# *Chapter 6*

# Facilitating North-South Knowledge Sharing: Conditions for Enhanced Knowledge Flows

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*This chapter discusses framework conditions needed to enhance North-South knowledge flows through the transfer of intellectual property, trade and foreign direct investment (FDI). These conditions include mechanisms for investing in human capital, outward-oriented trade policies and FDI policies that do not discriminate against local firms. As well as investing in education, science and technology, and R&D to enhance absorptive capacity for knowledge transfer, needs are identified for technological infrastructure, socioeconomic infrastructure, productive capacity and a national orientation, including transparent regulation, low risk and support for entrepreneurship. Specific incentives for FDI are also discussed.*

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## Introduction

Most of the world's commercial technology is produced by multinational corporations (MNCs) in developed countries. Most economies, developed as well as developing, rely to a great extent on these companies for the development of technology, productivity and real income. Some of the technology flows that occur take the form of arm's-length sales of licences, royalties and patent rights, but an even larger share of the aggregate technology flows takes place through trade in other goods and services and foreign direct investment (FDI) flows. Trade relations contribute to technology diffusion both as a result of the knowledge flows that accompany long-term trade relations, and because much technology is embodied in traded capital goods. FDI contributes directly to international technology diffusion, as foreign MNCs transfer technology to their foreign affiliates, and indirectly, as the technologies and practices employed by affiliates are diffused to local firms in the host countries.

The objective of this chapter is to discuss the broad framework conditions necessary to facilitate these kinds of international technology flows. It looks first at the market for technology, and then summarises some of the evidence of knowledge flows through international trade and FDI. Next, it asks what is required in terms of policy to enhance these knowledge flows: the main factors are arguably related to investments in human capital, outward-oriented trade policies, and FDI policies that do not discriminate against local firms. A brief conclusion follows.

## International technology flows: A review of the evidence

### *The technology market*

Unlike the markets for most physical commodities, the technology market is difficult to describe and analyse. The main reason, of course, is that "technology" is an inherently abstract concept and therefore difficult to observe and evaluate. None of the available proxies for technology and technology production – such as R&D expenditures, numbers of new patents, payments for licences and royalties, flows of knowledge-intensive services, stocks of capital equipment, and so forth – provides a perfect measure of technology. Simply put, knowledge and technology can take many forms, embodied as well as disembodied. Consequently, there are many different channels for transfers of technology from producers to users. To add further complications, markets for knowledge and technology are generally not very efficient. The reason is that buyers and sellers of technology often fail to agree about mutually acceptable prices. While potential sellers of technology may well have a good sense of the value of a specific technology, it is hard for a potential buyer to estimate the value without understanding the specifics of the technology. If the potential buyer is given the information necessary for assessing the value, he or she may be unwilling to pay the price. Having received all the relevant information, the buyer has already absorbed the relevant knowledge, whether or not a formal sale is agreed: it is difficult to guarantee "unlearning", *i.e.* ensuring that none of the knowledge transferred to the potential buyer is ever used if the technology sale falls through. While it might theoretically be possible to write contracts that reduce the risks borne by technology producers, transaction costs are likely to be very high. Hence, producers of technology are often more likely to "internalise" it (by engaging in vertical integration and using the technologies under their own ownership and control) than to sell it in arm's-length markets (Grossman and Hart, 1986). In fact, these imperfections in

technology markets are often seen as the main reasons for FDI and the existence of MNCs (Caves, 1996).

Against this backdrop, it is perhaps not surprising that more emphasis has been put on measuring inputs into technology production than on formal transactions on the technology market. In particular, attention has focused on expenditures for research and development (R&D) as an indicator of technology production, although this is only one part of the aggregate production of knowledge and technology in any society. Higher education, software production and investments in machinery and equipment are other important parts of total knowledge production.

A look at global investments in R&D shows that the most notable feature is its concentration in a few developed economies. OECD (2008) reports that the world's total R&D expenditures in 2005 amounted to just below USD 1 000 billion, adjusted for purchasing power. One-third of this was accounted for by the United States, with the EU accounting for one-quarter of the total and Japan adding 13%. Taken together, the share of the OECD reached nearly 80%, with most of this registered by only five countries – in addition to the United States and Japan, they are Germany, France and the United Kingdom. The only non-OECD countries with notable shares were China (with nearly 12%) and India, Brazil, Russia and Chinese Taipei (with a combined 6%). A similar picture applies for research and higher education, as well as patent applications, one of the few tangible (although very imprecise) measures of the results of investments in R&D. One of the few areas in which the dominance of the large OECD countries has been diminishing is the export of high-technology products, as China has rapidly captured a large market share. Between 1999 and 2005, China more than doubled its market share in world exports of high-technology manufactures; its share grew from 8% to 19% and it established itself as the world's largest exporter in that product category (NSB, 2008).

