Wiener Institut für Internationale Wirtschaftsvergleiche

The Vienna Institute for International Economic Studies

Research Reports | 380 | August 2012

*Neil Foster*

# Innovation and Technology Transfer across Countries

Neil Foster is a research economist at the Vienna Institute for International Economic Studies (wiiw).

This report was prepared as part of the EU-funded Framework 7 project AUGUR (Challenges for Europe in the World in 2030).

*Neil Foster*

**Innovation and Technology Transfer across Countries**

# Contents

## List of Tables and Figures

***Summary***

*Innovation is considered to be an important determinant of performance at the firm, industry and country level. This view is supported by empirical evidence showing the importance of innovative activities on firm and industry performance and country growth rates. The majority of the world's R&D is concentrated in a handful of countries however, meaning that domestic innovation is of little importance for most countries. Such countries can benefit from innovation conducted elsewhere however, if knowledge and technology is diffused across borders. In this paper we survey existing literature on innovation and technology diffusion and discuss descriptive statistics on the extent of innovation and technology diffusion across countries to provide insights into the likely developments in innovation and diffusion.*

***Keywords:*** *innovation, technology diffusion, R&D internationalization*

***JEL classification:*** *O3*

*Neil Foster*

# Innovation and technology transfer across countries

## 1. Introduction

Innovation is considered to be an important determinant of performance at the firm, industry and country level. This view is supported by empirical evidence showing the importance of innovative activities on firm and industry performance and country growth rates. The majority of the world's R&D is concentrated in a handful of countries however, meaning that domestic innovation is of little importance for most countries. Such countries can benefit from innovation conducted elsewhere however, if knowledge and technology is diffused across borders. The purpose of this paper is to identify trends in innovation and technology diffusion patterns. This is achieved through a combination of descriptive statistics and a literature survey. Given the difficulty in measuring innovation and technology diffusion and given that available measures are often only available for a small number of countries we revert to a literature survey to understand the causes and channels of technology diffusion.

The remainder of the paper is structured as follows. Section 2 discusses the importance of innovation and describes trends in patenting patterns and R&D spending over recent years. Section 3 concentrates on the more recent phenomenon of the internationalization of R&D and discusses the determinants of this process and the likely impacts. Section 4 turns to the issue of technology diffusion: Much of this section is devoted to a literature survey due to the wide variety of channels through which technology can diffuse and the difficulty in measuring these channels. This section does however use data on bilateral patenting to provide some clues as to where firms think that technology is likely to be used. Section 5 concludes.

## 2. Innovation trends and impacts

### *2.1. On the measurement of innovation*

The fact that the output of innovation (namely technology or knowledge) is typically intangible means that its measurement is not straightforward. Several measures have been employed in the empirical literature (see Keller, 2004), each with their own strengths and weaknesses. R&D expenditure data or data on the number of R&D personnel are often used, since R&D expenditures are the main input towards innovative activity. But such a measure fails to take into account that innovation is risky, so that a significant portion of R&D projects are unsuccessful, and there is the possibility of discovering new technology by chance. Moreover, there is likely to be a significant lag between the R&D expenditure and the delivery of a commercially viable product. A further drawback of this measure is that they are only available for a relatively small number of countries over a reasonable time period. In particular, while these data are available for a sub-sample of OECD countries since the early 1970s, the data are patchy for other countries and generally not available over a reasonable period of time.[1]

Patent applications are a measure of the output of innovation, and patents are recognized as the most important form in which industrial innovation is protected. The main advantage of patent counts is that they are available for a large sample of countries over a relatively long period of time. In addition, in order to be patented an innovation must meet some novelty requirement as judged by an expert in the field. The weaknesses of patent count data include the substantial variation in the value of patents, with the majority worth very little (though more than the cost of patenting), as well as the fact that many innovations are not patented. Moreover, the strictness of patent regimes differs across countries, while some inventions are not patentable. Such protection is also more important for some industries than for others. Evidence suggests that firms in most industries in advanced countries do not find patents to be a particularly effective means of appropriating the returns to R&D (see Cohen (1995) for a review of this evidence). Mansfield (1986) for example showed that although 65% of pharmaceutical and 30% of chemical inventions would not have taken place without patent protection, in most industries patent protection was unimportant. One reason put forward for its limited role is that patent protection often does not affect the rate of entry significantly (Mansfield, et al., 1981).

More recently attempts have been made to conduct innovation surveys to ask how much firms are innovating, the most important example being the Community Innovation Surveys (CIS) conducted in Europe, with similar surveys available for the US and for Japan. While these provide a direct measure of innovation at the firm-level they are currently only available for a small number of countries and years. Moreover, it is not always clear what the definition of innovation is (or should be), with early surveys asking whether new products and processes had been introduced, but not whether they were new to the firm or to the market (see Greenhalgh and Rogers, 2010). On a broader scale, measures of the changes in a country's or firm's TFP can be used as an indicator of technology change. This indicator is constructed by subtracting the contribution of changes in major factor (and material) inputs to changes in output with the remainder being assigned to changes in technology. Thus TFP is a derived measure of technology[2]. TFP is likely to capture a wide-variety of productivity improving effects and not just that related to innovation however.

1 Considering data on R&D expenditure as a percentage of GDP for example from the UNESCO database for example, we find a fairly complete time-series of data from 1996-2005 for around 50 countries, with some data over this time period reported for just over 100 countries. Data is available at the (broad) industry level from the OECD for a much smaller sample of countries.

2 See Keller (2004) for a discussion of the issues involved in the construction of TFP.

### 2.2. Empirical evidence

Innovation can be defined as the application of new ideas to the products, processes, or other aspects of the activities of a firm that lead to increased 'value' (Greenhalgh and Rogers, 2010). Two forms of innovation are usually considered: product and process innovation. Product innovation refers to the introduction of a new product or a significant improvement in the quality of an existing product, while process innovation refers to the introduction of a new process for making or delivering goods and services. Sometimes, a third type of innovation is also considered, namely organizational change within a firm. Innovation is distinguished from imitation by the concept of novelty, which Greenhalgh and Rogers (2010) consider to be the case if the innovation is new to the firm and new to the relevant market. These authors further distinguish between innovation and invention or discovery, arguing that for the former to take place the product or process must be introduced into the market place so that consumers or other firms can benefit.

At the firm-level the main purpose and benefit of process innovation is to reduce the cost of production, while for product innovation that introduces a new variety or improves the quality of an existing product the firm aims to achieve an outward shift (and steeper slope) of its demand curve. Both forms of innovation are expected to raise profits for the innovating firm. For consumers the major expected benefits of innovation are lower prices and increased product variety. Innovation activity within a firm may create additional benefits. Cohen and Levinthal (1989) for example talk of the so-called two faces of R&D, with R&D activities allowing a firm to learn from competitors with R&D in addition to its effect through the introduction of new products and processes. R&D may thus contribute to the diffusion of technology across firms.

At the aggregate level innovation is expected to impact upon economic growth and welfare. While early theories of economic growth, such as the Neoclassical model of Solow (1956) and Swan (1956), allowed for technological progress (i.e. innovation) to impact upon economic growth, the growth rate of technology was assumed exogenous. This was a major shortcoming of these early theories when faced with a mountain of anecdotal evidence and research findings (e.g. Solow, 1957) suggesting that innovation and technological progress were the major causes of economic growth. More recent theories beginning with the work of Romer (1986) however endogenize the growth rate of technology and thus allow for a relationship between explicit innovation activities and economic growth. In many of these models innovation by firms adds to a public stock of knowledge, which lowers the cost of future innovation and offsets any tendency towards diminishing returns to innovation at the firm-level.

A great deal of empirical research, much of it predating the development of endogenous growth models, has tested for a relationship between innovation and economic growth. A typical approach to examining the relationship between innovation and some measure of output or productivity at the firm, industry and country level has been to regress output on a number of inputs including a measure of cumulated research effort, often proxied by a weighted sum of past R&D expenditures. Alternatively, research has studied growth effects by regressing a measure of output or productivity growth on the growth of inputs including the intensity of R&D spending. Much of this literature is surveyed in Griliches (1995). Results using firm or line-of-business data tend to report fairly similar qualitative results, though estimated rates of return to R&D can differ substantially. The results tend to indicate that there exists a positive elasticity of output with respect to R&D. In addition, results tend to suggest that the benefit from government-financed R&D produces less benefit in terms of productivity than privately-financed R&D and that basic research appears to have the largest productivity effects of all R&D activity. Similar results to these were found at the industry level by Griliches and Lichtenberg (1984). Despite pointing to the significance of R&D and innovative activity to productivity within firms and industries, the estimated effects are usually found to be far too small to account for the productivity slowdown in the US in the 1970s for example (Griliches, 1995), indicating that the effects of innovation are likely to be limited. Griliches (1995) goes on to argue that R&D spillovers – i.e. indirect effects of R&D activity – are unlikely to have been the cause of the productivity slowdown and that a more likely explanation was that the returns to R&D declined during this period, due to the internationalization of R&D and the increase in the skills of competitors.

The importance of spillovers or externalities from R&D activity is fundamental to endogenous growth models.[3] Below in Section 4 the issue of knowledge or technological spillovers across borders is discussed in depth. Here we briefly discuss the empirical literature examining such spillovers within a country. To model such effects it is assumed that the productivity of a firm (or industry) depends not only on its own R&D efforts but also upon the stock of knowledge available to it. Under the assumption that the productivity of own R&D may be affected by the stock of knowledge available to the firm one may also expect an interaction effect between own R&D and this stock. The stock of knowledge available to a firm is unlikely to be limited to the knowledge produced within the industry in which it operates, and is likely to depend upon contacts with upstream and downstream industries. To capture these linkages a variety of methods have been adopted, with input-output tables capturing the linkages between industries being one particular example. Other examples that capture a broader measure of proximity between industries include the use of patent citations, and information on R&D product field or patent classifications. Scherer (1982) for example classified a large sample of patents by origin of its invention and its intended destination. Using this data he examined the impact of R&D spillovers on labour productivity, finding that the spillover effect was often larger and more significant than the impact of R&D on its own industry. Other studies using a similar approach provide less support for large spillover effects

3 There are two distinct notions of R&D spillovers. Rent spillovers refer to the process by which R&D intensive inputs are purchased from other industries at less than their full 'quality' price (Griliches, 1995, p. 65). These are not true spillovers and relate more to measurement problems. Pure spillovers are ideas borrowed from research teams in industry $i$ from the research results of industry $j$ (Griliches, 1995, p. 66). These latter spillovers need not be related to the extent of input purchases between industries, with other indicators of industry proximity being more appropriate.

(e.g. Griliches and Lichtenberg, 1984; Englander et al., 1988; Mohnen and Lepine, 1988). Jaffe (1986, 1988) uses an alternative measure of closeness between firms, namely the overlap in the distribution of their patents by detailed patent classes. Two firms that are active in the same technology field are thus assumed to be more likely to benefit from each other's innovation activities. Including a spillover variable based on this proximity measure Jaffe finds that such a variable has a positive impact upon both productivity and patenting.[4]

### *2.3. Innovation trends*

In this section we present descriptive statistics on the extent of innovation across countries. The primary data source for this description is the patent statistics database of the World Intellectual Property Organization (WIPO), which has data on residential and non-residential patent applications for a large number of countries over a long period of time. Data is further reported by technology field, which will allow us to identify the fields in which world innovation is concentrated. The dataset also has data for the more recent period on a bilateral basis, which will be used further below. In addition, we report statistics using R&D data for the more recent period (1996-2009) for a sub-sample of countries for which UNESCO reports data, and data from the OECD's ANBERD database on R&D expenditure by industry for a sample of around 35 countries over the period 1987-2006.

#### *2.3.1. Innovation Levels across Countries*

We begin in Figure 2.1 and Table 2.1 by reporting the average number of patent applications – a measure of the output of innovative activity – by domestic residents over the period 1960-2009 for each country for which we have data and for aggregate regions respectively.[5] Figure 2.1 indicates that the USA and Japan receive by far the most domestic patent applications followed by other larger developed countries such as Germany, Italy, France and the UK, along with China and Russia. Patenting is a minor activity throughout Africa (with the exception of South Africa) as well as parts of South Asia and South America.

Table 2.1 aggregates the data presented in Figure 2.1 up to the level of the regions. The table confirms that innovation, as measured by patent counts, is heavily concentrated in a small number of regions. In particular, 68% of domestic patent applications in our sample of countries are taken out in four regions; Japan, the USA, Central Europe and China (and Macao), with 10 of the 19 regions accounting for more than 95% of domestic patent applications. African regions, West Asia, Other South Asia, Central America and India combined apply for less than one per cent of the total domestic patent applications between them.

---

4 Jaffe et al (1993) use information on patent citations to examine the extent of diffusion geographically. They find that patent citations are highly localized with most citations occurring within the same state and municipal area.

5 Often the numbers of domestic patent applications for Japan are scaled down by a factor of between 3 and 4.5. This is because the Japanese patent system breaks the invention into more discrete stages, with the result that a Japanese patent is considered to be worth about one third of a U.S. patent. In the figures reported here the original numbers for Japan have been divided by 3.

Figure 2.1

## Average number of domestic patent applications, 1960-2009

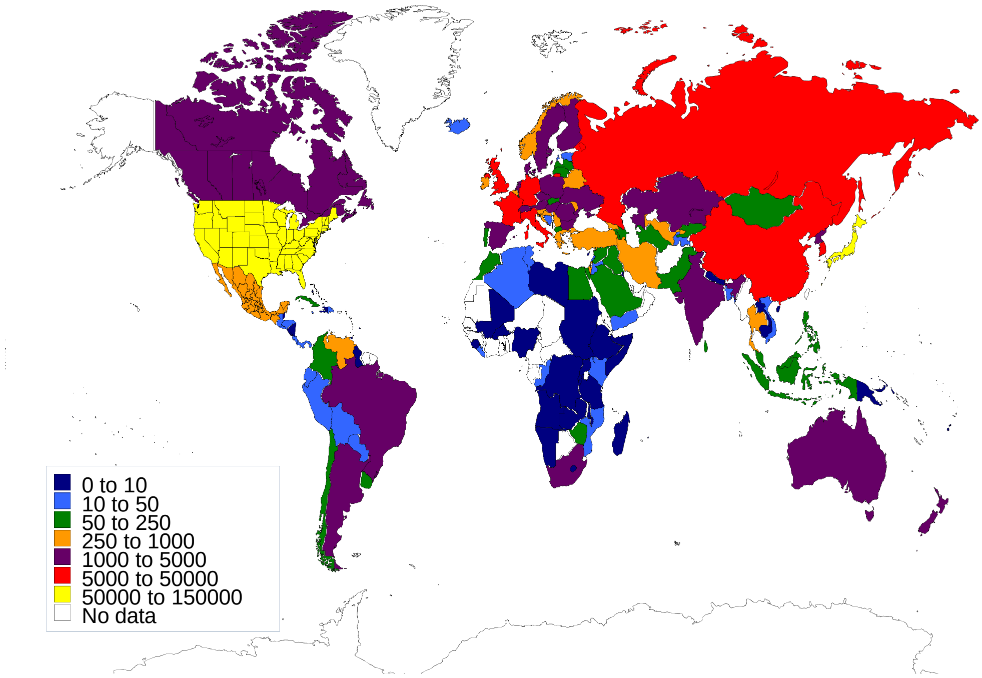



Table 2.1

## Average number of domestic patent applications by region (1960-2009)

| Region | Domestic patent applications | Share in total domestic patent applications | Cumulative share in total domestic patent applications |
|---|---|---|---|
| US | 101359 | 28.63 | |
| JA | 71580.4 | 20.22 | 48.85 |
| EUC | 56386.6 | 15.93 | 64.78 |
| EAH | 29991.3 | 8.47 | 73.25 |
| CN | 22618.6 | 6.39 | 79.64 |
| EUW | 19279.5 | 5.45 | 85.09 |
| EUE | 12447.5 | 3.52 | 88.60 |
| CI | 8586.82 | 2.43 | 91.03 |
| OD | 7386.32 | 2.09 | 93.12 |
| EUN | 7136.66 | 2.02 | 95.13 |
| EUS | 7046.04 | 1.99 | 97.12 |
| AM | 3338.24 | 0.94 | 98.07 |
| AFS | 2267.7 | 0.64 | 98.71 |
| IN | 1420.46 | 0.40 | 99.11 |
| EAO | 1152.8 | 0.33 | 99.43 |
| WA | 884.34 | 0.25 | 99.68 |
| ACX | 730.38 | 0.21 | 99.89 |
| AFN | 279.6 | 0.08 | 99.97 |
| ASO | 114.32 | 0.03 | 100.00 |

US – USA; JA – Japan; EUC – Central Europe; EAH – High Income East Asia; CN – China; EUW – West Europe; EUE – East Europe; CI – CIS; OD – Other Developed; EUN – North Europe; EUS – South Europe; AM – South America; AFS – Other Africa; IN – India; EAO – Other East Asia; WA – West Asia; ACX – Central America; AFN – North Africa; ASO – Other South Asia.

*Source:* World Intellectual Property Organization (WIPO).

Of perhaps more importance than the (average) level of domestic patenting, given our interest in the future development of innovation patterns, are the recent trends in innovative activity across countries. Figure 2.2 and Table 2.2 therefore report the average growth rates of domestic patent applications over the period 1960-2009 for each country and region respectively. Also reported in Table 2.2 (and in Figure 2.3) are the figures for the more recent period (1995-2009). Figure 2.2 indicates that those developed countries that patent heavily according to Figure 2.1 have had a relatively low growth rate of domestic patent applications over the period 1960-2009, and in a number of cases (e.g. the UK, France and Italy) the average growth rate is found to be negative. In contrast, China and Russia have enjoyed much higher growth rates of patent applications as have other countries across Asia and parts of Africa (though often starting from a very low number[6]).

Figure 2.2

**Average growth in domestic patent applications, 1960-2009**

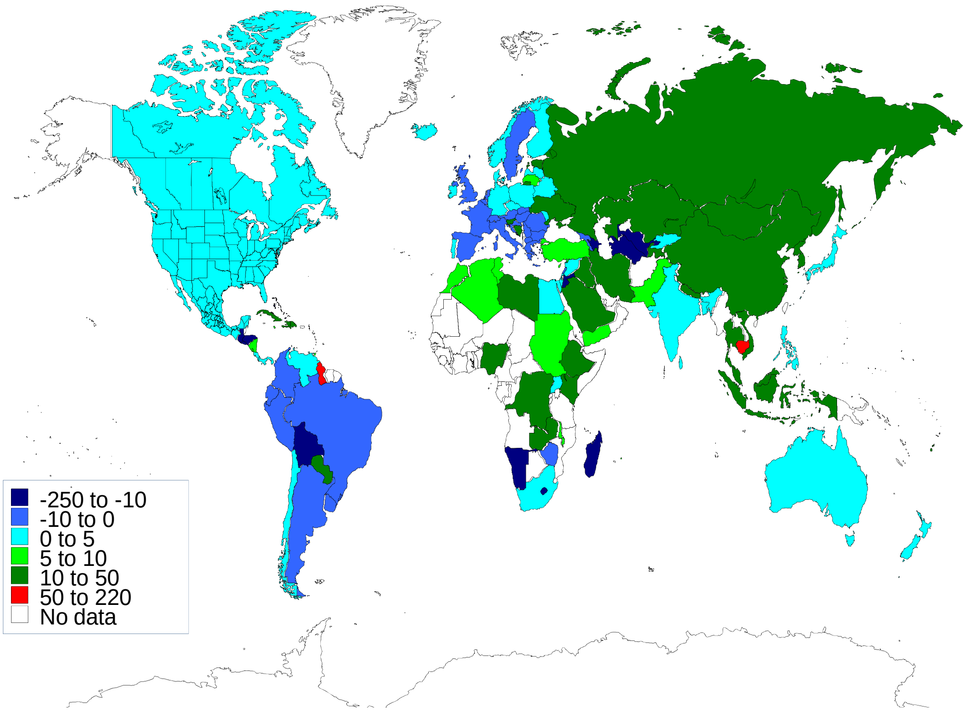



Table 2.2 reports the growth rates for the periods 1960-2009 and 1995-2009 for the different regions, with the data listed in decreasing order of the growth rates between 1960 and 2009. The table indicates that European regions (with the partial exception of South Europe) have seen very low growth or a decline in domestic patent applications over the period 1960-2009, with all experiencing a negative growth rate of domestic patents over the period 1995-2009. South Europe however has seen a growth rate in domestic patents of around 3% over the whole sample, and an even greater 7.7% over the more recent period. The US and Japan have also seen steady growth rates of around 3% over the entire

[6] For some countries the number of observations is also limited to a few observations.

sample, though in recent years their performances stand in stark contrast. While the US has seen an increase in the growth rate to around 5%, Japan's growth of patent applications has become negative. Much faster growth rates have been experienced by a number of African regions, though it has to be mentioned that in these regions patent applications were initially at a very low level initially and their performance has been weaker in recent years. The largest growth rates in patent applications have been observed in other East Asia, the CIS and China. Again though, these figures hide differences across time. In the case of China we observe that in the more recent period the growth rate of patent applications has been higher than the average over the full sample (at around 20%), while in East Asia the figure is smaller at around 10% and in the CIS the figure over the recent period is just 1%. In the more recent period we also observe high rates of growth of patent applications in India and High-Income East Asian countries.

Table 2.2

**Average growth of domestic patent applications**

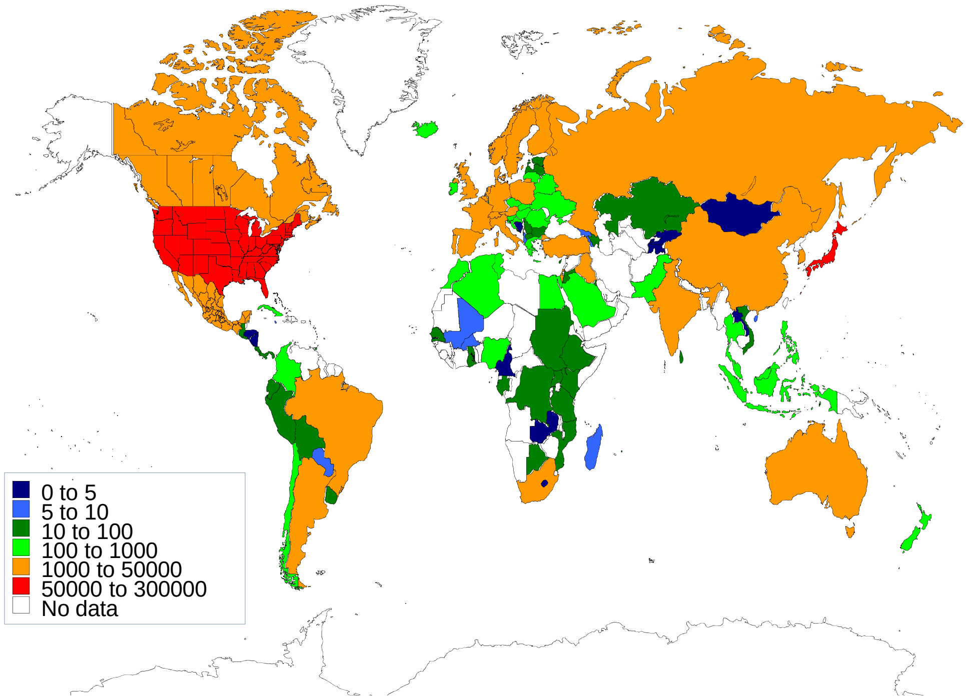
| **Region** | **1960-2009** | **1995-2009** |
|---|---|---|
| EAO | 20.2 | 9.9 |
| CI | 18.6 | 1.2 |
| CN | 17.1 | 20.1 |
| AFN | 12.8 | 6.0 |
| AFS | 9.4 | 3.8 |
| ASO | 8.5 | 0. 1 |
| WA | 7.2 | 5.4 |
| EAH | 6.9 | 11.6 |
| IN | 4.6 | 10.1 |
| ACX | 3.2 | 1.2 |
| JA | 3.2 | -0.5 |
| EUS | 3.0 | 7.7 |
| US | 2.6 | 5.0 |
| OD | 2.4 | 2.6 |
| AM | 2.1 | 1.8 |
| EUE | 0.4 | -1.2 |
| EUN | 0.4 | -0. 8 |
| EUC | -0.6 | 0. 4 |
| EUW | -0.9 | -0. 1 |

*Source:* WIPO.

Due to the problems with the use of patent data that were outlined above we further report information on R&D spending, which is obtained from UNESCO. This data is rather patchy and has data on a smaller number of countries and for a much shorter time period than the WIPO patent data. In particular, we report statistics for a sample of 123 countries using data averaged over the period 1996-2009. Figure 2.4 reports information on the average level of R&D spending, while Figure 2.5 reports the growth rate of R&D expenditure. Figure 2.4 confirms the patterns found using patent data indicating that innovation is heavily concentrated in the USA and Japan, with countries in Europe along with China, Canada, Brazil, India and Australia also undertaking considerable R&D. Figure 2.5 also confirms that while the USA and European countries have seen relatively low growth rates in R&D expenditure, China in particular has seen a dramatic rise in R&D expenditure over time. This can also be seen in Table 2.5 where we report the average R&D expenditure along with the shares of regions in total R&D and average growth rates for the different regions. The table indicates that seven regions accounted for more than 90% of total R&D during the period considered. The average growth rates for these regions however tended to be relatively low ranging (usually between 2% and 4%, with OD and EUS being exceptions). Growth rates for other regions, most notably China (16.2%) were usually higher.

Figure 2.4

**R&D expenditure (1,000,000s USD)**




Such patterns can also be seen when we use data from the OECD's ANBERD database. This database reports total business R&D expenditure (in Purchasing Power Parities, PPP) at the industry level for 38 countries over the period 1987-2006, albeit with a number of gaps for many countries in the early years. Figures 2.5 and 2.6 report the average shares of (business) R&D spending by country in 1991 and 2005 respectively for selected countries. Figure 2.5 reveals that in 1991 the USA accounted for 45% of total R&D spending of the ANBERD countries, with the USA, Japan, Germany, France and the UK accounting for 87% of R&D.[7] China in contrast accounted for just 1% of R&D spending. In 2005 however there had been a large change in these shares. The share of the US in total R&D spending

[7] The figures differ somewhat from those reported by UNESCO. The main reason for this is likely to be that ANBERD only considers business R&D rather than total (public plus private R&D).

had dropped 10% to 35%, while the share of the USA, Japan, Germany, France and the UK in total R&D dropped to 69%. The share of China increased to 8%.

Figure 2.5

**Average growth rate of R&D expenditure**

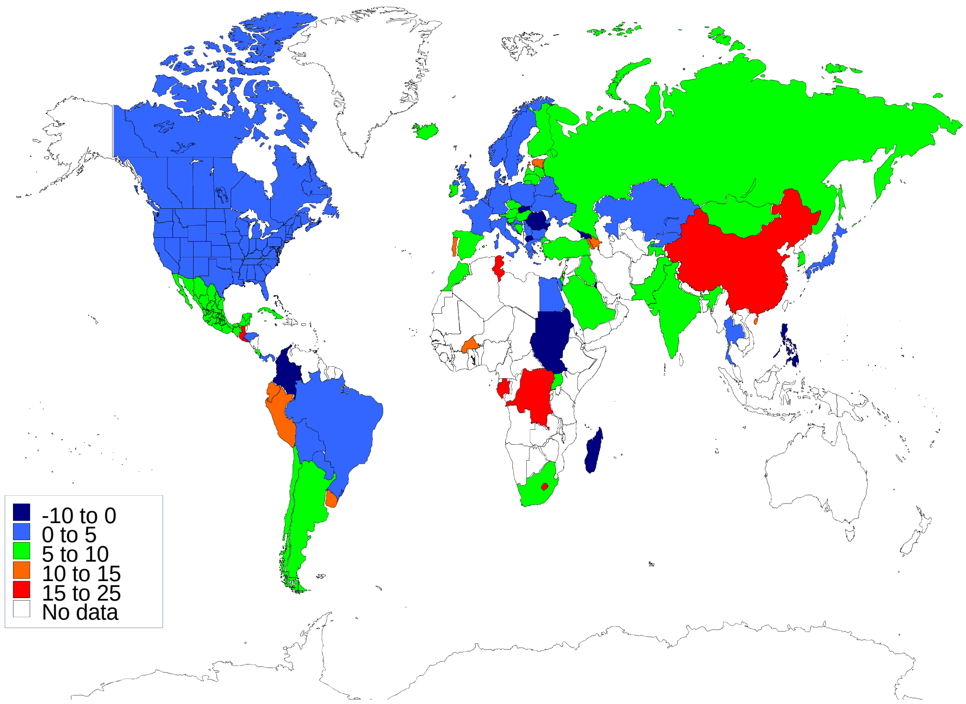


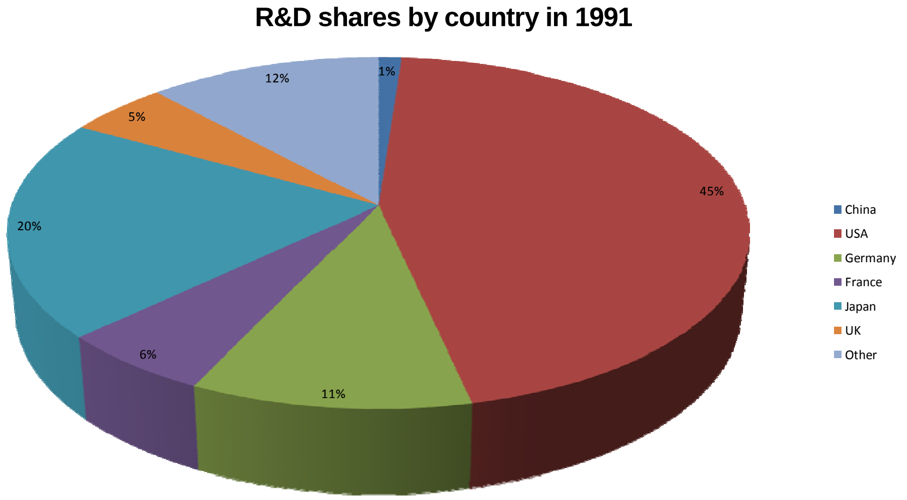

Table 2.3

**R&D spending by region**

| Region | R&D (1,000,000s USD) | Share in total R&D | Cumulative share | Growth rate of R&D |
|---|---|---|---|---|
| US | 269000 | 39.09 | | 3.56 |
| JA | 152000 | 22.09 | 61.18 | 2.69 |
| EUC | 101000 | 14.68 | 75.86 | 3.03 |
| OD | 28900 | 4.20 | 80.06 | 5.42 |
| EUW | 27700 | 4.03 | 84.08 | 2.24 |
| EUS | 22500 | 3.27 | 87.35 | 7.67 |
| EUN | 21100 | 3.07 | 90.42 | 4.26 |
| EAH | 19300 | 2.80 | 93.23 | 9.03 |
| CN | 17900 | 2.60 | 95.83 | 16.18 |
| AM | 9180 | 1.33 | 97.16 | 5.11 |
| IN | 3900 | 0.57 | 97.73 | 8.08 |
| CI | 3440 | 0.50 | 98.23 | 6.12 |
| WA | 2790 | 0.41 | 98.63 | 5.03 |
| EUE | 2740 | 0.40 | 99.03 | 4.09 |
| ACX | 2580 | 0.37 | 99.41 | 5.31 |
| AFS | 1800 | 0.26 | 99.67 | 8.95 |
| EAO | 1150 | 0.17 | 99.83 | 5.58 |
| AFN | 855 | 0.12 | 99.96 | 3.03 |
| ASO | 284 | 0.04 | 100.00 | 9.98 |

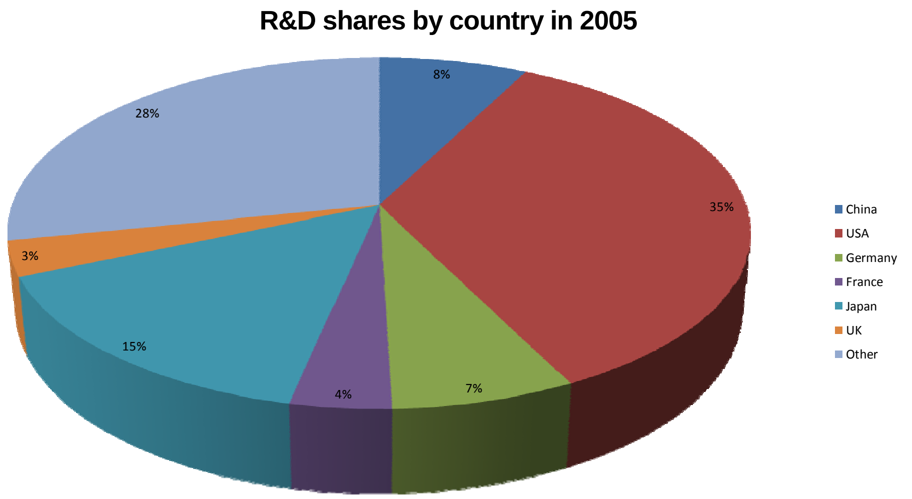
*Source:* UNESCO.

Figure 2.5




*Source:* ANBERD database, OECD.

Figure 2.6




*Source:* ANBERD database, OECD.

### *2.3.2. Innovation intensity across countries*

In addition to considering the level of innovative activities across countries we are also interested in the intensity of innovation, understanding which countries devote a relatively large share of their resources to innovation. Figure 2.7 reports the average R&D expenditure as a percentage of GDP by region over the period 1996-2009 for around 100 countries. These figures are again based on data from the UNESCO database. For some countries used in the construction of this table data is available for a few years only. These figures are also reported in Table 2.4 alongside values for the growth rate of the ratio of R&D to GDP. These figures show that the average share of R&D expenditure in GDP is below 1% for most regions, including China with a share of 0.56%. Regions with the largest shares are Japan (3.2%), the USA (2.6%), EUW (1.8%) and notably EUN (2.7%). Considering the growth rates of the ratio of R&D to GDP we observe that growth in the recent past has been higher in Asian regions in particular, as well as in Southern Europe. Regions that conduct the majority of R&D (i.e. the US, Japan and Western and Central Europe) have seen much smaller growth rates.

Figure 2.7

**Average R&D expenditure as a percentage of GDP (1996-2009)**

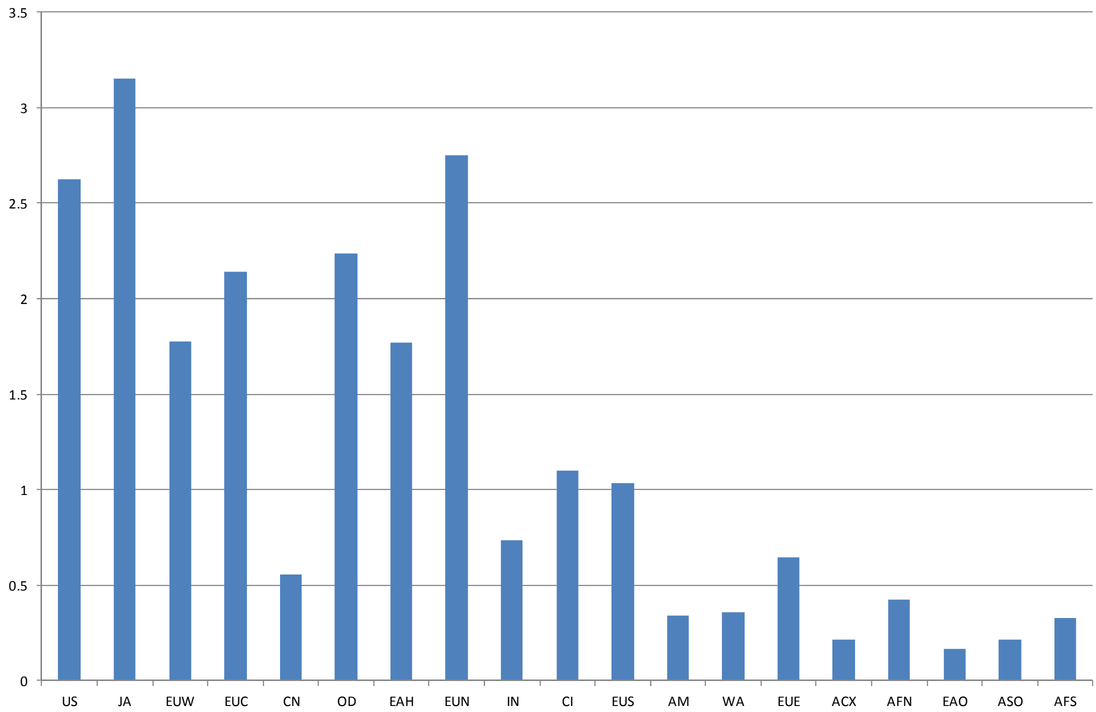



Table 2.4

**Level and growth rate of R&D to GDP by region**

| Region | R&D / GDP | Growth rate of R&D / GDP |
|---|---|---|
| JA | 3.154 | 1.7 |
| EUN | 2.749 | 1.91 |
| US | 2.627 | 0.7 |
| OD | 2.234 | 2.4 |
| EUC | 2.139 | 1.11 |
| EUW | 1.779 | 0.1 |
| EAH | 1.77 | 4.49 |
| CI | 1.101 | 1.94 |
| EUS | 1.034 | 5.46 |
| IN | 0.735 | 1.4 |
| EUE | 0.643 | 0.9 |
| CN | 0.558 | 4.6 |
| AFN | 0.425 | -1.09 |
| WA | 0.357 | 2.1 |
| AM | 0.343 | 2.82 |
| AFS | 0.33 | 2.78 |
| ASO | 0.217 | 6.9 |
| ACX | 0.216 | -0.6 |
| EAO | 0.168 | 6.3 |

*Note:* Data is constructed for all countries for which there are at least five observations on the growth of R&D expenditures.

*Source:* UNESCO.

### 2.3.3. *Innovation by sector / technology field*

For a sample of 31, mainly OECD, countries and an aggregate of other countries WIPO reports data on patent applications by technology class for the period 1990-2007. To give some indication of where innovation is occurring we report the average number of patent applications by technology class along with the average growth rate of patents by technology class over this period in Table 2.5, with Figures 2.8-2.13 presenting these figures graphically. The data indicate that the majority of patents are taken out in three broad technology fields; electrical engineering (30%), chemistry (23%) and mechanical engineering (24%). Within these broad fields computer technology and electrical machinery are the most popular areas for patents to be taken out in the electrical engineering category, while pharmaceuticals and organic chemicals have the highest share of patents applied for in the chemistry field. In the mechanical engineering field, transport, special machinery and handling are the most important sub-fields. Figures 2.14-2.18 report information on the growth rate of patent applications by technology field. Here we find that sectors such as IT methods for management, digital communication and micro-structural and nano-technology have experienced rapid rates of growth of patent applications, often starting from a very low level however. Technology classes in which the majority of innovation takes place also often grew at reasonable rates, with the growth in computer technology being 7%, electrical machinery 4.5% and pharmaceuticals 6.5%.

