sabrina Wulff Pabilonia*  
179

## PART 3: THE MEASURE OF THE COMPOSITION OF LABOUR INPUT

9. Main Sources of Quarterly Labour Productivity Data for the Euro Area; *Wim Haine and Andrew Kanutin*  
213

10. U.S. Quarterly Productivity Measures: Uses and Methods; *Lucy P. Eldridge, Marilyn E. Manser and Phyllis Flohr Otto*  
225

11. Labour Input Productivity: Comparative Measures and Quality Issues; *Antonella Baldassarini and Nadia Di Veroli*  
239
12. Changes in Human Capital: Implications for Productivity Growth in the Euro Area; *Guido Schwerdt and Jarkko Turunen*  

**PART 4: THE MEASURE OF CAPITAL INPUT**  

13. International Comparisons of Levels of Capital Input and Multi-factor Productivity; *Paul Schreyer*  

14. Research and Development as a Value Creating Asset; *Emma Edworthy and Gavin Wallis*  

15. Empirical Analysis of the Effects of R&D on Productivity: Implications for productivity measurement?; *Dean Parham*  

16. Infrastructures and New Technologies as Sources of Spanish Economic Growth; *Matilde Mas*  


**PART 5: THE MEASURE OF INDUSTRY LEVEL MULTI-FACTOR PRODUCTIVITY**  

18. Productivity Measurement at Statistics Netherlands; *Dirk van den Bergen, Myriam van Rooijen-Horsten, Mark de Haan and Bert M. Balk*  

19. Sectoral Productivity in the United States: Recent Developments and the Role of IT; *Carol Corrado, Paul Lengermann, Eric J. Bartelsman and J. Joseph Beaulieu*  

20. Estimates of Industry Level Multifactor Productivity in Australia: Measurement Initiatives and Issues; *Paul Roberts*  

21. Shopping with Friends gives more Fun; How Competition, Innovation and Productivity Relate in Dutch Retail Trade; *Harold Creusen, Björn Vroomen and Henry van der Wiel*  

22. Economic Growth in Sweden, New Measurements; *Tomas Skytesvall and Hans-Olof Hagén*  

23. Estimates of Labor and Total Factor Productivity by 72 Industries in Korea (1970–2003); *Hak K. Pyo, Keun Hee, Rhee and Bongchan Ha*  

List of Contributors  

259  

283  

285  

303  

337  

357  

379  

395  

397  

435  

455  

479  

505  

527  

551