Apart from a strong concentration across countries, there is also a significant concentration of technology production in a small number of industries and companies headquartered in the OECD area. The industries with the largest R&D expenditures are computers and electronic products (including telecommunications equipment), chemicals (including pharmaceuticals), computer-related services (including software), aerospace and defence manufacturing, R&D services, and automotive manufacturing (NSB, 2008). In each of these industries, significant shares are held by a few very large producers. In 2004, the top 25 R&D-spending corporations invested about USD 175 billion, more than what the entire non-OECD world spent on R&D (NSB, 2008). Moreover, a significant share of the R&D performed outside the leading OECD economies is actually controlled by MNCs headquartered in countries such as the United States, Japan, Germany and the United Kingdom. Academic knowledge production has a similar concentration in a few of the larger OECD countries.

Hence, developing countries, as well as smaller OECD economies, are to a great extent dependent on the knowledge created in the larger OECD countries. This chapter focuses on FDI and trade as channels for the diffusion of knowledge and technology from the main research producers to the rest of the world. There are other important diffusion channels, but they are only discussed parenthetically here. The movement of people is perhaps the most important channel for knowledge flows in an historical perspective. The mobility of students and researchers across international boundaries may be the most significant part of this today, but the mobility of entrepreneurs has been highly important in the past. There are also less formal types of knowledge flows that emerge when people move across international borders for business and tourism. The mass media play an

important role, diffusing information about products, processes and technologies through newspapers, books, TV and radio broadcasts, and, increasingly, through the Internet and other telecommunications channels.

Although trade in goods, formal technology transactions, and FDI are conceptually separate, they are difficult to keep apart in any empirical discussion. Since most commercial technology is produced by MNCs, it is clear that MNCs will also figure prominently in international trade in goods as well as technology. The scattered data that are available on MNC participation in licensing and goods trade are interesting because they confirm that MNCs are the main sources of technology, but also because they indirectly introduce FDI into the picture. MNCs control the supply of technology by virtue of their R&D efforts and their ownership of proprietary technologies, but they also account for a significant share of demand, via their foreign affiliates. This is most apparent for transfers of "disembodied" technology captured by data on trade in royalties, licences and patent rights. About three-quarters of the registered payments to the United States for technology sales in 2005 were made by foreign affiliates of US firms (NSB, 2008). Similar ratios of intra-firm technology payments have been reported for other major technology producers such as Germany and Japan in the 1980s and early 1990s (Kokko, 1992).

The intra-firm character of the technology transfers that take place through trade in capital equipment and other products is less apparent, but still distinguishable. What we know about MNC involvement from statistics on goods trade is that between 70% and 80% of the goods exports of both the United States and the United Kingdom – the main suppliers of embodied technology together with Japan and Germany – are accounted for by MNCs. Moreover, a significant share of the exports and imports of the major home countries (perhaps up to one-third overall, and more for complex and technologically sophisticated goods that supposedly embody more technology) flow between MNC parents and affiliates. A very important part of all formal technology transfers are, therefore, closely tied to FDI.

Recognising that it is probably impossible to keep trade and FDI completely separate, the next section looks at the empirical evidence on technology diffusion and knowledge flows generated through international trade. Thereafter, the focus shifts to the technology flows that can be more directly related to the foreign operations of MNCs.

### *Technology diffusion and trade*

The idea that knowledge is a public good that can diffuse from the producers of knowledge (or the investors in R&D) to other actors in the economy is an important component of endogenous growth theory (Grossman and Helpman, 1991). In addition to the return from their own R&D, which is eventually likely to exhibit diminishing returns, the investors will also benefit from knowledge spillovers from the existing stock of knowledge, which is growing over time. A consequence of knowledge spillovers is that the economy's growth rate may not necessarily fall as the stock of knowledge grows (as neoclassical growth theory would assume) but may instead be sustained at a permanently high level.

These knowledge spillovers also have an international dimension: knowledge created through R&D in one country can diffuse to other countries. The first empirical studies on international R&D spillovers in the endogenous growth tradition focused on international trade in intermediate goods as the main channel for international knowledge spillovers. By weighting measures of foreign R&D stocks with bilateral import shares, Coe and

Helpman (1995) examined how domestic total factor productivity (TFP) was affected by exposure to foreign knowledge through imports. Their results supported the idea that knowledge diffuses through trade: imports from countries with large knowledge stocks seemed to raise domestic productivity.

A host of earlier studies have discussed some of the processes that make traded goods effective carriers of technology and knowledge. Imports from R&D-intensive countries may prompt reverse engineering – the practice of taking apart and analysing products, to learn about the technologies embodied in them – which is often recognised as one of the main sources of involuntary technology dissemination (Zander, 1991). One of the few comprehensive quantitative assessments of the importance of imitation and reverse engineering was made by de Melto *et al.* (1980). They report that half of a sample of 280 significant innovations commercialised in Canada between 1960 and 1979 could be characterised as "imitations", and that more than half of these resulted from reverse engineering. Supporting these results, Mansfield *et al.* (1981) found that 60% of the patented innovations in their sample were imitated within four years. Kim and Kim (1985) also presented evidence of imitation and informal technology transfers in 42 Korean firms. Apart from reverse engineering, which essentially creates "unintentional" technology diffusion (from the perspective of the exporter), there are also processes which connect trade to intentional technology transfer. For instance, foreign exporters of sophisticated capital goods often have incentives to provide formal training in order to convince potential customers of the value of their products.