Table 2.5

## Patent applications by technology field

| Technology field | Patent applications | Share in total patent applications | Growth rate of patent applications |
|---|---|---|---|
| I - Electrical engineering | 383,385 | 29.78 | 5.88 |
| - Electrical machinery, apparatus, energy | 77,332 | 6.01 | 4.54 |
| - Audio-visual technology | 60,961 | 4.74 | 3.38 |
| - Telecommunications | 58,138 | 4.52 | 6.39 |
| - Digital communication | 29,852 | 2.32 | 12.37 |
| - Basic communication processes | 15,562 | 1.21 | 1.49 |
| - Computer technology | 77,990 | 6.06 | 7.07 |
| - IT methods for management | 11,034 | 0.86 | 27.82 |
| - Semiconductors | 52,516 | 4.08 | 5.80 |
| II - Instruments | 192,933 | 14.99 | 3.70 |
| Optics | 59,137 | 4.59 | 2.99 |
| Measurement | 53,115 | 4.13 | 2.67 |
| Analysis of biological materials | 8,244 | 0.64 | 4.20 |
| Control | 22,516 | 1.75 | 3.63 |
| Medical technology | 49,921 | 3.88 | 6.19 |
| III - Chemistry | 292,974 | 22.76 | 2.89 |
| Organic fine chemistry | 42,558 | 3.31 | 2.25 |
| Biotechnology | 26,866 | 2.09 | 4.98 |
| Pharmaceuticals | 44,435 | 3.45 | 6.49 |
| Macromolecular chemistry, polymers | 26,336 | 2.05 | 0.20 |
| Food chemistry | 16,738 | 1.30 | 5.68 |
| Basic materials chemistry | 33,694 | 2.62 | 2.13 |
| Materials, metallurgy | 28,153 | 2.19 | 0.85 |
| Surface technology, coating | 23,330 | 1.81 | 3.20 |
| Micro-structural and nano-technology | 1,025 | 0.08 | 31.73 |
| Chemical engineering | 31,047 | 2.41 | 1.19 |
| Environmental technology | 18,793 | 1.46 | 3.68 |
| IV - Mechanical engineering | 307,361 | 23.88 | 2.32 |
| Handling | 41,292 | 3.21 | 1.74 |
| Machine tools | 35,359 | 2.75 | 1.11 |
| Engines, pumps, turbines | 34,932 | 2.71 | 3.48 |
| Textile and paper machines | 35,496 | 2.76 | 0.57 |
| Other special machines | 44,184 | 3.43 | 0.97 |
| Thermal processes and apparatus | 22,220 | 1.73 | 2.83 |
| Mechanical elements | 39,097 | 3.04 | 3.10 |
| Transport | 54,780 | 4.26 | 4.57 |
| V - Other fields | 110,656 | 8.60 | 3.83 |
| Furniture, games | 34,357 | 2.67 | 5.85 |
| Other consumer goods | 27,208 | 2.11 | 3.74 |
| Civil engineering | 49,091 | 3.81 | 2.59 |

Figure 2.8

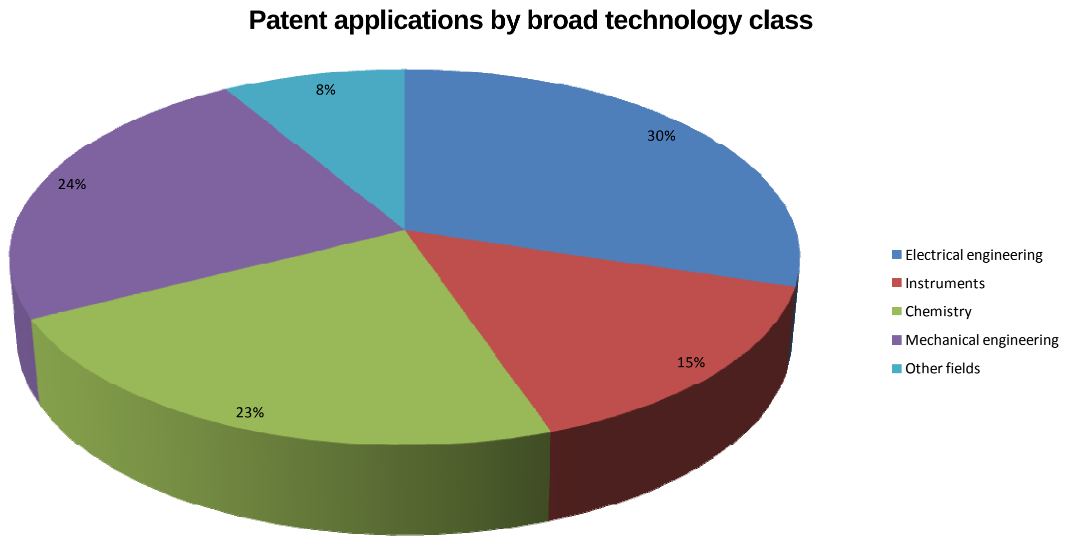



Figure 2.9

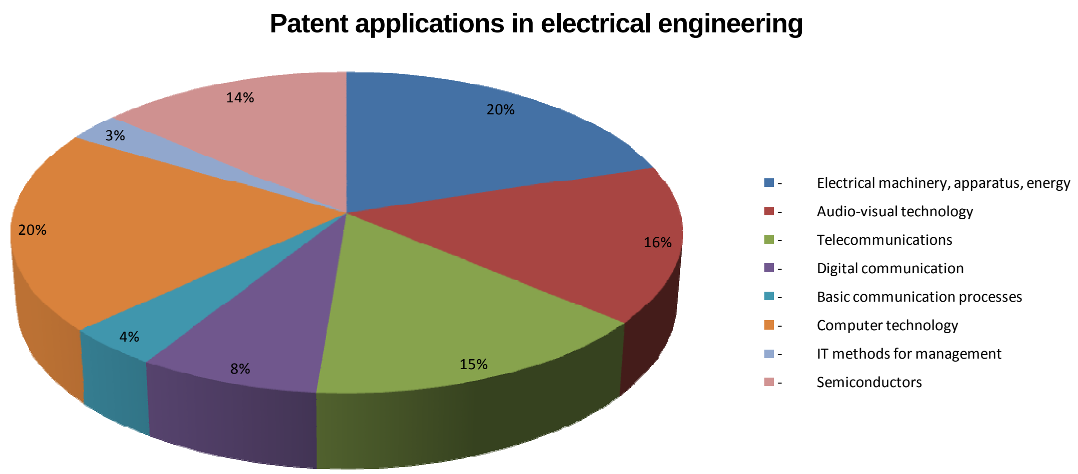



Figure 2.10

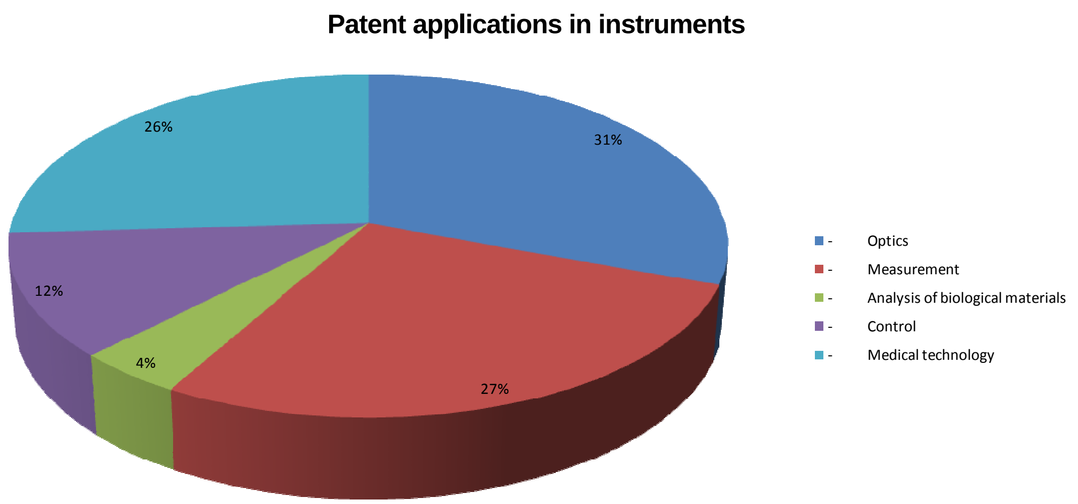


Figure 2.11

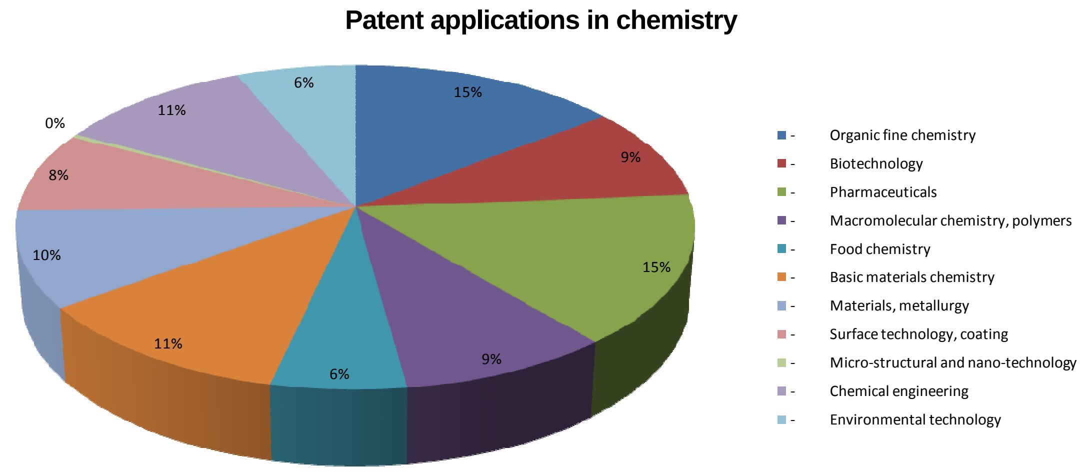



Figure 2.12

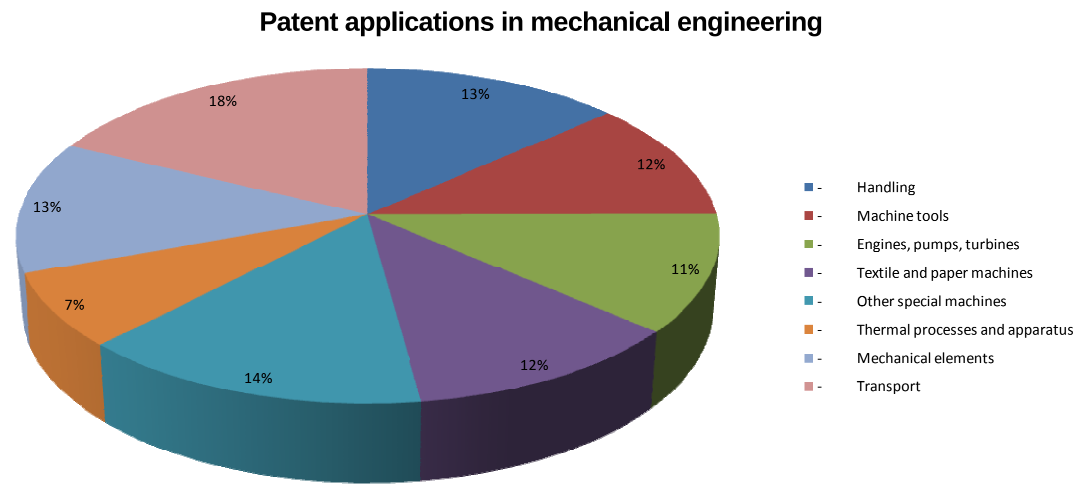



Figure 2.13

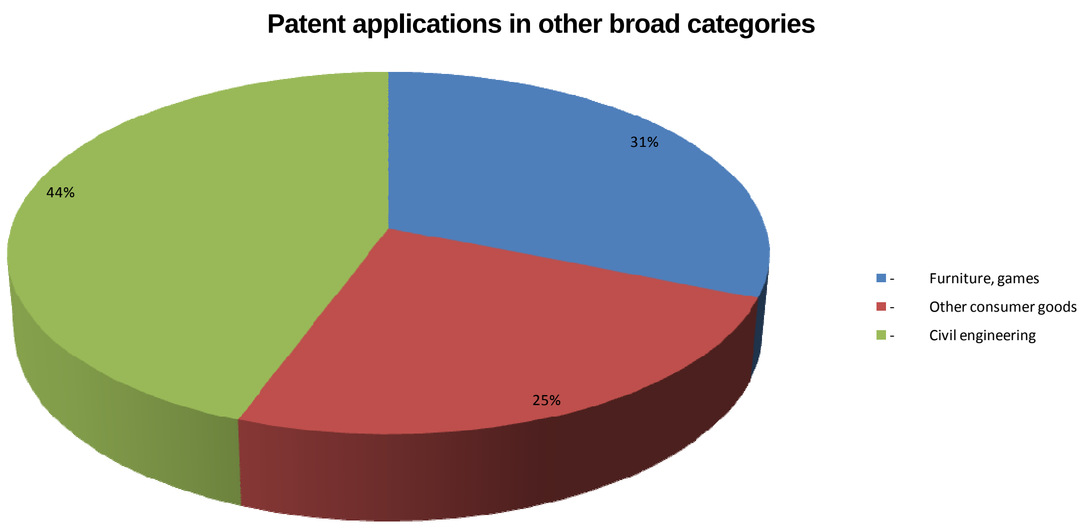


Figure 2.14

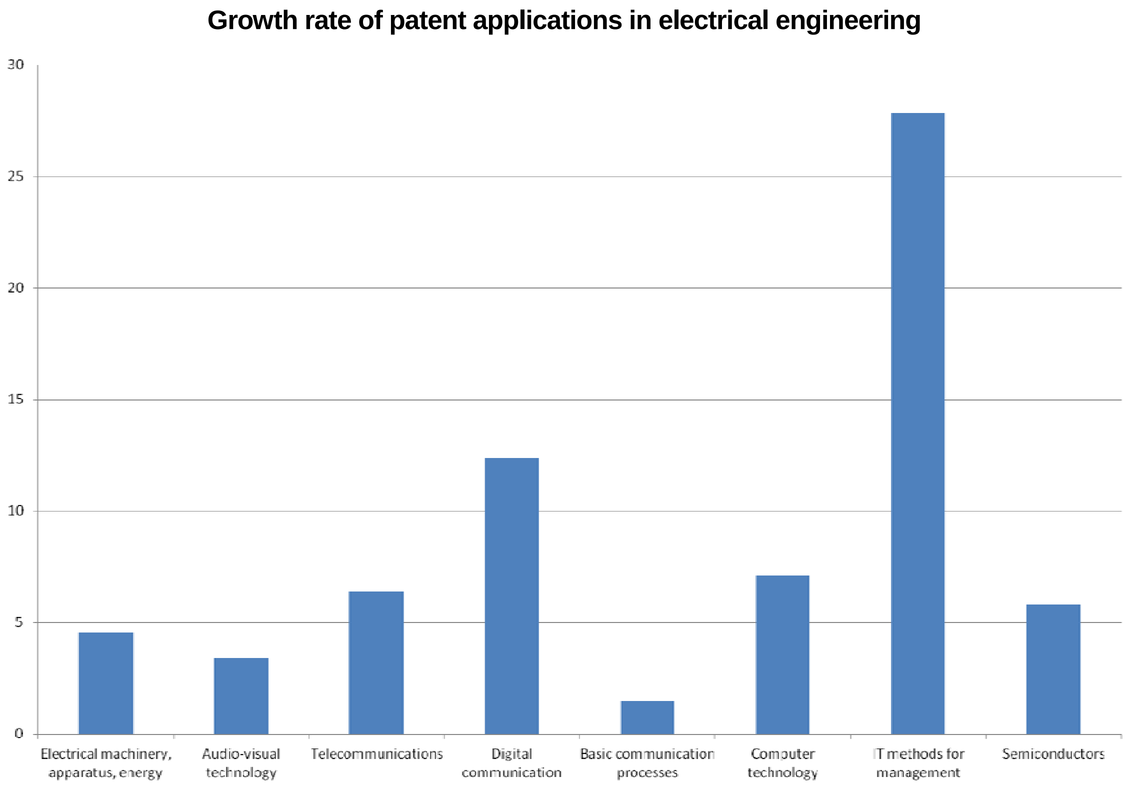



Figure 2.15

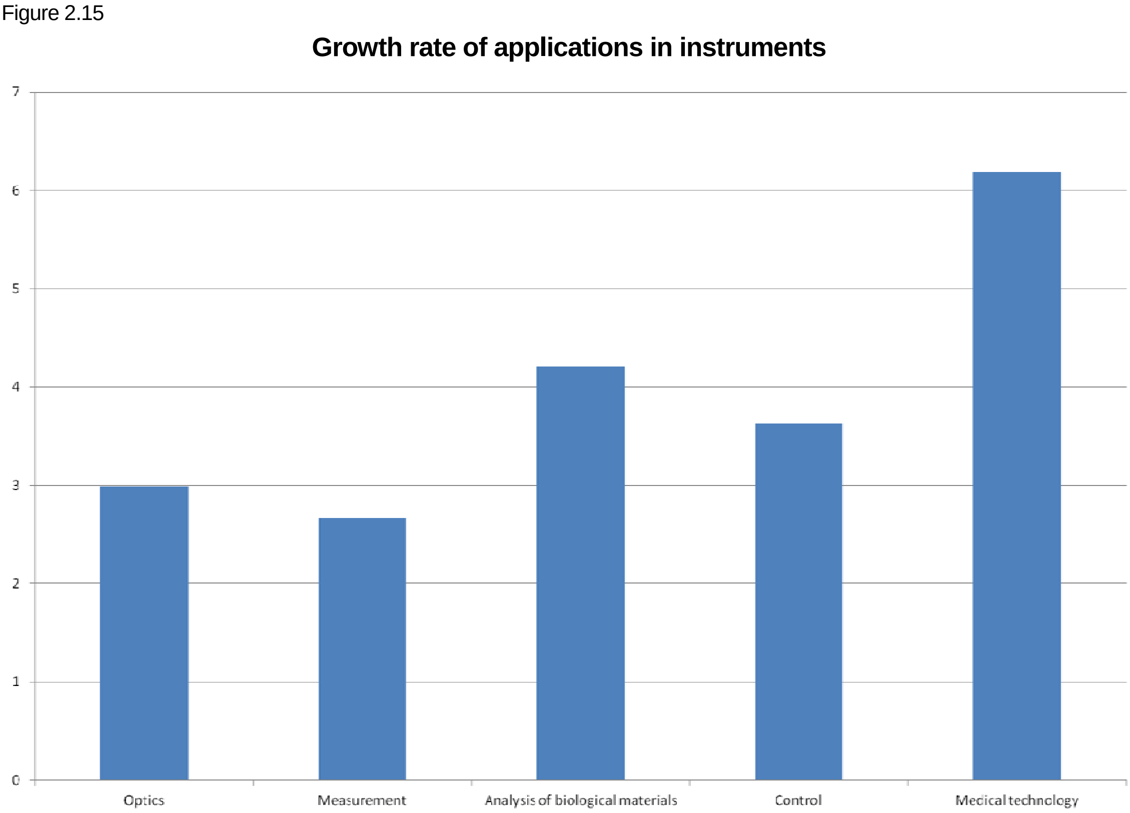


Figure 2.16

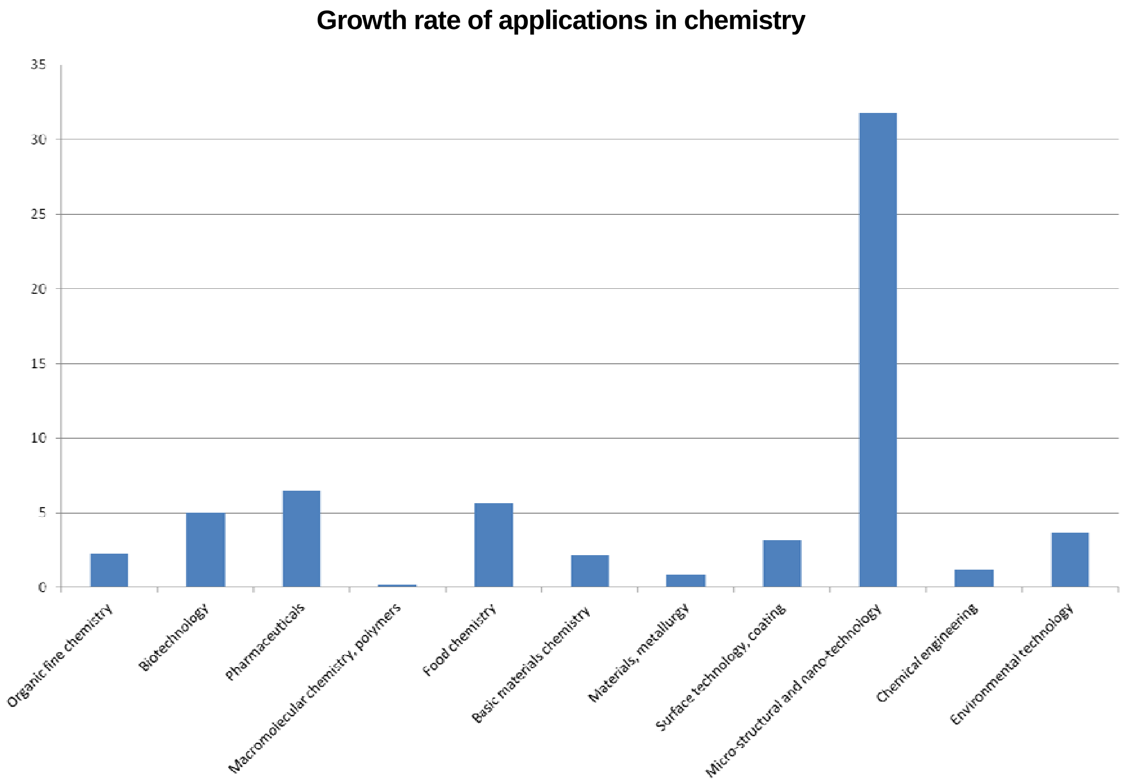



Figure 2.17

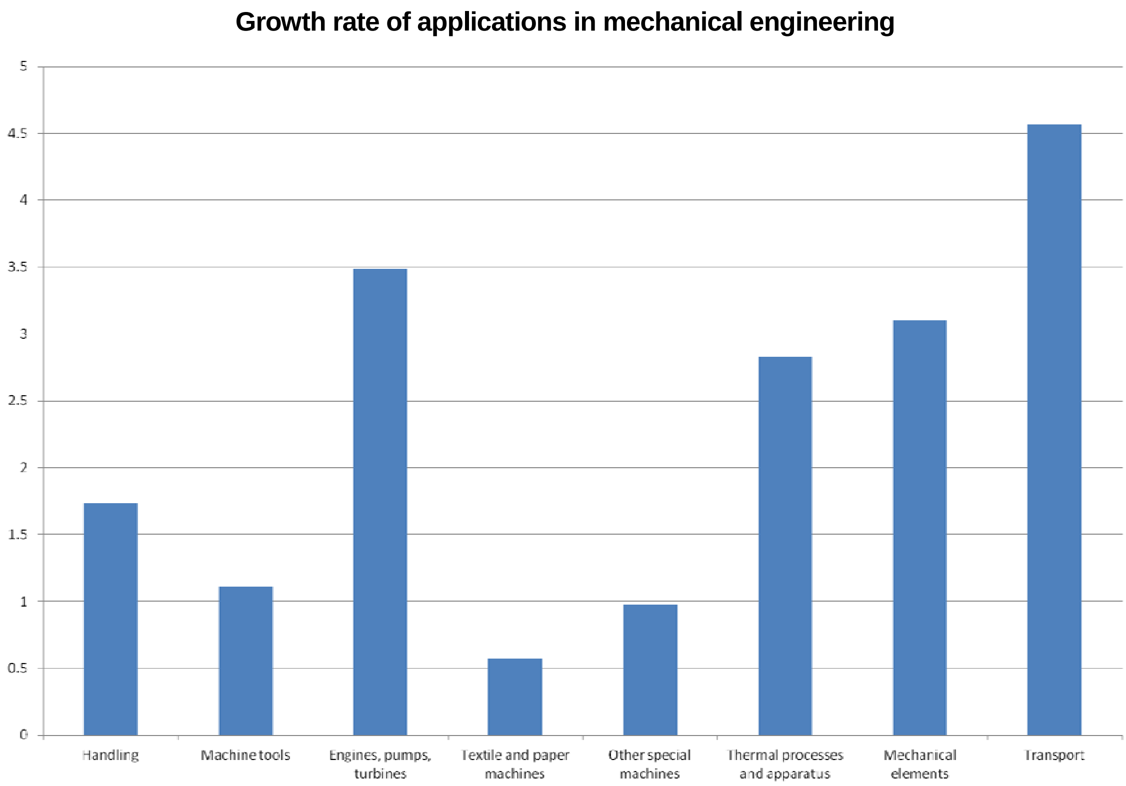
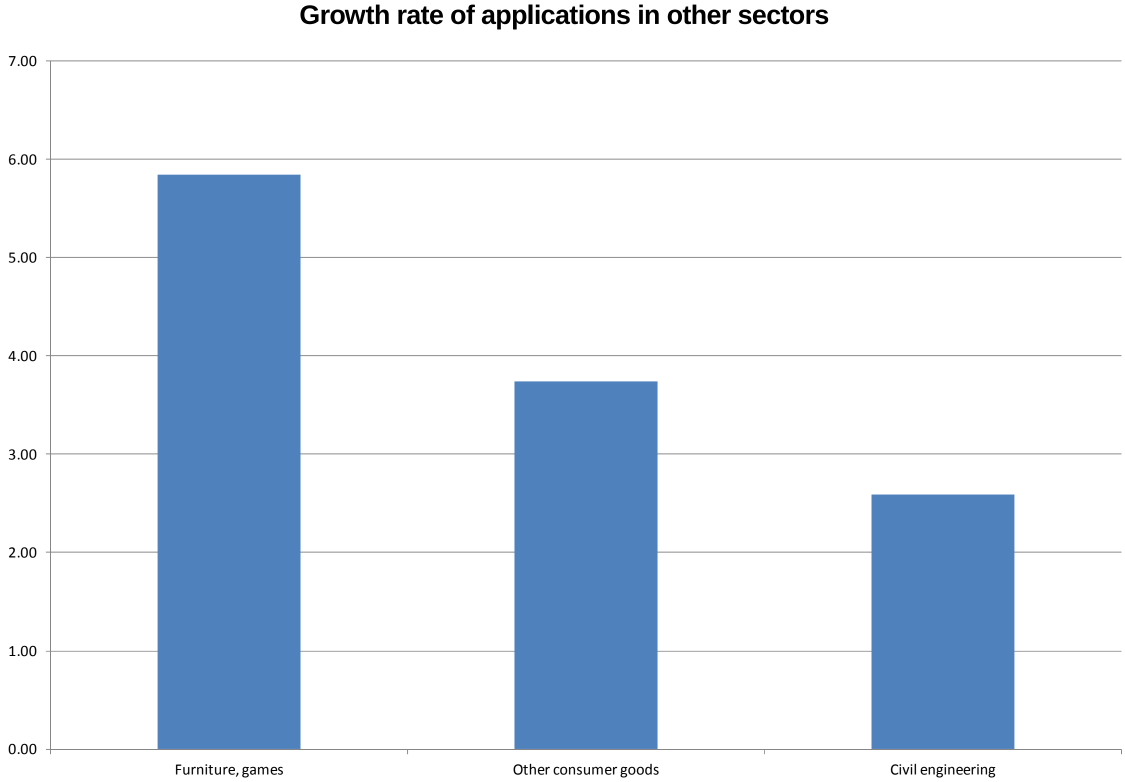


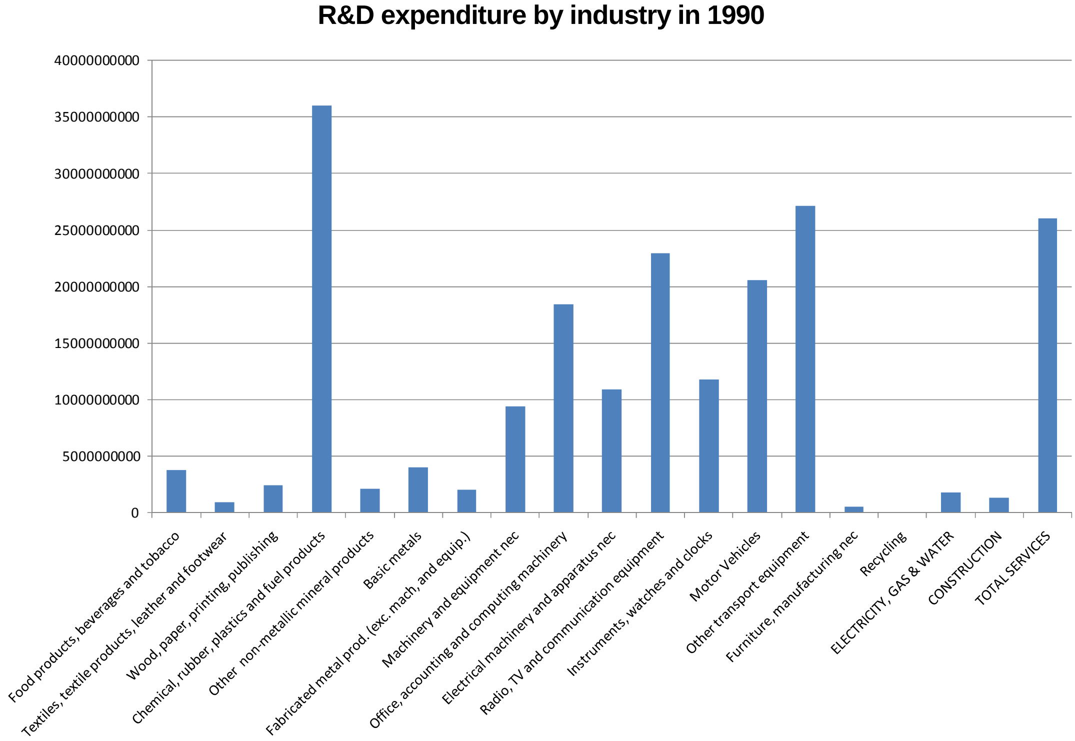
Figure 2.18




We also use information at the industry-level from ANBERD to shed more light on the issue of the industries in which the majority of R&D has occurred in recent years. Figures 2.19 and 2.20 report the levels of R&D expenditure by industry and their shares in total business R&D in 1990 respectively.[8] The figures reveal that the largest sectors in terms of R&D spending are chemicals, other transport equipment, services and radio and TV equipment, with textiles, furniture and recycling spending very little on R&D. This pattern remains when considering the shares in total R&D. Figures 2.21 and 2.22 report the average growth rates over the period 1987-2006 of the level and shares of R&D expenditure by industry. The largest growth rates in the level of R&D spending are in recycling and furniture – which partly reflects the initial low value of R&D expenditure in these industries – and in services. These industries are also the ones that have seen relatively large increases in the share of their R&D spending, with negative growth rates reported for a number of other industries including other transport equipment, other non-metallic minerals and electricity, gas and water.

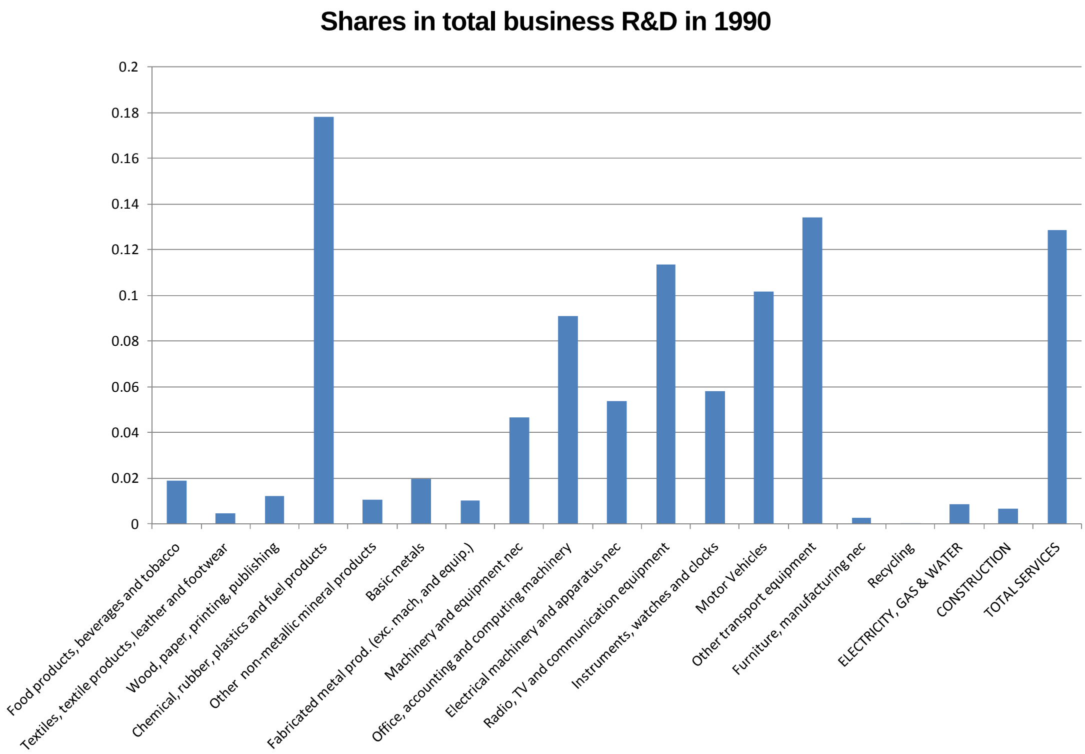
[8] We don't use the earliest period (i.e. 1987) because data on important countries such as China is not available in that year.

Figure 2.19



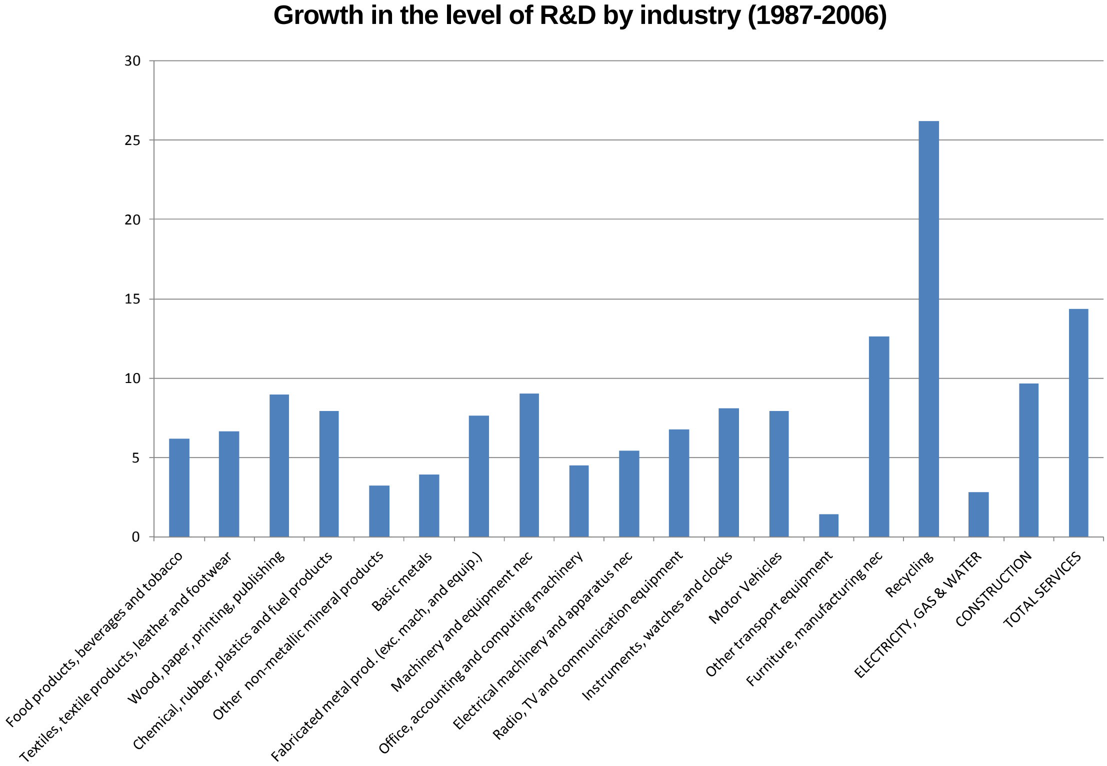

*Source:* ANBERD.

Figure 2.20



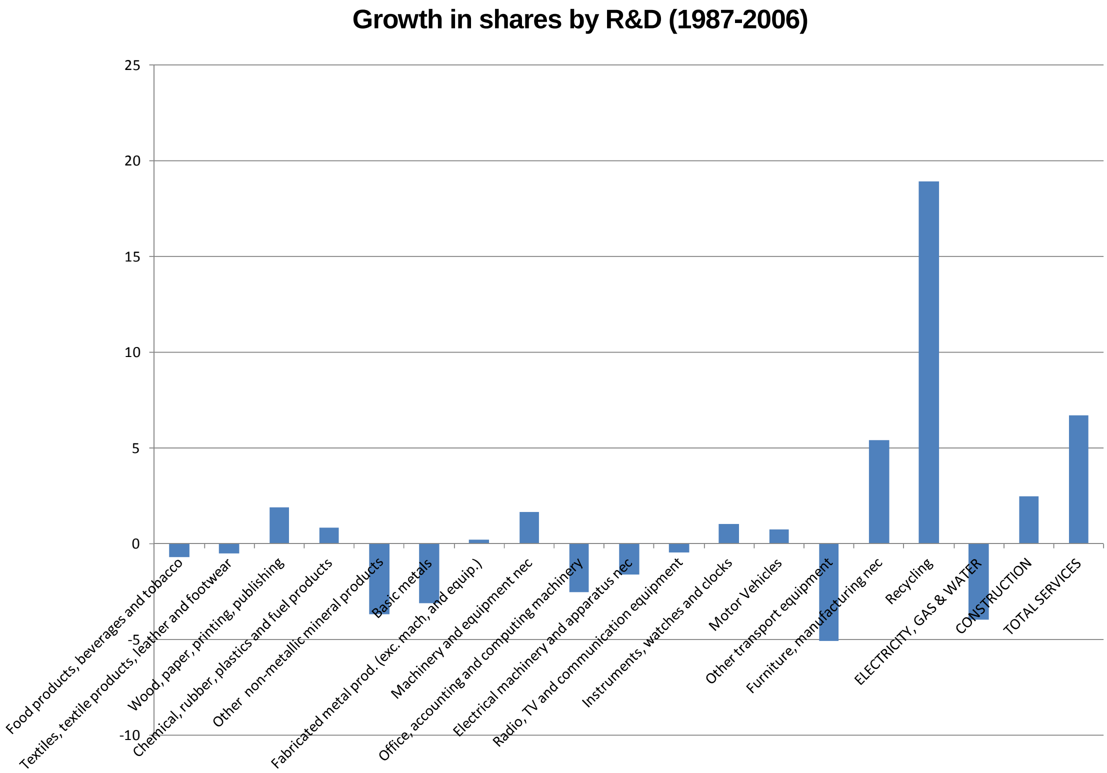

*Source:* ANBERD.

Figure 2.21




*Source:* ANBERD.

Figure 2.22




*Source:* ANBERD.

Considering information on both technology field/industry and country allows us to gain insights into which countries are investing heavily in innovation in the different technology fields/industries. As a first step we use information from WIPO which reports data for 35 countries and an 'other' aggregate averaged over the period 2003-2007. Figures 2.18-2.22 report the shares of patents taken out in a particular technology field for five countries/regions (USA, China, Japan, South Korea and the EU) and an amalgamation of the remaining countries.

Figure 2.23 reports the figures for electrical engineering and indicates that more than 60% of all patents applied for in the electrical engineering sub-sectors are applied for by firms from five countries. The USA is particularly strong in digital communications; computer technology; and IT methods for management, while the EU is relatively strong in electrical machinery, apparatus and energy; digital communications and basic communication processes. Korea has relatively large shares in electrical engineering and in particular in the telecommunications and semi-conductor sub-sectors, while China is relatively strong in digital communications.

The figures in Figure 2.24 also indicate that a large share of patent applications are taken out by just five countries, with around 70% of all patent applications taken out by our five countries in all sub-sectors except optics. The USA is again the most important innovator as measured by patent applications, and this is particularly the case in the analysis of biological materials and medical technology. The EU is also a strong innovator in this sector across all sub-sectors with the exception of optics. For Japan and Korea however the optics sector is the one where they patent most intensively.

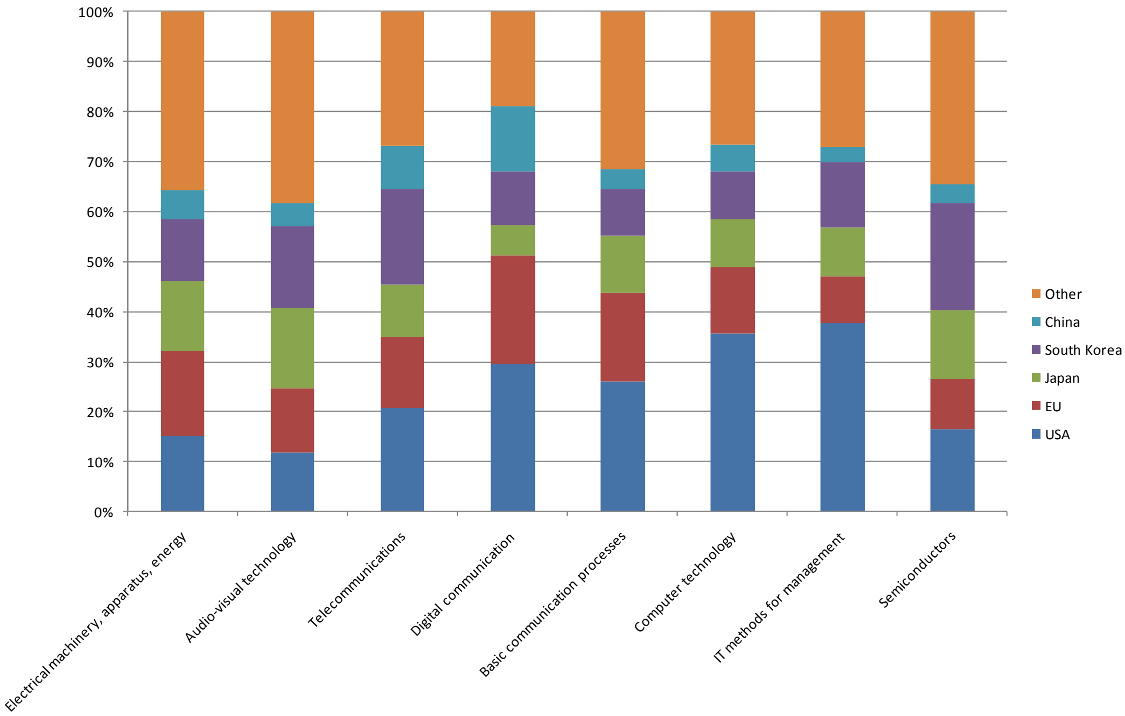
Results for chemicals (Figure 2.25) also indicate that our five countries account for around 70% of all patent applications. The USA is strong in all sub-sectors and in particular biotechnology, pharmaceuticals and organic fine chemistry, as is the EU. Japan is relatively strong in macromolecular chemistry; materials, metallurgy; and surface technology. Korea is found to patent relatively intensively in food chemistry; and micro structural and nanotechnology, while China patents relatively intensively in food chemicals and materials/metallurgy.

Figure 2.26 reports the figures for the mechanical engineering sector with our five countries once again dominating the number of patent applications. The mechanical engineering sector is one in which the USA performs relatively poorly, with less than 20% of all patent applications taken out by the USA in all sub-sectors. The EU however is found to patent more intensively in this sector, with consistently large shares found across the different sub-sectors. Japan makes up around 10% of all patent applications across the different sub-sectors, with the exception of textiles and paper machines where the share is around 15%. Both Korea and China are relatively strong in the thermal processing and apparatus sub-sectors.

Finally, Figure 2.27 reports the share of patents taken out by our five countries for the other sector. Once again our five countries are found to apply for between 60% and 70% of all patents in this sector. For our five countries we find fairly consistent shares across the different sub-sectors, with the EU having a larger share of civil engineering patent applications and Korea a larger share of other consumer goods.

Figure 2.23

**Share of electrical engineering patent applications by country**




As a second step to consider which countries are investing heavily in innovation we use data from the ANBERD dataset to examine the shares of countries in (business) R&D spending by industry. In particular, we consider six countries (USA, Japan, Germany, France, UK and China) and an amalgamation of the remaining countries in the ANBERD dataset. Figure 2.28 reports these shares for the year 2000. The USA has more than 40% of total R&D spending in four industries, namely wood, paper, printing and publishing; TV and communication equipment; instruments, watches and clocks; and other transport equipment. Japan is relatively strong in basic metals; accounting and computing machinery; and electrical machinery and apparatus not elsewhere classified. Germany is relatively strong in motor vehicles and to a lesser extent machinery and equipment, with France being relatively strong in other transport equipment and manufacturing not elsewhere classified and the UK in other transport equipment; and rubber, plastics and fuel products. China is also strong in a number of sectors with more than 10% of total business R&D in textiles, textile products, leather and footwear; other non-metallic mineral products; and basic metals.