It is also possible that bilateral trade flows are proxies for other types of contacts that contribute to knowledge sharing. The seminal analysis by Coe and Helpman (1995) has therefore been replicated and developed by a large number of other authors. While several of these contributions seem to confirm the central role of imports as a vehicle for international knowledge flows (Lichtenberg and van Pottelsberghe de la Potterie, 1998, Keller, 2000), others focus on more precise measures of international trade or alternative channels for knowledge flows. For instance, one group of studies has argued that overall imports or even manufacturing imports are blunt proxies for technology flows, and that it is more appropriate to look at capital goods (Xu and Wang, 2000), machinery and equipment, particularly for North-South knowledge flows (Coe *et al*., 1997), or machinery alone (Mayer, 2001). Lumenga-Neso *et al.* (2005) point out that a bilateral trade relation not only gives access to the technology created through R&D in the trade partner, but also to all of the knowledge used in the trade partner, even if that knowledge may have been produced in some other country. Hence, previous rounds of imports (which have built up the total knowledge stock and the capacity to export) need to be taken into account. Edmonds (2001) argues that exports are more important than imports, although Keller (2004) downplays this by noting that there is little empirical evidence from micro-data analyses to support the hypothesis that learning by exporting is of great importance. The "conventional wisdom" in this line of research is increasingly that the export premium found in most firm-level productivity analyses is not a result of learning by exporting, but rather a reflection of underlying selection processes (Andersson *et al*., 2008). There are substantial fixed export costs that only the most productive firms are able to overcome. Instead, it is likely that unobstructed access to imports (including embodied and disembodied technology) is a prerequisite for successful export performance, and that liberal trade policies are important to maximise inflows of technology. At the same time, it is necessary to note that exports often result in formal and informal linkages with foreign customers and partners, and that these linkages are likely to be of importance for flows of information and knowledge. This is perhaps most

obvious in cases in which local firms exports as subcontractors or suppliers to foreign firms, and receive technical assistance in order to meet necessary standards of quality and other product characteristics.

An interesting recent addition to this strand of literature is Henry *et al.* (2009), who look not only at how international trade affects knowledge flows from North to South, but also how the ability of countries to make use of foreign technologies differs depending on the economic environment. Like Coe *et al*. (1997), they conclude that imports of machinery and equipment seem to promote North-South knowledge flows. Moreover, in their stochastic frontier analysis, they find that trade policy and openness seems to affect the efficiency with which foreign technologies are employed: more open and outward-oriented countries exhibit higher efficiency. Similarly, Keller (2004) has emphasised the importance of absorptive capacity (mainly in the form of human capital) for the ability of developing countries to access foreign technology.

Broadening the analysis beyond imports and exports, Gong and Keller (2003) and Keller (2004) stress the fact that several different mechanisms for technology diffusion are likely to operate at the same time. These include, for example, geography, communications patterns (such as bilateral language skills) and FDI. Lee (2005) notes that much of the knowledge produced through R&D is intangible, and should not have to be embodied in goods. As an alternative, he looks at the role of telecommunications networks (including the Internet) as channels of knowledge flows. The results suggest that these "direct" effects are more robust than those that require imports of intermediate goods. Focusing specifically on developing countries, Savvides and Zachariadis (2005) also find that the direct effects are strong in comparison with imports of capital goods and FDI. Several studies have concentrated on the R&D spillovers related to FDI. As Keller (2004) and Blomström and Kokko (1998) note, the evidence on the role of FDI appears to be mixed, with plenty of studies showing potential for substantial spillover benefits, but others finding no significant effects. This motivates a closer look at the role of FDI.

Before that, however, it is appropriate to comment on the quantitative importance of foreign R&D for productivity growth. Summarising the results from the literature on R&D spillovers, Keller (2004) notes that estimates vary widely depending on methods and country characteristics. In particular, country size seems to matter. In the larger OECD countries, the weights of domestic and foreign R&D appear to be biased in favour of domestic knowledge; in the smaller OECD countries, the pattern is the opposite. This is consistent with the assumption that there are important scale effects in R&D which benefit larger countries. For small countries, the share of domestic R&D in total productivity increases may be as low as 10%, with the rest accounted for by foreign technology. However, Keller also notes that developing countries may be in a somewhat different position. Although poor countries receive almost all of their technology from abroad – since domestic R&D resources are very small – it might actually be the scarce domestic R&D that is most important for growth. One reason is that much of the modern technology invented in the rich countries may be inappropriate for poor economies, because it is based on the assumption that labour is relatively scarce while capital is relatively abundant. Another reason is that domestic R&D capacity may be necessary to adapt foreign technology to local conditions: it may proxy the need for "absorptive capacity" noted by many authors.