Figure 2.24

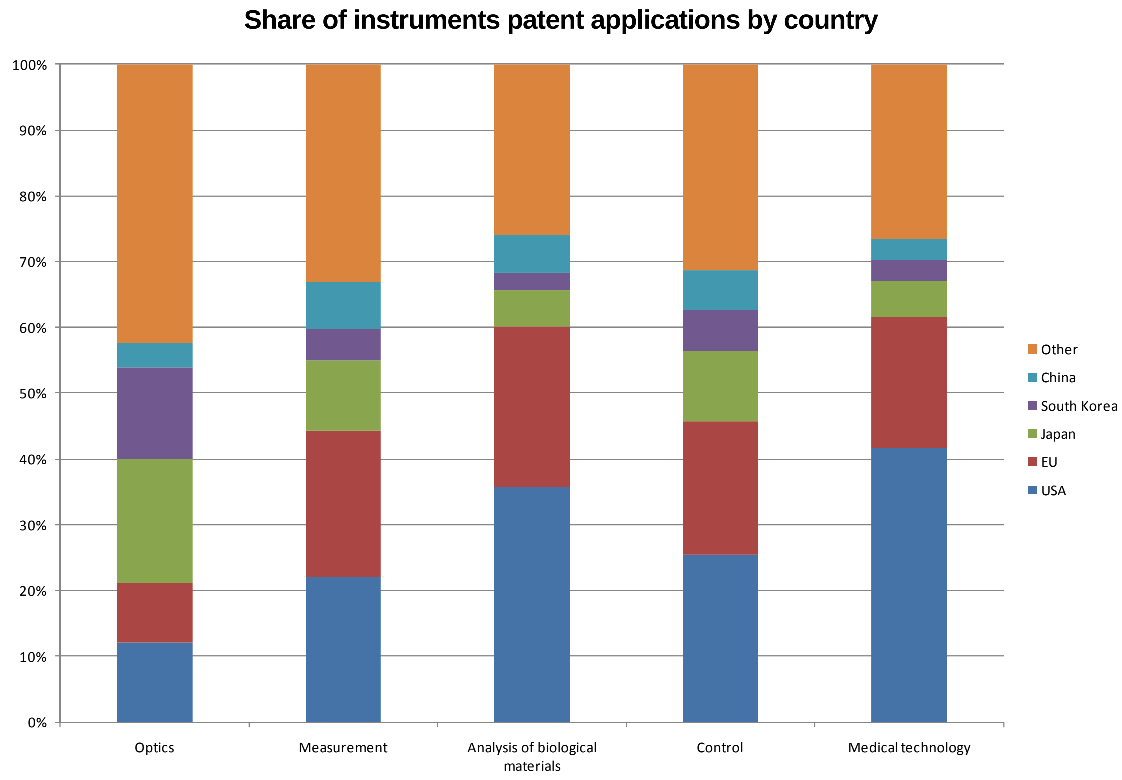



Figure 2.25

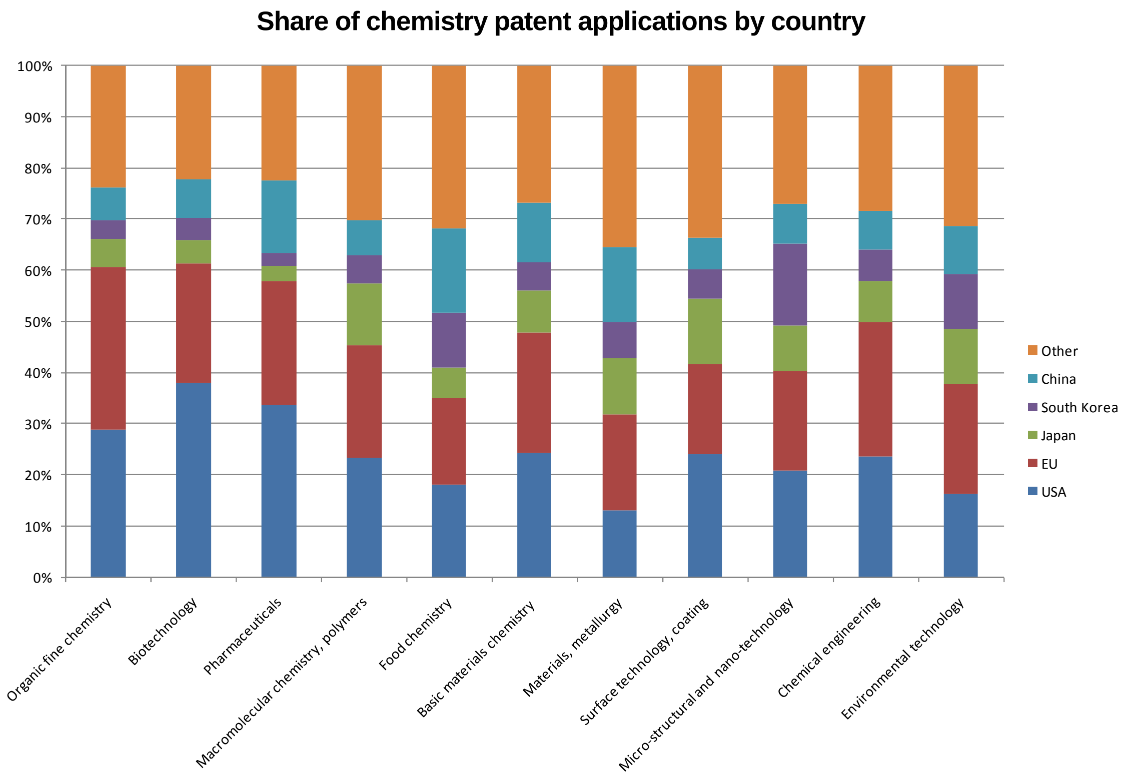


Figure 2.26

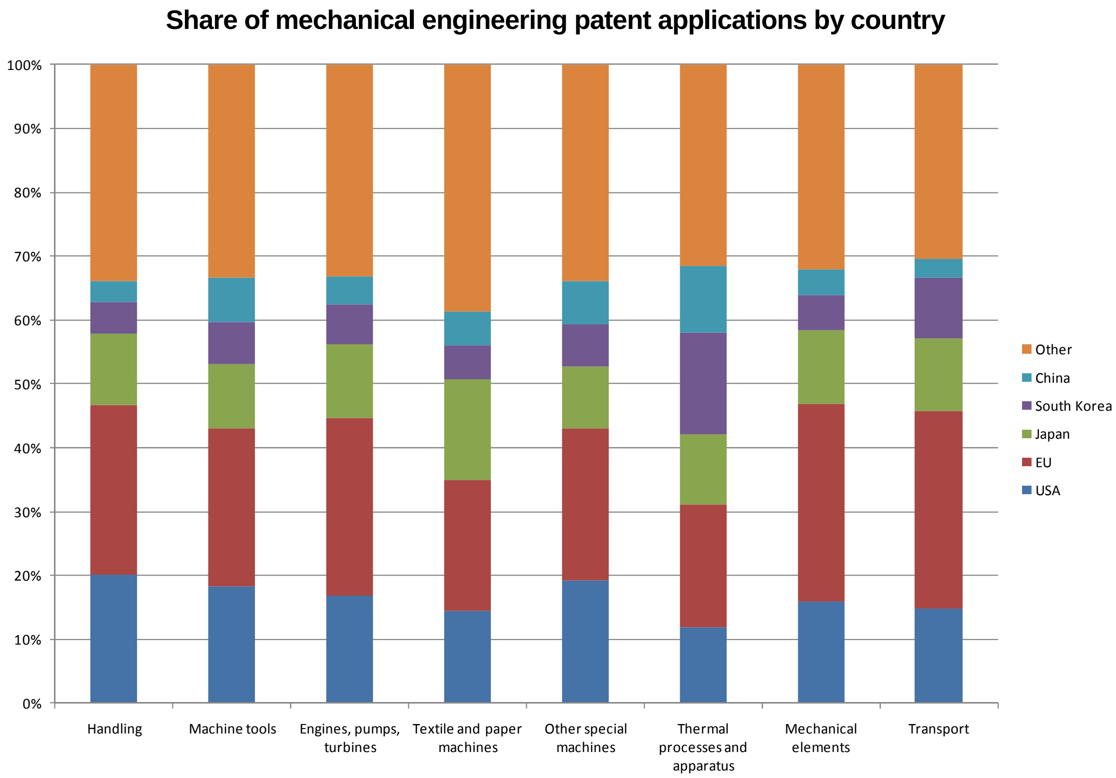



Figure 2.27

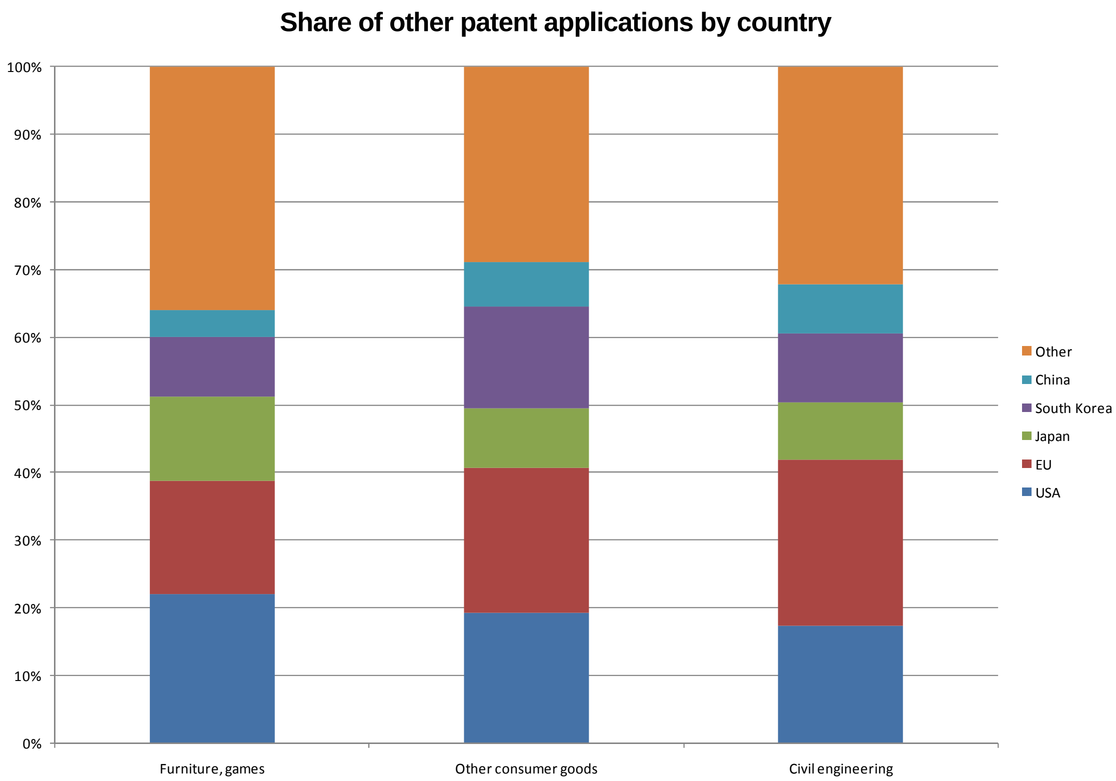
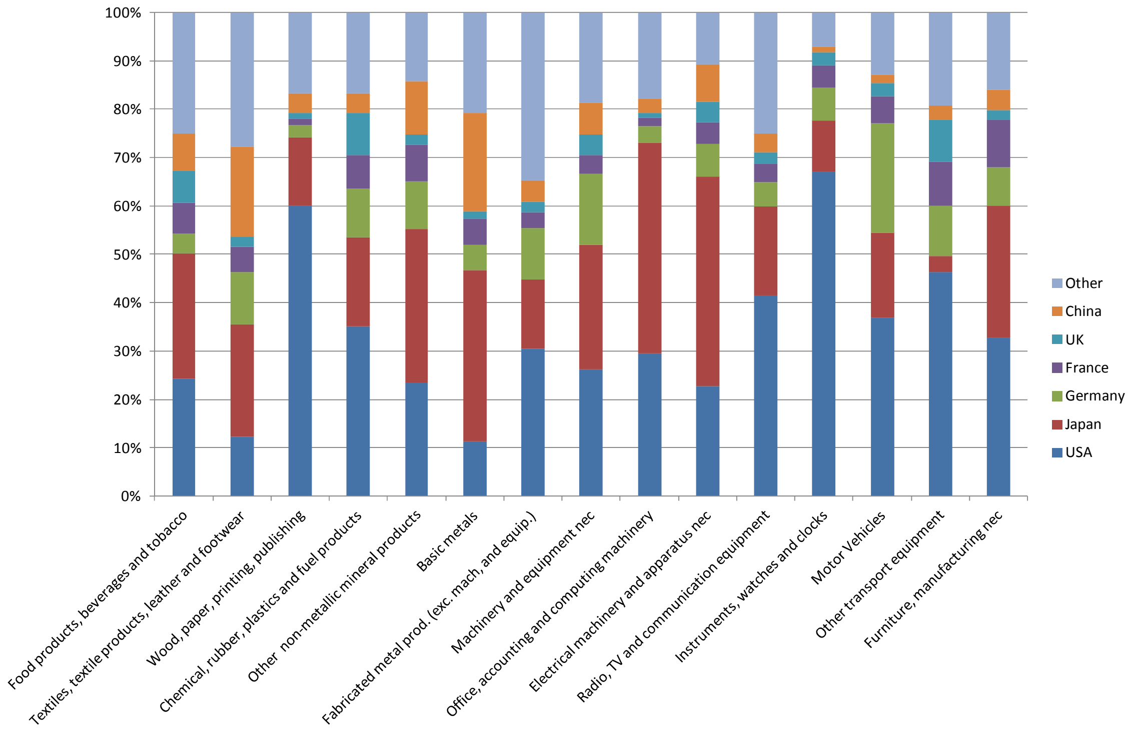


Figure 2.28

**Share of industry R&D by country in 2000**




### *2.3.4. R&D specialization measures*

Following on from the discussion of R&D spending and patenting by sector we address the issue of the specialization of R&D and patenting. We begin by considering measures of specialization using patent data. WIPO provides data on total patent applications by technology class for 31 countries, with the data averaged over the period 2003-2007. The vast majority of patent applications are taken out in these 31 countries. There are 35 technology classes that are defined within 5 broader fields (electrical engineering; instruments; chemistry, mechanical engineering; other), and patents can be assigned to more than one technology class. Specialization is measured using the Herfindahl index, which is defined as $h = \sum_i a_i^2$, with $a_i$ being the share of unit $i$ in total patent applications. This index is calculated for each country separately giving a measure of their specialization by technology class, as well as for each technology class separately giving a measure of specialization by country for each technology class. These are reported in figures 2.29 and 2.30 respectively. Figure 2.29 indicates that countries tend not to be highly specialized in patenting by technology class, with India being the country that is most specialized in terms of its patent applications. Other countries whose specialization indices seem to indicate a relatively high degree of specialization are Finland, Israel, Singapore and to a lesser extent Hungary, Denmark and Korea. Considering results by technology class we tend to observe higher values of the Herfindahl index, that is, patents tend to be more concentrated within particular countries when looking at individual technology classes. Electrical engineering classes tend to be more specialized. In particular, computer technology, IT methods for management, as well as medical and bio-technology appear to be relatively specialized classes.

Figure 2.29

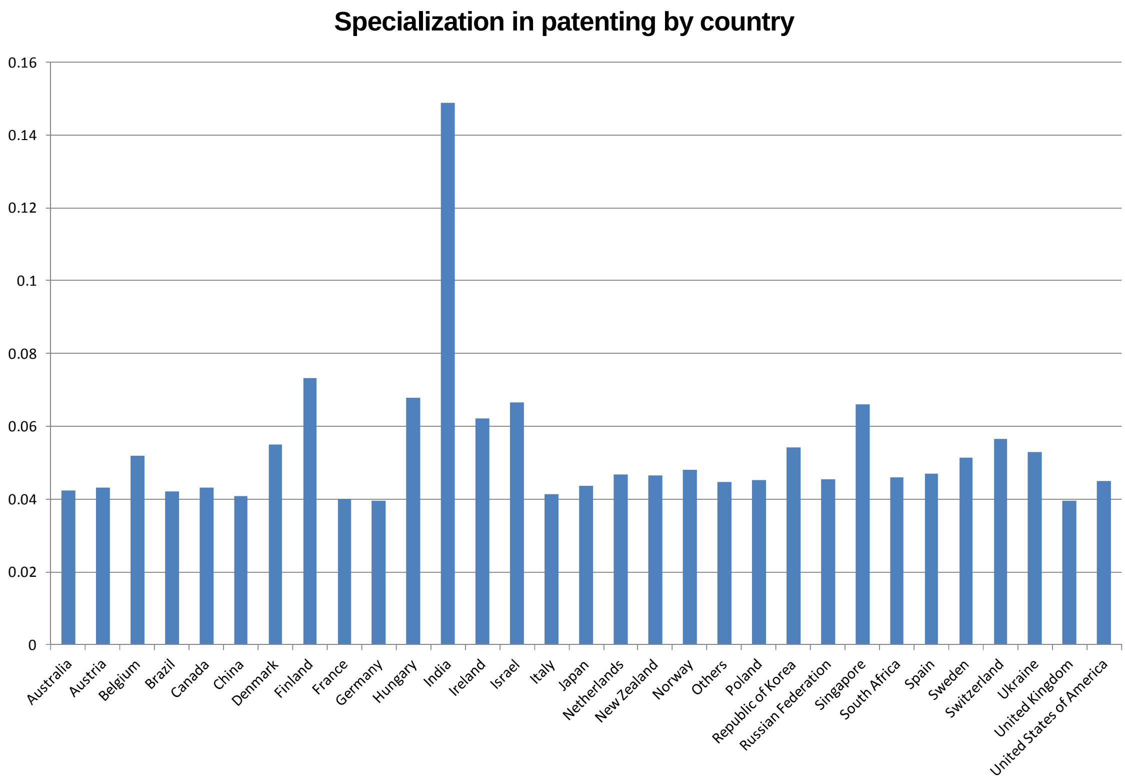
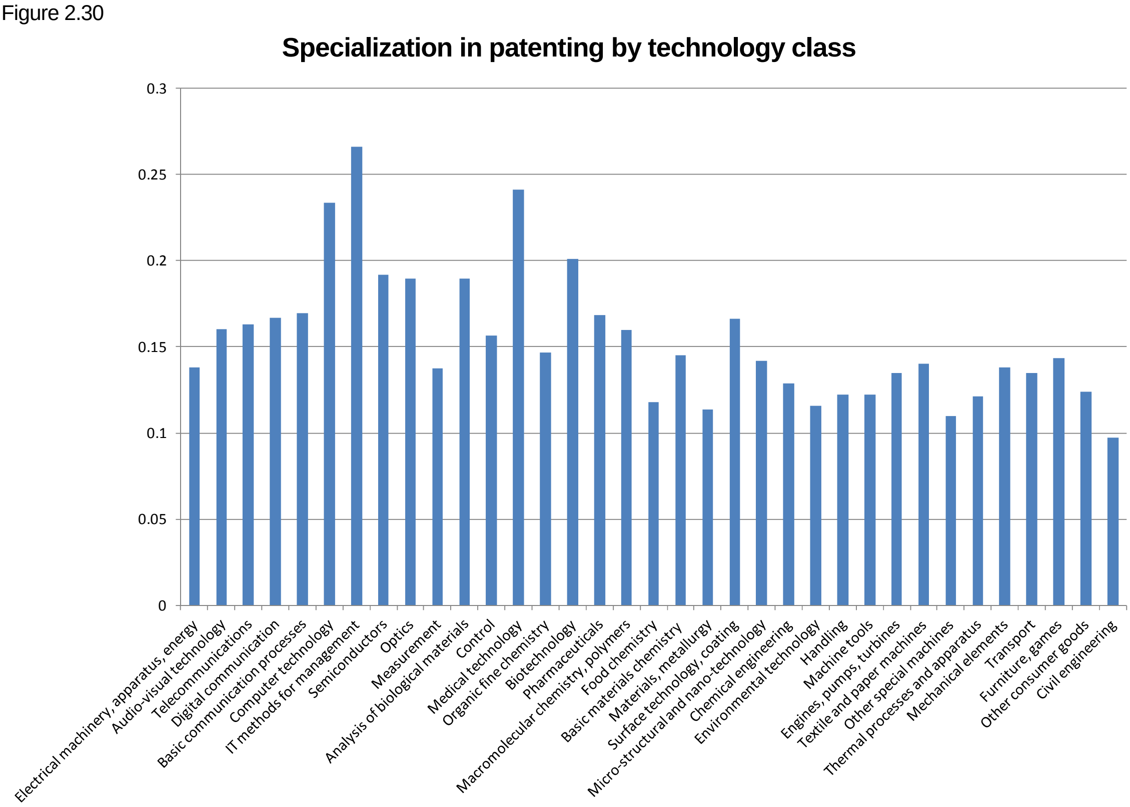


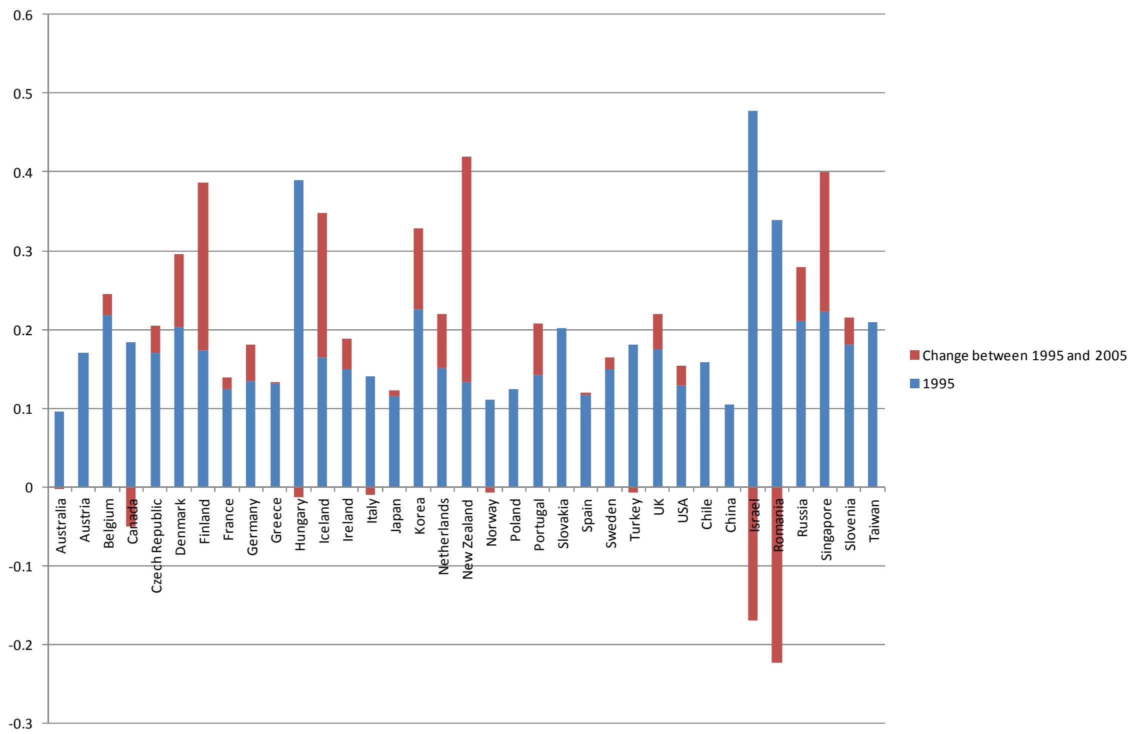

Figure 2.30



In a next step we construct the Herfindahl index using data on R&D expenditures from the ANBERD database, which are available for 35 countries. The Herfindahl is calculated using data for 23 2-digit industries with the data available annually from 1995 to 2005. Figure 2.31 reports the value of the Herfindahl index for each country in 1995 (or the nearest available year) and its change between 1995 and 2005. We can see that Hungary, Romania, Israel, Russia, Singapore and Taiwan were initially the most specialized, while Australia, China and Norway were the least specialized. The majority of countries have seen a shift towards increased specialization since 1995, most notably New Zealand, Finland, Iceland and Singapore, while Israel, Romania and to a lesser extent Canada have seen increased diversification of their R&D activities.

Figure 2.30

**R&D specialization by country in 1995 and its change between 1995 and 2005**




Finally, we combine information on a country's R&D specialization patterns with information on the growth of sectoral R&D to obtain an indicator of whether a country is specialized in high- or low-growth sectors. To do this we construct:

$$y_{it} = S_{ijt} \times g_{jt}^{W}$$

where $S_{ijt}$ is the share of sector $j$ in total R&D in country $i$ in time $t$ and $g_j^W$ is the average growth rate over the period 1995-2005 of sector $j$ in the 'World', where the world comprises the sample of countries for which data on that sector's R&D is available for all time periods. Figure 2.32 reports the values of this variable for 1995 and the change between 1995 and 2005, while Table 2.6 reports the values in 1995 and the percentage changes between

1995 and 2005. In Figure 2.32 we observe that values tend to be between 0.05 and 0.065 (i.e. 5 and 6.5%) for all countries, with Denmark, Israel, Singapore and Taiwan tending to have relatively high rates, and the Czech Republic, Iceland, New Zealand and Russia having relatively low rates. Most countries have seen an increase in the value of this variable over time, with Canada and Iceland having the largest increases. A number of countries also see a decline in the variable, indicating a shift in specialization away from high-growth sectors, examples including New Zealand, Russia, Romania and Singapore, but also Italy, Norway and the UK.

Figure 2.32

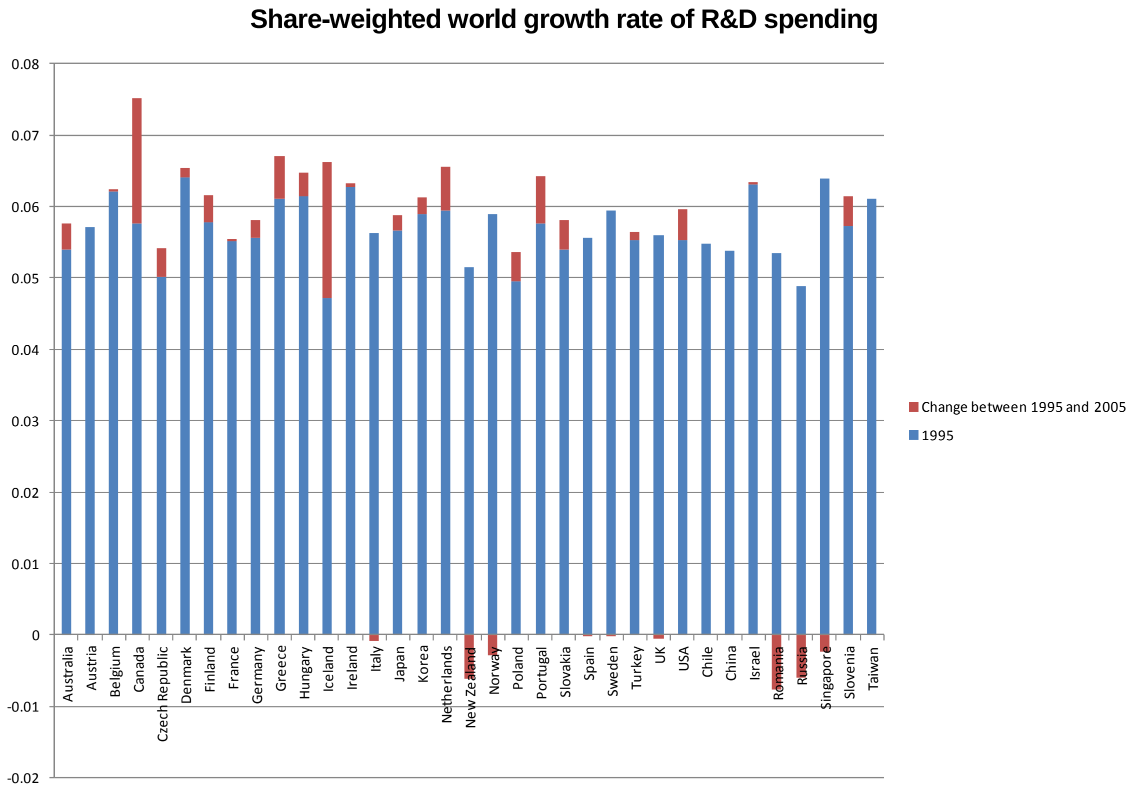


Table 2.6

**Share-weighted world growth rate of R&D spending and its change over time**

| | 1995 | Percentage change between 1995 and 2006 |
|---|---|---|
| Australia | 0.053951 | 6.705775 |
| Austria | 0.057082 | |
| Belgium | 0.062019 | 0.650333 |
| Canada | 0.057566 | 30.58981 |
| Czech Republic | 0.050122 | 7.964335 |
| Denmark | 0.064056 | 2.171923 |
| Finland | 0.057821 | 6.612996 |
| France | 0.055084 | 0.577483 |
| Germany | 0.055664 | 4.302586 |
| Greece | 0.061107 | 9.614216 |
| Hungary | 0.061377 | 5.559744 |
| Iceland | 0.047234 | 40.31636 |
| Ireland | 0.062666 | 0.846014 |
| Italy | 0.056297 | -1.48819 |
| Japan | 0.056671 | 3.805059 |
| Korea | 0.058902 | 4.012726 |
| Netherlands | 0.059462 | 10.11933 |
| New Zealand | 0.05141 | -12.0733 |
| Norway | 0.058961 | -4.75162 |
| Poland | 0.049567 | 8.112909 |
| Portugal | 0.05758 | 11.62477 |
| Slovakia | 0.053894 | 7.862434 |
| Spain | 0.055544 | -0.45035 |
| Sweden | 0.059509 | -0.22561 |
| Turkey | 0.055277 | 2.028859 |
| UK | 0.055944 | -0.86993 |
| USA | 0.055309 | 7.799531 |
| Chile | 0.054867 | |
| China | 0.053773 | |
| Israel | 0.063036 | 0.497252 |
| Romania | 0.053403 | -14.2255 |
| Russia | 0.048795 | -12.3868 |
| Singapore | 0.063858 | -3.70387 |
| Slovenia | 0.057291 | 7.325644 |
| Taiwan | 0.06103 | |

### *2.4. Summary*

During the 1980s and 1990s the vast majority of R&D was conducted by a handful of the world's economies. These countries also applied for the vast majority of patents. This is still the case today. Despite this, there have been a number of changes to the make-up of world R&D in the past ten to twenty years. In particular, the relative importance of some advanced countries such as the UK and France have declined, while other countries such as China and the Republic of Korea have seen their shares of world R&D increase. Given recent growth rates of R&D and domestic patent applications it seems likely that this shift in innovation performance is likely to continue with other countries such as Russia also likely to become important innovators. In addition to a shifting structure of innovation across countries, there has been even more of a shift within industries or technology fields. Considering technology patenting fields we observe three sectors with a growth rate of 10% or more, namely IT methods for management; digital communication; and micro structural and nano technology. When considering R&D data we again observe three industries with a growth rate of 10% or more, these being furniture, manufacturing, not elsewhere classified; recycling; and services. Interestingly, 20 to 30 years ago many of these sectors would either not have existed or been minor sectors.

## 3. R&D internationalization

A phenomenon that has increased in recent years and that has attracted a great deal of attention (see OECD, 2008) has been the increased extent of the offshoring or internationalization of R&D, in which firms locate R&D facilities abroad. This is largely a response to the rapid growth in FDI in recent times. For a long period of time however FDI usually involved the movement of assembly and production facilities abroad, with higher stages of production such as R&D tending to remain in the firm's home country. Indeed, evidence exists to suggest that Multinational Corporations (MNCs) were unwilling to locate R&D facilities abroad – particularly to developing countries – and that they may transfer older technology. While FDI continues to be dominated by the movement of production facilities abroad, there has been a recent increase in the extent of R&D internationalization. In this section we discuss the reasons for this increased R&D internationalization and provide some descriptive statistics showing a trend towards increasing R&D internationalization.

### *3.1. Costs and benefits of R&D internationalization for the host country*

The decision of firms to locate R&D facilities abroad entails both potential costs and benefits (Table 3.1 provides a summary of these costs and benefits). On the one hand, economies of scale in innovation, agglomeration economies and the need to protect firm-specific technology all discourage undertaking R&D abroad (Kumar, 2001). Moreover, a firm's competitive advantage is often linked to that of the home country, including its accumulated knowledge and labour force skills (OECD, 2008).

On the other hand, a number of factors suggest potential benefits from locating R&D facilities overseas. Most importantly, with firms increasingly locating production near to customers and suppliers it is often necessary for a firm to adapt its technology to meet local requirements.[9] In such cases, technology tends to flow from the home country to the host

[9] Lall (1979) and Patel (1997) present evidence suggesting that this type of R&D internationalisation has tended to involve the adaptation of production to domestic needs rather than the expansion of production in to high-tech sectors.

country R&D facility, such that the technological advantage of the affiliate reflects that of the home country and foreign R&D facilities tend to enhance the technology of the parent company. The level and type of R&D undertaken in the host country in such cases will depend upon the level of production in the host and the type of activity the foreign affiliate is undertaking (Dunning and Narula, 1995). Such internationalization of R&D has been termed home base exploiting (Kuemmerle, 1996) or asset exploiting (Dunning and Narula, 1995).

From the mid-1980s onwards evidence emerged suggesting that the internationalization of R&D increasingly started to take on a different form (Cantwell, 1995). In particular, evidence suggested that MNCs were establishing R&D facilities abroad to tap into knowledge and technology sources in scientific centres of excellence. Such a strategy can reduce the costs of R&D and avoid duplication of R&D efforts, but may also be seen as a means of facilitating technological spillovers from the host country (i.e. either local knowledge or firm-specific knowledge) to the parent firm. Such R&D activities have been termed home base augmenting (Kuemmerle, 1996) or asset seeking (Dunning and Narula, 1995). The location of R&D activities abroad in this case serves the purpose of improving existing assets and/or acquiring or creating new technological assets. Such R&D can also take advantage of cheap inputs, and allow the firm to benefit from trained R&D personnel and localized knowledge. In this case, knowledge tends to flow from the foreign R&D facility to the home R&D facility. The choice of locating R&D facilities abroad in such cases will depend on the technological infrastructure of the host country as well as the presence of other firms and institutions from which spillovers may occur. Lall (1979) for example discusses the benefits from the agglomeration of R&D in certain locations that result from spillovers from other R&D facilities, access to trained personnel, links with universities and governments and the existence of the appropriate infrastructure for certain kinds of research.

Table 3.1

**The determinants of R&D internationalization**

| **Centrifugal forces** | **Centripetal forces** |
|---|---|
| **Demand-driven factors:** | Economies of scale and scope in R&D |
| Need for proximity to local customers | Fear of leakages of key technology |
| Need to adapt products to local markets | High co-ordination and control costs |
| | Strong basis in home country comparative strengths and historical inertia |
| **Supply-driven factors:** | |
| Access to highly skilled scientific personnel | |
| Proximity to renowned university and private R&D laboratories | |
| Proximity to potential partners (customers and suppliers) | |
| Access to low-cost supply of R&D personnel | |

*Source:* Criscuolo (2005).

The internationalization of R&D can benefit host countries in several ways, but may also create problems and additional challenges for the host country. A summary of these costs and benefits is provided in Table 3.2, and are discussed more fully in the text below.

Table 3.2

**Potential impacts of the internationalization of R&D for host countries**

| Opportunities | Challenges |
|---|---|
| - Improved structure and performance of the National Innovation System (NIS)<br>- Innovative expenditure and capacity increases<br>- Knowledge and information spillovers<br>- Contribution to human resource development (R&D employment, training, support to higher education, reverse brain drain effects)<br>- Contributions to industrial upgrading; structural change and agglomeration effects | - Downsizing of existing local R&D and less radical innovations<br>- Unfair compensation for locally developed intellectual property<br>- Separation of R&D and production and loss of control over domestic commercialization<br>- Crowding out in the labour market, potential to harm to basic research<br>- Technology leakage<br>- Race to the bottom and unethical behaviour |

*Source:* UNCTAD (2005, p. 180).

The internationalization of R&D can serve as a training ground by providing challenging high-skill jobs to scientists and engineers, it can create new research skills enhancing human resources in a host country, it can bring in new knowledge and research know-how, and it can generate knowledge spillovers to domestic enterprises and other organizations, thus stimulating an R&D culture in the host country. The importance of these benefits will depend in part on the host country's technological capability, policies and institutions. Since MNCs that locate R&D overseas are often those engaged in high-technology activities such as software, electronics and life sciences, R&D internationalization may also help host countries to shift in to these knowledge-intensive fast growing industries.

The extent to which these supposed benefits affects the host country will depend on how and to what extent R&D internationalization affects the National Innovation System (NIS) of the host country. Different types of innovation (e.g. adaptive, innovative, technology-sourcing) are likely to have differing implications for the NIS of host countries. The effects are also likely to vary by the mode through which MNC internationalizes R&D (e.g. greenfield investment, acquisition, strategic alliances or subcontracting).

The R&D expenditures of MNCs are likely to lead to fundamental changes in the NIS of a country. Through their R&D activities foreign affiliates become a part of the NIS, interacting with local innovative firms, science and technology institutions (STIs) and government agencies. This interaction provides a channel for technology spillovers from the MNC to local innovators, as well as a channel for resource sharing. Foreign affiliates' interaction with such knowledge institutions may lead to further benefits for other innovative firms in the host country, by raising the research capabilities of knowledge institutions, bringing them into contact with industrial work and promoting spin-offs. The expansion of R&D activities within a country by a MNC will lead to the NIS of the host becoming ever more linked with the global R&D network of the MNC as well as innovation systems elsewhere.

While the majority of R&D of MNCs conducted abroad takes place in other developed countries, the trend is towards an increasing share going to developing countries. In such cases, the R&D of MNCs can help overcome the lack of an innovative enterprise sector. In most developing countries innovation activity is low and when present is often conducted by governments and universities, rather than private firms. In such cases, the presence of a foreign affiliate undertaking R&D can aid the economy by helping to develop an R&D sector more relevant to the productive sector, which in turn may have a greater impact on growth and competitiveness than the R&D conducted by government and universities.

The presence of foreign affiliates undertaking R&D activities may also lead to benefits through competition effects. The R&D activity of foreign affiliates adds R&D resources to host-country industrial clusters and may induce local firms to undertake more R&D to compete better. It may also show local competitors how to conduct R&D more effectively. Such benefits will require the existence of a competitive and innovative domestic enterprise sector however. By affecting the structure of the NIS and reallocating resources to more productive R&D, FDI in R&D may help enhance the overall efficiency of enterprise R&D in a host country. R&D efficiency can also be improved if R&D by foreign affiliates is better managed, better equipped and directed to more commercially feasible projects than that of other enterprises in an NIS. Efficiency can be improved if foreign affiliates initiate projects that would otherwise not have been carried out but that contribute to enhancing the specific strengths of the local NIS.

A further potential advantage of R&D undertaken by a MNC in a particular country is that it can enhance the level and quality of human resources in the host country. One aspect of this is that if a foreign affiliate develops R&D capacity they may transfer workers with the required skills in to the host country. To the extent that the knowledge of these individuals spreads to other local firms and other innovating institutions, this will create a benefit for the host country. The R&D activities of local affiliates can also enhance the level of human resources in a country through in-house training, supporting local education and collaborating with local universities. While the presence of foreign affiliates undertaking R&D should in general lead to an increase in the employment of R&D staff, if such R&D helps develop a thriving local R&D sector we may observe a reverse brain drain, with skilled nationals working abroad being attracted back to the host economy, potentially bringing with them additional skills to their scientific knowledge (e.g. new research techniques, large scale research management skills). To the extent that researchers move from foreign affiliates to local firms we may also expect to observe spillovers of knowledge and innovation techniques from MNCs to local firms. Such a consideration must be tempered however since foreign affiliates are likely to offer better employment conditions, with higher wages, better working facilities and more sophisticated training (Zhang, 2005). While a benefit to the individuals employed in foreign affiliates, this may limit the spread of knowledge to local firms through labour turnover. Finally, MNCs may help increase or upgrade training in specific skills, for example by providing internships and fellowships to high-performing students, and through collaboration with universities that offer a means of supporting higher education while simultaneously diffusing knowledge.

The public good nature of knowledge suggests that the R&D activities of a foreign affiliate will generate some spillover benefits to other firms and institutions in a host economy. With the establishment of foreign-invested R&D centres, tacit knowledge can be accessible locally to domestic entities. For the MNC obviously there is an incentive to limit the diffusion of knowledge through IPRs in particular, but also other means (e.g. secrecy). In addition to labour turnover, spillovers can take place through enterprise spin-offs and demonstration effects.

A further important and potential gain to host countries is that the R&D activities of foreign affiliates may help them move up the value chain and boost competitiveness. Adaptive R&D and some innovative R&D may contribute directly to process and product upgrading in domestic industry, which may be particularly relevant for developing countries with low levels of innovative capabilities. R&D by MNCs may lead to functional upgrading, which involves the movement to a new mix of activities or different activities in the value chain, from assembly work to R&D, design and other knowledge-based activities. While a lack of resources and local demand for these high value-added activities can often limit the development of such activities, the presence of MNCs can help remove this resource constraint as well as provide demand for these activities. Chain upgrading – which involves the movement to a new value chain in production of higher technology intensity – can also be facilitated by R&D of MNCs. The emergence of a developing country as a destination for the global or regional R&D centres of MNCs can change the public perception of that country and help attract FDI in other knowledge-based sectors. R&D by MNCs can also lead to the development of industrial clusters at the regional level.

Despite the above mentioned benefits of R&D internationalization for the host country, there are a number of potential costs and difficulties which need to be taken into account. One such concern is that the internationalization of R&D has often resulted from MNCs acquiring foreign companies that perform R&D. It is not clear whether such an investment will lead to an increase in R&D in the host economy and may even lead to a reduction of R&D activity due to rationalization as well as the relocation of R&D activities away from the host country. A further concern that has often been raised is that the R&D activities of MNCs in a host country can be associated with unfair compensation for locally developed intellectual property, and in particular that local firms, universities or research institutes collaborating with MNCs on R&D do not receive fair compensation for intellectual property developed locally. This has a number of potential consequences most notably that local firms will not be able to reap the long-term financial benefits that their innovative activity command, and that a country may become dependent on MNCs for its technological progress. A further issue – as mentioned above – relates to the fact that foreign affiliates tend to pay better wages and have better facilities. While this can reduce knowledge spillovers through a lack of labour turnover, it can also make it more difficult for local firms and other research institutes to attract and retain their R&D staff, which can lead to a crowding-out of local R&D activities. A final cost noted by the UNCTAD (2005) relates to the fact that MNCs increasingly divide their R&D activities into modules, allocating different tasks to different countries. If MNCs confine their R&D activities in developing host countries to low levels of skills or technology to protect valuable proprietary technology, this may deprive host countries of learning opportunities and reduce spillover benefits.

### *3.2. Empirical evidence on host countries*

Until at least the early 1980s very little empirical research was conducted on the causes and impacts of R&D internationalization. The reason for this probably relates to the widely held belief that innovation activities were concentrated in the home country, a view largely borne out by data for the US. Evidence also seems to indicate however that the example of the US is atypical, and that firms in Europe for example have long been engaged in the internationalization of R&D. More recently a literature has begun to develop examining the importance of R&D internationalization on the host country.

A first question that has been addressed is to what extent foreign affiliates undertake R&D and how this has changed. Dalton et al. (1999) discuss data on the magnitude, scope, sectoral distribution and the country of origin of R&D investment by foreign affiliates in the US over the period 1987-1997. The study shows that the R&D expenditure of foreign affiliates increased three-fold between 1987 and 1997. Much of this was due to mergers and acquisitions (M&As) in the pharmaceutical and biotechnology sectors. An interesting, yet not wholly unexpected, result of the study is that the internationalization of R&D occurs largely between a small number of developed countries, with Germany, Japan and the United Kingdom being the major foreign investors undertaking R&D in the US. Moreover, the R&D of foreign affiliates tends to be concentrated in high-tech sectors, with industrial chemicals and electronic equipment being important sectors in addition to pharmaceuticals and biotechnology. A further aspect of R&D internationalization in the US is that it tends to be geographically concentrated. Considering R&D investment by US MNCs abroad the authors show that this too increased almost three-fold between 1987 and 1997. R&D was again concentrated in a small number of countries (Germany, United Kingdom, Canada, France and Japan) and a small number of industries (pharmaceuticals, automotives, computers, and electronic components).

Criscuolo and Patel (2003) employ data on the patenting activities of 546 large MNCs from the US, Japan and Europe and find similar results to those found by Dalton et al. (1999). Between 1996 and 2000 they find that a greater percentage of patents granted in 17 European countries (28%) exceeded that in the US (9%) and Japan (4%). They also find that MNCs from the smaller European countries (e.g. Belgium, the Netherland, Sweden and Switzerland) tend to be the most internationalized in their R&D activities. The study also shows that the US has attracted most of the foreign technological activities of European and Japanese MNCs. At the sectoral level, the study shows that EU MNCs in pharmaceuticals, electrical & electronics, IT related activities, instrumentations, and food, drink & tobacco undertake more than half of their R&D activities outside their home countries.

Patel and Vega (1999) also use patent data from the USPTO to consider the nature of foreign R&D activities on the basis of home and host country relative technological advantage. In particular, they consider four different motives for undertaking R&D abroad (namely, home-base augmenting, home-base exploiting, host-country exploiting and market seeking) and examine whether different host country advantages and relative firm technological advantages are associated with the different motives for undertaking R&D abroad. They find the following associations: (i) the home-base augmenting strategy is associated with a situation in which both the MNC and host location show a relatively strong advantage in a particular technological field; (ii) home-base exploiting investment is undertaken to exploit a technological advantage that the firm has in its home market in a host which is weak in that particular technological domain. They also find that different R&D motives tend to be associated with specific industries, with home-base exploiting being the norm in electronics and metals, while more MNCs are engaged in home-base augmenting R&D in chemicals, pharmaceuticals, mining, food and materials.[10]

Cantwell and Janne (1999) address a similar issue, considering the international research strategy of 72 European MNCs over the period 1969-95. In particular, they examine the role of the national capabilities of both home and host countries in shaping the technological behaviour of foreign subsidiaries. They find that European MNCs from leading centres in an industry tend to adopt a more diversified spectrum of technological activities abroad so as to acquire complementary assets and to specialize in each market in accordance with host location patterns of technological development. In contrast foreign subsidiaries with headquarters in lower order centres appear to exploit their technological assets replicating their home country's technological specialization.

[10] Le Bas and Sierra (2002) conduct a similar analysis using patent data from the European Patent Office over the period 1994-96 and find that the home-base augmenting motive dominates in 22 out of 30 technological fields.

Related to this issue, a number of studies ask how the intensity of R&D undertaken by foreign affiliates compares with that of domestic firms. UNCTAD (2003) for example finds that in the South African automotive industry the R&D intensity of exporting firms exceeds that of non-exporting firms and that the transfer of technology have been associated with investment in local subsidiaries by parent companies. UNCTAD (2003b) however, finds that the R&D intensity of foreign affiliates is lower than that of local firms in India. Costa and Queiroz (2002) find that foreign affiliates in Brazil had more complex and deeper technological capabilities than their national firms, reflecting their more effective R&D activities. Liu and Chen (2003) find that the R&D intensity of foreign firms in Taiwan is positively related to export orientation, local sourcing of capital goods and materials, and the sectoral availability of R&D personnel. Javorcik and Saggi (2004) find evidence for transition countries indicating that joint ventures are likely to carry out more R&D than wholly owned subsidiaries.

A further question that has been addressed empirically is the question of what determines the location decisions of foreign R&D facilities. A number of studies use survey data, examples including Håkanson (1992) and Pearce and Singh (1992). Håkanson finds for Swedish MNCs that ‘demand-related’ are more important than ‘supply-related’ factors and that ‘political’ factors (such as trade barriers, the possibility of participating in government sponsored research programs) also play a role in determining the geographical location of foreign R&D operations. The results of Pearce and Singh (1992) based on a comprehensive sample of MNCs operating in 30 industries seems to confirm that most overseas R&D units carry out asset exploiting activities. More recent surveys however find substantial support for the increasing importance of ‘supply-side’ factors as motives for R&D internationalization. Florida (1997) surveys a sample of 207 R&D facilities in the US in four technology sectors (electronics, automotive, chemicals and materials, and biotechnology) with regard to the relative importance of their technology-oriented activities (i.e. home-base augmenting) and market oriented-activities (i.e. home-base exploiting). While both types of activities are found to be important, technology-oriented activities are relatively more significant, particularly in R&D facilities operating in biotechnology and pharmaceuticals. The survey also indicates that one of most often implemented strategies for gaining access to localized knowledge is the recruitment of high quality scientists.

Kuemmerle (1999) also investigates the motives, location characteristics, and mode of entry for R&D facilities abroad using data on 238 foreign R&D facilities from 32 American, Japanese and European pharmaceuticals and electronics companies in different host countries over time. Results indicate that technology sourcing has become an increasingly important motivation for establishing foreign R&D laboratories. The survey also finds that the location of foreign R&D sites seems to match the distribution of the knowledge sources they build upon. When the purpose of R&D is to try to gain access to localized knowledge, firms will establish centres in proximity to universities or national laboratories. If the purpose is to support manufacturing and marketing activities, R&D sites will be located near a lead market or within a cluster of competitors. Although in principle acquisition of a foreign laboratory could be a shortcut to localized knowledge, the study finds that greenfield investment is the dominant form of entry in both the case of both home-base exploiting and home-base augmenting sites.

Almeida (1996) employs the patent citation methodology of Jaffe et al.'s (1993) to investigate the technology sourcing activities of foreign affiliates. This method allows the author not only to assess whether, or to what extent, foreign subsidiaries draw on local sources of knowledge, but also to what degree they contribute to the local knowledge base. Almeida analyses the citations included in a sample of major patents granted by the USPTO to MNCs in the US semiconductor industry and finds that foreign subsidiaries build on localized sources of knowledge. The patents cited by foreign affiliates are more likely to have originated in the US or in the same US State where they operate. Almeida finds also that foreign affiliates contribute to the regional knowledge base: the patents granted to these foreign firms are cited by other patents originating in the same region more frequently than one would expect.

Frost (1998, 2001) adopts a similar approach to Almeida (1996) using a broader sample of MNCs operating in the US. The study shows that both the characteristics of the subsidiary, such as the amount and type of innovation activity carried out, and the technological specialization of the home and host country are important in determining the geographic sources of innovation. Less innovative affiliates are more likely to build on the knowledge base of the parent company, while more innovative subsidiaries, being more embedded in the local NIS, tend to draw upon local sources of knowledge. Frost finds further that foreign affiliates that devote much of their R&D efforts to adapting technologies developed in the home country are less likely to use technical ideas originating in the host country. Similarly, when foreign affiliates perform R&D activities in technical fields in which the home country has a technological advantage and the host country presents a technological disadvantage, they seem more likely to cite the home country's patents. The opposite case arises when foreign subsidiaries are active in technological fields in which the host country has a greater technological advantage with respect to the home country.

Singh (2004) using data on six countries (US, Japan, Germany, France, UK and Canada) over the period 1986-1995 finds that foreign subsidiaries cite host-country patents more often than do host-country inventors, suggesting that foreign subsidiaries gain more in terms of local knowledge than they contribute.

While the studies mentioned above discuss the extent of R&D internationalization and the determinants of the location decision, a further strand of the empirical literature examines the impact on the performance of the host country. Some research suggests that R&D spillovers take place from foreign affiliates to local firms in the US (Almeida, 1996). Peri

(2004) finds that foreign R&D has a positive effect on domestic innovation at the regional level in Europe, Canada and the US. Other studies find no or limited evidence in favour of R&D spillovers. Using firm-level data from Belgium Veugelers and Cassiman (2004a) find no evidence of technology transfers of foreign R&D. The R&D activities of local affiliates were less likely to be locally networked and to transfer technology to the local economy. Similar results were found for France (Veugelers and Cassiman, 2004b). Studying the effects of inward and outward FDI in Swedish manufacturing Braconier et al. (2000) also find no evidence of R&D spillovers at the firm or industry level. In Italy foreign affiliates with asset-seeking innovation strategies were found to interact more with local firms and institutions than those with adaptive R&D strategies (Balcet and Evangelista, 2005). Sigurdson and Palonka (2002) find that FDI in Indonesia has been less effective in transferring technology, with almost all R&D conducted by government research institutes with little relevance for the needs of the industrial sector. They argue that the failure of FDI to contribute to Indonesia's technological development to the local firm's lack of absorptive capacity and ineffective government policies. Todo and Miyamoto (2002) however argue that the R&D activities of foreign affiliates have improved the productivity of local firms in Indonesia, particularly in those firms that also carried out R&D. Chuang and Lin (1999) find, after controlling for selection bias, that R&D and FDI are substitutes in Taiwanese manufacturing. The authors claim that since foreign firms can receive technological support from their parent company, they have little incentive to conduct R&D themselves. Kearns and Ruane (2001) show using plant-level data for Ireland on different R&D activity measures (and after controlling for plant and sector characteristics) that R&D active MNC plants in Ireland had a higher probability of survival and created higher-quantity and better quality jobs than non R&D active MNC plants.

Driffield and Love (2007) concentrate on the motivation for FDI. Using a sample of data for the UK over the period 1987-1997 they split FDI into four categories, namely whether unit labour costs were higher or lower in the host sector and/or whether R&D was higher or lower than in the host sector, the latter of which allows them to consider the importance of technology sourcing or exploitation.[11] Their results indicate that FDI that was technology sourcing and exploiting a locational advantage resulted in a negative spillover effect on domestic productivity. Positive spillovers were found in the case of FDI that was exploiting superior technology, but not lower labour costs in the UK. No significant effects were found for FDI engaged in technology sourcing and originating from a country with lower labour costs, or from FDI with superior technology and higher unit labour costs in the country of origin.

Some evidence suggests that the impact of inward FDI in R&D on innovation and productivity varies by the level of economic development of the host economy (AlAzzawi, 2004).

[11] The former allows them to consider the importance of locational advantage, since locating production facilities in a region which has relatively lower costs will lower overall production costs for the MNC.

In particular, while inward FDI in R&D had positive innovation and productivity effects in newly industrializing countries, it had a negative effect on innovation (though a positive effect on productivity) in developed countries. Results for the Czech Republic (Srholec, 2005) also indicate that effects may differ, in this case across industries. In the automobile industry it was found that MNCs helped create a sophisticated innovation system because of their long-term commitment to upgrading their R&D capabilities, patenting as well as cooperation with universities and R&D labs. In the electronics industry however MNCs and domestic firms undertook little R&D, with the R&D intensity of foreign affiliates being below that of domestic firms.

Cassiman et al. (2004) examine the issue of whether R&D internationalization that occurs as a result of a merger results in a decline in R&D in the host country. Using firm-level data for the EU they find that in the case where R&D activities were competitive there was indeed a reduction in R&D activity after a merger. Evidence for Latin America also indicates that R&D was subsequently downsized or closed following acquisition (Velho, 2004; Cimoli, 2001; Cimoli and Katz, 2001). Kalotay and Hunya (2000) find for a sample of firms in Central and Eastern Europe that both R&D expenditures and R&D intensity fell following privatization, which were mainly taken over by MNCs. Despite this general trend in developing countries there are exceptions where R&D has either been maintained or expanded (see for example Queiroz et al., 2003; Costa, 2005). Closures of R&D labs and / or the diminishment of output from R&D does not appear to have occurred to such an extent in developed countries however (see Griffith et al., 2004; Munari and Sobrero, 2005), suggesting different reasons for FDI. In developed countries it is likely that FDI is undertaken to reap cost advantages from conducting R&D abroad or to access local skills and markets.

### *3.3. Costs and benefits of R&D internationalization for home countries*

In addition to its effect on the host country we can envisage a number of costs and benefits of R&D internationalization for the home country. Table 3.3 summarizes these costs and benefits, which are further discussed in the text below.

Table 3.3

**Potential Impacts of the Internationalization of R&D for Home Countries**

| Opportunities | Challenges |
|---|---|
| - Improved overall R&D efficiency | - ‘Hollowing out’ of domestic R&D base |
| - Reverse technology transfers and spillovers | - Disappearance of certain R&D jobs |
| - Market expansion effects | - Technology leakage |

*Source:* UNCTAD (2005, p. 180).

R&D undertaken abroad may have a number of effects on the home country including reverse technology transfers. This knowledge can help both the MNC and the NIS in which it operates. Depending on the extent of diffusion at home, reverse transfers can improve the productivity of the MNC, its vertically related enterprises, its competitors and the knowledge institutions with which it interacts. The extent of reverse technology transfers is likely to depend upon the type of R&D undertaken however. Adaptive R&D for example may not be capable of generating reverse knowledge transfers, but may generate other positive effects such as promoting market expansion. With the expansion of markets abroad, demand for material, inputs and services procured in a home county for global operations is likely to increase. The internationalization of R&D can also allow home countries to retain and focus more on higher value added activities.

For the MNC itself, R&D internationalization may also result in lower costs for the MNC, which can lead to increased R&D and competitiveness of the MNCs. As R&D grows more complex, it tends to use a more diverse set of information, skills and knowledge. This set may not be available within a single firm, or even a technology leader, or within a single country. In such cases, R&D internationalization may be necessary in order to conduct R&D efficiently by tapping a broader range of resources. The availability of research manpower or of a knowledge base abroad can accelerate new product development. All of these benefits potentially feed into the technological performance of the MNC's home countries, and thus their competitiveness and growth.

One potential cost of R&D internationalization for the home country is that R&D abroad replaces domestic R&D, relating to a hollowing out of the home economy NIS and a loss of skills. There may be cause for concern if MNCs reduce R&D at home due to perceived weaknesses in the home-country NIS. Innovating firms rarely shut down their domestic R&D completely however, a move which would risk losing valuable technological links at home. A movement of R&D abroad can lead to a loss of research jobs at home as well as downward pressure on wages. Weakness of the home country innovation system may arise from the shortage of good researchers, the rising cost of conducting R&D or the lack of a manufacturing base with which researchers can interact. Alternatively, R&D may be complementary with an increase in R&D abroad increasing domestic R&D. If R&D abroad results in the successful imitation of MNCs' technologies as well as of other technologies developed in the home country by foreign competitors, home countries may be worried that it may reduce the demand for their products in the short term. In the longer term a home country may fear losing control over some key technologies, with an erosion of its strategic position in the global markets.

### *3.4. Empirical evidence on home countries*

Evidence indicates that the extent of reverse technology transfers hinges on the purpose of the R&D. Todo and Shimiztuani (2005) find for Japan that the scope for positive spillover effects on the productivity of firms in the home country is large when foreign affiliates undertake innovative R&D that tap into advanced knowledge centres abroad. Adaptive R&D however was found to improve productivity in the host country, but did not contribute to enhanced productivity in the home country. Griffith et al. (2004) find that R&D investment by UK MNCs in the USA have resulted in benefits from reverse technology with the effects being larger in the case of R&D units set up to source technology. Results for Sweden however (e.g. Braconier et al., 2000; Fors, 1997) indicate that there have not been significant spillovers in the home country, possibly because much R&D has been of the adaptive type. AlAzzawi (2004) find in a large micro-study across 30 countries that outward-FDI-induced R&D had a positive impact on the home country's level of domestic innovation as measured by patenting activity in both developed countries and the NICs, but productivity benefits were found for NICs only.

## 4. Technology transfer and knowledge spillovers

The importance of technology for raising productivity and living standards has long been recognized. Innovation and technological progress can raise productivity through the introduction of new goods (capital and intermediate inputs in particular), the improvement of existing goods and by reducing the costs of production. More broadly, technological progress encompasses changes in production processes, organizational structures, management techniques and the like that raise productivity. Resources for such innovation tend to be highly concentrated in a small number of advanced OECD countries,[12] which have the requisite skills and institutions in place to undertake innovation and invest heavily in R&D. As a result firms in these countries register the bulk of patents (see Table 2.1 above). For countries whose firms are not at the technological frontier, the diffusion of technology from the frontier is likely to be an important source of productivity growth, through both imitation and also through follow-on innovation and adaptation (Evenson and Westphal, 1995).

International technology transfer or diffusion refers to the process by which a firm in one country gains access to and employs technology developed in another country. Some transfers occur between willing partners in voluntary transactions, but much comes through non-market transactions or spillovers. Technology flows across borders via a number of formal and informal channels, making measurement difficult. One such channel is trade in goods and services, with imports of goods having the potential to transfer knowledge

---

[12] The share of R&D financed by enterprises in advanced countries was 98% in the 1980s and 94% in the 1990s (UNIDO, 2002).

through reverse engineering, but also through the cross-border learning of production methods, product design, organizational structure and market conditions. Trade in capital and intermediate goods in particular is likely to be an important source of technology diffusion in this way. Exports are also likely to be an important channel for technology diffusion. Grossman and Helpman (1991) for example argue that sellers gain from the knowledge base of their buyers, especially where buyers suggest ways to improve the product or the process of manufacture. A second channel is FDI, inward FDI in particular, with MNCs expected to deploy advanced technology to their subsidiaries that may be diffused to host-country firms. Licensing, which involves the purchase of production and distribution rights for a product and the knowledge required to make effective use of these rights, is a further channel for technology diffusion. Joint ventures combine many of the properties of FDI and licensing and hence will also involve technology transfer. The movement of skilled workers across borders can act as a channel for international technology diffusion. These formal channels of technology diffusion are likely to be interdependent, with firms making their decision on which channel(s) to serve foreign markets based on the expected return to their technological assets.

Informal channels of technology diffusion include imitation; the movement of personnel from one firm to another taking with them specific knowledge of their original firm's technologies; data in patent applications and the temporary migration of people, such as scientists and students to universities and research institutes in advanced countries. What is specific to the informal channels, and is part of their attraction, is that there is no formal compensation to the original owner of the technology transferred. But there will still be costs. Imitation for example requires resources that may be drawn from local innovation.[13] The formal and informal channels are also related. It is likely that in order to be able to reverse engineer and imitate advanced technology some level of trade or temporary migration is required for example. The interdependence among formal channels and between formal and informal channels raises difficult issues for empirical studies.

Since technology itself is difficult to measure, we also tend to find that measures of technology diffusion are imperfect. Several approaches have been employed[14]. One approach, following the seminal contribution of Coe and Helpman (1995), has been to examine whether R&D conducted in one country (and/or industry) impacts upon TFP in other countries (industries). The starting point for this kind of analysis is to construct a stock of knowledge for each country (industry) using past R&D expenditures and then to weight these stocks by some variable indicating the access that other countries (industries) have to this knowledge. Weights used in the literature include imports (Coe and Helpman, 1995; Coe,

---

13 Mansfield et al (1981) show that the costs of imitation while lower than the cost of innovation are significant. Patenting innovations was found to raise the costs of imitation further, though even for products that were patented, 60% were imitated within four years.

14 See Keller (2004) for a review of the evidence on international technology diffusion.

Helpman and Hoffmaister, 1997), capital goods imports (Xu and Wang, 1999), inward and outward FDI (Xu and Wang, 2000) and exports (Funk, 2001; Falvey, Foster and Greenaway, 2004).

A second approach has been to use patent count data. While the decision to patent results in the publishing of the technical information relevant to the patent, as discussed above, Eaton and Kortum (1996) also argue that the decision of *where* to patent affords further information regarding where innovators see their ideas being used. Since patent laws are national in scope and since obtaining patent protection is costly, inventions are typically only patented in a small number of countries. Eaton and Kortum argue that this choice of where to patent is determined by market size and by where the invention is likely to be useful. They use a cross-section of 19 OECD countries to explain the number of patents taken out in one country (destination) by inventors in another country (source). The results suggest that technology diffusion is larger, the smaller the distance between two countries, the larger the ability of the destination to absorb technology (as measured by the level of human capital), and the higher the relative productivity of the destination. A higher ratio of imports to GDP is not always found to facilitate the diffusion of knowledge.

A third approach that has proved popular in the growth literature more broadly, has been to follow Nelson and Phelps (1966) who argue that the rate of technology absorption depends upon the 'technology gap', usually measured by the ratio of GDP per capita of a country to that of the technological leader (usually the US). Benhabib and Spiegel (1994), for example, regress the growth rate of GDP on standard variables including the interaction between the technology gap and a measure of human capital. They find a positive and significant coefficient on this interaction term and conclude that human capital speeds the adoption of foreign technology.

Given difficulties in measuring technology, the majority of empirical work in this area concentrates on a particular channel of diffusion and examines the extent of interaction between countries via this channel and its impact upon measures of economic performance at either the aggregate or firm-level. In the following sub-sections we review the existing empirical literature examining the importance and impact of some of the above channels of diffusion. Sub-section 4.1 considers international trade (both exports and imports), 4.2 considers FDI and Section 4.3 concentrates on international patenting as a form of diffusion.

### *4.1. International trade*

Coe, Helpman and Hoffmaister (1997) identify four channels through which knowledge produced in one country and transmitted through imports can affect productivity and growth in others: Firstly, through the importation of intermediate and capital goods which may enhance the productivity of domestic resources; Secondly, through the cross-border learning of production methods, product design, organizational structures and market conditions that can result in a more efficient allocation of domestic resources; Thirdly, through the imitation of new products; and finally through the development of new technologies or the imitation of foreign technology. Exports are also likely to play an important role in international technology diffusion. Exports are likely to be an important channel of information flows with overseas buyers sharing knowledge of the latest design specifications and production techniques that might otherwise be unavailable, as well as providing a competitive environment, in which efficiency advantages can be obtained. Such effects may be observable at both the aggregate and firm/plant-level and this is reflected in the empirical work that has taken place. In the following sub-sections (4.1.1 and 4.1.2) we review the accumulated empirical evidence at the aggregate and firm-level respectively.

#### *4.1.1. Aggregate-level studies*

Coe and Helpman (1995) examine the impact of international R&D spillovers and the importance of imports in facilitating these spillovers for 22 OECD countries. They construct a stock of R&D for each country in their sample using past R&D expenditures. A measure of the stock of foreign knowledge that is available to each destination country is then constructed by weighting the R&D stocks of its source (exporting) trade partners by the bilateral import shares.[15] TFP is then regressed on both the foreign and domestic stocks of knowledge.[16] The results suggest that both domestic and foreign knowledge stocks are important sources of productivity growth, although the former has a much larger impact in the larger countries. Smaller countries it is argued tend to be more open and benefit to a greater extent from foreign knowledge spillovers.[17]

The initial results of Coe and Helpman (1995) proved to be controversial. Keller (1998) compared the results of Coe and Helpman (1995) with those from assigning bilateral trade partners randomly and found that regressions based on simulated data generated on average larger estimated foreign knowledge spillovers and a better fit. Coe and Hoffmaister (1999) note however that Keller's bilateral import shares are similar to equal weights, or simple averages of trading partners' knowledge stocks, suggesting that Keller's weights are not in fact random. Using alternative random weights, Coe and Hoffmaister (1999) find that the estimated foreign knowledge spillovers are extremely small and present a poor fit. They conclude that using bilateral import weights or simple averages perform better than random weights suggesting that a country's productivity is related to its trading partners'

15 This literature is not without controversy, particularly over the appropriate weighting of the spillover variable and whether the volume or indeed the composition of imports is important in facilitating spillovers (Keller, 2004). See Falvey, Foster and Greenaway (2002) for a discussion of the interpretation and testing of alternative weighting schemes.

16 In their preferred specification the stock of foreign knowledge is interacted with the overall import share to take account of the level as well as the distribution of imports.

17 This outcome is not replicated when patent count data is employed, however. Eaton and Kortum (1996) find only limited evidence of a role for imports in facilitating technology diffusion among OECD countries as mentioned above.

knowledge stock, but concede that the actual intensity of the trading relationship may not be that important due to the public good nature of knowledge. In addition, while Coe and Helpman (1995) argue that there exists a cointegrating relationship between their variables, allowing them to consider the relationship in levels without having to transform the data they choose not to report t-statistics for their results since at the time of writing the paper the asymptotic distribution of the t-statistic was not known. Kao et al. (1999) argue that since the estimated coefficients are small it is not clear whether they are significant. They use non-stationary panel techniques examine whether there are indeed significant foreign knowledge spillovers. They find that while the coefficient on the spillover variable remains positive, it is not significant.[18]

This type of analysis has been extended to consider North-South foreign knowledge spillovers by Coe, Helpman and Hoffmaister (1997) who find evidence that spillovers from the advanced North to the developing South are also an important source of productivity growth, with imports again being an important channel for such diffusion. The approach has also been extended to the industry level (e.g. Keller, 2000) with positive R&D spillovers again found at the industry level. Different trade weightings have also been used in the literature, with Xu and Wang (1999) using capital goods imports as weights rather than total imports and Funk (2001) and Falvey et al. (2004) employing export rather than import data. A further extension of the literature has been to consider the possibility of indirect spillovers through imports. This raises the possibility that country A can benefit from the R&D undertaken in country C even if it does not trade with this country. This would occur if country A imported from country B, which in turn imported from country C. Lumengo-Neso et al. (2005) capture this indirect effect and find that the results provide stronger evidence of trade-related R&D spillovers than found by Coe and Helpman (1995). Such results support the view that indirect spillovers are important.

Simply providing access to foreign technology through imports may not be sufficient in itself for technology diffusion. Other conditions may be necessary before a country is able to absorb and implement such technology in its domestic production. Using the Coe and Helpman framework, Crespo-Cuaresma et al. (2004) find that the benefits of foreign R&D spillovers are stronger in OECD countries that conduct significant R&D and that have relatively high levels of absorptive capacity as measured by education variables. Coe et al. (2009) also search for conditions enhancing the benefits of R&D spillovers, concentrating on the importance of institutions. They find that measures of institutions such as legal origin and patent protection impact upon the extent of R&D spillovers.

---

18 Engelbrecht (1997) tests the robustness of the results on the R&D spillover variable to the inclusion of a general human capital variable and a catch-up term. He finds that their inclusion reduces the coefficient on the R&D spillover variable by around 30%. Lichtenberg and van Pottelsberghe de la Potterie (1998) argue that there is an aggregation bias in the construction of the R&D spillover variable and propose an alternative that removes this bias. Results using this alternative still find trade to be an important channel of R&D spillovers.

An alternative method is to use patent citation data. Sjöholm (1996) for example relates the citations of Swedish firms to patents owned by foreign inventors to a number of correlates including bilateral imports. The results suggest a positive correlation between patent citations and imports, a result consistent with imports contributing to international knowledge spillovers. Eaton and Kortum (1996) use information on where country's patent arguing that this is likely to convey information on where ideas are likely to be used. Relating bilateral patenting in OECD countries to a number of explanatory variables they find that imports are not a significant determinant of technology diffusion as measured by bilateral patenting.

### *4.1.2. Firm-level studies*

#### 4.1.2.1. Theory

The theory relating trade – and exporting in particular – to firm-level performance has largely followed and been driven by empirical results. The recent theoretical literature has focussed on two related issues; firstly, why some firms export and others choose to focus on production for the domestic market only: and secondly the relationship between exporting and productivity.

In terms of the first issue, the major explanations proposed for why some firms export and others don't rely on the presence of sunk costs of exporting. Such costs include market research, product modification costs, compliance and so on. In the presence of such costs profit-maximizing firms will enter export markets only if the present value of their profits exceeds the fixed costs of entry (Girma et al., 2004). In terms of the second issue, there are two alternative – though not necessarily mutually exclusive – explanations as to why exporters may be more productive than non-exporters, namely self-selection and learning-by-exporting. Self-selection of the more productive firms into export markets may occur because there are additional costs associated with selling goods abroad. Such costs may include transport, distribution and marketing costs, the cost of personnel with skill to manage foreign networks, or production costs from modifying domestic products for foreign consumption (Fryges and Wagner, 2007). According to the learning-by-exporting hypothesis exporting results in an improvement in post-entry performance. Exporting can be an important channel of information flows with overseas buyers sharing knowledge of the latest design specifications and production techniques that might otherwise be unavailable, as well as providing a competitive environment, in which efficiency advantages can be obtained.[19] In recent years theories have been developed that allow for both such effects.

[19] As mentioned by Fryges and Wagner (2007) in open economies domestic firms also face competition from foreign companies because of imports to the domestic market. As such, the productivity premia of exporting may be lower in more open economies.

Clerides et al. (1998) assume a monopolistic setting in which marginal costs ($c$) are invariant to both output and market. Since marginal costs do not depend upon output profits can be written as $\pi f\left(c, z^f\right)$, where $z^f$ represents demand shifters, such as the foreign income level or exchange rate. Trade frictions in the form of man-made barriers and transport costs consume some of the revenue generated by exporting. As such, the authors let $M$ represent the per-period fixed costs of being an exporter. Thus the firm's foreign demand and marginal revenue schedules lie everywhere below its domestic equivalent (see Figure 4.1). While gross profits ($\pi$) from exporting are given by the shaded area, net profits will be lower because of the per-period fixed costs of being an exporter, $M$. Entry will thus only take place when:

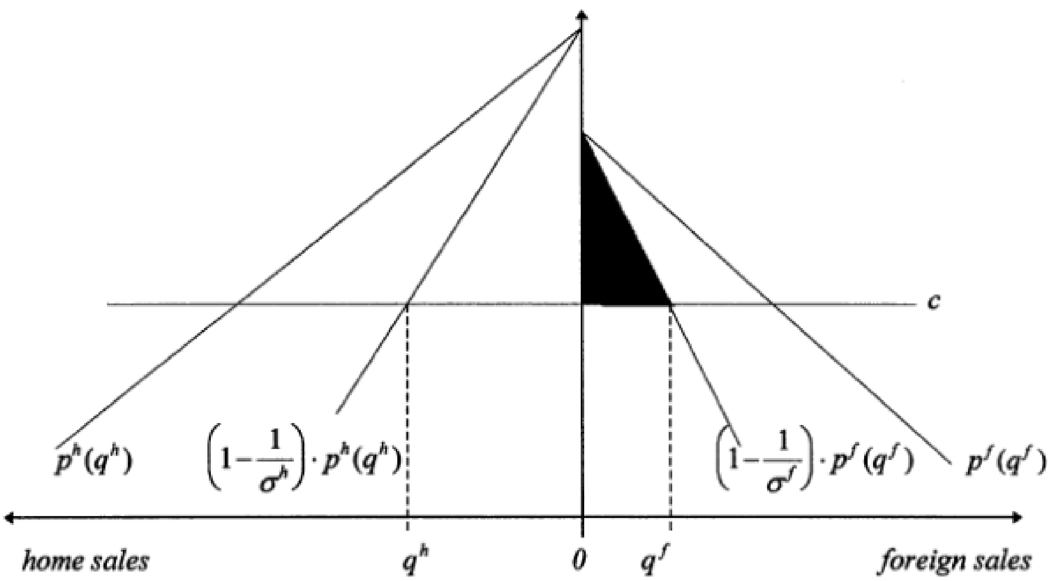
$$\pi f\left(c, z^f\right) > M. \tag{4-1}$$

If $M$ is positive (as depicted in Figure 4.1) firms with marginal costs below some threshold will self-select into export markets. This result underpins the proposition that firms that export will be more productive than firms that do not, though there is nothing in the model allowing one to identify which firms will be more productive.

In the presence of sunk start-up costs the results may be modified somewhat. If an entry cost $F$ is incurred every time a firm enters or re-enters the export market, then it may be optimal to keep exporting even if currently $\pi f\left(c, z^f\right) < M$, since by remaining in the export market, the plant avoids future re-entry costs. Firms may thus export today in anticipation of cost reductions or foreign demand increases in the future.

Figure 4.1

**Gross operating profits from exporting**




The framework of Clerides et al. (1998) can also generate results consistent with the learning from exporting hypothesis, which would occur if exporters that were more efficient to begin with become even more efficient by virtue of their presence in export markets (i.e. a firm's presence in export markets reduces $c$). An implication of their results is that learning allows firms to enter and remain in export markets with higher production costs, since the incentives to export are larger when learning occurs.

This model also has implications for firms exiting export markets. Firms that become less productive will tend to leave export markets, though not necessarily in the period in which productivity dips. In any period, it may still be optimal to continue to export if (4-1) is not satisfied, to avoid re-entry costs or in anticipation of cost reductions. As such, one would expect that firms that leave export markets will be less productive, but that the decline in productivity may occur with a lag.

While the above model shows that more productive firms are more likely to become exporters, it doesn't provide any mechanism for there to be differences in pre-entry productivity across firms. Recently authors have incorporated firm-level heterogeneity into their models. Melitz (2003) developed a monopolistically competitive model of trade with firm heterogeneity, in which only the most productive firms export, while less productive firms may not survive or only serve the domestic market. In this model, potential firms can enter an industry by paying a fixed entry cost, which is thereafter sunk. These potential entrants face uncertainty over their productivity in an industry: once they have paid the fixed entry cost the firm draws its productivity from a fixed probability distribution. The assumption of fixed production costs implies that firms drawing a productivity level below some threshold would make negative profits if they produced, and therefore choose to exit the industry. It is also assumed that there are both fixed and variable costs of exporting. The presence of such costs implies that only those firms with a high productivity draw (i.e. above a higher export productivity threshold) find it profitable to export in equilibrium.[20]

### *4.1.2. Empirical evidence*

#### 4.1.2.1. Exporting and firm-level performance

A large empirical literature has looked to examine whether there are benefits in terms of economic performance for firms that export, and whether any relationship found is due to self-selection or learning-by-exporting effects. The evidence we review indicates that exporters tend to be more productive than non-exporters and that there is self-selection into exporting, but the evidence of specific learning effects is mixed.

Following the contribution of Bernard and Jensen (1995) the approach adopted in the empirical literature to consider the relationship between exporting and productivity has become fairly standard. The first step is to simply compare the level of average productivity of exporters and non-exporters and test for significant differences. This gives an uncondi-

[20] Other theoretical models highlighting self selection effects include Bernard et al (2003) and Yeaple (2005).

tional productivity differential (Wagner, 2007). In the second stage the majority of studies estimate a regression of the form:

$$\ln TFP_{it} = \alpha + \beta_1 E_{it} + \sum_{j=1} \delta_j X_{jit} + \varepsilon_{it} \qquad (2.2)$$

where $TFP$ is the level of total factor productivity, $E$ is a binary indicator accounting for whether the firm is exporting or not and $X_j$ is a set of control variables. The control variables often include measures of firm size, and year, region, plant and industry fixed effects. Estimating such an equation provides an estimate of the exporter premia, defined as the ceteris paribus percentage difference of productivity between exporters and non-exporters, with the export premia being calculated as $100(\exp(\beta_1) - 1)$ (Wagner, 2007).

While this is the standard method, the model may differ from this equation in a number of ways, in particular:

(i) TFP is replaced by an alternative measure of productivity, such as labour productivity (and other performance measure as we will see below);

(ii) the binary exporter variable is replaced by a measure of the *intensity* of exporting, rather than just its presence;

(iii) the binary exporter variable is replaced by similar binary variables that account for new exporters, continuing exporters and export exiters. To consider this, authors often estimate a regression model of the form (Wagner, 2007):

$$\ln TFP_{it} - \ln TFP_{i0} = \alpha + \beta_1 Start_{it} + \beta_2 Stop_{it} + \beta_3 Both_{it} + \sum_{j=1} \delta_j X_{jit} + \varepsilon_{it} \qquad (2.3)$$

where: $Start_{it} = 1 \text{ if}(Export_{i0} = 0)\text{and } (Export_{it} = 1)$

$Stop_{it} = 1 \text{ if}(Export_{i0} = 1)\text{and } (Export_{it} = 0)$

$Both_{it} = 1 \text{ if}(Export_{i0} = 1)\text{and } (Export_{it} = 1)$

with non-exporters in both years being the reference category. The coefficients on the different binary variables allow the researcher to address different questions. Considering the coefficient on the variable $Start$, $\beta_1$, allows the researcher to examine whether there are pre-entry differences in productivity between non-exporters and future exporters. If more productive firms self-select into exporting, we would expect the coefficient on this variable to be positive. The coefficient $\beta_3$ allows the researcher to compare the productivity differences between exporters and non-exporters, while the coefficient $\beta_2$ allows the researcher to examine whether stopping exporting is negatively correlated with productivity.

Since the seminal study of Bernard and Jensen (1995) there have been a large number of research papers that have considered the relationship between exporting and firm-level performance, with new papers still appearing. These papers consider data on a large number of developed, developing and transition economies, with the major results being summarized in Table A1.[21] Despite differences in methodology (i.e. OLS, Quantile Regression (QR), stochastic dominance tests) and differences in country samples the results tend to be fairly consistent. With a couple of exceptions the results point to the conclusion that productivity is higher for exporters. In a recent meta-analysis of the existing empirical literature, Martins and Yang (2009) survey over 30 papers on the relationship between export status and productivity growth and find that: (i) the impact of exporting on productivity is higher in developing than developed countries; (ii) the productivity effect of exporting is higher in the year that firms start exporting than in later years; (iii) the productivity effect is lower when only matched firms are considered.[22] In addition to productivity, many studies examine the relationship between export status and other indicators of performance, examples including employment, shipments, value-added, investment measures and capital intensity. The results from estimating such relationships tend to be consistent with those from considering the relationship between exporting and productivity and indicate that various firm performance measures are higher for exporters than for non-exporters.

#### 4.1.2.2. Self-selection versus learning-by-exporting

As discussed above there is a potential causality problem when considering the relationship between export status and firm-level productivity; exporters may be more productive because more productive firms export, or because exporting is good for productivity, or both. The first hypothesis points to self-selection of the more productive firms into export markets. As discussed above one reason for this is that selling goods in foreign countries involves additional costs. Such costs provide an entry barrier that less successful firms cannot overcome. The second hypothesis points to the importance of learning-by-exporting. Knowledge flows from international buyers and competitors help to improve the post-entry performance of export starters. According to this hypothesis, the productivity-increasing effect of exporting results from knowledge and expertise related to the foreign market that non-exporters do not have (Aw et al., 2000). In addition to the learning-by-exporting hypothesis, it is argued that firms participating in international markets are exposed to more intense competition and must improve faster than firms who sell their products domestically only. Thus, exporting makes firms more productive.

To help address the issue of causality a number of studies include different indicators for non-exporters, export starters, continuers and exiters. Bernard and Jensen (1999) for example consider firms before, during and after exporting to better understand the direction of causality between exporting and performance. They find that ‘good’ firms do become exporters. Future exporters already have most of the desirable properties several years before they begin exporting. In addition, firms that become exporters grow faster, in terms of shipments and employment, than future non-exporters in the few years before they start

[21] Wagner (2007) in his survey includes information on 45 empirical studies covering 33 different countries.

[22] Matching occurs when the researcher attempts to match an exporter to one or more non-exporters with similar characteristics. This method is discussed further below.

exporting. The major benefit to the firm of exporting is that it has an increased probability of survival. Productivity performance will be no better however. Kraay (2002) allows the coefficient on lagged exports to vary with the export history of the firm, by considering five types of export history: (i) firms that export over the entire period; (ii) firms that begin exporting during the sample period; (iii) firms that export initially but exit exporting during the sample period; (iv) firms that switch between exporting and not exporting more than once during the period; and (v) firms that never export. The results indicate that learning effects are consistently positive and significant only for established exporters, that is, those that export over the entire period. Interestingly, there is some evidence to suggest negative effects of exporting for new entrants, suggesting that entry in to export markets may initially be costly.

The majority of studies conclude in favour of self-selection and against the learning-by-exporting hypothesis (see for example Bernard and Jensen, 1999; Isgut, 2001; Delgado et al., 2002), with only a few studies reaching the opposite conclusion (for example Kraay, 2002; Bigsten et al., 2004; Aw et al., 2000). In general, evidence in favour of learning effects tend to be stronger in developing countries. The lack of evidence in favour of learning-by-exporting in the developed world is attributed to the fact that the most advanced technologies are already available in the home market. In contrast, in emerging and developing economies exporters often trade with relatively more skilled countries where they can benefit from customer's technical assistance, new managerial practices, market information, information systems and supply chain networks for example. The survey of Wagner (2007) concludes that 'details aside the big picture that emerges after ten years of microeconometric research in the relationship between exporting and productivity is that exporters are more productive than non-exporters, and that the more productive firms self-select into export markets, while exporting does not necessarily improve productivity' (Wagner, 2007: 67). This conclusion has to be tempered however. Fryges and Wagner (2007) argue for example that firms might be forward-looking in the sense that the desire to export tomorrow leads a firm to improve performance today to be competitive on the foreign market. If this is the case, the approach of including separate dummy variables for non-exporters, new exporters, continuing exporters and export exiters may not be valid. In addition, non-exporting firms may also benefit from other firms' exporting activities through domestic spillovers, such that exporting activity benefits both exporters and non-exporters.

An additional approach to get around the issue of causality that has been adopted in the literature is to consider the literature looking at the impact of labour market programs. The problem is the following: if participants – or treated units – are not selected randomly from a population but are selected or self-select according to certain criteria, the effect of a treatment cannot be evaluated by comparing the average of the treated and non-treated. However, given that each unit either participated or not, we have no information about its performance in the counterfactual situation. One solution is to use matching analysis.[23] Here a control group is constructed in such a way that every treated unit is matched to an untreated unit that has been as similar as possible at the time before the treatment.[24] Differences between the two groups after the treatment can then be attributed to the treatment, meaning that a causal link between exporting and firm-level performance can be identified. The use of a matching approach to search for causal effects of entry to or exit from export markets on productivity (and other dimensions of firm performance) has been pioneered by Wagner (2002) and Girma, Greenaway and Kneller (2003, 2004), and it has been used in a growing number of empirical studies (including De Loecker, 2004; Arnold and Hussinger, 2005; Alvarez and López, 2005; Harris and Li, 2007; Bigsten and Gebreeyesus, 2009). These initial papers considered entry in to export markets (Wagner, 2002) and exit from export markets (Girma et al., 2003)[25], with the results suggesting a positive impact of entry on employment growth, wages and labour productivity, a small negative impact of exit on productivity, and a large negative impact on output and employment.

Girma, Greenaway and Kneller (2004) adopt the matching approach using data on UK manufacturing firms over the period 1988 to 1999 to consider the effects of exporting on the growth rates of employment, output, labour productivity and TFP. The Probit model employed to predict the probability of exporting at time $t$ has the lagged levels of TFP, size, ownership and wages as explanatory variables, along with regional, sectoral and time dummies. The results lead to 781 non-exporting firms being matched with 1387 new export-market entrants. After selecting the comparison group Girma et al. use difference-in-difference analysis to isolate the role of exporting in the performance of firms. This methodology involves: (i) calculating the difference between the average growth rates of TFP before and after entry in to export markets (conditional on past performance, size, age and industry, region and time effects), and (ii) calculating the difference in the difference obtained in the first stage with respect to the before and after differences for the control group of non-exporters. This second difference removes the effects of common shocks and provides a more accurate description of the impact of exporting. The results indicate that the growth rate of output and employment increase immediately after entering export markets, a result consistent with learning-by-exporting effects. In addition, export intensity is found to have a significant impact on firm performance.

---

23 Alternatives include the use of instrumental variables (IV) techniques and Heckman control functions (see van Biesebroeck, 2005; Baldwin and Gu, 2003). Harris and Li (2007) use matching, IV and Heckman control functions for UK manufacturing firms and find evidence of both self-selection and learning effects.

24 The treated and untreated can be compared along various characteristics. Wagner (2002) uses the size of the labour force as the matching variable, while others use additional variables.

25 The stated reason for considering exit from export markets is that if, as the recent literature suggests, there are benefits to firms from entering export markets, then understanding what happens to the firm upon leaving export markets is equally important.