### *Direct and indirect effects of FDI*

As noted above, MNCs undertake a major part of the world's private R&D efforts and produce, own and control most of the world's advanced technology. These R&D and technology investments are heavily concentrated in a few home countries, unlike MNC investment, production and employment which are spread more widely across both industrialised and developing economies. Yet, the assets created through R&D are important ingredients in the foreign production activities of MNCs. One reason is that knowledge and other intangible assets are necessary to overcome the "disadvantages of foreignness" (Hymer, 1960/1976; Luo and Mezias, 2002). Another reason is that intangible assets are difficult to sell in arm's-length markets: a firm that wants to profit from its intangible asset outside the home market may find it is necessary to "internalise" the asset and exploit it through FDI (Cantwell, 1989; Caves, 1996). Hence, by establishing production outside their home countries, MNCs inevitably contribute to the international diffusion of knowledge.

However, it is not obvious exactly how MNC technology reaches new users in foreign markets, and what role MNCs themselves play in the process. FDI differs from arm's-length sales of equipment or licences in that the MNC chooses to retain the control and ownership of its proprietary technologies within the corporation. Is there any significant diffusion of technology to new users or is the MNC affiliate able to protect its technology from spreading to outsiders? And if technology spreads from the MNC affiliates to host country firms, what are the channels of diffusion?

An important finding in this regard is that there is a potential for spillovers of technology to independent local firms, which may be able to improve their own efficiency and productivity as a result of the presence of foreign MNCs. When foreign MNCs set up a subsidiary, they bring some of the firm-specific intangible assets that allow them to compete successfully with local firms. Some of these intangible assets – knowledge and skills related to product and process technologies as well as management, marketing and other aspects of firm operations – can be expected to spill over to local firms over time, as a result of employee turnover, linkages or simple demonstration effects. In fact, technology and productivity spillovers have sometimes been identified as the most important benefits of FDI, particularly for developing countries in which domestic technologies are less advanced than those developed and employed by foreign MNCs. Numerous econometric studies have demonstrated a positive relation between the presence of foreign firms and the productivity of local firms (controlling for various other firm and industry level determinants of productivity) and concluded that this is a sign of positive technology spillovers from FDI (Blomström and Kokko, 1998).

At the same time, there have also been a number of studies which cast some doubt on the hypothesis that all or most host countries may expect to benefit from technology spillovers (Aitken and Harrison, 1999; Görg and Greenaway, 2004). It has been particularly worrying that several studies of transition economies have not yielded any positive evidence of spillovers, considering the high hopes regarding international integration – the most obvious expression of which may be cross-border investment flows – expressed in many of these economies. For instance, Konings (2000) reports that foreign presence had no significant impact on the productivity of local firms in transition economies during the 1990s. Similarly, Damijan *et al*. (2003) conclude that FDI does not generate any positive intra-industry spillovers for domestic firms. The same conclusion is reached by Hale and Long (2007) in a study of Chinese manufacturing. However, Liu and Wang (2003) emphasise foreign presence, together with domestic R&D and firm size, as

the main factors contributing to TFP growth in Chinese industry, while Chuang and Hsu (2004) point to the importance of both international trade and FDI for domestic productivity. Moreover, the latter study highlights the importance of absorptive capacity, noting that spillover effects seem to be larger in sectors with small technology gaps. Liu (2008) also finds that there is a positive impact on productivity growth in local firms following FDI in their four-digit industry classification.

One reason for the mixed results could be methodological: most of the studies finding significant spillovers are cross-section analyses, whereas panel data models have systematically found less significant spillover effects. There is a possible bias in cross-section studies if foreign investors were mainly attracted to the industries that were most productive to begin with – this would give a spurious correlation between foreign presence and local productivity and lead to systematic over-estimation of spillovers.

Another source for a bias in favour of finding signs of spillovers is that cross-section analyses mainly reflect the long-term effects of foreign presence. If foreign MNCs have been present in the host country for a long time, it is likely that only the strongest local firms have survived the competition, while the weakest and least productive locals have already been forced out of business. This is consistent with a process in which some firms survive and grow strong because they are able to learn from the foreigners, *i.e.* because they benefit from spillovers, but the problem is that it is also consistent with other processes leading to productivity growth. For instance, the surviving local firms might have grown stronger because of their own R&D efforts or for other reasons that have nothing to do with technology transfers from foreign MNCs' affiliates. Still, if foreign entry triggers more competition, an econometric analysis would suggest that there is a positive relation between foreign presence and local productivity in both cases. Conversely, in panel studies, it is typically assumed that spillovers materialise instantaneously or with a very short time lag, which is clearly not the case. It takes time and resources before local firms are able to learn about and absorb the technologies employed by foreign firms (Teece, 1976). The main short-run effects may instead be related to competition and capacity utilisation: the new foreign entrants capture a share of the market, which means that less is available for incumbent firms which are likely to appear less productive because they are forced to reduce output with unchanged short-run capacity and capital stock.

There are also differences between studies that explore intra-industry and inter-industry spillovers. More specifically, it appears that foreign MNCs are less defensive in their relations with suppliers, subcontractors and customers than their competitors. Hence, while they may invest in protecting their competitive assets from firms operating in the same industry (Zander, 1991) they are typically engaged in knowledge-sharing arrangements with upstream and downstream partners.

Another reason is that the capability of local firms to absorb spillovers is likely to vary between host countries and industries (Girma, 2005; Kinoshita, 2001; Kokko, 1994; Kokko *et al.*, 1996). It can be assumed that spillovers are more likely when the technological capability of local firms is sufficient to understand and adopt the technologies used by foreign affiliates: in those cases, local firms can use existing knowledge to adapt and adjust foreign technologies for their own purposes. More generally, earlier studies have stressed the importance of local conditions, noting that high education levels, good infrastructure, a strong financial sector, protection of intellectual property rights (IPRs) and other indicators of relatively high development promote spillovers (Rodriguez-Clare, 1996; Javorcik, 2004; Yudaeva *et al.*, 2003). The

level of competition between foreign and local firms also matters. Incentives to learn from foreign firms will clearly be strongest when the foreign and local firms are in direct competition with each other, and when passivity will result in lost market shares and profits (Wang and Blomström, 1992; Kokko, 1996; Sjöholm, 1999).

A question that has been discussed to a lesser extent concerns the "appropriateness" of MNC technology. It has been noted that MNC technology is typically designed for the factor price ratios that apply in rich home countries, where labour is relatively scarce and human and physical capital relatively abundant. Both human and physical capital are in short supply in developing countries, which suggests that it may be uneconomical to apply foreign technologies that require large amounts of these factors: in particular, the skill requirements may be difficult to meet. Moreover, a large difference in relative factors prices – which is often an indication of a large technology gap – is likely to make it more difficult to adapt foreign technologies to local conditions. These arguments suggest that a large technology gap has a negative impact on knowledge flows, because local firms may be unable to absorb advanced foreign knowledge. An implication is that there is substantial potential for South-South knowledge flows from FDI originating in China, India and other dynamic non-OECD countries as these presumably have domestic technologies that are not too far advanced for other developing economies. However, it is possible that foreign MNCs become more concerned about leakages of technology if they only have a small technological advantage over competing local firms. A small technology gap also means that only a limited amount of new knowledge could potentially spill over.

The debate regarding the relation between the size of the technology gap and the ability of local firms to benefit from spillovers continues, and the empirical results are still contradictory. One reason is probably that foreign MNCs' technology choices and the size of the technology gap are in fact dependent on various host country characteristics which also affect the ability and willingness of local firms to invest in learning from foreign investors. For instance, it is helpful to consider the circumstances under which foreign MNCs introduce technologies that are not at all adjusted to local factor prices and production conditions. This would presumably require some form of protection from local competitors: if MNCs operate in a competitive environment, they will have strong motives to select technologies that are well suited to local conditions. With restricted competition, local firms would also have limited incentives to invest in learning, which could well explain the lack of evidence of spillovers in these environments.

A closely related reason for differences in spillovers is that the behaviour and strategies of foreign subsidiaries may vary depending on their role in the multinational corporation. It has, for instance, been suggested that export-oriented affiliates may provide less scope for pure technology spillovers than import-substituting local-market-oriented affiliates (Javorcik, 2004; Kokko *et al*., 2001). While local-market-oriented affiliates typically bring with them technologies that are weak or missing in the host country, export-oriented affiliates are more likely to focus on activities and technologies in which the host country already has a comparative advantage. In these cases, the competitive assets of the MNC may be superior marketing knowledge (related, for instance, to knowledge about foreign preferences or access to existing distribution networks) rather than superior production technology. As a result, there is perhaps no reason to expect positive spillovers of production technology to local firms (although some of the knowledge related to exporting may well spill over).

However, in these cases it is appropriate to keep in mind that the micro and macro effects of FDI may be different. Even if the technology spillovers in import-substituting industries are "larger" in some sense than spillovers in export-oriented industries, they may occur in the wrong sectors. Import substitution occurs in sectors in which the host country has comparative disadvantages and where the chances of ever developing internationally competitive firms may be weak. Even if spillovers improve local productivity in these sectors, it might be better to focus resources in other sectors. This highlights a contradiction between medium-term technical efficiency (because FDI is likely to improve productivity in protected sectors) and long-run allocative efficiency (because there are other sectors with stronger comparative advantages that should get the investments instead). A preliminary conclusion is that there is reason to be very cautious in any policy recommendations based on arguments about spillovers in sectors protected by high trade barriers.

More generally, it has been asserted that MNCs' decisions regarding the amount and kind of technology transferred to subsidiaries are important determinants of the potential for spillovers to local firms (Blomström *et al*., 1994; Sjöholm, 1999). However, the potential for technology spillovers is not only determined by the amount of technology transferred from the parent or other related firms to the affiliate, but also by the affiliate's own capability to innovate. This can be expected to vary depending on the environmental factors that motivate investments in innovative capability and on how much autonomy the parent MNC decides to grant to its affiliate.