Related to the issue of causality some recent studies have argued that the extent of learning-by-exporting may depend on the characteristics of the firm and its export strategy (see for example Delgado et al., 2002; Baldwin and Gu, 2003; Fernandes and Isgut, 2007; Anderson and Lööf, 2009). Delgado et al. (2002), Baldwin and Gu (2003) and Fernandes and Isgut (2007) for example, all find evidence suggesting that learning-by-exporting effects are important for firms with relatively high export intensities. Baldwin and Gu (2003) further argue that learning by exporting should be more important for young firms, which are expected to have more limited internal capabilities and thus more to gain from exports than larger and more established firms. Andersson and Lööf (2009) for example argue that for persistent exporters with high export intensity, exports are important and their potential to learn from exports should be relatively large. Using data on a panel of Swedish manufacturing firms they find evidence of learning effects for persistent exporters with a high export intensity. Interestingly, when distinguishing between large and small firms the results indicate that both persistence and a high export intensity is needed for large firms to benefit from learning by exporting, but persistence is sufficient for small firms.

#### 4.1.2.3. Export intensity and firm-level productivity

Most studies that empirically investigate the learning-by-exporting hypothesis only distinguish between exporting and non-exporting firms. It may be the case however that the effect of exporting on firm performance depends not only on a firm's export status, but also on the *intensity* of the firm's export activities. Fryges and Wagner (2007) discuss the possibility of an inverted *U*-shaped relationship between productivity and export shares. They argue that firms with small export-sales ratio may only have infrequent contacts with a limited number of foreign customers, leading to a limited flow of ideas from foreign knowledge sources to the domestic firm. On the other hand, when a firm increases its export activities beyond a critical level the costs of coordination and control may rise. This may be due to firms expanding their export sales into more distant markets, which due to greater geographical distances and differences in culture may raise the costs of exporting. As such, there might be an optimal value of the export-sales ratio, leading to an inverted *U*-shaped relationship between a firm's export intensity and its labour productivity growth. Andersson and Lööf (2009) also discuss why the effect of exporting may depend on both export intensity and persistence. They argue that knowledge and information flows are unlikely to be important for firms that either export only occasionally or that export a small fraction of their output, since they are unlikely to interact with foreign customers regularly. Firms that are persistent exporters and have a high export intensity are likely to have a variety of customers and competitors, and to have penetrated relatively advanced markets where the score for learning effects is larger.[26] They further argue that the identification and adaption of better business processes as a consequence of exporting are not likely to apply to firms that export only from time to time and for firms where exporting is a minor activity.

[26] De Loecker (2007) and Trofimenko (2008) find some evidence that learning effects are stronger for exports to advanced destination countries.

While the majority of the studies summarized in Table A1 consider a binary indicator of export status, a smaller number of papers consider the relationship between productivity – and other performance criteria – the extent of a firms' export activities. Castellani (2002) for example finds a positive linear effect of the share of exports in total sales on firms' productivity growth, while Liu et al. (1999) finds a negative relationship. More recently published studies find a curvilinear relationship. Gomes and Ramaswamy (1999) find evidence of an inverted *U*-shaped relationship, whereas some empirical studies even argue in favour of multiple waves in the relationship between firms' levels of foreign involvement and their performance (see for example Hitt et al., 1994, Sullivan, 1994, and Riahi-Belkaoui, 1998). Other studies classify firms into different categories, with each category representing a predefined subinterval of firms' export-sales ratios in the range from zero to one. Geringer et al. (1989) for example adopt such an approach and find support for an inverted U-shaped relationship. Fryges and Wagner (2007) test the inverted U-shaped hypothesis on German data using the Generalized Propensity Score (GPS) of Imbens (2000) and Hirano and Imbens (2004).[27] Their results confirm the inverted U-shaped hypothesis, with exporting only found to improve labour productivity growth within a sub-interval of firms' export-sales ratios. The results show that the maximum value of labour productivity growth rate is reached at an export-sales ratio of 19%, with the effect of a firm's export activity at this level having a productivity effect of around 3%.

#### 4.1.2.4. Export destination and productivity

One recent extension of the discussion on exporting and productivity has been to consider whether the choice of export destination can affect the extent of learning. As Boermans (2010) notes some exporters in developing countries only trade with developing countries, whereas others have operations directed to more developed regions. The question that arises is whether there are differences in the productivity effects of exporting to different destinations. The main hypothesis considered in the literature is that if the export destination is to a more developed country, the firm can subsequently learn from trade, while exporting to developing countries that have lower technology levels may not reap productivity benefits from exporting.

DeLoecker (2007) shows that Slovenian firms gain from internationalization when they export to a more advanced country. Using a similar dataset, Damijan et al. (2004) confirm the importance of export destination for learning to occur. Graner and Isaksson (2007) provide evidence that Kenyan firms also learn from regional export participation.[28] In fixed effects regressions it is found that exporting to other African countries and not to the North

[27] This methodology was also employed by Fryges (2006) using data on young, technology-oriented German and UK firms.

[28] Mengistae and Pattillo (2004) also find learning effects of Kenyan exporting firms inside Africa, although they indicate the impact of outside Africa trade is larger. Eaton et al (2008) find for Colombian firms that exporting within the region and exporting to neighbours can be a stepping-stone to tapping into other destinations and enhance growth further by experimentation.

yields learning effects. It is argued that Northern techniques of production may be too advanced for significant learning to take place, with that of other (African) developing countries more in line with production techniques used in Kenya. Graner and Isaksson further show that the destination of exports impacts on the effect of efficiency on exports.[29] Firms have to be efficient in order to export to markets outside of Africa, but this is not the case for exporting within Africa. The destination of exports also impacts on the effects of other determinants of export status: firm size has a positive effect on the decision to export outside of Africa, but not on the decision to export within Africa. High capital intensity increases the probability of exporting within Africa, but factor proportions have no explanatory power on export activities outside of Africa.

Graner and Isaksson provide an explanation for the results obtained. They argue that existing evidence shows that South-South exports are more intensive in physical and human capital than are exports from South to North (Amsden, 1980; Havrylyshyn and Wolff, 1987). Amsden argues that since greater South-South trade increases the skill and capital content of production, South-South exports embody high learning effects, while learning effects from labour-intensive South-North exports are more or less absent. Havrylyshyn and Wolff (1987) argue that although we may expect learning effects to be stronger for South-South trade, the fact that poor export and growth performance is biased towards trade with other developing countries implies that learning is not really important. One reason may be that learning potential arising from knowledge and technology transfer from the export recipient is higher for South-North exports.

Boermans (2010) considers data from 1991-2003 on five African countries (Ghana, Kenya, Nigeria, Tanzania and South Africa). He explores the determinants of export participation showing that firm size, foreign ownership and human capital positively affect the decision. He then moves on to consider the specific effects of export destination on firm productivity using matching and a difference-in-difference methodology. The results confirm both the selection and learning-by-exporting hypotheses with exporters being more competitive before they internationalize and having higher productivity because of export participation. Exporters with destinations outside Africa tend to be bigger, more capital intensive and pay higher wages than exporters that only trade within Africa. One explanation for this result is that products exported to more developed countries require high product standards to be competitive that can only be met with capital investments and skilled labour. In contrast firms that export within Africa downsize on relative capital investment and these firm-level adjustments including hiring more (low-skilled) employees at higher wages strongly decreases firm productivity. Boermans also finds that firms exporting to several destinations (within and outside Africa) are the ones able to reap most the benefits of exporting.

---

[29] When considering the determinants of exporting the authors have a trichotomous variable (i.e. exporter, exporter within Africa, and at least some exports outside Africa). The model is thus estimated using a multinomial logit model.

4.1.2.5. Exporting and innovative activities

A number of recent papers have considered the linkages between investment in innovation, firm-level productivity and the decision to export (see for example Costantini and Melitz, 2007; Lileeva and Trefler, 2007 and Bustos, 2006).

Aw, Roberts and Winston (2007) find a significant role for firm R&D investments in explaining Taiwanese firm export patterns. In addition, they find interaction effects between firm R&D and export choices when explaining firm-level productivity. Aw et al. (2008) outline a model of firm's investments in R&D, physical capital and the decision to export. Firms are heterogeneous in their productivity and each firm's return to investment in R&D, physical capital and exporting depends on its productivity level. These investments in turn have feedback effects that may alter the path of future productivity for the firm. The model results in policy functions for exporting, R&D investment and physical capital investment. Aw et al. (2008) note that the form of these functions will depend upon the assumptions made, such as whether R&D investment is a sunk as opposed to a variable cost, whether R&D adds to a stock of knowledge that lowers the costs of future innovation and affects future productivity, and whether there are learning by exporting effects. Applying this model to Taiwanese electronics producers the authors find that prior exporting is positively correlated with current investment in R&D, which is consistent with the larger export market providing higher returns to R&D as modelled by Lileeva and Trefler (2007) and Constantini and Melitz (2007). In terms of firm profitability the results indicate that past R&D and physical capital investment have a positive and significant effect, as does past exporting status. Including an interaction between exporting status and R&D to account for the role of R&D in allowing firms to assimilate knowledge from external sources (see Cohen and Levinthal, 1989) they find a negative and significant coefficient, which is against expectations and the results of Aw, Roberts and Winston (2007).

Aw et al. (2005) argue that many studies that fail to find evidence of learning by exporting may have neglected a potentially important element of the process of productivity change: the investments made by firms to absorb and assimilate knowledge and expertise from foreign contacts. This means that both importing and exporting may have helped firms to become more innovative in terms of the production processes or products, which may impact upon productivity growth and/or firm survival in the long-run.

Criscuolo et al.. (2005) examined the differences in knowledge between internationally engaged firms and domestic firms using the *knowledge production function* framework (see Griliches, 1979; 1990) that links output of new knowledge to two types of input, namely investment in discovering new knowledge (e.g., spending on research and development) and flows of ideas from existing stock of knowledge. The authors show that globally engaged firms generate more innovative outputs due to, among other things, more learning from sources like suppliers and customers, universities, and the intra-firm worldwide pool of information. Wagner (2006) reports similar findings in a replication study using German plant level data.

#### 4.1.2.6. Spillovers from exporting

Most of the papers reviewed by Wagner only examine direct effects of firms' export activities on labour productivity. Under circumstances involving regional spillover effects, non-exporting firms might also profit from other firms' exporting activities such that international business activities have a productivity-increasing effect on both exporting and non-exporting companies (see Aitken et al., 1997).

Clerides et al. (1998) examine whether exporters generate external benefits to other firms, either by acting as a conduit for knowledge that they acquire through trade, or by causing improvements in international transport and export support services. They find some evidence suggesting that a firm is more likely to export if it belongs to an export-intensive industry or region. Moreover, for Colombian firms they find that firms in export-oriented regions enjoy relatively lower production costs, regardless of their own market orientation.

#### 4.1.2.7. Importing and economic performance

While the focus of the empirical firm-level literature has been on the relationship between exports and productivity there are good reasons to believe that imports could also be a significant source of productivity benefits.[30] Krugman writing in 1993 for example states that 'What a country really gains from trade is the ability to import things it wants. Exports are not an objective in and of themselves; the need to export is a burden that a country must bear because its import suppliers are crass enough to demand payment.'

Capital and intermediate goods imports for example that embody new technologies would be expected to bring in new knowledge that may ultimately enhance a country's – or firm's – productivity (Helleiner, 1994). Imported intermediates for example can affect productivity through: (i) being of a better quality than domestic counterparts, and (ii) complementarity – combining different intermediates creates gains that are more than the sum of their parts, which could be due to imperfect substitution across goods as in love-of-variety models as well as learning spillovers between foreign and domestic goods. Indeed, a large empirical literature at the country and industry level has examined the importance of knowledge spillovers through imports (see above) and found them to be economically significant both between developed countries, and also from developed to developing countries. Cheaper imports may allow firms to produce existing goods using the same inputs as before, but at a lower cost. They could also open up new ways of producing existing goods, and even allow entirely new goods to be made.

---

[30] Amiti and Konings (2007) document that the productivity gains from cutting tariffs on intermediates are twice as big as those from comparable cuts for final goods in Indonesia, while Goldberg et al (2008) show that access to intermediates produces substantial gains for India.

At the firm-level Bernard, Jensen, Redding and Schott (2007) find that the data on US importers displays many of the same characteristics as for US exporters. Firm-level importing is relatively rare, though less rare than exporting. In addition, there is a strong correlation between firms that import and those that export, as well as between industries with a large share of firms that export and a large share of firms that import. Importing firms – like exporting firms – tend to be bigger (in terms of sales and employment), more productive, pay higher wages, be more skill- and capital-intensive than non-importers. Bernard, Jensen, Redding and Schott (2007) argue that the presence of importing in all manufacturing industries and the similarity between importing and exporting may be related to offshoring: if some stages of production are undertaken abroad and others at home, firms will both import and export, since components and final products are shipped between countries.

A small number of papers examine the impact of importing on productivity at the firm level. Sjoholm (1999) for example considers measures of both export and import status and intensity for Indonesian firms in 1980 and 1991. He finds statistically significant effects of export status and intensity for his sample of countries. While the evidence in favour of an effect from importing is limited, in some specifications and samples he finds evidence of a statistically significant impact of importing intensity on productivity.

Halpern et al. (2009) use firm-level data for Hungary to examine the productivity effect of imported inputs over the period 1992-2003. They formulate a model of importer-producer firms who use differentiated inputs to produce a final good, with intermediate goods affecting output by improving the quality of intermediates and through the complementarity of domestic and foreign intermediates. In the empirical model, the firm level production function depends on standard factors as well as a term related to the number of intermediate imported inputs. The results suggest that imports generate substantial gains. In particular, increasing the fraction of goods imported from 0 to 100 % would increase productivity by 11%. Additional results indicate that about 60% of firm's productivity gains from importing are due to the complementarity channel.

Keller and Yeaple (2009) using data for the US regress the change in firm-level TFP on a measure of imports in to the industry in which a firm belongs to examine the extent of import spillovers. Their results provide little evidence supporting the view that spillovers through imports in to the US are significant. One explanation for this may be that given that the US is considered to be the technological leader imports in to the US do not offer significant additional technology. Considering this issue for different countries, and developing countries in particular, would seem to be an interesting line of research.

### 4.2. FDI and technology spillovers

Foreign Direct Investment (FDI) occurs when a Multinational Corporation (MNC) has a sufficient cost or technological advantage over firms in the host country to offset the higher costs of operating internationally. FDI can be vertical, in which case the subsidiary produces inputs or undertakes assembly from components that are likely exported within the MNC, or horizontal, in which case the subsidiary produces products and services similar to those produced by the parent firm. Increasingly, FDI is undertaken in industries in which knowledge and technology are important. This is because technology advantages can be transferred relatively easily across borders, and because technology acts as a public good within the firm, where it can be employed in several locations without reducing its availability for others. The decision on where to invest will depend on locational considerations that include local market size, resource availability, distance from markets and production costs. Where technology is relevant to the FDI decision an adequate supply of labour with the appropriate skills will also be important.

According to the 2008 World Investment Report, FDI inflows in 2007 – i.e. before the onset of the economic crisis – grew by 30%, reaching a level of USD 1,833 billion, well above the previous high set in 2000. In developing countries FDI inflows grew by 21% between 2006 and 2007 reaching their highest levels. In 2007 the stock of FDI was over USD 15 trillion with the total sales of MNCs exceeding USD 31 trillion, an increase of 21% over 2006. There are numerous reasons for this dramatic increase in FDI, but an important aspect has been government policy. A large number of countries have enacted laws aimed at making it easier for firms to invest in their country, while many countries offer various monetary incentives and tax incentives to encourage inward FDI. The desire to attract FDI is due not only to the fact that FDI brings in new investment boosting national income and employment, but also due to the expectation that inward FDI would also provide additional spillover benefits to the local economy that can result in higher productivity growth and increased export growth.

Due to the increasing importance of FDI an empirical literature has developed examining its impact on economic performance in the host economy. As with the empirical literature examining the relationship between international trade and economic performance, the early literature on FDI and economic performance tended to employ aggregate data. Borensztein et al. (1998) for example find that FDI has a positive impact on growth in countries with a sufficiently educated workforce. Blömstrom et al. (1994) find no evidence of an effect for education, but obtain results suggesting that FDI has a stronger effect on growth in richer countries. Alfaro et al. (2003) and Balusubramanyam et al. (1996) also find evidence in favour of a contingent relationship between FDI and growth, with the former concentrating on how developed financial markets are and the latter the level of trade openness.

A related strand of literature using country-and industry-level data has examined the role of FDI in facilitating the spillover of knowledge and technology. While FDI can be an important channel for technology diffusion when firm-specific technology is transferred across borders, one important advantage of FDI relative to licensing or joint ventures from the MNC's perspective is that FDI keeps the technology internal to the firm. This may limit the diffusion of technology within the host country. Even so a number of considerations suggest that the presence of MNCs in a country will provide spillover benefits to the recipient economy.[31] Fosfuri, Motta and Ronde (2001) for example argue that such benefits may appear through labour training and turnover, while Rodriguez-Clare (1996) suggests that the provision of high-quality intermediate inputs may provide an important externality when they also become available to domestic firms. Imitation through reverse engineering may also be facilitated when the product is produced locally (Das, 1987). Domestic firms may find it easier to export once foreign MNCs establish distribution networks, a transport infrastructure and satisfy the relevant regulatory arrangements (Aitken, Hanson and Harrison, 1997).

Using aggregate data the empirical evidence linking FDI to technology diffusion is mixed. In general, there is little evidence of substantial FDI spillovers for developed or developing countries. Xu and Wang (2000) extend the approach of Coe and Helpman (1995), adding both inward and outward FDI flows as weights on foreign knowledge stocks for a sample of up to 21 OECD countries over the period 1971-1990 and find little evidence of spillovers through inward FDI, but some evidence of spillovers through outward FDI. Globermann, Kokko and Sjöholm (2000) using data on patent applications by Swedish MNCs and non-MNCs also find evidence that outward FDI is the more important source of technology transfer. An alternative approach has been to consider patent citations as an indicator of the extent of spillovers. Using data on Japanese FDI into the United States, Branstetter (2001) finds evidence that FDI encourages technology spillovers through subsidiaries bringing technology from their countries of origin and through MNCs facilitating learning of foreign technologies.

In addition to aggregate level studies a literature has also developed using industry-, firm- and plant-level data to examine the relationship between FDI and economic performance at the micro-level. A particular aspect of this research has been to examine whether domestic firms benefit from the presence of foreign owned firms in their industry and/or region. The affiliates of foreign firms are likely to differ from their domestic counterparts in a number of important ways. In particular, they are likely to possess some proprietary technology and knowledge that provides them with a firm-specific advantage that allows them to compete with other MNCs and local firms, which presumably have superior knowledge of local markets, consumer preferences and business practices (Blomström and Kokko, 1998). These differences may include specialized knowledge about production, superior management and marketing capabilities, export contacts, and relationships with buyers

[31] See Blomstrom and Kokko (1998) and Saggi (2002) for a detailed discussion of the potential benefits of FDI.

and suppliers. The differences between foreign and domestically owned firms have lead researchers to address the issues of whether foreign-owned firms perform better than their domestic counterparts, and whether the presence of foreign-owned firms has spillover effects on domestic firms. Without the above-mentioned differences between foreign and domestic firms it is difficult to envisage significant spillovers occurring from foreign to domestically-owned firms. It is this literature which is discussed in the following sub-sections. Sub-section 4.2.1 discusses the literature examining whether foreign-owned firms perform better than domestic ones, while 4.2.2 discusses the literature searching for spillovers from FDI at the plant and firm level.

### *4.2.1. Do foreign owned firms outperform domestically owned firms?*

An initial question of interest is whether MNCs perform better than domestically owned firms. There are a number of reasons to expect such differences. As discussed above we would expect that MNCs possess some firm-specific advantage that allows them to compete with domestic firms, which may lead one to expect that foreign-owned firms perform better than domestically-owned firms. Moreover, Harris (2009) argues that FDI may reduce the productivity of domestic firms in the short-run through increased competition. In imperfectly competitive markets with increasing returns to scale, increased competition by lowering domestic firm's market share can raise the average costs of domestic firms, thus reducing their productivity levels. Harris (2009) also discusses reasons why MNCs need not perform better than domestically-owned firms. Foreign owned firms may have lower efficiency levels in the short-run if there are difficulties in assimilating newly acquired plants in to their FDI network. There may also be initial fixed costs in acquiring knowledge of how business is conducted in a country, which can lead to reduced efficiency levels. MNCs may also decide to keep most of their high value-added operations (e.g. R&D and new products) at home, concentrating on lower value-added assembly operations in the host nation. Some evidence supports this hypothesis (see Mansfield, 1986; Javorcik, 2004). It has further been argued (Driffield and Love, 2007) that some FDI is intended to source rather than exploit technology. This is likely when the industry in the host country is more R&D intensive than that industry in the MNCs' home country. In such cases, it may be expected that such plants will have relatively lower productivity.

A number of papers address empirically whether foreign-owned firms perform better than domestically owned ones. Griffith (1999) for example using data on UK establishments estimates a Cobb-Douglas production function and shows that foreign owned establishments in the motor vehicles industry do not have significantly higher levels of productivity, once differences in factor inputs are taken into account. One criticism levelled at the approach of Griffith (1999) is that she did not weight the data to account for the fact that the sample was biased towards larger establishments. After weighting the data, Harris (2002) found that foreign-owned plants were significantly more productive than domestically owned ones. Productivity of EU and US owned foreign firms was found to be between 21% and 26% higher than productivity in domestically owned firms.

Harris and Robinson (2003) considering data on 20 UK manufacturing industries over the period 1974-1995 also examine whether there are differences in performance for domestic and foreign owned firms. An interesting extension of their approach is that they include a separate foreign ownership dummy for each nationality of ownership. This allows them to detect whether productivity performance statistically varies by nationality. If this is the case, it may explain the insignificant effects found elsewhere, with the positive effects of some countries investment being cancelled out by the negative effect of others. Their results indicate that for most industries US owned plants performed better than domestic ones. For six industries there were insignificant differences in performance, while for two industries domestically owned firms performed better. EU owned plants outperformed domestically owned plants in only four cases. The evidence for other home countries (i.e. old commonwealth countries, South East Asian countries, and the rest of the world) was mixed, with foreign owned firms performing better in some industries, but worse in others.

Yasar and Morrison-Paul (2007a) consider data from 2002 for five transition economies. They find that firms with a foreign ownership share are more productive than their domestic counterparts, and that a greater foreign share implies higher productivity. Such firms are also found to be larger, pay higher wages, employ more people, and have a greater export share of sales and import share of materials. Aitken and Harrison (1999) in their study of Venezuela also find that foreign ownership is associated with enhanced performance.

The importance of non-linearities has also been raised in this literature. Vahter (2005) examines the productivity of export-oriented versus domestic-oriented foreign firms. Using data for Estonia he finds that export-oriented foreign-owned firms have lower productivity than domestically-oriented foreign-owned firms. Similarly, Harris and Li (2007) use tests of first order stochastic dominance to examine whether foreign-owned firms in the UK are more productive than their domestic counterparts. Their results indicate that exporters dominate non-exporters in terms of productivity. The results also indicate that the distribution of TFP for foreign-owned firms dominates that of domestically owned non-exporters. The results for foreign-owned versus domestically-owned exporters however indicate that MNCs dominated domestic exporters in less than half of the industries, while domestically owned exporters dominated MNCs in 9 of the 30 industries.

### *4.2.2. Spillovers from FDI?*

#### 4.2.2.1. Firm-level FDI spillovers – the theory

Foreign investment is assumed to affect the domestic economy by bringing in much-needed capital, new technologies, marketing techniques and management skills, and by bringing in secondary spillovers to the host economy that affects the performance of domestic firms.[32] Such spillovers can arise due to the leakage of the MNCs proprietary knowledge or due to the response of domestic firms to the arrival of foreign firms. Such spillovers – if present – are likely to affect the productivity of domestic firms in the same industry, but can also have effects on wages and market access, as well as productivity in upstream and downstream industries.[33]

Görg and Greenaway (2004) argue that the only way competing domestic firms can access the technology of MNCs is through some form of indirect technology transfer, since the foreign investor will not hand over the source of their advantage voluntarily. As mentioned above however, while FDI can be an important channel of technology diffusion one important advantage of FDI relative to licensing or joint ventures from the MNC's perspective is that FDI keeps the technology internal to the firm, which may limit the diffusion of technology within the host country. Despite this there are a number of reasons to suggest that the presence of MNCs in a country will provide spillover benefits to domestic firms. Table 4.1 reports a typology of potential spillovers as described by Harris and Robinson (2004). Theory identifies a number of channels through which such diffusion can take place, examples being imitation, skills acquisition, competition, and through exporting.[34]

Imitation can include product and process imitation, as well as managerial and organizational innovations (Das, 1987). Such imitation could result in benefits to local firms in terms of enhanced productivity. This form of spillover is likely to arise through reverse engineering or the hiring of specialist labour from MNCs, and as such could be considered more relevant for developed countries. Skills acquisition can occur through labour flows (see Fosfuri et al., 2001), with two potential productivity effects: (i) a direct spillover to complementary workers; (ii) workers that move may carry with them knowledge, new technology and new management techniques.[35] Blomström and Kokko (1998) discuss the possibility of demonstration effects, whereby MNCs bring new technology into a country. In such cases, the entry of MNCs can demonstrate the existence and profitability of new products and processes, which may then be adopted by local firms. We may expect that such a source of spillovers would have the advantage that they would be repeated every time a new technology is used by MNCs. Such spillovers may also be expected to be more relevant for developing countries.

---

32 For surveys on spillovers and FDI see Görg and Greenaway (2004), Blomström and Kokko (1998) and Lipsey (2002).

33 In terms of the definitions of Scitovsky (1954) and Griliches (1979) vertical spillovers are often termed pecuniary (or welfare or rent) spillovers and are based on market transactions and buyer-seller linkages and occur because quality improvements in inputs and outputs are not fully appropriated and thus are not entirely reflected in the price of such goods and services, while horizontal spillovers are often called non-pecuniary (or knowledge or technological) spillovers and are based on non-market interactions usually involving the sharing of knowledge and expertise.

34 There are also obviously potential negative effects from foreign participation, including market and labour 'stealing", which are highlighted in Table 1.

35 Some evidence supports this hypothesis, e.g. Görg and Strobl (2002).

Table 4.1

**Typology of spillovers**

| Transmission mechanism | Effect | Likely impact |
|---|---|---|
| **Intra-industry** | | |
| Demonstration Effects | Imitation of FDI products and processes; licensing of new technology | + |
| | Difficulties in absorption of new technology due to lack of technological complementarities | - |
| Competition Effects | Reduction in costs/inefficiency in order to respond to entry (threat) | + |
| | FDI market share pushes domestic firms up their average cost curves | - |
| Labour Market | Hiring of FDI-trained staff with improved human capital | + |
| | Domestic firms mismatch between current capabilities and human capital of FDI-trained staff | - |
| **Inter-industry** | | |
| Forward linkages | Technology transfer and/or new management practices to upgrade quality/lower cost of products demanded by upstream FDI | + |
| | Difficulties in absorption of new technology/practices; less efficient domestic firms are 'crowded out' | - |
| Backward linkages | Purchase of improved intermediate products; technological upgrading of own products | + |
| | Difficulties in absorption of new technology/products; rising costs of domestic suppliers (due to FDI competition) are passed-on | - |
| **Agglomeration** | | |
| Labour market | Pool of FDI-trained workers available to local labour markets; increase in entrepreneurial activity (new firm formations) | + |
| | 'Poaching' of better staff to FDI (higher pay and career development offered); upward pressure on wage costs | - |
| Infrastructure | Access to greater range of business services (especially R&D which is attracted to service FD); intra/inter-industry effects stronger in cluster (diminish over space); minimization of transport costs | + |
| | Higher costs (e.g. premises); congestion; 'crowding out' due to FDI competition for local resources | - |

*Source:* Harris and Robinson (2004).

Foreign investment will provide competition to indigenous firms potentially leading to a reduction in X-inefficiency. Competition may also increase the speed of adoption of new technology or the speed with which it is imitated. Blomström and Kokko (1998) argue that MNCs are likely to enter into monopolistic industries since many of the typical features of MNCs, such as scale economies, advanced technology, high initial capital requirements and intensive advertising, are also characteristics of industries that have high barriers to entry, high concentration and low levels of competition. There are also potentially negative effects of foreign entry on competition, with MNCs potentially crowding-out domestic firms, by acquiring significant market shares reducing the opportunities of domestic firms to exploit returns to scale.

Domestic firms may learn to export from multinationals. To become a successful exporter involves fixed costs in the form of establishing distribution networks, transport infrastructure, learning about consumer's tastes, and so on. Few local firms, particularly in developing countries will have these skills (see Keesing and Lall, 1992, and also the more recent literature considering the anatomy of exporters (Eaton et al., 2007; Eaton et al., 2008; Bernard et al., 2007). MNCs are more likely to have such information given the international nature of the corporation. MNCs are also often larger than local firms and may be able to afford the high fixed, sunk costs needed to develop the appropriate transport, communication and financial infrastructure necessary to become a successful exporter. Domestic firms can benefit from the export activities of MNCs in a number of ways. One possibility is that through linkages to export-oriented MNCs and copying, domestic firms can learn how to export (see Aitken et al., 1997; Greenaway et al., 2004), for example by providing knowledge concerning foreign market conditions and preferences. Alternatively, when domestic firms are employed as suppliers and sub-contractors they will benefit from the export activities of MNCs, even if they don't export directly. Blomström and Kokko (1998) discuss further the possibility that domestic firms may benefit by employing labour from MNCs trained in export management and through trade associations and other industry organizations, of which MNCs are often prominent members.

A further relevant factor is whether and to what extent the foreign investor establishes upstream and downstream networks (alternatively termed backward and forward linkages). The greater the extent of such networks, the more rapid will be technology transfer as a result of domestic firms being involved in supply and distribution chains gaining exposure to and familiarity with new technology. FDI can affect the productivity of upstream industries in two ways: (i) it can be a source of new technology (Caves, 1974) especially for firms in developing countries (World Bank, 1993). This new technology may come in a variety of forms, including employee training, quality control, inventory management, as well as new product and process technology; (ii) FDI may influence a local firm's productivity even if it doesn't become a supplier to an entering MNC. The competitive pressure to win the MNCs business may spur local firms to improve their performance in order to increase the probability of winning the contract (Caves, 1974; Chung et al., 2003). The presence of MNCs in downstream industries may also allow local suppliers to reap the benefits of economies of scale. Indeed, there are good reasons to believe that spillovers to upstream industries may be more important than horizontal spillovers. Firstly, while it is in the interests of the MNC to avoid leakage to competitors they have incentives to share their technology with their suppliers in order to improve their productivity. In addition, to reduce dependency on a single supplier, the MNC may establish relationships with multiple vendors. Secondly, while the technology gap between foreign and domestic producers may limit within-industry technology transfer, MNCs are likely to procure inputs requiring less sophisticated production techniques, for which local firms are well suited.[36] It is also possible that there exist forward spillovers, whereby spillovers occur from MNCs in upstream

[36] A theoretical justification for such backward or upstream spillovers is provided by Rodriguez-Clare (1996) and Markusen and Venables (1999).

industries. This would be the case if MNC presence in upstream industries provided inputs that were either previously unavailable or which are more technologically advanced, less expensive, or accompanied by the provision of complementary services (Javorcik, 2004).

Agglomeration or regional spillovers may be another important source of benefits. FDI spillovers may decrease with geographical distance, largely because many of the potential sources of FDI spillovers – labour turnover, competition and demonstration effects – are likely to be limited in space. Firms may locate in close proximity to one another for a number of reasons: (i) to reduce the costs of purchasing from suppliers and shipping to downstream customers; (ii) if there is a large common pool of labour to maximize the fit between productivity levels in firms and workers, and to facilitate workers acquiring industry-specific skills, since the risk of not being able to appropriate the returns from training are lower where there are a larger number of potential employers; (iii) to obtain knowledge spillovers that occur when similar firms engage in R&D to solve similar or related problems. Physical proximity (and density) speeds the flow of ideas, especially when a significant part of intangible knowledge is often tacit, and social networks tend to be strong. Spillovers can also result from urbanization externalities due to the size and diversity of an urban agglomeration. A greater range of activities may lead to inter-industry spillovers.

While the above discussion hints at a number of potential spillover channels from FDI, it may be that such spillovers are not automatic and depend upon conditions in the host economy. Findlay (1978) for example suggests that relative backwardness may be a relevant determinant of the extent of spillovers from FDI. He argues that the greater the distance between two economies in terms of development the greater the backlog of available opportunities to exploit in the less advanced economy, the greater the pressure for change and therefore the more rapidly new technology is imitated/adopted. Glass and Saggi (1998) also see a role for technological distance, but one that is different to Findlay. They argue that the bigger the technology gap, the lower the level of absorptive capacity, and the less likely it is that the host will have the human capital, physical infrastructure and distribution networks to support inward investment. This will influence the decision to invest, but also what kind of technology to transfer. They argue that the bigger the gap the lower the quality of technology transferred and the lower the potential for spillovers. Technological distance is thus likely to be directly related to the potential gains from spillovers, but indirectly related to the probability that indigenous firms are able to access them. Findlay (1978) also discusses the possibility of contagion or the extent to which the activities of the foreign firm pervades the local economy. Thus, if the MNC quickly establishes upstream and downstream networks, technology transfer will be more rapid as a result of domestic firms involved in supply and distribution chains gaining exposure to and familiarity with new technology and promoting its diffusion.

The absorptive capacity of firms is likely to be an important determinant of the extent of spillovers for a number of reasons, including: (i) firms with greater absorptive capacity are likely to be better able to evaluate new technologies that MNCs bring. Without such capacity firms may not recognize the benefits of these valuable new technologies; (ii) absorptive capacity may help the firm to assimilate the new technology. In such cases, prior related knowledge is crucial for being able to learn about and understand the MNC's technologies; (iii) absorptive capacity may aid in the process of exploiting the new technology. Firms with greater capacity are likely to have a greater ability to disseminate internally the information learned from MNCs, and to incorporate the new technology into their existing routines and processes (Zahra and George, 2002).

In addition to absorptive capacity and relative backwardness a number of other factors have been suggested as potentially affecting the extent of spillovers from FDI, many of which are discussed by Crespo and Fontoura, 2007. FDI spillovers may be higher for non-exporting domestic firms for instance, since the exporting ones already face competitive pressures (Blomström and Sjohölm, 1999) and because the domestic market is less relevant for them. Firm size may also be an important determinant, with small firms that are unable to benefit from returns to scale less able to compete with MNCs.

#### 4.2.2.2. Empirical evidence on spillovers from FDI at the firm-level

Empirically, the issue of spillovers from foreign investment has been examined by looking at the relationship between foreign investment and the productivity of domestic firms. More specifically, a measure of firm-level performance (usually output, labour productivity, total factor productivity or efficiency) for domestically-owned firms[37] is regressed on a range of independent variables. To measure productivity spillovers from MNCs a variable is included which proxies the extent of foreign firms' penetration, usually calculated as the share of employment, sales or capital of MNCs in total industry employment, sales or capital in a given sector.[38] A typical specification is therefore

$$lnY_{ijt} = \alpha + \beta_1 FDI\_SECTOR_{jt} + \beta_2 X_{ijt} + \varepsilon_{ijt}$$

where $Y$ is a measure of performance in firm $i$ in sector $j$ in time $t$, $X$ is a vector of inputs and $FDI\_SECTOR$ is a measure of the presence of foreign ownership in the industry. A positive coefficient on $FDI\_SECTOR$ is taken as evidence that spillovers have occurred from MNEs to domestic firms. Most studies use either the contemporaneous level of foreign penetration, or relatively short lags as explanatory variables. The results of a large number of these studies are summarized in Table A2.

---

37 Sometimes, studies consider all firms and not just domestically-owned ones.

38 Castellani and Zanfei (2002) argue that one should use the absolute level of foreign activity in the sector, rather than the proportion of foreign relative to total activity, since using a ratio imposes the restriction that changes of the same magnitude in foreign and aggregate activities within a sector have no effect on the dependent variable. Görg and Greenaway argue that while this is an interesting econometric argument it is not clear what the economic rationale for using absolute rather than relative FDI penetration would be.

Görg and Greenaway (2004) review the evidence from 40 studies of FDI spillovers, finding positive and significant results in 19 of those studies. All but eight of these positive effects are found in cross-section studies, which, as argued by Görg and Strobl (2001) may give biased results. One problem with cross-section data is that if the data are aggregated at the sectoral level (such as with the $FDI\_SECTOR$ variable in the equation above), they fail to control for time-invariant differences in productivity across sectors, which might be correlated, but not caused by, foreign presence. This can lead to biased results. As an example, if productivity in the electronics sector is higher than that in the food industry, multinationals may be attracted to the former. In a cross-section, one would find a positive and statistically significant relationship between the level of foreign investment and productivity, consistent with spillovers, even though foreign investment did not cause high levels of productivity, but rather was attracted by them. In panel data one can follow the approach of Aitken and Harrison (1999) amongst others and include sector-specific fixed effects to control for differences in productivity across sectors. In panel studies there is much weaker evidence of positive spillovers from FDI. Of the studies considered by Görg and Greenaway only seven panel studies produce evidence indicating positive spillovers from FDI in the aggregate, and none of these consider developing countries. Industry level studies tend to show a positive correlation between foreign presence and average value-added in a sector.[39] Given the cross-section nature[40] of most of these studies it could be that the findings are due to self-selection, with MNCs tending to locate in high-productivity industries. An alternative explanation is that FDI inflows force less productive domestic firms to exit, with MNCs increasing their share of the host country market. More recently, a number of studies for more developed countries have found evidence of positive spillovers. Haskel et al. (2007) for example find using the population of UK manufacturing firms that spillovers are positive and economically significant along industry lines, but find no significant evidence of spillovers occurring along regional lines. Keller and Yeaple (2009) using data on US manufacturing firms over the period 1987-1996 show that spillovers from foreign multinationals to US firms can explain a significant part of US manufacturing productivity growth.

In addition to the survey of Görg and Greenaway (2004) there are a handful of meta-studies considering the importance of spillovers from FDI (e.g. Görg and Strobl, 2001; Havanek and Irsova, 2010; Meyer and Sinani, 2010; Wooster and Diebel, 2006). A number of results appear consistently from such studies. The results of Görg and Strobl (2001) indicate that studies which use cross-sectional data tend to produce evidence of stronger productivity spillovers. Their results also suggest that the choice of foreign proxy variable may be an important determinant of differences across studies, with the use of employment shares tending to produce more evidence of spillovers than the use of output shares. Finally, they show that it doesn't appear to matter whether a study uses industry or firm level data, whether a study uses developed or developing country data, or how recent the data is. The meta-analysis of

[39] Early studies include Caves (1974), Blomström and Persson (1983) and Blomström and Wolff (1994).

[40] Exceptions being Blomström (1986) and Liu et al (2000).

Havranek and Irsova (2010) is the largest, considering 67 different empirical studies. Their results indicate that a higher number of observations leads to more significant spillover effects, with cross-section studies also more likely to result in significant observed spillover effects. Studies using newer data are less likely to find significant spillover effects. Their results also indicate that cross-sectional studies, industry-level aggregation and the share of employment as a foreign presence variable are more likely to lead to evidence of positive spillovers. Meyer and Sinani (2010) consider a sample of 66 research papers for their meta-analysis. Their results show that productivity spillovers are related in a U-shaped form to the host country's level of development in terms of GDP, human capital and institutional development, while patenting activity and trade openness have a positive effect.

Wooster and Diebel (2006) split their discussion in to three components: (i) factors affecting the significance of spillover, (ii) factors explaining positive versus negative spillovers, and (iii) factors explaining the magnitude of spillovers. They find that studies using more recent data are less likely to result in significant spillover effects, though more recent data increases the likelihood of a positive spillover effect. In addition, studies including a measure of sectoral R&D intensity as a control variable are less likely to report significant spillover effects, though its inclusion is more likely to lead to a negative spillover effect. Different to Görg and Strobl (2001) they find that the use of output share as a measure of foreign presence increases the likelihood of finding significant spillovers. Studies that employ data on Asia are also more likely to result in significant (and positive) spillover effects. They further show that the use of capital and output shares as the foreign presence variables are more likely to generate negative spillovers when compared with the use of employment shares. Different to Görg and Strobl (2001) they find no evidence indicating that the likelihood of obtaining a positive spillover effect differs between cross-section and panel studies, but the level of data aggregation does make a difference – with positive spillovers being less likely in firm-level studies. Cross-section studies are found to lower the magnitude of estimated spillover effects however.

One interesting aspect of the existing literature on FDI spillovers is the large number of papers reporting evidence of negative effects of foreign presence on domestic spillovers. The studies by Aitken and Harrison (1999), Castellani and Zanfei (2002), Djankov and Hoekman (2000), Konings (2001), Zukowska-Gagelmann (2002) and Damijan et al. (2001) for example all find negative spillover effects in panel regressions using firm-level data, usually for developing and transition economies. One explanation put forward for the negative impact is that increased competition in product and factor markets can have a negative impact on a domestic firm's productivity (Aitken and Harrison, 1999; Konings, 2001). Here the argument is that MNCs have lower marginal costs due to some firm specific advantage, which allows them to attract demand away from domestic firms, forcing them to reduce production and move up their given average cost curve. As discussed by Görg and Greenaway (2004) this is not inconsistent with positive spillover benefits via competition: it could be that for some firms there are negative competition effects in the short-run, while for others efficiency is improved due to increased competition in both the short- and long-run. Indeed, Kokko (1996) and Driffield (1999) find evidence of positive competition effects for Mexico and the UK respectively. Recently, Liu (2008) has suggested that foreign presence may have a negative level, but a positive growth effect on productivity. The argument of Liu is that to benefit from advanced technology and other assets of foreign firms requires an initial outlay in terms of investment in machinery, tools and training. In the short-run this will lower productivity, but in the medium- to long-run these investments will have positive productivity effects (and a higher rate of productivity growth).

In the majority of cases considered by Görg and Greenaway (2004) however, no significant effect of FDI presence on firm productivity is found. Görg and Greenaway discuss a number of reasons to explain the lack of significant spillover effects. One possibility is that there simply aren't significant spillover effects. This would be the case if MNCs were able to guard their firm-specific advantages to prevent leakages to domestic firms. Alternatively, it may be that the methods employed have been unable to capture spillover effects adequately. In particular, there may be lags in the learning process, which short-run regression analysis doesn't pick up. A further possibility is that there may be heterogeneity in spillovers – with spillovers only affecting a subset of firms – which are not captured in aggregate studies. Such heterogeneity in outcomes may be due to firm characteristics – such as its relative backwardness or absorptive capacity – which determine the benefits a firm receives from the presence of foreign firms. A final possibility raised in the literature is that spillovers do not occur horizontally (i.e. intra-industry), but through vertical linkages which are missed in conventional studies. Görg and Greenaway (2004) discuss the possibility that MNCs may voluntarily or involuntarily help to increase the efficiency of domestic suppliers (upstream) or customers (downstream) through vertical input-output linkages. MNCs for example, may provide technical assistance to enable suppliers to raise the quality of the intermediate products they produce or by providing high quality standards for local inputs thus providing an incentive for local suppliers to upgrade their technology. MNCs may also provide assistance to domestic customers to enable them make the most efficient use of the products supplied by the MNC.