A preliminary conclusion from these observations is that while there is potential for substantial spillovers – or knowledge flows – from MNCs to their host countries, these spillovers are not automatic consequences of FDI or the presence of foreign firms. The economic environment in the host country appears to be of great importance, determining both the kinds of technologies chosen by MNC affiliates, and how much local firms are able and willing to invest in learning from these foreign affiliates. This conclusion shifts attention to the policies implemented by host countries.

## What is required for successful technology transfer?

A common conclusion from the analysis of the roles of trade and FDI for international technology flows is that countries differ in their ability to realise the potential benefits from these sources of knowledge. While some developing countries have made great progress and begun to converge towards the levels of OECD countries – with China and other East Asian economies the main success stories in recent years – others have failed to narrow the gap. It is of obvious interest to explore what may explain the differences in performance.

Cross-country differences in size and resource endowments explain some of the international variation in economic performance, but it is not likely that these are the main reasons for the differences in countries' abilities to absorb and utilise foreign technology. Instead, the reasons are probably to be found in various aspects of economic policy and institutions. The discussion on trade and FDI above has already highlighted two policy-related characteristics that promote international knowledge flows. First, studies on R&D spillovers from international trade and productivity spillovers from FDI emphasise the importance of openness and of outward orientation. For the case of trade-related R&D spillovers, it is obvious that trade restrictions will limit the range, quality and/or volume of imports that may potentially contribute to domestic knowledge. In terms of productivity spillovers from FDI, trade restrictions may either result in a fall in FDI

inflows (and a corresponding reduction in the learning potential) or a shift in the industry structure of FDI towards sectors in which foreign investors are protected from import competition. In this latter case, it is unlikely that the potential for knowledge flows is strong enough to compensate for the losses that occur when resources are allocated to sectors without comparative advantages. Moreover, foreign investors that are protected from import competition may feel that they do not have to adjust their technologies to local factor prices, since they can raise their output prices to cover costs and mark-ups. This may result in imports of technologies that are not appropriate for local conditions, and therefore more difficult for local firms to absorb. Hence, open and outward-oriented trade policies can be expected to promote technology flows for several reasons that affect both the supply of technology and the ability (and perhaps also the motives) of local firms to adopt and absorb foreign technology.

Second, and perhaps most importantly, both broad cross-country evidence and the experience of China and the other successful East Asian economies highlight the importance of systematic investments in education, science and technology, and R&D. China differs from most of today's other developing economies in its very systematic efforts to build knowledge and human capital. Chinese investments in R&D have grown at an annual rate of more than 16% since 1995 (OECD, 2008), with similar investments in higher education. In spite of the low per capita incomes, the ratio of Chinese R&D to GDP has reached 1.3%, which is higher than the ratio in EU countries such as Ireland, Italy and Spain. More than a million Chinese students have travelled abroad for higher education since the early 1980s, at the same time as several Chinese universities have developed into world class centres of research and higher education. While China is a special case, there is a direct link to the policies of other successful East Asian economies. Japan, Korea, Chinese Taipei and Singapore are all examples of economies that made early investments in human capital and managed to create a base for sustainable development.

Given their comprehensive investments in domestic technological capability and human capital, the rapidly developing East Asian economies have also been able to develop substantial capacity to absorb spillovers from foreign R&D investment, whether they are channelled through trade linkages and FDI, or diffused directly, in the form of intangible and disembodied knowledge. In fact, it can be argued that the main benefits of the knowledge investments were initially not measured in terms of the new technologies created by domestic researchers, but rather by the capacity to adapt and absorb existing foreign technology.

Of course, a host of other variables apart from liberal trade policies and investments in knowledge and skills determine the ability of developing countries to catch up to the developed world. Discussing the long-term competitiveness of developing countries in high-technology manufacturing and exports, NSB (2008) points to four areas in which substantial capacity has to be developed in order to facilitate sustainable growth and convergence. They are also important for the ability to utilise foreign knowledge. A first area is technological infrastructure, including domestic investments in R&D, education and imports of foreign knowledge. These investments make up the foundation for technical progress and competitiveness. However, although investments in technological infrastructure are necessary requirements for take-off, they are not sufficient to guarantee success. A second core area in which capacity is needed is socioeconomic infrastructure. This refers to the institutions needed to support sustainable technology-based growth and covers broader educational achievements as well as policies facilitating an open and outward-oriented policy environment. This is also the category in which important

economic institutions, such as physical and intellectual property rights, belong. The third area is productive capacity, which includes the physical and human resources available for the manufacturing sector. The final component is national orientation, and covers the policies and attitudes that constitute a business-friendly investment climate, with transparent regulation, low investment risk, and positive attitudes towards entrepreneurship and technology.