#### 4.2.2.3. A non-linear effect of foreign presence

As discussed above there are a number of reasons to believe that there may be a great deal of heterogeneity in the importance of FDI spillovers across firms and sectors. In response, an empirical literature has emerged testing for non-linear effects of foreign presence. While the majority of such studies tend to concentrate on the importance of absorptive capacity and the technology gap, studies also consider a variety of other variables that may influence the extent of FDI spillovers.

The results when considering measures of the technology gap are found to differ significantly across studies. Kokko (1994) argues that spillovers are likely to depend upon the complexity of the technology transferred by MNCs and the technology gap between domestic firms and MNCs. He tests these hypotheses on a cross-section of data for Mexico at the industry level. He finds that there is no evidence of spillovers in the case where MNCs use highly complex technology as measured by capital intensity and payments on patents. He further shows that a large technology gap does not appear to hinder technology spillovers on average. Related to this last result, Kokko et al. (1996) using data on Uruguay finds significant spillovers to domestic firms with moderate technology gaps (measured as the difference between the firm's labour productivity and the average labour productivity in foreign firms), but not for firms with large technology gaps. Girma and Görg (2005, 2007) report that the link between increases in FDI presence in an industry and domestic firm productivity increases is U-shaped, which is explained by the counteracting effects of positive spillover and negative competition effects. They argue that firms with the lowest levels of absorptive capacity are unlikely to be in direct competition with foreign firms and so need not suffer from competition effects. They also note however that such firms are unlikely to absorb any (technological) spillovers from foreign-owned firms, leaving pecuniary externalities as a remaining source of spillovers for these firms. Haskel et al. (2007) find weak evidence suggesting that the extent of spillovers is stronger for plants that are smaller and less technologically advanced, which suggests that spillovers accrue predominantly to lagging domestic plants, not leading ones.

Chuang and Hsu (2004) measure the technology gap by considering the difference between average output per worker in foreign and domestic owned firms. Sectors with a higher than average differences are considered as high-technology gap sectors. The authors find that while spillovers are significant for both the high and low technology gap sectors, they are significantly larger in low-technology gap sectors, suggesting that the greater the technological capacity of domestic firms the easier it is to obtain spillovers. Sjöholm (1999), on the other hand, finds using data for Indonesia that spillovers are largest in high-technology gap sectors, as does Jordaan (2005) using data for Mexico. Keller and Yeaple (2009) show that FDI spillovers are strongest in high-tech industries and have a larger impact within industries on the productivity growth of those firms that are farthest from the productivity frontier.

A variety of indicators of absorptive capacity have been employed in the literature, again with results that differ substantially across studies. Following the arguments of Cohen and Levinthal (1989) that in addition to generating new technology R&D also has a role to play in increasing a firm's ability to utilize existing technology and knowledge, both Kinoshita (2001) and Damijan et al. (2001) examine whether there is a non-linear relationship between FDI presence and domestic firm productivity dependent upon the R&D intensity of the domestic firms. Kinoshita finds that spillovers are larger for more R&D intensive industries in the Czech Republic, while Damijan et al. who consider a number of transition economies find when interacting FDI presence with firm R&D negative spillovers for Czech Republic and Poland, positive spillovers for Romania and no evidence for the other countries in the sample. Kathuria (2002) also includes an interaction between R&D intensity and the foreign-owned firm output share, which is found to be positive and significant, indicating that FDI and R&D intensity mutually facilitate productivity growth. Similar results are found by Kinoshita (2000). Both of these studies tend to find negative coefficients on the foreign share variable included linearly, suggesting that a certain threshold R&D intensity must be reached before positive spillovers take place (with firms below this threshold suffering negative productivity effects). Other studies use a measure of human capital to proxy absorptive capacity. Sinani and Meyer (2004) for example include an interaction term between foreign presence and human capital, finding a coefficient that is negative. Blalock and Gertler (2009) show that capacity measured by R&D expenditure and human capital increase a firm's propensity to benefit from spillovers.

A variety of other variables have been considered as relevant in determining the extent of FDI spillovers. In addition to technological proximity, others have considered the role of geographic proximity as being relevant for whether a firm benefits from the presence of foreign firms. The benefits of labour turnover and upstream and downstream networks may depend upon the distance from the foreign firms for example. To capture this, a number of studies have included a measure of foreign presence in a particular region (as opposed to sector) in their regression analysis. The results testing for a regional dimension to spillovers are at best mixed. Aitken and Harrison (1999) find no evidence of a regional aspect to FDI spillovers in Venezuela, while Girma and Wakelin (2002) do find some evidence of a regional effect in the UK, but only for firms in the same sector and with a low technology gap.

Some studies divide firms into exporters and non-exporters, based in part on the expectation that domestically owned exporters will have higher levels of absorptive capacity. In addition, foreign owned firms are divided in to those that export and those that sell only to firms in the host economy, with an additional expectation that spillovers from FDI may be larger in MNC subsidiaries that also export. Barrios and Strobl (2002) considering a panel of Spanish manufacturing firms find evidence for spillovers to domestic exporters only. They argue that the reason for this is that exporting firms are more exposed to international competition and are therefore more likely to use advanced technologies and more likely to benefit from positive spillovers than non-exporters. Kneller and Pisu (2007) find for the UK that foreign-owned firms that export in the same industry have positive and significant impacts on the decision of domestic firms to participate in export markets. In addition, foreign-owned firms (in general) who supply to domestic firms have a positive impact on the intensity of exports of these domestic firms. Girma et al. (2008) split domestic and foreign-owned firms in to exporters and non-exporters and examine whether there are productivity spillovers from such linkages. They find that domestic exporters experience positive intra-industry spillovers, but only from export-oriented MNCs. In terms of backward linkages they find that domestic-market oriented MNCs who sell to domestic firms impart positive spillover effects, which increase with absorptive capacity, while export-oriented MNCs have a small negative effect of productivity in domestic firms, which increases with absorptive capacity.

Driffield and Love (2007) concentrate on the motivation for FDI. Using a sample of data for the UK over the period 1987-1997 they split FDI into four categories, namely whether R&D was higher or lower than in the host sector, and/or whether unit labour costs were higher or lower in the host sector. This allows them to consider the importance of technology sourcing or exploitation and the importance of locational advantage (proxied using relative unit labour costs, such that locating production facilities in a region which has relatively lower costs will lower overall production costs for the MNC). Their results indicate that FDI that was technology sourcing and exploiting a locational advantage resulted in a negative spillover effect on domestic productivity. Positive spillovers were found in the case of FDI that was exploiting superior technology, but not lower labour costs in the UK. No significant effects were found for FDI engaged in technology sourcing and originating from a country with lower labour costs or from a country with superior technology and higher unit labour costs.

Aitken and Harrison (1999) find that productivity in small Venezuelan firms (less than 50 employees) has increased following the presence of MNCs, but there does not appear to be a similar effect on large domestic firms. Similar results are also presented for the US by Keller and Yeaple (2009).

#### 4.2.2.4. Vertical spillovers from FDI?

A number of studies examine whether there is evidence of vertical or inter-industry spillovers from FDI. A summary of the main results from this literature is listed in Table A3. The simplest approach is to include a measure of FDI presence in other sectors and examine whether such a variable helps explain the productivity of domestic firms in a given sector. Kugler (2001) finds evidence of inter-industry spillovers using industry-level data for Colombia over the period 1974-1998, but finds little evidence of horizontal spillovers. Similar results are found by Harris and Robinson (2003) using UK plant-level data. This methodology doesn't allow for a distinction between upstream and downstream industries to be made however.

Javorcik (2004) amongst others adopts an alternative approach that allows her to search for backward and forward linkages separately. A measure of backward spillovers is constructed as a weighted sum of the foreign presence variable of other sectors, where the weights are taken from Input-Output tables. In a similar manner, forward spillovers are defined as the weighted share of output in upstream industries produced by foreign-owned firms. Javorcik (2004) uses panel data over the period 1996-2000 on Lithuanian firms to examine whether the productivity of domestic firms is correlated with the presence of MNCs in both downstream and upstream industries. The results indicate the presence of significant backward spillovers, but there is no consistent evidence of spillovers occurring through either horizontal or forward linkages. The productivity effect is found to originate from investments with joint foreign and domestic ownership but not from fully owned foreign affiliates, a result which Javorcik argues is consistent with existing evidence of a larger amount of local sourcing undertaken by jointly owned projects. In her model, firm output is regressed upon a number of inputs, the share of a firm's foreign equity, and measures of horizontal backward and forward linkages. The measure of horizontal linkages is defined as the foreign equity participation averaged over all firms in the sector, weighted by each firm's share in sectoral output, while the backward linkage variable is calculated as the weighted sum of other industry's horizontal measure, where the weights are the proportion of the other industry's output supplied to the industry of interest taken from Input-Output (IO) tables. The measure of forward linkages is defined as the weighted share of output in upstream sectors produced by firms with foreign capital participation. Since only intermediates sold in the domestic market are relevant, goods produced by foreign affiliates for exports are excluded.

Similar results are found by Blalock and Gertler (2003, 2008) using plant-level panel data for Indonesia, for Hungary by Schoors and van der Tol (2001) and for Spain by Jabbour and Mucchielli (2007). Chung et al. (2003) find that downstream FDI by Japanese car manufacturers has a positive effect on upstream suppliers in the US car components industry. The fact that this positive effect was similar for suppliers that did not contract with Japanese car manufacturers suggests that the effect is due to competitive pressure and not from technology transfer per se.

Both Javorcik (2004) and Schoors and van der Tol (2001) find some limited evidence of a negative effect on forward linkages suggesting that foreign presence in upstream industries has a negative impact on performance of local firms in using industries. One explanation proposed for this result is that after buying out domestic firms in supplying sectors foreign owners upgrade production facilities and manufacture more sophisticated products that are then sold at a higher price. Local firms in using sectors purchase these inputs may have a limited ability to benefit from their higher technological content, but are forced to bear the higher price. Driffield et al. (2002) on the other hand consider horizontal, backward and forward linkages using plant level data in the UK over the period 1984-1992 and find significant evidence of spillovers through forward linkages, but little evidence of backward and horizontal spillovers.

Blalock and Simon (2009) consider both the issue of spillovers from downstream FDI and the absorptive capacity of domestic firms, by examining the effect of local supplier firms' capabilities on their productivity response to FDI in downstream industries. They argue that differences in firm capabilities may enable some local firms to benefit more than others from downstream FDI. In particular, they consider three categories of capabilities: (i) production capabilities – firms with weaker production capabilities may have a stronger incentive to adopt new technology because they can initially choose low-hanging technology with low marginal costs and high marginal returns; (ii) absorptive capacity – firms with greater absorptive capacity are probably better able to exploit external knowledge; (iii) complementary capabilities and resources – larger firms with greater complementary capabilities and resources may be more likely to win supply contracts from the entering MNCs. These are measured in the paper in the following way: (i) as estimates of the fixed effects from a productivity equation regression excluding FDI; (ii) whether firms engaged in R&D and the percentage of employees with senior high school or higher degrees; (iii) firm size. Using data on Indonesian firms over the period 1988-1996 they find that firms with stronger production capabilities benefit less than others, while those with greater absorptive capacity benefit more from downstream FDI. Some evidence is found suggesting that larger firms with greater complementary capabilities benefit more from downstream FDI. In terms of the former result it is suggested that the reason for this result is that firms with poor initial technology are more likely to encounter new processes that yield high returns at low cost.

### *4.3. International patenting*

Since patent applications require the inventor to provide a written description of their invention it would be expected that patent applications are a significant source of knowledge and technology upon which other innovators can build. Patent applications made by non-residents therefore are likely to be important sources of knowledge and technology developed abroad. Eaton and Kortum (1996) argue that patents are indirect evidence of research output and that where patent protection is sought reflects where inventors expect their ideas to be used. Eaton and Kortum argue that patents provide protection in two ways: (1) by protecting the inventor from imitators producing in that country, and (2) by protecting the inventor from imitators selling in that country. Since patenting is not costless however (costs include the publication of the specification in the local language that could lead to a leakage of information/knowledge as well as filing fees, agents fees, etc) firms tend to seek protection in only a small fraction of the countries of the world, with most innovations only being protected in the home market. It is argued that the pattern of (foreign) patenting may convey important information, with firms seeking to patent in countries with large markets and in countries where the invention is likely to prove useful. Based on these ideas they develop a model of innovation and international technology diffusion to explain relative productivity and growth among countries. In their model they relate the level of patenting by one country in another to five factors: (1) the source's research effort; (2) the destination's market size; (3) how rigorously the destination protects intellectual property; (4) the cost of patenting in the destination, and (5) the likelihood that inventions from the source can be adopted into the destination's technologies.

In the empirical analysis the authors relate a country's inventiveness to the number of researchers in that country, and relate technology diffusion between two countries (i.e. the probability that an invention from country $i$ will be adopted in country $j$) to whether $i$ and $j$ are the same country, the distance between $i$ and $j$, the level of human capital of $j$ and the level of imports from $i$ relative to $j$'s GDP. The model developed leads to two estimating equations, one for a country's productivity growth rate and one for the number of patent applications from country $i$ to country $j$, which they fit to data from 19 OECD economies. The explanatory variables considered can be split into three categories: (i) each country's productivity as a source of innovation, (ii) the diffusion of technology between each country pair, (iii) the returns to patenting an invention from country $i$ to $j$, conditional on diffusion.

The authors initially estimate the patent equation only. The patenting equation explains over 75% of the variation in international patenting per source country worker. The coefficients imply that imports are not an important vehicle for technology diffusion, but that ideas diffuse more within countries than between them. Technology diffusion between countries falls as the distance between them increases. Human capital has the effect of raising the ability of a country to absorb technology. Countries providing strong IPR protection are more attractive destinations for foreign patents. The productivity of the source country relative to the destination country has a positive effect on patenting, while the elasticity of idea production with respect to research employment is precisely estimated to be close to unity. The results from the productivity equation imply that international trade in ideas is a major factor in world growth: every OECD country other than the United States obtains more than 50% of its productivity growth from ideas that originated abroad, and for all but the five leading research countries (the US, Japan, Germany, France and the UK) the figure is more than 90%.

Inkmann et al. (1998) argue that international patenting is a part of a firm's export strategy. They model the export decision of a firm and its relationship to patenting choice. Empirically they model the firm's patenting decision in terms of a binary choice problem, employing data on the patent applications of 887 German firms at the German patent office, the European patent office and the US patent and trademark office. The model estimated is a trivariate probit model estimating the three patent decisions at the three major patent offices. The variables that are consistently significant across the three destinations are measures of firm size, R&D expenditure of the firm (and occasionally the domestic sector or presence of an R&D department) and whether it is a subsidiary of a foreign firm. Putnam (1996) shows that a country's percentage of the total value of patent rights granted worldwide conforms closely to the relative size of its domestic economy measured in terms of GDP. Slama (1981) offers an explanation of patent flows between countries based on the 'gravity' model of trade. His results suggest that a significant fraction of the variation in international patent flows can be explained by the size of the two economies and their physical distance apart.

In what follows we use information from WIPO on the number of patent applications made by non-residents to examine the importance of this channel of diffusion and to understand the determinants of this channel. In addition to reporting the number of patent applications by non-residents, WIPO also reports data on its website from 1995 onwards on bilateral patenting, that is the number of patent applications taken out in a destination country by residents of a partner country. Using these data we describe the pattern of international patenting across countries.

### *4.3.1. International patenting – descriptive analysis*

Using data on patent applications by non-residents and the more detailed data on bilateral patenting, which is available on the WIPO website since 1995, allow one to examine which countries are recipients of large numbers of patent applications by non-residents and which countries patent abroad intensively. Figure 4.2 reports the average number of patents applied for by non-residents over the period 1995-2009 by country. The data indicate that patenting by non-residents is extensive in the USA and Japan as expected, but also in Canada, Australia, Brazil and notably China. Other countries where patenting is extensive include the larger European economies, Russia, India, and South Africa. Market size would thus seem to be an important factor in affecting the number of applications by non-residents, while factors such as distance and a common language – which can affect flows of goods and services and FDI, and the cost of patenting respectively – may help explain the large number of patent applications by non-residents in countries such as Canada, Brazil and Australia.

Figure 4.2

**Average number of patents applied for by non-residents (1995-2009)**

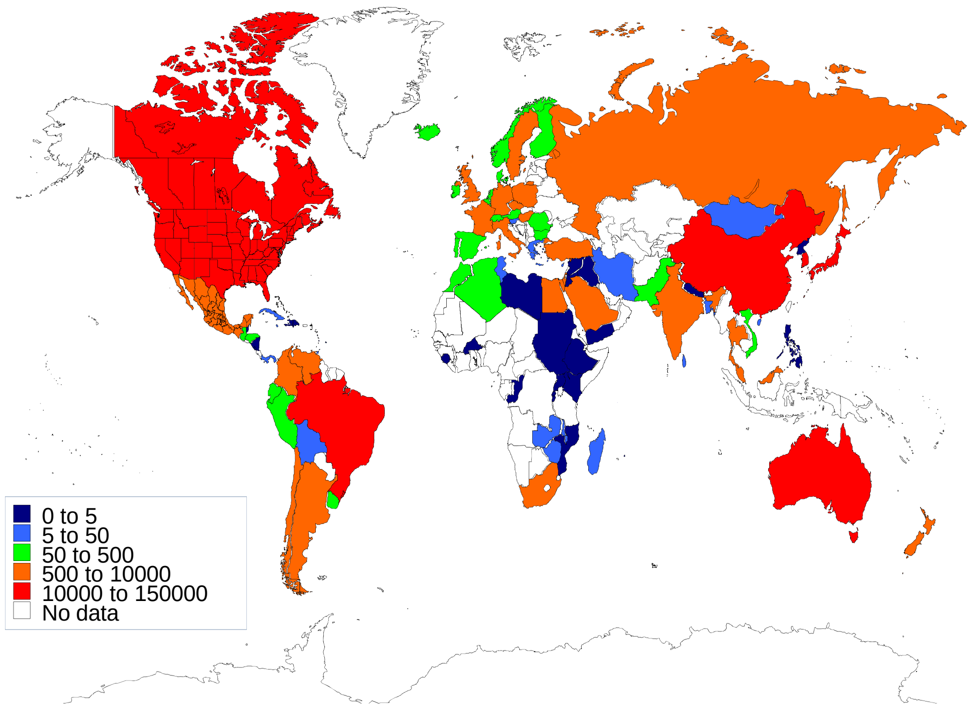
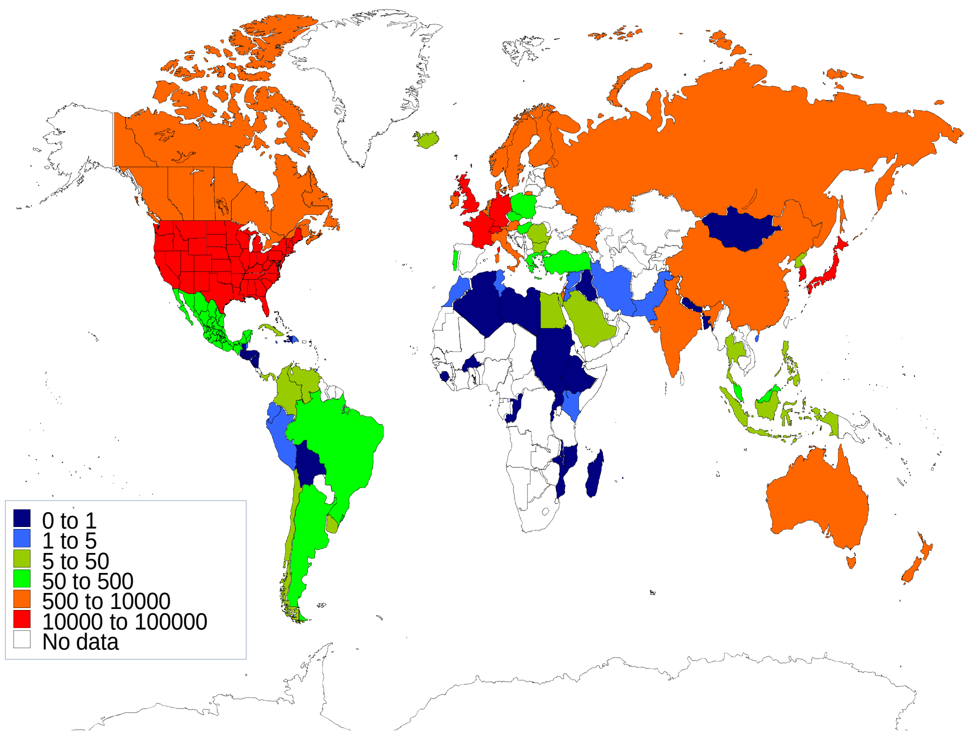


Figure 4.3 reports information on the countries that apply for patents abroad extensively, again using data averaged over the period 1995-2009. Unsurprisingly, the countries that are the major innovators – as measured by R&D expenditure and domestic patent applications – are the countries that patent most extensively abroad, with the USA, Japan, Germany, France and the UK patenting the most abroad along with South Korea. Other countries that patent extensively are China, Russia, India, Canada, Italy, Australia and the Scandinavian countries.

Figure 4.3

**Average number of patents applied for abroad (1995-2009)**




Figures 4.4 and 4.5 report the average growth rates of the number of patent applications by non-residents and the number of patents applied for abroad respectively. With a couple of exceptions that reflect a limited number of observations on which to calculate the growth rates (e.g. Madagascar) we see that the growth rate of the number of patent applications by non-residents is particularly strong in China and Brazil, along with Japan, New Zealand, Mexico, Italy and Poland amongst others. Average growth rates in the USA, Germany, the UK and Russia are also positive but smaller, while those in France, Canada and the Scandinavian countries are negative. In terms of patenting abroad (Figure 4.5) Indonesia along with Chile has experienced high growth rates in the number of patents taken out abroad, with China, India, Australia and Scandinavian countries also having high growth rates. Growth rates in the UK, France and Italy are significantly smaller, though still positive.

Figure 4.4

**Average growth rate in the number of non-residential patent applications**

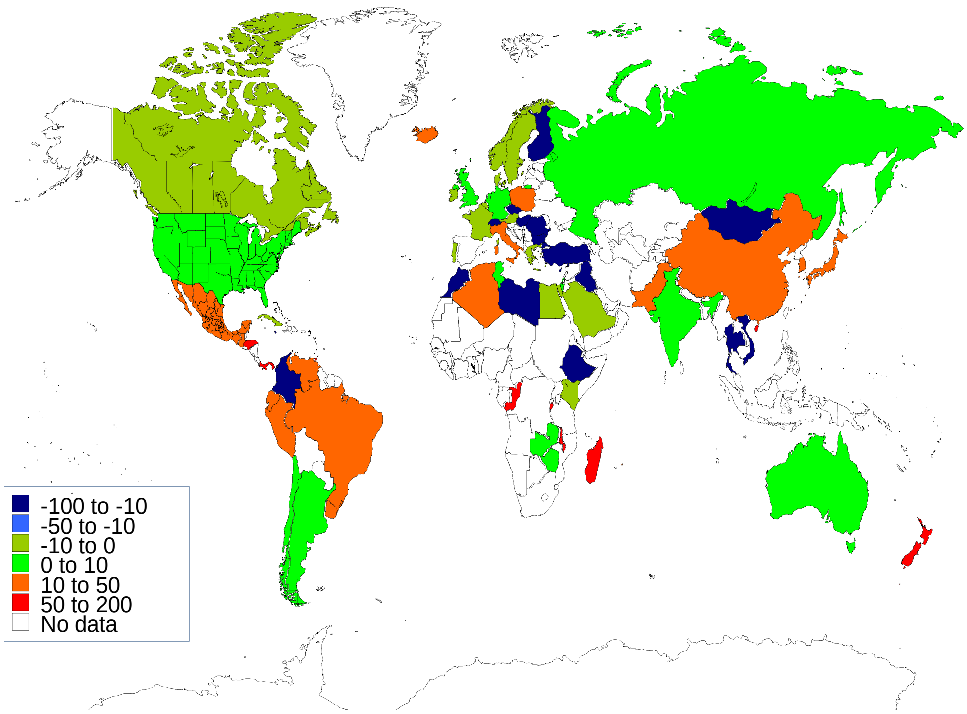
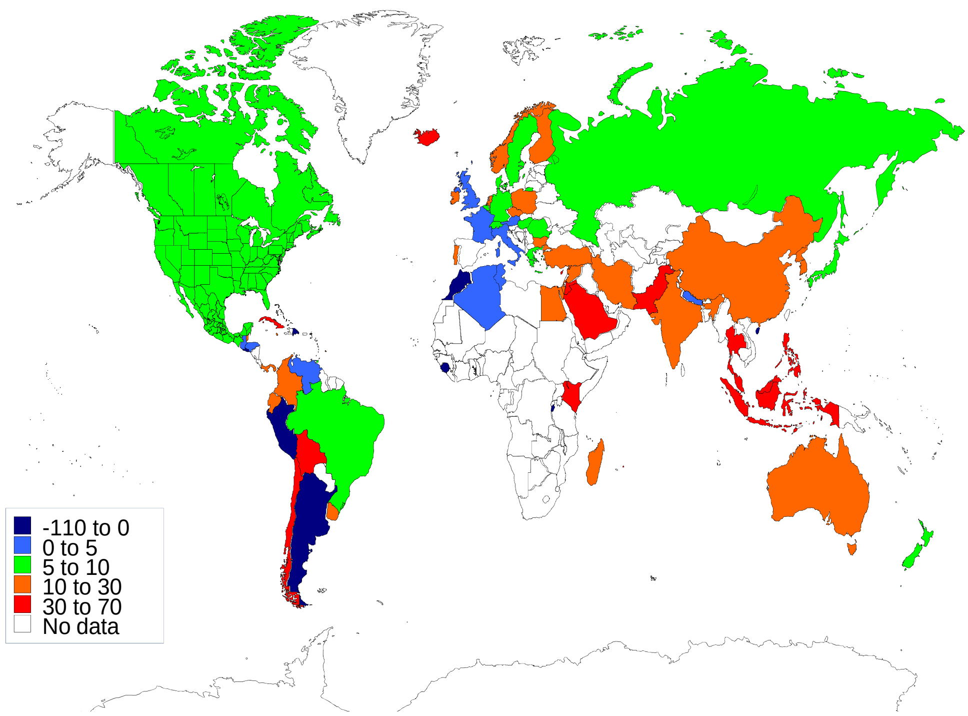



Figure 4.5

**Average growth in the number of patents applied for abroad**




Moving on to consider the data by region we consider the extent of patenting within regions as well as examining how important intra-regional patenting is. Table 4.2 reports the average number of patent applications made in each region by non-residents along with the growth rate over the period 1995-2009. This table reinforces the view that the majority of non-residential patenting takes place in the developed world along with the bigger developing countries (i.e. China). An interesting feature of the data is that 36% of all non-residential patenting takes place in the USA. In terms of growth rates China, Japan and other East Asian high income countries have seen the highest growth rates of non-residential patent applications, which is suggestive of a shift in technology flows towards East Asia. Table 4.3 reports a similar set of figures but for the number of patent applications taken out abroad by region. As with Figure 4.3 this figure indicates that patenting abroad is largely undertaken by advanced developed regions, with Japan, USA and Central Europe each accounting for more than 20% of total applications taken out abroad. Growth rates tend to be highest for those regions with the lowest levels of patenting abroad however, though this may reflect the low initial level of patenting abroad and that the data for these regions is patchy. China and India along with other high income East Asian countries have also experienced rapid increases in the extent of patenting abroad however.

Table 4.2

**Average number and growth rate of patent applications from non-residents by region**

| Bloc | Applications | Share in total non-residential applications | Growth in applications |
|---|---|---|---|
| US | 117180 | 36.39 | 6.86 |
| CN | 35427.3 | 11.00 | 22.25 |
| OD | 34557.3 | 10.73 | 7.93 |
| EAH | 34289.5 | 10.65 | 13.34 |
| JA | 25845.5 | 8.03 | 10.02 |
| AM | 18013.2 | 5.59 | 11.5 |
| EUC | 13650.8 | 4.24 | 1.78 |
| ACX | 9462.91 | 2.94 | 9.99 |
| EUW | 8934.55 | 2.77 | 2.07 |
| IN | 5552.64 | 1.72 | 7.74 |
| CI | 4991.36 | 1.55 | 7.58 |
| EUE | 4231.82 | 1.31 | 0.61 |
| EAO | 3067.27 | 0.95 | -39.5 |
| WA | 2106.82 | 0.65 | -24.1 |
| EUN | 1499.45 | 0.47 | -17.4 |
| EUS | 1311.82 | 0.41 | 1.46 |
| AFN | 1065.82 | 0.33 | 4.24 |
| AFS | 566.09 | 0.18 | 2.08 |
| ASO | 266.46 | 0.08 | -49.93 |

Table 4.4 considers the extent of intra-regional patenting by listing the average number of patents taken out by countries within a region in other countries within this region, along with the shares in total applications abroad and the growth rate of intra-regional patenting by region. Since we are concentrating on patents taken out abroad some of the regions

with only one country (e.g. the USA) do not appear in this table since the value of intra-regional patenting abroad for these countries and regions will be zero. Table 4.4 indicates that with the exception of a small number of developed regions (i.e. EUC and EUN) the extent of intra-regional patenting is largely not significant. While some of this effect is likely due to the fact that some regions have a small number of countries included making it unlikely to have high shares of intra-regional patenting this remains a surprising finding. The shares for other high income East Asian countries are found to be increasing rapidly however. These data on intra-regional patenting are in stark contrast to the figures for patenting by residents from the USA in regions (Table 4.5). Table 4.5 indicates that the USA is a major contributor to total non-residential patenting in all regions, with its share being above 20% in all regions and above 50% in some. Shares are particularly large in Central America and the Caribbean, in other developed countries and in Japan. Shares tend to be lowest in European regions, which is likely due to the fact that patenting in European countries by other European countries is relatively large, a fact suggestive of a regional aspect to international patenting in Europe at least.

Table 4.3

**Average number and growth rate of patent applications taken out abroad by region**

| Bloc | Applications | Share of total non-residential applications | Growth in applications |
|---|---|---|---|
| JA | 90467.6 | 28.09 | 7.77 |
| EUC | 80569.6 | 25.02 | 6.09 |
| US | 76592.6 | 23.79 | 8.9 |
| EAH | 17195 | 5.34 | 17.04 |
| OD | 16463.5 | 5.11 | 8.47 |
| EUW | 13743 | 4.27 | 4.86 |
| EUN | 13388.1 | 4.16 | 9.51 |
| EUS | 8843.5 | 2.75 | 5.41 |
| CN | 1235 | 0.38 | 24.28 |
| IN | 1002 | 0.31 | 28.41 |
| AM | 804.4 | 0.25 | 5.85 |
| EUE | 561.6 | 0.17 | 10.41 |
| CI | 522.2 | 0.16 | 6.26 |
| ACX | 347.5 | 0.11 | 10.1 |
| EAO | 173.5 | 0.05 | 37.95 |
| WA | 81.4 | 0.03 | 25.01 |
| AFS | 13.2 | 0.00 | 24.32 |
| AFN | 13 | 0.00 | 24.32 |
| ASO | 3.5 | 0.00 | 65.98 |

Finally, Table 4.6 considers the number of patent applications made by residents of regions in the USA. While the actual numbers of applications in the USA differ substantially, being relatively small in AFN, AFS and ASO and relatively large in JA, OD and EUC, the actual shares in total patenting abroad by these regions is generally large. In all but one case (AFS) the share of total patenting abroad that goes to the USA is above 30%, being particularly large in CI and OD. Overall, these tables indicate that while own regions tend not to be a significant source of or destination for non-residential patent applications, the USA does play an important role.

Table 4.4

**Average number, growth and share of non-resident patent applications from own region**

| Bloc | Applications | Share in total applications | Growth in applications |
|---|---|---|---|
| ACX | 9.64 | 0.10 | 19.14 |
| AFN | 0.27 | 0.03 | N/A |
| AFS | 0.00 | 0.00 | N/A |
| AM | 191.00 | 1.06 | -0.89 |
| ASO | 0.00 | 0.00 | N/A |
| CN | 0.18 | 0.00 | N/A |
| EAH | 113.09 | 0.33 | 44.49 |
| EAO | 0.00 | 0.00 | N/A |
| EUC | 4390.55 | 32.16 | -1.98 |
| EUE | 42.91 | 1.01 | 6.78 |
| EUN | 237.64 | 15.85 | -6.33 |
| EUS | 91.18 | 6.95 | 0.00 |
| OD | 1404.55 | 4.06 | 10.94 |
| WA | 0.18 | 0.01 | N/A |

N/A indicates that inadequate data was available to construct the growth rates.

Table 4.5

**Average number, growth and share of non-resident patent applications from the US**

| Bloc | Applications | Share in total applications | Growth in applications |
|---|---|---|---|
| ACX | 5485.64 | 57.97 | 8.74 |
| AFN | 484.64 | 45.47 | 2.82 |
| AFS | 211.91 | 37.43 | -43.23 |
| AM | 8003.91 | 44.43 | 10.12 |
| ASO | 102.91 | 38.62 | -75.76 |
| CI | 1416.45 | 28.38 | 7.68 |
| CN | 8542.91 | 24.11 | 23.94 |
| EAH | 10741.60 | 31.33 | 16.48 |
| EAO | 1027.36 | 33.49 | -34.03 |
| EUC | 2929.55 | 21.46 | 6.45 |
| EUE | 985.73 | 23.29 | 3.52 |
| EUN | 351.82 | 23.46 | -18.31 |
| EUS | 314.82 | 24.00 | 3.42 |
| EUW | 3541.18 | 39.63 | 7.02 |
| IN | 2184.55 | 39.34 | 7.34 |
| JA | 11609.80 | 44.92 | 8.73 |
| OD | 17876.80 | 51.73 | 8.74 |
| WA | 781.00 | 37.07 | -28.13 |

Table 4.6

**Number, growth and share of non-resident patent applications in the US by region**

| Bloc | Applications | Share in total applications | Growth in applications |
|---|---|---|---|
| ACX | 164.64 | 48.66 | 8.08 |
| AFN | 6.82 | 32.93 | 46.54 |
| AFS | 3.91 | 28.43 | -40.13 |
| AM | 329.82 | 40.10 | 9.85 |
| ASO | 2.82 | 51.27 | 87.97 |
| CI | 317.91 | 61.11 | 5.04 |
| CN | 691.91 | 49.71 | 26.95 |
| EAH | 8110.18 | 45.56 | 19.05 |
| EAO | 123.18 | 32.36 | 60.01 |
| EUC | 28411.20 | 35.21 | 4.88 |
| EUE | 218.36 | 37.66 | 12.13 |
| EUN | 4737.27 | 35.72 | 6.27 |
| EUS | 3458.45 | 39.00 | 5.01 |
| EUW | 6665.82 | 48.17 | 4.26 |
| IN | 610.91 | 58.94 | 27.77 |
| JA | 52697.60 | 58.96 | 5.91 |
| OD | 10590.30 | 64.56 | 7.72 |
| WA | 38.64 | 43.99 | 27.30 |

## 5. Conclusions

Innovation is considered to be an important determinant of performance at the firm, industry and country level. This view is supported by empirical evidence showing the importance of innovative activities on firm and industry performance and country growth rates. The majority of the world's R&D is concentrated in a handful of countries however, meaning that domestic innovation is of little importance for most countries. Such countries can benefit from innovation conducted elsewhere however, if knowledge and technology is diffused across borders. In this paper we survey existing literature on innovation and technology diffusion and discuss descriptive statistics on the extent of innovation and technology diffusion across countries to provide insights in to the likely developments in innovation and diffusion.

Truly innovative activities – as measured by R&D expenditures and domestic patent applications – have historically been largely concentrated in a small number of the most advanced countries. For much of the twentieth century the vast majority of R&D was concentrated in the USA, Japan, Germany, France and the UK. This concentration of innovative activities is likely to continue, though a small number of large developing economies – most notably China – are also likely to join this group. Given the relatively weak growth rates of R&D in some developed countries and the relatively strong growth rates in these larger developing countries we would expect that the relative importance of countries such as France and the UK in R&D activities will diminish over time however.

In terms of the direction of R&D spending the recent past has shown that sectors such as telecommunications, digital communication, computer technology and transport have expanded relatively quickly. Given the size of these sectors in total R&D expenditure we would expect that these sectors would continue to be important. The largest growth rates of patenting and R&D have often appeared in new sectors however, such as nanotechnology, recycling and services. Many of these sectors were very small or non-existent 20 to 30 years ago, which partly explains the rapid growth of these sectors.

The USA is the biggest supplier of new technology to other countries as measured by patent applications by non-residents. This view is consistent with empirical literature (e.g. Eaton and Kortum, 1996) that finds that the majority of both developed and developing country's technology comes from the USA. The USA is also the biggest recipient of others technology however, with a large share of a country's or region's patenting abroad being in the USA. Reasons for this probably relate to the market size of the US economy, plus the fact that intellectual property is strongly protected in the US. In regions with a large market size (e.g. Europe) or a rapidly growing market size (e.g. East Asia) however, there is some evidence of a regional dimension to technology diffusion (as measured by patent applications taken out abroad). Whether such regional patterns develop or whether the US continues to be the dominant supplier of new technology for most countries is an important issue for the future development of innovation and diffusion patterns.

## References


Aitken, B., Harrison, A. and R.E. Lipsey, 1996. Wages and foreign ownership: A comparative study of Mexico, Venezuela, and the United States. *Journal of International Economics*, 40, 345-371.

Aitken, B., G. H. Hanson and A.E. Harrison, 1997. Spillovers, foreign investment, and export behaviour. *Journal of International Economics*, 43, 103-132.

Aitken, B. and A. E. Harrison, 1999. Do domestic firms benefit from direct foreign investment? *American Economic Review*, 89, 605-618.

Alazzawi, S., 2004. Foreign direct investment and knowledge flows: Evidence from patent citation. Mimeo, University of California, Davis.

Alfaro, L., Areendam, C., Kalemli-Ozcan, S. and S. Selin, 2003. FDI and economic growth: The role of local financial markets. *Journal of International Economics*, 61, 512-533.

Almeida, P., 1996. Knowledge sourcing by foreign multinationals: Plant citation analysis in the US semiconductor industry. *Strategic Management Journal*, 17, 155-165.

Alvarez, R. and R.A. Lopez, 2005. Exporting and Performance: Evidence from Chilean plants. *Canadian Journal of Economics*, 38(4), 1384-1400.

Amiti, M. and J. Konings, 2007. Trade liberalization, intermediate inputs, and productivity: Evidence from Indonesia. *American Economic Review*, 97(5), 1611-1638.

Andersson, M. and H. Lööf, 2009. Learning-by-exporting revisited: The role of intensity and persistence. *Scandinavian Journal of Economics*, 111(4), 893-916.

Arnold, J.M. and K. Hussinger, 2005. Export behaviour and firm productivity in German manufacturing. A firm-level analysis. *Review of World Economics*, 141(2), 219-243.

Aslanoglu, E., 2000. Spillover effects of foreign direct investment on Turkish manufacturing industry. *Journal of International Development*, 2, 1111-1130.

Aw, B.Y., Chen, X. and M.J. Roberts, 1997. Firm level evidence on productivity differentials, turnover and exports in Taiwanese manufacturing. NBER Working Paper no. 6235, National Bureau of Economic Research.

Aw, B.Y., Chung, S. and M.J. Roberts, 2000. Productivity and turnover in the export market: Micro-level evidence from the Republic of Korea and Taiwan (China). *World Bank Economic Review*, 14, 65-90.

Aw, B.Y. and A.R. Hwang, 1995. Productivity and the export market: A firm-level analysis. *Journal of Development Economics*, 47, 313-332.

Aw, B.Y., Roberts, M.J. and T. Winston, 2005. The complementary role of exports and R&D investments as sources of productivity growth. NBER Working Paper no. 11774, National Bureau of Economic Research.

Aw, B.Y., Roberts, M.J. and T. Winston, 2007. Export market participation, investments in R&D and worker training, and the evolution of firm productivity. *World Economy*, 30, 83-104.

Aw, B.Y., Roberts, M.J. and D. Yi Xu, 2008. R&D investments, exporting and the evolution of firm productivity. *American Economic* Review, 98, 451-456.

Balcet, G. and R. Evangelista, 2005. Global technology innovation strategies of foreign affiliates in Italy. *Transnational Corporations*, 14, 53-92.

Baldwin, J.R. and W. Gu, 2003. Export-market participation and productivity performance in Canadian manufacturing. *Canadian Journal of Economics*, 36, 634-657.

Balusubramanyam, V.N., Salisu, M. and D. Sapsford, 1996. Foreign direct investment and growth in EP and IS countries. *Economic Journal*, 106, 92-105.

Banga, R., 2003. The export-diversifying impact of Japanese and U.S. foreign direct investments in Indian manufacturing sector. Indian Council for Research on International Economic Relations.

Barrios, S., 2000. Foreign direct investment productivity spillovers: Evidence from the Spanish experience (1990-1994). FEDEA Working Papers no. 2000-19.

Barrios, S. and E. Strobl, 2002. Foreign direct investment and productivity spillovers: Evidence from the Spanish experience. *Review of World Economics*, 138, 459-481.

Barrios, S., Görg, H. and E. Strobl, 2003. Explaining firm's export behaviour: R&D, spillovers and the destination market. *Oxford Bulletin of Economics and Statistics*, 65, 475-496.

Barrios, S., Dimelis, S., Louri, H. And E. Strobl, 2004. Efficiency spillovers from foreign direct investment in the EU periphery: A comparative study of Greece, Ireland, and Spain. *Review of World Economics*, 140, 687-705.

Barry, F., Görg, H. and E. Strobl, 2005. Foreign direct investment and wages in domestic firms in Ireland: Productivity spillovers versus labour-market crowding out. *International Journal of the Economics of Business*, 12, 67-84.

Benhabib, J. and M. M. Spiegel, 1994. The role of human capital in economic development: Evidence from aggregate cross-country data. *Journal of Monetary Economics*, 34, 143-173.

Bernard, A.B., 1995. Exporters and trade liberalization in Mexico: Production structure and performance. MIT, mimeo.

Bernard, A.B. and J.B. Jensen, 1995. Exporters, jobs, and wages in U.S. manufacturing: 1976-1987. *Brookings Papers on Economic Activity: Microeconomics*, 67-119.

Bernard, A.B. and J.B. Jensen, 1999. Exceptional exporters performance: Cause, effect or both? *Journal of International Economics*, 47, 1-25.

Bernard, A.B. and J.B. Jensen, 2004. Exporting and productivity in the USA. *Oxford Review of Economic Policy*, 20, 343-357.

Bernard, A.B., Eaton, J., Jensen, J.B. and S.E. Kortum, 2003. Plants and productivity in international trade. *American Economic Review*, 93, 1268-1290.

Bernard, A.B., Jensen, J.B., Redding, S.J. and P.K. Schott, 2007. Firms in international trade. *Journal of Economic Perspectives*, 21, 105-130.

Bernard, A.B. and J. Wagner, 1997. Exports and success in German manufacturing. *Review of World Economics*, 133, 134-157.

Bernard, A.B. and J. Wagner, 2001. Export entry and exit by German firms. *Review of World Economics*, 137, 105-123.