Defining and quantifying indicators for these four areas or country characteristics, NSB (2008) goes on to compare the implicit potential for developing high-technology exports in 14 developing countries. A first group consists of the large developing economies in the following order, *i.e.* from the highest to the lowest potential: China, India, Russia, Mexico, Brazil, and Indonesia. A second group includes eight smaller countries, again ranked from highest to lowest potential: Malaysia, Poland, Hungary, Thailand, South Africa, Argentina, the Philippines and Venezuela.

While it is difficult to disagree with the key areas for capacity development or the rankings of countries, it is appropriate to highlight the fact that development is related to the strength of the economic system as a whole. The countries that can be expected to be successful do not exhibit good performance only in one or two of the policy areas that are important. Instead, their overall business climate is considered favourable, with relatively low levels of risk and good prospects for future growth. Although the ranking does not explicitly recognise the importance of political stability and predictability, it is obvious that this is a crucial precondition for sustainable progress. Countries plagued by wars, political unrest or even substantial political uncertainty are likely to fail to generate the kinds of long-term investments that are needed to build sustainable capability. With reference to the rankings, it can be argued that countries such as Venezuela, the Philippines, Argentina, South Africa and perhaps even Indonesia are affected by concerns related to these issues. Moreover, it is noteworthy that an abundance of natural resources is not among the country characteristics that are considered favourable for sustainable development – several of the countries with relatively low rankings have rich endowments of resources. Although it may be difficult to argue convincingly that a resource curse is unavoidable, it is clear that abundant resources may, in a worst case scenario, mainly provide possibilities for bad policy (Sachs and Warner, 2001).

A favourable business environment is of particular importance for local enterprises, whose productivity and competitiveness are largely determined by incentives and restrictions in the domestic market, but it is also important for foreign enterprises: the local business environment is one of the main determinants of the inflows of FDI. However, few countries have relied only on a favourable business environment to attract FDI. Instead, most have introduced policies to attract FDI and to raise the likelihood that foreign technology and knowledge will spill over to local firms.

The policies aiming to attract FDI are typically based on various kinds of incentives, ranging from help with information about local business opportunities to tax holidays, employment subsidies and land grants. The main theoretical motive for providing such incentives is that FDI is eventually expected to add some value to the local economy, either directly through job creation and tax revenues, or indirectly via the technology or productivity spillovers discussed above. Where spillovers are important, the foreign investor's private benefits will be lower than the social benefits of the investment (including the spillovers). Hence, when foreign investors base their investment decisions on their private costs and benefits, they will invest less than what would be socially desirable. Total foreign investment will fall short of the socially optimal amount unless

various investment incentives encourage the foreign investor to invest more than what is motivated by a purely market transaction.

However, it is not easy to determine how much a host country should invest in investment incentives. In particular, it is difficult to predict where and how spillovers will occur. This creates problems of "picking winners". It is also difficult to calculate the value of the externalities, although this is important, since national welfare will increase only if the investment incentive is smaller than the value of the externality.

Another problem with international investment incentives is that they prepare the ground for rent seekers. It is well known from the trade literature that selectivity, in combination with lack of transparency, increases the risk of rent seeking and corruption (*e.g.* Tollison and Congleton, 1995). Policy measures that focus on broad and general forms of support that are available to all firms, irrespective of nationality, will not result in similar dead-weight losses (Kokko, 2003). Moreover, competition among governments (national or local) to attract FDI may create additional problems (Oman, 2000). When governments compete to attract FDI there is a tendency to overbid and the subsidies may very well surpass the level of spillover benefits, with welfare losses as a result. These problems may be particularly severe if the incentives discriminate against local firms.

As noted earlier, there is convincing evidence that spillovers are not automatic, but depend crucially on the responses of local firms. The potential for spillovers is not likely to be realised unless local firms have the ability and motivation to learn from foreign MNCs and to invest in new technology. This implies that investment incentives aiming to increase the potential for spillovers may be inefficient unless they are complemented with measures to improve the local learning capability and to maintain a competitive local business environment.

Taking these arguments into account, there is reason to be restrictive in the use of investment incentives that target only foreign investors. If incentives are offered, they should be available on equal terms to all investors irrespective of industry and nationality, rather than based on discretionary decisions. The motive for supporting foreign investors – including existing investors that may consider expanding their activities – is to equalise social and private returns to investment. One reason for providing at least equal support to local firms is to strengthen their capacity to absorb foreign technology and skills. Another is to avoid distorting competition between firms of different nationalities. If foreign firms have access to various investment incentives that are not available to local firms, it is obvious that local firms will not be able to compete on equal terms with foreigners actors, who already benefit from superior technical capabilities.