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, J.W., Oduro, A., Oostendorp, R., Pattillo, C., Soderbom, M., Teal, F. and A. Zeufack, 2004. Do African manufacturing firms learn from exporting. *Journal Development Studies*, 40, 115-141.

Bigsten, A. and M. Gebreeyesus, 2009. Firm productivity and exports: Evidence from Ethiopian manufacturing. *Journal of Development Studies*, 45(10), 1594-1614.

Blake, A., Deng, Z. and R. Falvey, 2010. How does the productivity of foreign direct investment spill over to local firms in the Chinese manufacturing? *Journal of Chinese Economic and Business Studies*, 7, 183-197.

Blalock, G. and P.J. Gertler, 2003. Technology from foreign direct investment and welfare gains through the supply chain. Mimeo, Cornell University.

Blalock, G. and P.J. Gertler, 2004. Learning from exporting revisited in a less developed setting. *Journal of Development Economics*, 75, 397-416.

Blalock, G. and P.J. Gertler, 2008.Welfare gains from foreign direct investment through technology transfer to local suppliers. *Journal of International Economics*, 74, 402-421.

Blalock, G. and P.J. Gertler, 2009. How firm capabilities affects who benefits from foreign technology. *Journal of Development Economics*, 90, 192-199.

Blalock, G. and D.H. Simon, 2009. Do all firms benefit equally from downstream FDI? The moderating effect of local suppliers' capabilities on productivity gains. *Journal of International Business Studies*, 40, 1095-1112.

Blomström, M., 1986. Foreign investment and productive efficiency: The case of Mexico. *Journal of International Economics*, 35, 97-110.

Blomstrom, M. and A. Kokko, 1998. Multinational corporations and spillovers. *Journal of Economic Surveys*, 12, 247-277.

Blomström, M. and H. Persson, 1983. Foreign investment and spillover efficiency in an underdeveloped economy: Evidence from the Mexican manufacturing industry. *World Development*, 11, 493-501.

Blomström, M. and F. Sjöholm, 1999. Foreign direct investment technology transfer and spillovers: Does local participation with multinationals matter? *European Economic Review*, 43, 915-923.

Blomström, M. and E.N. Wolff, 1994. Multinational corporations and productivity convergence in Mexico. In M. Blomstrtöm and E.N. Wolff (eds.), *Convergence of Productivity: Cross-national Studies and Historical Evidence*, Oxford and New York: Oxford University Press, pp. 243-259.

Boermans, M.A. 2010. Learning-by-exporting and destination effects: Evidence from African SMEs. MPRA Paper no. 22658, Munich Personal RePEc Archive.

Borensztein, E., DeGregorio, J. and J.W. Lee, 1998. How does foreign investment affect growth? *Journal of International Economics*, 45, 115-172.

Bosco, M., 2001. Does FDI contribute to technological spillovers and growth? A panel analysis of Hungarian firms. *Transnational Corporations*, 10, 43-68.

Bouoiyour, J., 2004. Foreign direct investment in Morocco. In Perrin, S. and F. Sachwald (eds.), *Foreign Direct Investment in Developing Countries: Leveraging the Role of Multinationals*, Paris, AFD, pp. 149-167.

Braconier, H., Ekholm, K. and K-H. Midelfart Knarvik, 2000. Does FDI work as a channel for R&D spillovers? Evidence based on Swedish data', Discussion Paper no. 2469, Centre for Economic Policy Research.

Branstetter, L. G., 2001. Are knowledge spillovers international or intranational in scope? Microeconometric evidence from the US and Japan. *Journal of International Economics*, 53, 53-79.

Buckley, P.J., Clegg, J. and C. Wang, 2002. The impact of inward FDI on the performance of Chinese manufacturing firms. *Journal of International Business Studies*, 33, 637-655.

Buckley, P.J., Clegg, J. and C. Wang, 2007. Is the relationship between inward FDI and spillover effects linear? An empirical examination of the case of China. *Journal of International Business Studies*, 38, 447-459.

Bustos, P., 2006. Multilateral Trade Liberalization, Exports and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinean Firms. Working paper, Universitat Pompeu Fabra.

Buyinza, F., 2009. Uganda manufacturing firms' productivity and export performance.Mimeo, University of Linz.

Bwalya, M.S., 2006. Foreign direct investment and technology spillovers: Evidence from panel data analysis of manufacturing firms in Zambia. *Journal of Development Economics*, 81, 514-526.

Cantwell, J., 1995. The globalization of technology: What remains of the product life cycle model? *Cambridge Journal of Economics*, 19, 155-174.

Cantwell, J. and O. Janne, 1999. Technological globalization and innovative centres: The role of corporate technological leadership and locational hierarchy. *Research Policy*, 28, 119-144.

Cassiman, B., Colombo, M., Garrone, P. and R. Veugelers, 2004. The impact of M&A on the R&D process: An empirical analysis of the role of technological and market relatedness. Mimeo.

Castellani, D., 2002. Export behaviour and productivity growth: Evidence from Italian manufacturing firms. *Review of World Economics*, 138, 605-628.

Castellani, D. and A. Zanfei, 2002. Technology gaps, absorptive capacity and the impact of inward investments on productivity of European firms. *Economics of Innovation and New Technology*, 12, 555-576.

Caves, R.E., 1974. Multinational firms, competition and productivity in host country markets. *Economica*, 41, 176-193.

Chuang, Y.C. and P.F. Hsu, 2004. FDI, trade, and spillover efficiency: Evidence from China's manufacturing sector. *Applied Economics*, 36, 1103-1115.

Chuang, Y-C. and C-M. Lin, 1999. Foreign direct investment, R&D, and spillover efficiency: Evidence from Taiwan's manufacturing firms. *Journal of Development Studies*, 35, 117-137.

Chudnovsky, D., Lopez, A., and G. Rossi, 2008. Foreign direct investment spillovers and the absorptive capabilities of domestic firms in the Argentinean manufacturing sector (1992-2001). *Journal of Development Studies*, 44, 645-677.

Cimoli, M., 2001. Networks, market structures and economic shocks: The structural changes of innovation systems in Latin America. Paper presented at the seminar on 'Redes Peroductivas e institucionales en America Latina', Buenos Aires, 9-12 April.

Cimoli, M. and J. Katz, 2001. Structural reforms, technological gaps and economic development: A Latin American perspective. Paper presented at the DRUID, Nelson and Winter conference, Aalborg, 12-15 June.

Clerides, S.K., Lach, S. and J.R. Tybout, 1998. Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico, and Morocco. *Quarterly Journal of Economics*, CXIII, 903-947.

Coe, D. T. and E. Helpman, 1995. International R&D Spillovers. *European Economic Review*, 39, 859-887.

Coe, D. T., E. Helpman and A. W. Hoffmaister, 1997. North-South R&D spillovers. *Economic Journal*, 107, 134-149.

Coe, D.T. and A.W. Hoffmaister, 1999. Are there international R&D spillovers among randomly matched trade partners? A response to Keller. IMF Working Papers no. 99/18, International Monetary Fund.

Coe, D.T., Helpman, E. and A.W. Hoffmaister, 2009. International R&D spillovers and institutions. *European Economic Review*, 53, 723-741.

Cohen, W. M., 1995. Empirical studies of innovative activity. In P. Stoneman (ed.), *Handbook of the Economics of Innovation and Technical Change*, Oxford, Basil Blackwell.

Cohen, W. M. and D. A. Levinthal, 1989. Innovation and learning: The two faces of R&D. *Economic Journal*, 99, 569-596.

Costa, I., 2005. Notes on R&D and TNCs affiliates in Brazil. Paper presented at the UNCTAD Expert Meeting on the Impact of FDI on Development, Geneva, 24-26 January.

Costa, I. and S.R.R. de Queiroz, 2002. Foreign direct investment and technological capabilities in Brazilian industry. *Research Policy*, 31, 1431-1443.

Costantini, J.A. and M.J. Melitz, 2007. The dynamics of firm-level adjustment to trade liberalization. Mimeo

Crespi, G., Criscuolo, C. and J. Haskel et al. 2008. Productivity, exporting, and the learning-by-exporting hypothesis: Direct evidence from UK firms. *Canadian Journal of Economics*, 41, 619-638.

Crespo, N. and Fontoura, M.P., 2007. Determinant factors of FDI spillovers – What do we really know? *World Development*, 35, 410-425.

Crespo-Cuaresma, J., N. Foster and J. Scharler, 2004. On the determinants of absorptive capacity: Evidence from OECD Countries. *Current Issues in Economic Growth, Proceedings of OeNB Workshops*, Vienna, Austrian National Bank, 58-81.

Criscuolo, P., 2005. On the road again: Researcher mobility inside the R&D network. *Research Policy*, 34, 1350-1365.

Criscuolo, P. and P. Patel, 2003. Large firms and internationalization of R&D: 'Hollowing out' of national technological capacity? Paper presented at SETI workshop, May 15-16, Rome.

Criscuolo, C., Haskel, J. and M. Slaughter, 2005. Global engagement and the innovation activities of firms. NBER Working Paper no. 11479, National Bureau of Economic Research.

Cuyvers, L., Soeng, R. and D. van den Bulcke, 2008. The contribution of MNEs to economic success of small open economies. The case of Cambodia. In van den Bulcke, D. and A. Verbeke (eds.), *Small Nations in the Global Economy: The Contribution of Multinational Enterprises to National Economic Success*, Cheltenham, Edward Elgar.

Dalton, D., Serapio, M. and P. Yoshida, 1999. *Globalizing Industrial R&D*. U.S. Department of Commerce, Technology Administration, Office of Technology Policy.

Damijan, J.P., MAjcen, B, Rojec, M. and M. Knell, 2001. The role of FDI, R&D accumulation, and trade in transferring technology to transmission countries: evidence from firm panel data for eight transition countries. Working Paper no. 2001/10, University of Ljubljana.

Damijan, Knell, M., Majcen, B. and M. Rojec, 2003. The role of FDI, R&D accumulation and trade in transferring technology to transition countries: Evidence from firm panel data for eight transition countries. *Economic Systems*, 27, 189-204.

Damijan, J.P., Polanec, S. and J. Prasnikar, 2004. Self-selection, export market heterogeneity and productivity improvements: Firm level evidence from Slovenia. LICOS Discussion Paper 148/2004.

Das, S., 1987. Externalities and technology transfer through multinational corporations: A theoretical analysis. *Journal of International Economics*, 22, 171-182.

Delgado, M.A., Farinas, J.C. and S. Ruano, 2002. Firm productivity and export markets: A non-parametric approach. *Journal of International Economics*, 57, 397-422.

DeLoecker, J., 2007. Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics*, 73, 69-98.

DeLoecker, J., 2007. Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics*, 73(1), 69-98.

DePropis, L. and N. Driffield, 2006. The importance of clusters for spillovers from foreign direct investment and technology sourcing. *Cambridge Journal of Economics*, 30, 277-291.

Dimelis, S.P., 2005. Spillovers from foreign direct investment and firm growth: Technological, financial and market structure effects. *International Journal of the Economics of Business*, 12, 85-104.

Dimelis, S. and H. Louri, 2002. Foreign ownership and production efficiency: A quantile regression analysis. *Oxford Economic Papers*, 54, 449-469.

Djankov, S. and B. Hoekman, 2000. Foreign investment and productivity growth in Czech enterprises. *World Bank Economic Review*, 14, 49-64.

Driffield, N., 1999. Determinants of entry and exit in the foreign owned sector of UK manufacturing. *Applied Economics Letters*, 6, 153-156.

Driffield, N., 2001. The impact on domestic productivity of inward investment in the UK. *Manchester School*, 69, 103-119.

Driffield, N., 2004. Regional policy and spillovers from FDI in the UK. *The Annals of Regional Science*, 38, 579-594.

Driffield, N. and S. Girma, 2003. Regional foreign direct investment and wage spillovers: Plant level evidence from the UK electronics industry. *Oxford Bulletin of Economics and Statistics*, 65, 453-474.

Driffield, N., Munday, M. and A. Roberts, 2002. Foreign direct investment, transactional linkages and the performance of the domestic sector. *International Journal of the Economics of Business*, 9, 335-351.

Driffield, N. and J.H. Love, 2007. Linking FDI motivation and host economy productivity effects: Conceptual and empirical analysis. *Journal of International Business Studies*, 38, 460–473.

Dunning, J. and R. Narula, 1995. The R&D activities of foreign firms in the United States. *International Studies of Management and Organization*, 25, 39-73.

Eaton, J. and S. Kortum, 1996. Trade in ideas: Patenting and productivity in the OECD. *Journal of International Economics*, 40, 79-90.

Eaton, J., Kortum. S. and F. Kramarz, 2007. An Anatomy of International Trade: Evidence from French Firms. Working Paper, New York University, Department of Economics.

Eaton, J., Eslava, M., Kugler, M. and J. Tybout, 2008. Export dynamics in Colombia: Transactions level evidence. Mimeo, Central Bank of Colombia.

Englander, A.S., Evenson, R.E. and M. Hanazaki, 1988. R&D, Innovation, and the total factor productivity slowdown. OECD Economic Studies, 11, 7-42.

Evenson, R. and L. Westphal, 1995. Technological change and technology strategy. In Behrman, J. and T. Srinivasan (eds.), *Handbook of Development Economics, Vol. 3A*, Amsterdam, North Holland Publishing Company, pp. 2209-2229.

Falvey, R. E., N. Foster and D. Greenaway (2002), 'North-South Trade, Knowledge Spillovers and Growth', *Journal of Economic Integration*, 17, pp. 650-670.

Falvey, R. E., N. Foster and D. Greenaway, 2004. Imports, exports, knowledge spillovers and growth. *Economics Letters*, 85, 209-213.

Farinas and Martin-Marcos, 2007. Exporting and economic performance: Firm-level evidence of Spanish manufacturing. *World Economy*, 30, 618-646.

Feinberg, S.E. and S.K. Majumdar, 2001. Technology spillovers from foreign direct investment in the Indian pharmaceutical industry. *Journal of International Business Studies*, 32, 421-437.

Fernandes, A. and A. Isgut, 2007. Learning-by-exporting effects: Are they for real? MPRA Working Paper no. 3121, University of Munich.

Findlay, R., 1978. Relative backwardness, direct foreign investment and the transfer of technology: A simple dynamic model. *Quarterly Journal of Economics*, 92, 1-16.

Florida, R., 1997. The globalization of R&D: Results of a survey of foreign-affiliated R&D laboratories in the United States. *Research Policy*, 32, 1381-1396.

Fors, G., 1997 Utilization of R&D results in the home and foreign plants of multinationals. *Journal of Industrial Economics*, XLV, 341-358.

Fosfuri, A., M. Motta and T. Ronde, 2001. Foreign direct investment and spillovers through worker's mobility. *Journal of International Economics*, 53, 205-222.

Frost, T., 1998. The geographic sources of innovation in the multinational enterprise: U.S. subsidiaries and host country spillovers, 1980-1990. PhD Thesis, MIT, Cambridge, MA.

Frost, T., 2001. The geographic sources of foreign subsidiaries' innovation. *Strategic Management Journal*, 22, 101-123.

Fryges, H., 2006. The export-growth relationship: Estimating a dose-response function. ZEW Discussion Paper no. 06-028, Mannheim.

Fryges, H. and J. Wagner, 2007. Exports and productivity growth – first evidence from a continuous treatment approach. Discussion Paper no. 07-032, Centre for European Economic Research.

Funk, M., 2001. Trade and international R&D spillovers among OECD countries. *Southern Economic Journal*, 67, 725-737.

Geringer, J.M., Beamish, P.W. and R.C. da Costa, 1989. Diversification strategy and internationalization: Implications for MNE performance. *Strategic Management Journal*, 10, 109-119.

Girma, S., 2005. Absorptive capacity and productivity spillovers from FDI: A threshold regression analysis. *Oxford Bulletin of Economics and Statistics*, 67, 281-306.

Girma, S. and H. Görg, 2003. FDI spillovers and the role of absorptive capacity: Evidence from the UK using quantile regressions. Discussion Paper no. 3584, Center for Economic Policy Research.

Girma, S. and H. Görg, 2007. The role of the efficiency gap for spillovers from FDI: Evidence from the UK electronics and engineering sectors. *Open Economies Review*, 18, 215-232.

Girma, S., Görg, H. and E. Strobl, 2004. Exports, international investment, and plant performance: Evidence from a non-parametric test. *Economics Letters*, 83, 317-324.

Girma, S., Görg, H. and M. Pisu, 2008. Exporting, linkages and productivity spillovers from foreign direct investment. *Canadian Journal of Economics*, 41, 320-340.

Girma, S., Görg, H. and E. Strobl, 2004. Exports, international investment, and plant performance: Evidence from a non-parametric test. *Economics Letters*, 83, 317-324.

Girma, S., Greenaway, D. and R. Kneller, 2003. Export market exit and performance dynamics: A causality analysis of matched firms. *Economics Letters*, 80, 181-187.

Girma, S., Greenaway, D. and R. Kneller, 2004. Does exporting increase productivity? A microeconometric analysis of matched firms. *Review of International Economics*, 12, 855-866.

Girma, S., Greenaway, D. and K. Wakelin, 2001. Who benefits from foreign direct investment in the UK? *Scottish Journal of Political Economy*, 48, 119-133.

Girma, S. and K. Wakelin, 2002. Are there regional spillovers from FDI in the UK? In D. Greenaway, R. Upward and K. Wakelin (eds.), *Trade, Investment, Migration and Labour Markets*, Basingstoke, Macmillan.

Glass, A.J. and K. Saggi, 1998. International technology transfer and the technology gap. *Journal of Development Economics*, 55, 369-398.

Globerman, S., 1979. Foreign direct investment and 'spillover' efficiency benefits in Canadian manufacturing industries. *Canadian Journal of Economics*, 12, 42-56.

Globermann, S., A. Kokko and F. Sjöholm, 2000. International technology diffusion: Evidence from Swedish patent data. *Kyklos*, 53, 17-38.

Gomes, L. and K. Ramaswamy, 1999. An empirical examination of the form of the relationship between multinationality and performance. *Journal of International Business Studies*, 30, 173-188.

Görg, H. and D. Greenaway, 2004. Much Ado about Nothing: Do Domestic Firms Really Benefit from Foreign Direct Investment? *World Bank Research Observer*, 19, 171-197.

Görg, H. and E. Strobl, 2002. Multinational companies and entrant start-up size: Evidence from quantile regressions. *Review of Industrial Organization*, 20, 15-31.

Görg, H. and E. Strobl, 2005. Spillovers from foreign firms through worker mobility: An empirical investigation. *Scandinavian Journal of Economics*, 107, 693-709.

Görg, H. and E. Strobl, 2003. Multinational companies, technology spillovers and plant survival. *Scandinavian Journal of Economics*, 105, 581-595.

Graner, M. and A. Isaksson, 2007. Firm efficiency and the destination of exports: Evidence from Kenyan plant-level data. Mimeo, United Nations Industrial Development Organization.

Greenaway, D., Sousa, N. and K. Wakelin, 2004. Do domestic firms learn to export from multinationals? *European Journal of Political Economy*, 20, 1027-1043.

Greenaway, D., Gullstrand, J. and R. Kneller, 2005. Exporting may not always boost firm productivity. *Review of World Economics*, 141, 561-582.

Greenaway, D. and R. Kneller, 2004. Exporting and productivity in the United Kingdom. *Oxford Review of Economic Policy*, 20, 358-371.

Greenaway, D. and R. Kneller, 2004a. Industry differences in the effect of export market entry: Learning by exporting? GEP Research Paper no. 04/33, University of Nottingham.

Greenaway, D. and R. Kneller, 2007. Industry differences in the effect of export market entry: Learning by exporting? *Review of World Economics*, 143, 416-432.

Greenaway, D. and Yu, Z., 2004. Firm-level interactions between exporting and productivity: Industry-specific evidence. *Review of World Economics*, 140, 376-392.

Greenhalgh, C. and M. Rogers, 2010. *Innovation, Intellectual Property, and Economic Growth*. Princeton, Princeton University Press.

Griffith, R., 1999. Using the ARD establishment-level data to look at foreign ownership and productivity in the UK. *Economic Journal*, 109, F416-F442.

Griffith, R., S. Redding, and J. van Reenen, 2004. Mapping the two faces of R&D: Productivity growth in a panel of OECD industries. *Review of Economics and Statistics*, 86, 883-895.

Griliches, Z., 1979. Issues in assessing the contribution of R&D to productivity growth. *Bell Journal of Economics*, 10, 92-116.

Griliches, Z., 1995. R&D and productivity: Econometric results and measurement issues. In Stoneman, P. (ed.), *Handbook of the Economics of Innovation and Technological Change*, Oxford, Blackwell.

Griliches, Z. and F. Lichtenberg, 1984. Interindustry technology flows and productivity growth: A re-examination. *Review of Economics and Statistics*, 66, 324-329.

Grossman, G. M. and E. Helpman (1991), *Innovation and Growth in the Global Economy.* Cambridge, MA, The MIT Press.

Haddad, M. and A.E. Harrison, 1993. Are there positive spillovers from direct foreign investment? Evidence from panel data for Morocco. *Journal of Development Economics*, 42, 51-74.

Hagemejer, J and J.J. Kolasa, 2008. The political economy of Poland’s trade policy: Empirical verification of the Grossman-Helpman model. *Eastern European Economics*, 46, 27-46.

Hahn, C-E., 2004. Exporting and performance of plants: Evidence from Korean manufacturing. NBER Working Paper no. 10208, National Bureau of Economic Research.

Håkanson, L. (1992), 'Locational determinants of foreign R&D in Swedish multinationals', In Grandstand, O., Håkanson, L. and S. Sjölander (eds.), Technology Management and International Business: Internationalisation of R&D and Technology, Chichester; Wiley.

Hale, G. and C. Long, 2007. Are there productivity spillovers from foreign direct investment in China? Pacific Basin Working Paper no, 2006-13.

Hallward-Dreimeier, M., Iarossi, G. and K.L. Sokoloff, 2002.Exports and manufacturing productivity in East Asia: A comparative analysis with firm-level data. NBER Working Paper no. 8894, National Bureau of Economic Research.

Halpern, L. and B. Muraközy, 2007. Does distance matter in spillover? *Economics of Transition*, 15, 781-805.

Halpern, L., Koren, M. and A. Szeidl, 2009. Imported inputs and productivity. CeFiG Working Papers no. 8, Center for Firms in the Global Economy.

Hansson, P. and N.N. Lundin, 2004. Exports as an indicator on or promoter of successful Swedish manufacturing firms in the 1990s. *Review of World Economics*, 140, 415-445.

Harris, R., 2002. Foreign ownership and productivity in the United Kingdom – Some issues when using the ARD establishment level data. *Scottish Journal of Political Economy*, 49, 318-335.

Harris, R., 2009. Spillover and backward linkage effects of FDI: Empirical evidence for the UK. SERC Discussion Paper no. 0016, Spatial Economics Research Centre, London School of Economics.

Harris, R. and Q. Li, 2007. Firm level empirical study of the contribution of exporting to UK productivity growth. Report to UK Trade and Investment.

Harris, R. and C. Robinson, 2003. Foreign ownership and productivity in the United Kingdom: Estimates for UK manufacturing using the ARD. *Review of Industrial Organization*, 22, 207-223.

Harris, R. and C. Robinson, 2004. Industrial policy and its effect on total factor productivity in UK manufacturing plants, 1990-1998. *Scottish Journal of Political Economy*, 51, 528-543.

Haskel, J.E., Pereira, S.C. and M.J. Slaughter, 2007. Does inward foreign direct investment boost the productivity of domestic firms? *Review of Economics and Statistics*, 2007, 89, 482-496.

Havranek, T. and Z. Irsova, 2010. Meta-analysis of intra-industry FDI spillovers: Updated evidence. *Czech Journal of Economics and Finance*, 60, 151-174.

Havrylyshyn, O. and M. Wolf, 1987. What have we learned about South-South trade? In O. Havrylyshyn (ed.), *Exports of Developing Countries: How Direction Affects Performance*. Washington, DC; World Bank.

Helleiner, G.K. (ed.), 1994. *Trade Policy and Industrialisation in Turbulent Times*. Routledge, London.

Hirano, K. and G.W. Imbens, 2004. The propensity score with continuous treatments. Working Paper, University of California, Berkeley.

Imbens, G.W., 2000. The role of the propensity score in estimating dose-response functions. *Biometrika*, 83, 706-710.

Imbriani, C. and F. Reganati, 2003. The effects of direct investments on local firms: Some evidence from panel data for the Italian manufacturing sector. HawaiiInternational Conference on Social Sciences, June.

Inkmann, J., Pohlmeier, W. and L.A. Ricci, 2000. Where to patent? Theory and evidence on international patenting. In Vosgerau, H-J. (ed.), *Institutional arrangements for global economic integration*, Basingstoke, Palgrave Macmillan, pp. 122-140.

Isgut, A., 2001. What's different about exporters? Evidence from Colombian manufacturing. *Journal of Development Studies*, 37, 57-82.

Jabbour, L. and J.L. Mucchielli, 2007. Technology transfer through vertical linkages: The case of the Spanish manufacturing industry. Journal of Applied Economics, 115-136.

Jaffe, A., 1986. Technological opportunity and spillovers of R&D: Evidence from firm's patents, profits and market value. American Economic Review, 75, 984-1002.

Jaffe, A., 1988. Demand and supply influences in R&D intensity and productivity growth. *Review of Economics and Statistics*, 70, 431-437.

Jaffe, A.B., Trajtenberg, M. and R. Henderson, 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, 108, 577-598.

Javorcik, B.S., 2004. Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. *American Economic Review*, 94(3), 605-627.

Javorcik, B.S. and K. Saggi, 2004. Technological asymmetry among foreign investors and mode of entry. Trade and Development Research Group, Washington, World Bank.

Javorcik, B., Saggi, K. and M. Spatareanu, 2004. Does it matter where you come from? Vertical spillovers from foreign direct investment and the nationality of investors. Policy Research Paper no. 3449, The World Bank.

Jensen, J.B. and N. Musick, 1996. Trade, technology, and plant performance. Mimeo.

Jordaan, J., 2005. Determinants of FDI-induced externalities: New empirical evidence for Mexican manufacturing industries. *World Development*, 33, 2103-2118.

Kalotay, K. and G. Hunya, 2000. Privatization and foreign direct investment in Central and Eastern Europe. *Transnational Corporations*, 9, 39-66.

Kao, C., Chiang, M.H. and B. Chen, 1999. International R&D spillovers: An application of estimation and inference in panel cointegration. *Oxford Bulletin of Economics and Statistics*, 61, 691-709.

Karpaty, P. and L. Lunderberg, 2004. Foreign direct investment and productivity spillovers in Swedish manufacturing. Working Paper no. 194, Trade Union Institute for Economic Research.

Kathuria, V., 2000. Productivity spillovers from technology transfer to Indian manufacturing firms. *Journal of International Development*, 12, 334-369.

Kathuria, V., 2001. Foreign firms, technology transfer and knowledge spillovers to Indian manufacturing industries: A stochastic frontier analysis. *Applied Economics*, 33, 625-642.

Kathuria, V., 2002. Liberalisation, FDI, and productivity spillovers – an analysis of Indian manufacturing firms. *Oxford Economic Papers*, 54, 688-718.

Kearns, A. and F. Ruane, 2001. The tangible contribution of R&D-spending foreign-owned plants to a host region: A plant level study of the Irish manufacturing sector (1980-1996). *Research Policy*, 30, 227-244.

Keesing, D.B. and S. Lall, 1992. Marketing manufactured exports from developing countries: Learning sequences and public support. In Helleinger, G.K. (ed.), *Trade Policy, Industrialization and Development: New Perspectives*, Oxford, Clarendon Press.

Keller, W., 1998. Are international R&D spillovers trade-related? Analyzing spillovers among randomly matched trade partners. *European Economic Review*, 42, 1469-1481.

Keller, W. ,2000. Do trade patterns and technology flows affect productivity growth? *World Bank Economic Review*, 14, 17-47.

Keller, W., 2004. International technology diffusion. *Journal of Economic Literature*, 42, pp. 752-782.

Keller, W. and S.R. Yeaple, 2009. Multinational enterprises, international trade, and productivity growth: Firm level evidence from the United States. *Review of Economics and Statistics*, 91, 821-831.

Khawar, M., 2003. Productivity and foreign direct investment – evidence from Mexico. *Journal of Economic Studies*, 30, 66-76.

Kinoshita, Y., 2000. R&D and technology spillovers via FDI: Innovation and absorptive capacity. Working Paper no. 349, William Davidson Institute at the University of Michigan.

Kinoshita, Y., 2001. R&D and technology spillovers via FDI: Innovation and absorptive capacity. Discussion Paper no. 2775, Center for Economic Policy Research.

Kneller, R. and M. Pisu, 2004. Export-oriented FDI in the UK. *Oxford Review of Economic Policy*, 20, 424-439.

Kokko, A., 1994. Technology, market characteristics and spillovers. *Journal of Development Economics*, 43, 279-293.

Kokko, A., 1996. Productivity spillovers from competition between local firms and foreign affiliates. *Journal of International Development*, 8, 517-530.

Kokko, A., Tasini, R. and M. Zejan, 1996. local technological capability and productivity spillovers from FDI spillovers in the Uruguayan manufacturing sector. *Journal of Development Studies*, 32, 602-611.

Kokko, A., Tasini, R. and M. Zejan, 2001. Trade regimes and spillover effects of FDI: Evidence from Uruguay. *Weltwirtschaftliches Archiv*, 137, 124-149.

Konings, J., 2001. The effects of foreign direct investment on domestic firms: Evidence from firm-level panel data in emerging economies. *Economics of Transition*, 9, 619-633.

Kraay, A., 2002. Exports and economic performance: Evidence from a panel of Chinese enterprises. In Mary-Francoise Renard (ed.), *China and its Regions. Economic Growth and Reform in Chinese Provinces*, Cheltenham, Edward Elgar, 278-299. (Originally published in Revue d'Economique du Developpement, 1-2, 1999).

Kuemmerle, W., 1996. *Home Base and Foreign Direct Investment in R&D*. PhD Thesis, Boston, MA.

Kuemmerle, W., 1999. The drivers of foreign direct investments into research and development: An empirical investigation. *Journal of International Business Strategy*, 30, 1-24.

Kugler, M., 2001. The diffusion of externalities from foreign direct investment: The sectoral pattern of technological spillovers. Mimeo, University of Southampton.

Kumar, N., 2001. Determinants of location of overseas R&D activity of multinational enterprises: The case of US and Japanese corporations. *Research Policy*, 30, 159-174.

Lall, S., 1979. The international allocation of research activity by U.S. multinationals. *Oxford Bulletin of Economics and Statistics*, 41, 313-331.

Le Bas, C. and C. Sierra, 2002. Location versus country advantages in R&D activities: Some further results on multinationals' locational strategies. *Research Policy*, 31, 589-609.

Lichtenberg, F. and B. van Pottelsberghe de la Potterie, 1998. International R&D spillovers: A re-examination. NBER Working Paper no. 5668, National Bureau of Economic Research.

Lileeva, A. and D. Trefler, 2007. Improved access to foreign markets raises plant-level productivity...For some plants. NBER Working Paper no. 13297, National Bureau of Economic Research.

Lipsey, R.E., 2002. Home and host country effects of FDI. NBER Working Paper 9293, National Bureau of Economic Research.

Lipsey, R.E. and F. Sjöholm, 2001.Foreign direct investment and wages in Indonesian manufacturing. NBER Working Paper no 8299, National Bureau of Economic Research.

Liu, Z., 2002. Foreign direct investment and technology spillover: Evidence from China. *Journal of Comparative Economics*, 30, 579-602.

Liu, Z., 2008. Foreign direct investment and technology spillovers: Theory and evidence. *Journal of Development Economics*, 85, 176-193.

Liu, M-C. and S-H. Chen, 2003. International R&D deployment and locational advantage: A case study of Taiwan. NBER Working Paper no. 10169, National Bureau of Economic Research.

Liu, X., Siler, P., Wang, C. and Y. Wei, 2000. Productivity spillovers from foreign direct investment: Evidence from UK industry level panel data. *Journal of International Business Studies*, 31, 407-425.

Lumengo-Neso, O., Olarreaga, M. and M. Schiff, 2005. On 'indirect' trade related R&D spillovers. *European Economic Review*, 49, 1785-1798.

Lutz, S. and O. Talavera, 2004. Do Ukranian firms benefit from FDI? *Economics of Planning*, 37, 77-98.

Mansfield, E., 1986. Patents and innovation: An empirical study. *Management Science*, February, 173-181.

Mansfield, E., M. Schwartz and S. Wagner, 1981. Imitation costs and patenting: An empirical study. *Economic Journal*, 91, 907-918.

Markusen, J.R. and A.J. Venables, 1999. Foreign direct investment as a catalyst for industrial development. *European Economic Review*, 43, 335-356.

Martins, P.S. and Y. Yang, 2009. The impact of exporting on firm productivity: A meta-analysis of the learning-by-exporting hypothesis. *Review of World Economics*, 145, 431-445.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71, 1695-1725.

Meller, P., 1995. Chilean export growth, 1970-90: An assessment. In Helleiner, G.K. (ed.), *Manufacturing for Export in the Developing World. Problems and Possibilities*. London, Routledge, pp. 21-53.

Mengistae, T. and C. Pattillo, 2004. Export orientation and productivity in Sub-saharan Africa. *IMF Staff Papers*, 51, 327-353.

Meyer, K.E. and E. Sinani, 2009. When and where does foreign direct investment generate positive spillovers? A meta analysis. *Journal of International Business Studies*, 40, 1075-1094.

Mohnen, P.A. and N. Lepine, 1988. Payments for technology as a factor of production. Working Paper no. 8818, University of Montreal.

Murakami, Y., 2007. Technology spillover from foreign-owned firms in Japanese manufacturing industry. *Journal of Asian Economics*, 18, 284-293.

Munari, F. and M. Sobrero, 2005. The effects of privatization on R&D investments and productivity: An empirical analysis of European firms. Mimeo.

Nelson, R. R. and E. S. Phelps, 1966. Investment in humans, technological diffusion, and economic growth. *American Economic Review, Papers and Proceedings*, 69-75.

OECD, 2008. *The Internationalisation of Business R&D: Evidence, Impacts and Implications*. Paris, Organisation for Economic Cooperation and Development.

Patel, P., 1997. Localised production of technology for global markets. In Archibugi, D. and J. Michie (eds.), *Technology, Globalisation and Economic Performance*, Cambridge, Cambridge University Press.

Patel, P. and M. Vega, 1999. Patterns of internationalisation of corporate technology: Location vs. Home country advantages. *Research Policy*, 28, 145-155.

Pearce, R.D. and S. Singh, 1992. *Globalising research and development*. London, Macmillan.

Peri, P., 2004. Catching-up to foreign technology? Evidence on the 'Veblen-Gerschenkron' effect of foreign investments. NBER Working Paper no. 10893, National Bureau of Economic Research.

Petroulas, P., 2008. Foreign direct investment in Greece: Productivity and spillover effects. *Economics Bulletin*, 31, 31-48.

Putnam, J., 1996. The Value of International Patent Rights. PhD Thesis, Yale University.

Queiroz, S., Zanatta, M. and C. Andrade, 2003. Internationlization of MNCs' technological activities: What role for Brazilian subsidiaries? Paper presented at SPRU Conference in honour of Keith Pavitt, Brighton, 13-15 November.

Rattso, J. and E.H. Stokke, 2003. Learning and foreign technology spillovers in Thailand: Empirical evidence on productivity dynamics. *Nordic Journal of Political Economy*, 29, 47-66.

Rodriguez-Clare, A., 1996. Multinationals, linkages and economic development. *American Economic Review*, 86, 852-873.

*Romer, P.M., 1986. Increasing returns and long run growth.* Journal of Political Economy*, 94, 1002-1037.*

*Ruane, F. and A. Ugur, 2005. Foreign direct investment and productivity spillovers in Irish manufacturing industry: Evidence from plant level panel data.* International Journal of the Economics of Business*, 12, 53-66.*

Saggi, K., 2002. Trade, foreign direct investment, and international technology transfer: A Survey. *World Bank Research Observer*, 17, 191-235.

Sasidharan, S., 2006. Foreign direct investment and technology spillovers: Evidence from the Indian manufacturing sector. Mimeo.

Scherer, F.M., 1982. Interindustry technology flows and productivity growth. *Review of Economics and Statistics*, 627-634.

Schoors, K. and van der Tol, B., 2002. Foreign direct investment spillovers within and between sectors: Evidence from Hungarian data. Working Paper no. 157, Ghent University, Belgium.

Schoors, K. and B. van der Tol, 2002. Foreign direct investment spillovers within and between sectors: Evidence from Hungarian data. Working Paper no. 157, Ghent University, Belgium.

Sgard, J., 2001. Direct foreign investments and productivity growth in Hungarian firms, 1992-1999. CEPII Working Paper no. 19, CEPII.

Sigurdson, J. and K. Palonka, 2002. Technological governance in ASEAN – Failings in technology transfer and domestic research. Working Paper no. 162, Stockholm School of Economics and European Institute of Japanese Studies.

Sinani, E., 2003. Export market participation: The importance of sunk costs and spillovers. Center for East European Studies, Copenhagen Business School.

Sinani, E. and K.E. Meyer, 2004. Spillovers from technology transfer: The case of Estonia. *Journal of Comparative Economics*, 32, 445-466.

Singh, J., 2004. Multinational firms and knowledge diffusion: Evidence using patent citation data. Mimeo, Department of Economics, Harvard Business School.

Sjöholm, F., 1996. International transfer of knowledge: The role of international trade and geographic proximity. *Review of World Economics*, 132, 97-115.

Sjöholm, F., 1999. Exports, imports and productivity: Results from Indonesian establishment data. *World Development*, 27, 705-715.

Sjöholm, F., 1999a. Technology gap, competition and spillovers from direct foreign investment: Evidence from establishment data. *Journal of Development Studies*, 36, 53-73

Sjohölm, F., 1999b. Technology gap, competition and spillovers from foreign direct investment: Evidence from establishment data. *Journal of Development Studies*, 36, 53-73.

Slama, J., 1981. Analysis by means of a gravitation models of international flows of patent applications in the period 1967-1978. *World Patent Information*, 3, 2-8.

Solow, R., 1956. A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70, 65-94.

Solow, R., 1957. Technical change and the aggregate production function. *Review of Economics and Statistics*, 39, 312-320.

Srholec, M., 2005. Research and development activity of foreign affiliates: Firm-level evidence from the Czech Republic. Mimeo, Oslo, University of Oslo.

Swan, T., 1956. Economic growth and capital accumulation. *Economic Record*, 32, 344-361.

Takii, S., 2005. Productivity spillovers and characteristics of foreign multinational plants in Indonesian manufacturing 1990-1995. *Journal of Development Economics*, 76, 521-542.

Thuy, T.L., 2007. Technological spillovers from foreign direct investment: The case of Vietnam. Mimeo, Graduate School of Economics, University of Tokyo.

Tian, X., 2007. Accounting for sources of FDI technology spillovers: Evidence from China. *Journal of International Business Studies*, 38, 147-159.

Todo, Y. and K. Miyamoto, 2002. Knowledge diffusion from multinational enterprises: The role of domestic and foreign knowledge-enhancing activities. OECD Development Center Technical Papers 196, Paris; OECD.

Todo, Y. and K. Miyamoto, 2006. Knowledge spillovers from foreign direct investment and the role of local R&D activities: Evidence from Indonesia. *Economic Development and Cultural Change*, 55, 173-200.

Todo, Y. and S. Shimiztuani, 2005. Overseas R&D activities by multinational enterprises: Evidence from Japanese firm-level data. Hi-Stat Discussion Paper Series no. 05-91, Institute of Economic Research, Hitotsubashi University.

Trofimenko, N., 2008. Learning by exporting: Does it matter where one learns? *Economic Development and Cultural Change*, 56, 871-894.

Tsou, M-W., Liu, J-T. and J. Hammit, 2002. Worker turnover and job reallocation in Taiwanese manufacturing. *Applied Economics*, 34, 401-411.

UNCTAD (2005), *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D*, New York and Geneva; United Nations.

UNCTAD, 2008. *Transnational Corporations and the Infrastructure Challenge*. New York and Geneva; United Nations.

UNIDO (2002), *Industrial Development Report 2002/2003.* Vienna, United Nations Industrial Development Organization.

Vahter, P.A., 2005. Which firms benefit more from inward foreign direct investment? Bank of Estonia Working Paper no. 2005-11, Bank of Estonia.

Vahter, P.A. and J. Masso, 2007. Home versus host country effects of FDI: Searching for new evidence of productivity spillovers. *Applied Economics Quarterly*, 53, 165-196.

Van Biesebroeck, J., 2005. Exporting raises productivity in sub-saharan African manufacturing firms. *Journal of International Economics*, 67(2), 373-391.

Velho, L., 2004. Science and technology in Latin America and the Caribbean: An overview. Discussion Paper 2004-4, Maastricht; UNU-INTECH.

Veugelers, R. and B. Cassiman, 2004a. Foreign subsidiaries as a channel of international technology diffusion: Some direct firm level evidence from Belgium. *European Economic Review*, 48, 455-476.

Wagner, J. 2002. The causal effects of exports on firm size and labor productivity: first evidence from a matching approach. *Economics Letters*, 77, 287-292.

Wagner, J., 2006. Exports, foreign direct investment, and productivity: Evidence from German firm level data. *Applied Economics Letters*, 13, 347-349.

Wagner, J., 2007. Exports and productivity: A survey of the evidence from firm-level data. *World Economy*, 30, 60-82.

Wei, Y. and X. Liu, 2003. Productivity spillovers among OECD, diaspora and indigenous firms in Chinese manufacturing. Working Paper no. 2003/008, Lancaster University Management School.

Wei, Y. and X. Liu, 2006. Productivity spillovers from R&D, exports and FDI in China's manufacturing sector. *Journal of International Business Studies*, 37, 544-557.

Wooster, R.B. and D.S. Diebl, 2006. Productivity spillovers from foreign direct investment in developing countries: A meta-regression analysis. Mimeo.

World Bank, 1993. *The East Asian Miracle*. Washington, DC; Oxford University Press.

Veugelers, R. and B. Cassiman, 2004b. Foreign subsidiaries as a channel of international technology diffusion: Some direct firm level evidence from Belgium. *European Economic Review*, 48, 455-476.

Xu, B. and J. Wang, 1999. Capital goods trade and R&D spillovers in the OECD. *Canadian Journal of Economics*, 32, 1258-1274.

Xu, B. and J. Wang, 2000. Trade, FDI and international technology diffusion. *Journal of Economic Integration*, 15, 585-601.

Yasar, M. and C.J. Morrison Paul, 2007. International linkages and productivity at the plant level: Foreign direct investment, exports, imports and licensing. *Journal of International Economics*, 72, 373-388.

Yasar, M., Nelson, C.H. and R.M. Rejesus, 2006. Productivity and exporting status of Turkish manufacturing firms: Evidence from quantile regressions. *Review of World Economics*, 142, 675-694.

Yeaple, S.R., 2005. A simple model of firm heterogeneity, international trade, and wages. *Journal of International Economics*, 65, 1-20.

Yudaeva, K., Kozlov, K., Melentieva, N. and N. Ponomaryova, 2003. Does foreign ownership matter? Russian experience. *Economics of Transition*, 11, 383-410.

Zahra, S. and G. George, 2002. Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, 27, 185-203.

Zhang, Y. (2005), 'Globalization of R&D: New trend of economy globalization', Paper presented at UNCTAD Expert Meeting of FDI and Development, Geneva, 24-26 January.

Zukowska-Gagelmann, K., 2000. Productivity spillovers from foreign direct investment in Poland. *Economic Systems*, 24, 223-256.

## Annex

Table A1

### Summary of evidence on exporting and productivity at the firm level

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| Aw and Hwang (1995) | Taiwan (electronics industry) | Cross-section (1986)<br>Blinder-Oaxaca decomposition | Labour productivity | - Exporters are larger (measured by sales, employment, value-added), more capital-intensive and older than firms producing for the domestic market<br>- Labour productivity higher for export-oriented when compared with domes-tic-market-oriented firms in the electronics industry |
| Bernard (1995) | Mexico | Panel (1986-1990) | Labour productivity | - Labour productivity higher for exporters than non-exporters<br>- Growth of productivity not significantly different between exporters and non-exporters<br>- Growth of productivity not significantly different between either export-starters or export-stoppers and non-exporters |
| Bernard and Jensen (1995) | USA | Panel (1976-1987) | Labour productivity | - Labour productivity higher in exporters compared to non-exporters |
| Meller (1995) | Chile | Panel (1986-1989) | Labour productivity | - Labour productivity higher in both small and large export firms than in non-export firms.<br>- The productivity differential differs between industries |
| Jensen and Musick (1996) | USA | Panel (1987-1992) | Labour productivity | - Growth of labour productivity not significantly different between exporters and non-exporters<br>- Growth of labour productivity not significantly different for export-starters and non-exporters<br>- Growth of labour productivity not significantly different for export-stoppers and non-exporters |
| Aw, Chen and Roberts (1997) | Taiwan | Panel (1981-1991) | TFP | - Higher TFP for exporters relative to non-exporters (varying by industry)<br>- Firms entering export markets were more productive than non-exporters in the years prior to entry<br>- Firms exiting export markets have higher productivity than non-exporters |
| Bernard and Wagner (1997) | Germany | Panel (1978-1992) | Labour productivity | - Labour productivity lower in smaller export firms, but higher in larger export firms<br>- Growth of labour productivity slower in exporting than in non-exporting firms |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| | | | | - Pre-entry growth of starters is insignificant<br>- Growth of labour productivity higher for exporter starters than for non-exporters immediately after entering<br>- Growth of labour productivity lower for export stoppers than non-exporters immediately after exiting |
| Clerides, Lach and Tybout (1998) | Colombia (1981-1991);<br>Mexico (1986-1990);<br>Morocco (1984-1991) | Panel Data | Labour productivity;<br>Average Variable Cost | - For Colombia and Mexico plants that cease exporting get worse before dropping out of export market<br>- For Colombia and Mexico exporters and starters have the lowest variable costs, with quitters having the highest<br>- For Morocco exporters usually have lower costs than non-exporters, but this is not guaranteed.<br>- For Colombia and Morocco entrants perform best in terms of labour productivity, followed by continuing exporters with exiters performing worst of all.<br>- In terms of productivity similar results are found in Mexico, though productivity is not higher for entrants.<br>- Only limited evidence suggesting that productivity increases following entry<br>- Higher productivity of exporters partly due to their higher skill-intensity<br>- The presence of many exporters in a region increases a firm's chances of being an exporter itself<br>- For Colombia, production costs for all firms become lower in those regions where export activity increases |
| Bernard and Jensen (1999) | USA | Panel (1984-1992) | Labour productivity | - Higher growth rate of labour productivity in exporters than in non-exporters, but in the short-run only<br>- Pre-entry growth in future starters not significantly different from that in non-starters<br>- Growth of labour productivity higher for export starters than non-exporters in the short, medium and long run<br>- Growth of labour productivity lower for export stoppers than non-exporters in the short, medium and long run |
| Sjöholm (1999) | Indonesia | Panel (1980-1991) | Labour productivity<br>(levels and growth rate) | - Labour productivity higher for exporters than non-exporters<br>- Productivity higher for exporters and increasing with the share of exports in output<br>- Limited evidence suggesting that productivity is higher for importers than non-exporters, especially those with a higher share of imports in output |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| Aw, Chung and Roberts (2000) | Taiwan | Panel (1981-1991) | TFP | - TFP higher for exporters than for non-exporters<br>- TFP growth across industries lower in exporters than non-exporters when significant<br>- Entrants have higher TFP prior to entry than non-exporters<br>- New entrants are more productive than non-exporters |
| Aw, Chung and Roberts (2000) | Republic of Korea | Panel (1983-1993) | TFP | - TFP higher for exporters than non-exporters<br>- TFP growth not different between exporters and non-exporters<br>- No significantly higher levels or growth rates of TFP for entrants prior to entry<br>- Entrants have higher TFP than non-entrants<br>- Exiting plants have higher TFP than non-exporters in 2 out of the 5 industries |
| Bernard and Wagner (2001) | Germany | Panel (1978-1992) | Labour productivity | - Higher productivity strongly positively correlated with future export entry |
| Isgut (2001) | Colombia | Panel (1981-1991) | Wages by type of worker; sales/worker; value-added/worker; share of non-production to total workers; Investment measures; capital/worker; employment by type | - Exporters are found to perform significantly better across all performance criteria<br>- Export premia are found to be lower for plants that export a higher share of their output<br>- Future exporters perform better than non-exporters across all performance criteria except the blue-collar wage<br>- Such differences between future exporters and non-exporters increase over time before entry actually takes place<br>- Firms tend to self-select into export markets after a period of increased sales, labour productivity and capital accumulation<br>- Performance tends to be better in export starters than in non-starters over the medium-run<br>- New exporters tend to increase their employment of white-collar workers, technicians and managers relative to blue-collar workers<br>- Growth of labour productivity is not significantly lower for stoppers compared with non-exporters over the medium-run. |
| Castellani (2002) | Italy | Panel (1989-1994) | Labour productivity | - Labour productivity higher for exporters than non-exporters<br>- No significant different labour productivity growth between exporters and non-exporters |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| | | | | - Productivity growth higher in firms with a higher share of exports in total sales<br>- Productivity higher in future export starters than in non-starters prior to entry<br>- Growth of labour productivity not significantly different between starters and non-starters<br>- Labour productivity and its growth have no impact on the probability to start exporting |
| Delgado, Farinas and Ruano (2002) | Spain | Panel (1991-1996) | TFP | - TFP distribution for exporters stochastically dominates the distribution for non-exporters<br>- TFP distribution for export starters dominates the distribution for non-exporters prior to entry<br>- No evidence of divergence of TFP distribution between exporters and non-exporters |
| Hallward-Driemeier, Iarossi and Sokoloff (2002) | Indonesia, Korea, Malaysia, Phillipines, Thailand | Panel (1996-1998) | TFP | - TFP larger for exporters than non-exporters<br>- The gap is larger the less developed the local market is |
| Kraay (2002) | China | Panel (1988-1992) | Labour productivity; TFP; Unit Costs | - A firm's export status is highly persistent over time<br>- Labour productivity and TFP significantly higher in exporters than in non-exporters.<br>- Exporters tend to enjoy lower unit costs<br>- For established exporters, past exports are positively related to productivity and TFP today.<br>- For new entrants learning effects are insignificant or negative. |
| Tsou, Liu and Hammitt (2002) | Taiwan | Panel (1986-1996) | Labour productivity; TFP | - Growth of labour productivity higher for plants that export, but this is driven by effects in upturns rather than downturns<br>- Growth of TFP substantially higher for export starters than for non-exporters<br>- Growth of TFP not different between export stoppers and non-exporters |
| Wagner (2002) | Germany | Panel (1978-1989) | Labour productivity | - Growth of labour productivity in export starters higher than in matched non-starters, but difference is insignificant. |
| Baldwin and Gu (2003) | Canada | Panel (1974-1996) | Labour productivity; TFP | - Labour productivity and TFP higher for exporters than non-exporters<br>- Labour productivity and growth of labour productivity higher for starters than for non-exporters<br>- Entrants had faster LP growth than non-entrants<br>- Exiters less productive (and had slower growth) than continuers |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| Girma, Greenaway and Kneller (2003) | UK | Panel (1991-1997) | TFP | - For matched firms export exiting has a small negative effect on TFP in the year of exit, but no significant effect in later years |
| Greenaway and Kneller (2004) | UK | Panel (1989-2002) | Labour productivity | - Productivity higher in exporters than in non-exporters<br>- For matched firms entry is associated with a significant increase in labour productivity<br>- No evidence of productivity effects beyond the first few years, but for firms more exposed to export markets |
| Sinani (2003) | Estonia | Panel (1994-1999) | Labour productivity | - Labour productivity higher for exporting firms than non-exporters<br>- Growth of labour productivity much higher for exporters than non-exporters |
| Bernard and Jensen (2004) | USA | Panel (1983-1992) | | - Plants that always export are more productive than those that never export<br>- Exporters have lower productivity growth when compared with non-exporters<br>- Prior to starting exporting firms have productivity levels higher than continuing non-exporters, but lower than continuing exporters<br>- In the year of entry firms have higher productivity growth when compared with other firms<br>- Plants that exit export markets have productivity growth lower than continuing non-exporters |
| Bigsten et al. (2004) | Cameroon, Ghana, Kenya, Zimbabwe | Panel (1991-1995 depending on country) | TFP | - Exporters exhibit higher average efficiency levels than non-exporters<br>- Initial exporters tend to exhibit significantly higher levels of efficiency than other firms<br>- Lagged efficiency has no significant impact on the export decision |
| Blalock and Gertler (2004) | Indonesia | Panel (1990-1996) | Labour productivity | - Labour productivity higher for exporters than non-exporters<br>- Productivity does not rise prior to exporting<br>- Firms receive a productivity boost following entry into exporting across all industries<br>- No decline in productivity if firms stop exporting |
| Damijan, Polanec and Prasnikar (2004) | Slovenia | Panel (1994-2002) | Labour productivity | - Productivity higher for exporters than for non-exporters<br>- Firms that export to more markets are on average more productive<br>- Productivity in starters higher than in non-starters in years before starting<br>- Productivity difference higher for firms that start to export to more advanced markets |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| | | | | - Only short-run productivity gains from exporting and only from serving advanced, high-wage foreign markets<br>- Firms that stop exporting exhibit lower productivity when compared with old exporters |
| Girma, Görg and Strobl (2004) | Ireland | Cross-section (2000) | Labour productivity; Net profit per employee | - Labour productivity higher for exporters than non-exporters<br>- The hypothesis of identical distributions of productivity and profits for exporters and non-exporters cannot be rejected<br>- The distribution of productivity and profits for multinationals dominate those of exporters and non-exporters |
| Girma, Greenaway and Kneller (2004) | UK | Panel (1988-1999)<br>Matching analysis | Employment; output; wages; labour productivity; TFP | - Exporting raises the growth rate of output and employment<br>- Productivity higher for exporters than for non-exporters<br>- Entrants more productive before entry than non-entrants<br>- For matched firms new entrants experience higher TFP growth than non-starters in the year of entry<br>- A higher share of exports raises the rate at which TFP grows after entry |
| Greenaway and Kneller (2004a) | UK | Cross-section | Labour productivity; TFP | - Labour productivity and TFP higher for exporters than for non-exporters<br>- Past levels of TFP have a positive influence on the probability of entering export markets<br>- Past productivity growth of future entrants higher compared with non-entrants<br>- TFP growth faster in the year of entry and subsequent years than for continuing non-exporters |
| Greenaway and Yu (2004) | UK (chemical industry) | Panel (1989-1999) | TFP | - Exporters more productive than non-exporters<br>- Probability of export entry is increasing in the level of TFP<br>- Learning-by-exporting strongest among new entrants, and is weaker for firms with more past export experience and negative for established exporters |
| Hahn (2004) | Republic of Korea | | Labour productivity; TFP | - Labour productivity and TFP higher for exporters than non-exporters<br>- Labour productivity (but not TFP) higher in entrants prior to entry than in non-entrants<br>- Export starters widen TFP gap with never exporters and close gap with always exporters<br>- Export stoppers show a decrease in TFP i absolute terms and relative to always exporters, starters and never exporters both before and after exit. |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| Hansson and Lundin (2004) | Sweden | Panel (1990-1999) | Labour productivity; TFP | - Productivity higher for exporters than for non-exporters<br>- Labour productivity and TFP higher for future starters two years before entry, but lower three years before<br>- Differences in growth of TFP and labour productivity of new exporters not significantly different from non-exporters prior to exporting<br>- No significant differences in TFP growth between various export groups and non-exporters<br>- Starters' labour productivity growth higher than non-exporters' |
| Mengistae and Pattillo (2004) | Ethiopia, Ghana and Kenya | Panel (1992-1995) | TFP | - Exporters tend to be larger than non-exporters and to have been in business longer. They also tend to hold more foreign equity, to be more likely to operate using foreign licenses or enter into technical assistance arrangements, and consume more imported intermediate goods<br>- The level and growth rate of TFP is higher for exporters than for non-exporters<br>- While the impact is large and significant for direct exporters, there is no significant effect for indirect exporters<br>- The exporting effect is largest for firms that are direct exporters to regions outside of Africa<br>- The impact of exporting varies across countries, tending to be largest for Kenya and smallest for Ghana |
| Alvarez and Lopez (2005) | Chile | Panel (1990-1996) | Labour productivity; TFP | - Labour productivity higher in export than in non-export firms<br>- Productivity differential differs significantly between industries<br>- Firms that enter export markets have higher productivity and TFP than non-exporters<br>- Differences in productivity and TFP growth insignificant or negative for export starters compared to non-exporters. |
| Arnold and Hussinger (2005) | Germany | Panel (1992-2004) | TFP | - TFP higher for exporters than for non-exporters<br>- Higher productivity firms are more likely to be exporters<br>- Prior to entry future exporters experience an increase in TFP (productivity Granger causes exporting)<br>- Productivity gap between exporters and non-exporters does not widen over time (exporting does not Granger cause productivity)<br>- For matched firms there are no differences in levels or growth rates of TFP between exporters and non-exporters in the years after entry |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| Greenaway, Gullstrand and Kneller (2005) | Sweden | Panel (1980-1997) | Labour productivity; TFP | - Labour productivity higher for exporters than for non-exporters<br>- TFP lower for exporters than for non-exporters, becoming positive when industry fixed effects included<br>- TFP lower for starters in the year of entry than for never exporters<br>- For matched firms first time entry into export markets is not associated with faster TFP growth compared to non-exporters |
| Van Biesebroeck (2005) | Nine SSA countries: Burundi; Cameroon; Cote d'Ivoire; Ethiopia; Ghana; Kenya; Tanzania; Zambia; Zimbabwe. Roughly 200 firms in each country | Panel (1992-1996) | Labour productivity; Wages; Capital intensity; Investment rate; Firm size | - Exporting firms pay higher wages, produce more output per worker, produce more capital-intensively, have higher investment rates and operate at a larger scale<br>- The level and growth rate of labour productivity is higher for exporters than for non-exporters<br>- Labour productivity higher for export starters than for non-exporters prior to entry<br>- Labour productivity not different between newly entered and continuous exporters, but higher compared to non-exporters<br>- Labour productivity lower in export-stoppers than in continuous exporters, but higher than in non-exporting firms<br>- Returns to scale are an important explanation for the productivity gap, with exporters having exhausted scale economies |
| Yasar, Nelson and Rejesus (2006) | Turkey | Panel (1990-1996) | Labour productivity | - Export premia of around 19% based on OLS estimates<br>- Export premia differs across quantiles, being larger in larger firms<br>- Productivity highest for continuous exporters, compared to non-exporters and firms that change their export status<br>- Productivity higher for new exporters compared with non-exporters (the effect again being higher at higher quantiles)<br>- Productivity higher in export exiters compared with non-exporters |
| Bernard, Jensen, Redding and Schott (2007) | USA | Cross-section (2002) | Employment; Sales; Value-added per worker; TFP; Wages; Capital per worker; Skill per worker | - In bivariate regressions exporters have higher values of all variables than non-exporters<br>- Such differences persist after controlling for industry fixed effects and firm size |
| De Loecker (2007) | Slovenia | Panel (1994-2002) | Labour productivity | - For matched firms that begin to export productivity is immediately improved |
| Farinas and Martin-Marcos (2007) | Spain | Panel (1990-1999) | Labour productivity; TFP | - Labour productivity and TFP higher for exporters than for non-exporters |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| | | | | - Labour productivity higher for new exporters prior to entry when compared with non-exporters<br>- Labour productivity of new exporters significantly higher than that of non-exporters<br>- Growth of labour productivity and TFP not different between new exporters and non-exporters<br>- The level of labour productivity and the growth rates of productivity and TFP for exiting exporters are not significantly different from non-exporters |
| Fryges and Wagner (2007) | Germany | Panel (1995-2005)<br>Generalized Propensity Score (GPS) | Labour productivity | - An inverted U-shaped relationship between labour productivity growth and a firm's export-sales ratio<br>- Exporting improves labour productivity growth only within a sub-interval of firm's export-sales ratio<br>- At an export-sales ratio of 19% a firm's export activity have a causal effect on its labour productivity growth |
| Graner and Isaksson (2007) | Kenya | 1992-1994 | Technical efficiency | - Exporters are larger and use more physical and human capital<br>- Firm efficiency is higher among exporters than non-exporters<br>- The destination of exporters matter: exports to African generate learning, but not exports to the North |
| Greenaway and Kneller (2007) | UK | Panel (1990-1998)<br>Matching estimator | TFP | - Exporters have significantly higher levels of TFP, employment and productivity than non-exporters<br>- Probability of export entry is increasing in the level of TFP<br>- For matched firms productivity growth in new exporters is faster than in non-exporters<br>- Effect is lower in industries in which (i) firms are exposed to high levels of trade and IIT; (ii) exposure to foreign firms is greater |
| Harris and Li (2007) | UK | Panel (1996-2004) | Labour productivity | - Firms that are older, possess intangible assets and have higher productivity in the year prior to exporting are more likely to sell overseas<br>- Post-entry productivity improvement for firms entering export markets<br>- A negative productivity effect for exiting firms<br>- Large productivity increases while exporting for both export starters and exiters |
| Yasar and Morrison Paul (2007a) | Five transition economies (Moldova, Poland, Tajikistan, | Cross-section dataset | Labour productivity; TFP; Output; Capital input; Capital | - Firms with a foreign ownership share are more productive than their domestic counterparts |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| | Uzbekistan, Kyrgyz Republic). Sample of 437 firms YEARS | | input per worker; Wages by employment type; Employment by employment type; Share of sales exported; Share of materials imported; Whether the firm developed/upgraded a new product line or introduced a new technology; Whether firm regularly uses the internet or email in interactions with clients and suppliers | - Such firms are larger, pay more, hire more and have a greater export share of sales and import share of materials<br>- Industry presence of foreign affiliates of MNCs leads to performance improvements for domestic firms |
| Crespi et al. (2008) | UK | Panel (1994-2000) | Labour productivity; Learning from customers | - Firms who exported in the past are more likely to learn from clients<br>- Firms who learned from clients in the past are more likely to have higher productivity<br>- Past productivity growth is not related to learning from clients and past learning is not associated with more exporting |
| Hagemejer and Kolasa (2008) | Poland | | | |
| Bigsten and Gebreeyesus (2009) | Ethiopia | Panel (1996-2005)<br>Matching Estimator | Employment; Wages; Capital per worker; Labour productivity; TFP | - Fewer than 5% of firms exported, with the percentage of exports in manufacturing being less than 8%<br>- Exporters tend to have more workers, pay higher wages, employ more capital per worker and produce more output per worker<br>- Wages, output per worker and TFP are higher in exporters<br>- Firms that always exported, new exporters and export switchers performed better than those never exporting<br>- New exporters performed better than non-exporters prior to exporting, with the gap widening after entry<br>- Previous export experience has a positive impact on performance |
| Blalock and Gertler (2009) | Indonesian manufacturing firms | Panel data (1988-1996)<br>Indicator of FDI presence is calculated by industry and region | Productivity (translog production function) | - Productivity of firms is increasing in the share of foreign ownership<br>- Productivity of domestic firms increases with the share of foreign presence in an industry<br>- Firms with greater absorptive capacity and firms with highly educated employees are able to adopt more technology from foreign entrants than others<br>- Firms that have a narrow technology gap benefit less than firms with weak prior technical competency |

| Study | Sample | Method / Data | Dependent variable(s) | Results |
|---|---|---|---|---|
| Buyinza (2009) | Uganda,<br>300 manufactured firms | Panel (2000-2005) | TFP | - Firm export status have a positive and significant effect on firm productivity<br>- Former export status, firm size, firm sales and education of managers has a positive influence on the export decision, while firm age has a negative impact |
| Andersson and Lööf (2009) | Sweden (approximately 5000 firms per year) | Panel (1997-2004) | Labour productivity | - Exporting firms are more productive than firms serving only the domestic market<br>- Persistent exporters are more productive than temporary exporters, and persistent exporters with high export intensity are more productive than other firms<br>- Relationship between productivity and variable reflecting persistent exporters with high export intensity is positive and significant<br>- While persistence and high export intensity required for large firms to benefit from LBE, persistence is sufficient for small firms |
| Boermans (2010) | Ghana, Kenya, Nigeria, Tanzania, South Africa | Panel (1991-2003); Matched difference-in-difference | TFP; firm size and age; capital intensity; wages; skilled labour | - Exporting firms are bigger, older, more capital-intensive, pay higher wages and employ higher-skilled workers<br>- Exporters outside of Africa are bigger, more capital-intensive and pay wages than intra-African exporters<br>- Results support both self-selection and learning-by-exporting when considering productivity growth and other performance measures<br>- Exporting outside Africa leads to more capital-intensive production.<br>- Exporting within Africa leads to a downsizing on relative capital investment and these firm-level adjustments including hiring more (low-skilled) employees at higher wages strongly decreases firm productivity. |

*Source:* Adapted and updated from Wagner (2005).

Table A2

## Summary table of existing evidence on intra-industry spillovers from FDI

| Study | Country | Year(s) | Data Type | Aggregation | Result |
|---|---|---|---|---|---|
| Caves (1974) | Australia | 1966 | Cross-section | Industry | + |
| Globerman (1979) | Canada | 1972 | Cross-section | Industry | + |
| Blomström and Persson (1983) | Mexico | 1970 | Cross-section | Industry | + |
| Blomström (1986) | Mexico | 1970/1975 | Cross-section | Industry | + |
| Haddad and Harrison (1993) | Morocco | 1985-1989 | Panel | Micro and Industry | ? |
| Blomström and Wolff (1994) | Mexico | 1970/1975 | Cross-section | Industry | + |
| Kokko (1994) | Mexico | 1970 | Cross-section | Industry | + |
| Kokko (1996) | Mexico | 1970 | Cross-section | Industry | + |
| Kokko et al. (1996) | Uruguay | 1990 | Cross-section | Micro | ? |
| Blomstrom and Sjöholm (1999) | Indonesia | 1991 | Cross-section | Micro | + |
| Sjöholm (1999a) | Indonesia | 1980-1991 | Cross-section | Micro | + |
| Sjöholm (1999b) | Indonesia | 1980-1991 | Cross-section | Micro | + |
| Chuang and Lin (1999) | Taiwan | 1991 | Cross-section | Micro | + |
| Aitken and Harrison (1999) | Venezuela | 1976-1989 | Panel | Micro | - |
| Asanoglu (2000) | Turkey | 1993 | Cross-section | Industry | ? |
| | | | | | |
| Djankov and Hoekman (2000) | Czech Republic | 1993-1996 | Panel | Micro | - |
| Kathuria (2000) | India | 1976-1989 | Panel | Micro | ? |
| Liu et al. (2000) | UK | 1991-1995 | Panel | Industry | + |
| Zukowska-Gagelmann (2000) | Poland | 1993-1997 | Panel | Micro | - |
| Bosco (2001) | Hungary | 1993-1997 | Panel | Micro | ? |
| | | | | | |
| Driffield (2001) | UK | 1989-1992 | Cross-section | Industry | + |
| Feinberg and Majumdar (2001) | India | 1980-1994 | Panel | Firms | ? |
| Girma et al. (2001) | UK | 1991-1996 | Panel | Micro | ? |
| Girma and Wakelin (2001) | UK | 1980-1992 | Panel | Micro | ? |
| Harris and Robinson (2003) | UK | 1974-1995 | Panel | Micro | ? |
| Kathuria (2001) | India | 1975-1989 | Panel | Micro | ? |
| Kinoshita (2001) | Czech Republic | 1995-1998 | Panel | Micro | ? |
| Kokko et al. (2001) | Uruguay | 1988 | Cross-section | Micro | ? |
| Konings (2001) | Bulgaria, Poland, Romania | 1993-1997 | Panel | Micro | - for Bulgaria and Romania, ? for Poland |
| Kugler (2001) | Colombia | 1974-1988 | Panel | Industry | ? |
| Sgard (2001) | Hungary | 1992-1999 | Panel | Micro | + |
| Barrios and Strobl (2002) | Spain | 1990-1994 | Panel | Micro | ? |
| Buckley et al. (2002) | China | 1995 | Cross-section | Industry | + |
| Castellani and Zanfei (2002) | France, Italy, Spain | 1992-1997 | Panel | Micro | + for Italy, - for Spain, ? for France |
| Dimelis and Louri (2002) | Greece | 1997 | Cross-section | Micro | + |
| Girma (2005) | UK | 1989-1999 | Panel | Micro | ? |
| Görg and Strobl (2005) | Ghana | 1991-1997 | Panel | Micro | + |

| Study | Country | Year(s) | Data Type | Aggregation | Result |
|---|---|---|---|---|---|
| Liu (2002) | China | 1993-1998 | Panel | Industry | + |
| Schoors and van der Tol (2002) | Hungary | 1997-1998 | Cross-section | Micro | ? |
| Bouoiyour (2004) | Morocco | 1987-1996 | Panel | Micro | ? |
| Damijan et al. (2003) | Bulgaria, Czech Republic, Estonia, Hungary, Poland, Romania, Slova-kia, Slovenia | 1994-1998 | Panel | Micro | ? or -,<br>+ only for Romania |
| Girma and Görg (2003) | UK | 1980-1992 | Panel | Micro | ? |
| Görg and Strobl (2003) | Ireland | 1973-1996 | Panel | Micro | + |
| Imbriani and Reganati (2003) | Italy | 1994-1996 | Panel | Micro | ? |
| Barrios (2000) | Spain | 1990-1994 | Panel | Micro | ? |
| Khawar (2003) | Mexico | 1990 | Cross-section | Micro | ? |
| Rattsø and Stokke (2003) | Thailand | 1975-1996 | Panel | Industry | ? |
| Wei and Liu (2003) | China | 2000 | Cross-section | Micro | + |
| Yudaeva et al. (2003) | Russia | 1993-1997 | Panel | Micro | + |
| Barrios et al. (2004) | Greece, Ireland, Spain | 1992, 1997 | Cross-section | Micro | ? |
| Driffield (2004) | UK | 1983-1997 | Panel | Micro | - |
| Karpaty and Lunderberg (2004) | Sweden | 1990-2000 | Panel | Micro | + |
| Lutz and Talavera (2004) | Ukraine | 1998-1999 | Panel | Micro | + |
| Sinani and Meyer (2004) | Estonia | 1994-1999 | Panel | Micro | + |
| Smarzynska-Javorcik (2004) | Lithuania | 1996-2000 | Panel | Micro | ? |
| Barry et al. (2005) | Ireland | 1990-1998 | Panel | Micro | - |
| Dimelis (2005) | Greece | 1992, 1997 | Cross-section | Micro | + |
| Girma (2005) | UK | 1989-1999 | Panel | Micro | ? |
| Ruane and Ugur (2005) | Ireland | 1991-1998 | Panel | Micro | ? |
| Takii (2005) | Indonesia | 1990-1995 | Panel | Micro | + |
| Thuy (2005) | Vietnam | 1995-2002 | Panel | Micro | + |
| Jordaan (2005) | Mexico | 1993 | Cross-section | Micro | ? |
| Vahter (2005) | Estonia and Slovenia | 1196-2001; 1994-2000 | Panel | Micro | ? |
| Vahter and Masso (2007) | Estonia | 1995-2000 | Panel | Micro | ? |
| Bwalya (2006) | Zambia | 1993-1995 | Panel | Micro | ? |
| DePropris and Driffield (2006) | UK | 1993-1998 | Panel | Micro | - |
| Todo and Miyamoto (2006) | Indonesia | | Panel | Micro | ? |
| Wei and Liu (2006) | China | 1998-2000 | Panel | Micro | + |
| Buckley et al. (2007) | China | 1995 | Cross-section | Industry | +/- |
| Driffield and Love (2007) | UK | 1987-1997 | Panel | Industry | + |
| Flôres et al. (2007) | Portugal | 1992-1995 | Panel | Industry | ? |
| Hale and Long (2007) | China | 2001 | Cross-section | Micro | ? |
| Halpern and Muraközy (2007) | Hungary | 1996-2003 | Panel | Micro | ? |
| Haskel et al. (2007) | UK | 1973-1992 | Panel | Micro | + for industry spillovers/<br>? for regional spillovers |
| Murakami (2007) | Japan | 1994-1998 | Panel | Micro | - |
| Tian (2007) | China | 1996-1999 | Panel | Micro | ? |

| Study | Country | Year(s) | Data Type | Aggregation | Result |
|---|---|---|---|---|---|
| Yasar and Morrison Paul (2007) | Poland, Moldova, Tajikistan, Uzbekistan, Kyrgyz Republic | 2003 | Cross-section | Micro | + |
| Chudnovsky et al. (2008) | Argentina | 1992-2001 | Panel | Micro | ? |
| Cuyvers et al. (2008) | Cambodia | 2002-3 | Cross-section | micro | + |
| Liu (2008) | China | 1995-1999 | Panel | Micro | - |
| Petroulas (2008) | Greece | 2002-2006 | Panel | Micro | ? |
| Keller and Yeaple (2009) | USA | 1987-1996 | Panel | Micro | + |

*Notes:* This is an updated version of that in Görg and Greenaway (2004) and Meyer and Sinani (2009).
Micro refers to firm, plant or establishment level data.
A + indicates a finding of a positive and significant effect, - a negative and significant effect, and ? indicates mixed results or a statistically insignificant effect on the foreign presence variable for the aggregate sample.

Table A3

## Summary table of existing evidence on vertical spillovers from FDI

| Study | Country | Year(s) | Data Type | Aggregation | Horizontal | Backward | Forward |
|---|---|---|---|---|---|---|---|
| Kugler (2001) | Colombia | 1974-1998 | Panel | Industry | ? | Many + | n.a. |
| Driffield et al. (2002) | UK | 1984-1992 | Panel | Industry | ? | ? | + |
| Harris and Robinson (2003) | UK | 1974-1995 | Panel | Micro | ? | ? | ? |
| Javorcik (2004) | Lithuania | 1996-2000 | Panel | Micro | ? | + | n.a. |
| Blalock and Gertler (2003) | Indonesia | 1988-1996 | Panel | Micro | ? | + | n.a. |
| Javorcik et al. (2004) | Romania | 1998-2000 | Panel | Micro | n.a. | ? (+ for MNCs whose head-quarters are far away) | n.a. |
| Sasidharan (2006) | India | 1994-2002 | Panel | Micro | ? | ? | ? |
| Blake et al. (2009) | China | 2000 | Panel | Micro | ? | ? | ? |

*Notes:* This is an updated version of that in Görg and Greenaway (2004).
See Table A2.
Kugler (2001) and Harris and Robinson (2003) do not distinguish backward and forward spillovers.
n.a. – not applicable.

Table A4

## Summary table of existing evidence on wage spillovers from FDI

| Study | Country | Year(s) | Data Type | Aggregation | Result |
|---|---|---|---|---|---|
| Aitken et al. (1996) | Mexico, Venezuela, USA | 1984-1990 | Panel, cross-section for USA | Industry | -, + for USA |
| Lipsey and Sjöholm (2001) | Indonesia | 1996 | Cross-section | Micro | + |
| Girma et al. (2001) | UK | 1991-1996 | Panel | Micro | ? |
| Driffield and Girma (2003) | UK | 1980-1992 | Panel | Micro | ? |

*Notes:* This is an updated version of that in Görg and Greenaway (2004).
See Table A2.

Table A5

### Summary table of existing evidence on export spillovers from FDI

| Study | Country | Year(s) | Data Type | Aggregation | Result |
|---|---|---|---|---|---|
| Aitken et al. (1997) | Mexico | 1986, 1989 | Cross-section | Micro | + |
| Kokko et al. (2001) | Uruguay | 1998 | Cross-section | Micro | ? |
| Greenaway et al. (2004) | UK | 1992-1996 | Panel | Micro | + |
| Banga (2003) | India | 1994-2000 | Panel | Micro / Industry | + |
| Barrios et al. (2003) | Spain | 1990-1998 | Panel | Micro | ? |

*Notes:* This is an updated version of that in Görg and Greenaway (2004).
See Table A2.

# Short list of the most recent wiiw publications (as of August 2012)

For current updates and summaries see also
wiiw's website at www.wiiw.ac.at

### Innovation and Technology Transfer across Countries

by Neil Foster

wiiw Research Reports, No. 380, August 2012
117 pages including 20 Tables and 37 Figures
hardcopy: EUR 24.00 (PDF: free download from wiiw's website)

---

### Sectoral Employment Effects of Economic Downturns

by Robert Stehrer, Terry Ward et al.

wiiw Research Reports, No. 379, August 2012
246 pages including 64 Tables and 39 Figures
hardcopy: EUR 24.00 (PDF: free download from wiiw's website)

---

### Surveying Romanian Migrants in Italy Before and After the EU Accession: Migration Plans, Labour Market Features and Social Inclusion

by Isilda Mara

wiiw Research Reports, No. 378, July 2012
136 pages including 39 Tables and 112 Figures
hardcopy: EUR 24.00 (PDF: free download from wiiw's website)

---

### Fasting or Feasting? Europe – Old and New – at the Crossroads

by Leon Podkaminer, Kazimierz Laski, Peter Havlik, Hermine Vidovic, Doris Hanzl-Weiss, Michael Landesmann et al.

wiiw Current Analyses and Forecasts. Economic Prospects for Central, East and Southeast Europe, No. 10, July 2012
150 pages including 31 Tables and 17 Figures
hardcopy: EUR 80.00 (PDF: EUR 65.00)

---

### wiiw Monthly Report 7/12

edited by **Leon Podkaminer**

- Financial balances of the private, foreign and public sectors: long-term tendencies for the European Union
- Labour hoarding during the crisis: Evidence for selected new member states from the Financial Crisis Survey
- The European banking crisis and spillover effects in the countries of CESEE revisited
- Statistical Annex: Selected monthly data on the economic situation in Central, East and Southeast Europe

wiiw, July 2012
30 pages including 11 Tables and 14 Figures
(exclusively for subscribers to the wiiw Service Package)

---

**Wirtschaftsentwicklung divergiert in den kommenden Jahren auch in Mitteleuropa, Ost- und Südosteuropa zwischen Norden und Süden**

by **Vasily Astrov, Doris Hanzl-Weiss, Mario Holzner and Sebastian Leitner**

wiiw Research Papers in German language, June 2012
(reprinted from: WIFO-Monatsberichte, Vol. 85, No. 5, May 2012)
10 pages including 5 Tables and 4 Figures
hardcopy: EUR 8.00 (PDF: free download from wiiw's website)

---

**Labour Hoarding during the Crisis: Evidence for selected New Member States from the Financial Crisis Survey**

by **Sandra M. Leitner and Robert Stehrer**

wiiw Working Papers, No. 84, June 2012
17 pages including 10 Tables and 1 Figure
hardcopy: EUR 8.00 (PDF: free download from wiiw's website)

---

**Bilateral Exchange Rates and Jobs**

by **Eddy Bekkers and Joseph Francois**

wiiw Working Papers, No. 83, June 2012
31 pages including 2 Tables and 3 Figures
hardcopy: EUR 8.00 (PDF: free download from wiiw's website)

---

**Import Prices, Income, and Inequality**

by **Eddy Bekkers, Joseph Francois and Miriam Manchin**

wiiw Working Papers, No. 82, June 2012
44 pages including and 4 Tables
hardcopy: EUR 8.00 (PDF: free download from wiiw's website)

---

**Trade in Value Added and the Valued Added in Trade**

by **Robert Stehrer**

wiiw Working Papers, No. 81, June 2012
20 pages including 7 Tables and 1 Figure
hardcopy: EUR 8.00 (PDF: free download from wiiw's website)

---

**wiiw Monthly Report 6/12**

edited by **Leon Podkaminer**

- The transformation of international financial markets and the future of the eurozone
- The harmonization of banking supervision: a chokehold
- The impact of offshoring on the skill structure of labour demand
- Statistical Annex: Selected monthly data on the economic situation in Central, East and Southeast Europe

wiiw, June 2012
30 pages including 15 Tables and 4 Figures
(exclusively for subscribers to the wiiw Service Package)

---

**Value Added and Factors in Trade: A Comprehensive Approach**

by **Robert Stehrer, Neil Foster and Gaaitzen de Vries**

wiiw Working Papers, No. 80, June 2012
23 pages including 9 Tables
hardcopy: EUR 8.00 (PDF: free download from wiiw's website)

---

**wiiw Database on Foreign Direct Investment in Central, East and Southeast Europe, 2012: Short-lived Recovery**

by **Gábor Hunya**. Database and layout by **Monika Schwarzhappel**

wiiw Database on Foreign Direct Investment in Central, East and Southeast Europe, May 2012
142 pages including 109 Tables and 8 Figures
hardcopy: EUR 70.00 (PDF: EUR 65.00), CD-ROM (including hardcopy): EUR 145.00

---

**International Spillovers in a World of Technology Clubs**

by Roman Stöllinger

wiiw Working Papers, No. 79, May 2012
25 pages including 8 Tables and 3 Figures
hardcopy: EUR 8.00 (PDF: free download from wiiw's website)

---

**wiiw Monthly Report 5/12**

edited by **Leon Podkaminer**

- Interim Romanian government sworn in: any room for manoeuvring?
- Croatia's EU membership: lessons from earlier accessions
- The cold civil war in Poland
- Statistical Annex: Selected monthly data on the economic situation in Central, East and Southeast Europe

wiiw, May 2012
22 pages including 8 Tables
(exclusively for subscribers to the wiiw Service Package)

---

**Convergence of Knowledge-intensive Sectors and the EU's External Competitiveness**

by Robert Stehrer et al.

wiiw Research Reports, No. 377, April 2012
123 pages including 30 Tables and 60 Figures
hardcopy: EUR 8.00 (PDF: free download from wiiw's website)

---

**wiiw Monthly Report 4/12**

edited by **Leon Podkaminer**

- Slovakia after the elections
- Labour market issues in Europe's Eastern and Western Balkan neighbours
- Net private savings in relation to the government's financial balance
- Statistical Annex: Selected monthly data on the economic situation in Central, East and Southeast Europe

wiiw, April 2012
28 pages including 10 Tables and 4 Figures
(exclusively for subscribers to the wiiw Service Package)

---

**wiiw Service Package**

The Vienna Institute offers to firms and institutions interested in unbiased and up-to-date information on Central, East and Southeast European markets a package of exclusive services and preferential access to its publications and research findings, on the basis of a subscription at an annual fee of EUR 2,000.

This subscription fee entitles to the following package of **Special Services**:

– A free invitation to the Vienna Institute's **Spring Seminar**, a whole-day event at the end of March, devoted to compelling topics in the economic transformation of the Central and East European region (for subscribers to the wiiw Service Package only).

– Copies of, or online access to, ***The Vienna Institute Monthly Report***, a periodical consisting of timely articles summarizing and interpreting the latest economic developments in Central and Eastern Europe and the former Soviet Union. The statistical annex to each *Monthly Report* contains, alternately, country-specific tables or graphs with monthly key economic indicators, economic forecasts, the latest data from the wiiw Industrial Database and excerpts from the wiiw FDI Database. This periodical is not for sale, it can only be obtained in the framework of the wiiw Service Package.

– Free copies of the Institute's ***Research Reports*** (including ***Reprints***), ***Current Analyses and Forecasts***, ***Country Profiles*** and ***Statistical Reports***.

– A free copy of the ***wiiw Handbook of Statistics*** (published in October/November each year and containing more than 400 tables and graphs on the economies of Albania, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Montenegro, Poland, Romania, Russia, Serbia, the Slovak Republic, Slovenia and Ukraine)

– Free online access to the **wiiw Monthly Database**, containing more than 1200 leading indicators monitoring the latest key economic developments in ten Central and East European countries.

– **Consulting**. The Vienna Institute is pleased to advise subscribers on questions concerning the East European economies or East-West economic relations if the required background research has already been undertaken by the Institute. We regret we have to charge extra for *ad hoc* research.

– Free access to the Institute's specialized economics library and documentation facilities.

Subscribers who wish to purchase wiiw data sets **on CD-ROM** or special publications not included in the wiiw Service Package are granted considerable **price reductions**.

**For detailed information about the wiiw Service Package**
**please visit wiiw's website at www.wiiw.ac.at**

To
The Vienna Institute
for International Economic Studies
Rahlgasse 3
A-1060 Vienna

- O Please forward more detailed information about the Vienna Institute's Service Package
- O Please forward a complete list of the Vienna Institute's publications to the following address

Please enter me for

- O 1 yearly subscription of *Research Reports* (including *Reprints*) at a price of EUR 120.00 (hardcopy, Austria), EUR 135.00 (hardcopy, Europe), EUR 155.00 (hardcopy, overseas) and EUR 48.00 (PDF download with password) respectively
- O 1 yearly subscription of *Current Analyses and Forecasts* a price of EUR 150.00 (hardcopy, Austria), EUR 155.00 (hardcopy, Europe), EUR 170.00 (hardcopy, overseas) and EUR 120.00 (PDF download with password) respectively

Please forward

- O the following issue of *Research Reports* ..........................................................................................
- O the following issue of *Current Analyses and Forecasts* ......................................................................
- O the following issue of *Working Papers* ..........................................................................................
- O the following issue of *Research Papers in German language* ...........................................................
- O the following issue of *wiiw Database on Foreign Direct Investment* ..................................................
- O the following issue of *wiiw Handbook of Statistics* ............................................................................
- O (other) ..............................................................................................................................

.............................................................................................................................................................

Name

.............................................................................................................................................................

Address

.............................................................................................................................................................

Telephone Fax E-mail

........................................................... ...........................................................

Date Signature

---

Herausgeber, Verleger, Eigentümer und Hersteller:
Verein „Wiener Institut für Internationale Wirtschaftsvergleiche“ (wiiw),
Wien 6, Rahlgasse 3
ZVR-Zahl: 329995655
Postanschrift: A-1060 Wien, Rahlgasse 3, Tel: [+431] 533 66 10, Telefax: [+431] 533 66 10 50
Internet Homepage: www.wiiw.ac.at

P.b.b. Verlagspostamt 1060 Wien