A further question concerns whether policy can maximise the spillovers from FDI rather than just the amount of FDI. In broad terms, the focus has been on three types of policies that affect the amount of foreign technology imported by the foreign multinationals (the "potential" for spillovers) and/or the likelihood that foreign technology will spill over. A first set of policies includes various kinds of formal technology transfer requirements that aim to force (or encourage) MNCs to bring in the types of technology needed in the host country. However, these types of requirements are rarely efficient, since it is difficult to monitor exactly how much and what types of technology the foreign MNC decides to import; most of the technology is sourced from the parent company rather than the arm's-length market, and the parent company sets the nominal price for the technology. It is also difficult to establish good incentives to ensure that the requirements are fulfilled. For instance, it is typically quite costly to follow a requirement to import any technology other than that which is motivated by profit

maximisation. If it is not very simple to determine whether a requirement has been fulfilled, it might be profitable for MNCs to do little on the technology side, and instead spend resources to convince authorities that they have actually fulfilled the requirements. Although it is possible to find cases in which strong host countries have been able to promote technology flows through regulation, the results have typically been disappointing. For instance, when looking at the operations of US manufacturing affiliates abroad, both Kokko and Blomström (1995) and Kay *et al*. (1996) fail to find any indications that technology transfer requirements would have resulted in increased technology flows to the affiliate.

An alternative to performance requirements is to design FDI incentives that are not of the *ex ante* type (*i.e.* granted prior to the investment), but rather performance-based and promoting activities that can be expected to have a particularly favourable impact on technology transfer and diffusion. These activities include education and training focused on local employees, R&D activities and linkages between foreign and local firms. An advantage of performance-based incentives is that they may affect the entire stock of investments, rather than just the flow of new investment. It is also clear that these incentives are more efficient when they are available to all firms, irrespective of the nationality of the owner. In fact, new technology and knowledge probably diffuse faster when the first user is a local rather than a foreign firm. One argument is that local firms are more likely to select technologies that are appropriate for local conditions, whereas the MNC affiliates' choice of technology is often based on what is available from the parent company. Local firms are also more deeply integrated with the local economy. They have stronger links with other local actors; this raises the number of contacts that may result in some sort of knowledge transfer. Hence, given their broad scope, it could be argued that performance-based incentives should be considered part of the economy's innovation and growth policies rather than a policy area that is only relevant for foreign investors.

Joint-venture requirements make up a second policy instrument which has been commonly used in many developing countries. One of the ideas behind these requirements is that local part-ownership in FDI projects should guarantee at least that the local partners will get access to all information about the foreign technologies and organisational practices employed in the project. However, the empirical evidence on the effects of joint-venture requirements is mixed. On the one hand, several studies find stronger spillover benefits from joint ventures (Dimelis and Louri, 2002; Javorcik, 2004). On the other, some studies fail to detect any significant differences between joint ventures and wholly owned affiliates. It appears that a larger share of the available knowledge is diffused to the local economy from joint-venture projects than from wholly owned FDI projects, but there are also differences in how much knowledge is available for diffusion in the two project types. In particular, joint ventures do not tend to receive the most recent or the most valuable technologies. To minimise leakages of strategically important knowledge and technology to outsiders, MNCs often reserve the most advanced technologies for use in the home country or in their wholly owned foreign affiliates (Blomström and Sjöholm, 1999; Muller and Schnitzer, 2006). Hence, there is a risk that the introduction of joint-venture requirements may actually reduce imports of some technologies, and perhaps even lead some investors to stay outside the local market. These risks appear particularly great for small open economies with neighbours that apply less restrictive policies, so that foreign MNCs have the option to serve the local market from alternative regional locations.

A third alternative is to encourage technology imports and technology diffusion by providing a business environment that is favourable for innovation and entrepreneurship. This involves general measures to modernise infrastructure, raise the level of education and labour skills, and provide strong IPRs, but may also include investment incentives targeting technology-intensive activities, as discussed earlier. Ensuring that barriers to competition are low may also be important to create incentives for technology upgrading and productivity growth: in fact, competition from imports and local firms appears to have a stronger impact on the technology imports of MNC affiliates than formal technology transfer requirements (Blomström *et al*., 1994; Kokko and Blomström, 1995). It can be expected that these broad measures are more efficient from a technology transfer perspective than general FDI incentives and technology transfer requirements, in particular when they are available on equal terms to foreign and local firms. One reason is that these policies will support the growth and development of local industry whatever specific effects they have on attracting FDI and promoting technology imports.

Among Western countries, Ireland seems to be an excellent example of the advantages of such policies. There is no doubt that the Irish success in attracting FDI and benefiting from such investments stems to a large extent from having the right "fundamentals" (Barry, 1999). Ireland has for a long time been considered a preferred location for FDI. It should be noted that the various incentives for attracting foreign investors, including low taxes, good infrastructure, access to the EU market, and continuously increasing labour skills, have also been available to local companies. This is a likely reason for the positive links between inward FDI and local industry found, for example, by Görg and Strobl (2001) and Barry *et al*. (2003). Another example is provided by Sweden, which was the world seventh largest recipient of foreign investment during the second half of the 1990s, and has been in the top ten in several years since then. This is remarkable for a small economy with less than 10 million consumers. Sweden provides an attractive business environment, and its industrial policies do not distinguish between foreign and domestic investors.

The relevance and relative importance of various policies will of course vary among countries, depending on market size, geographical location, level of development, and a host of other factors that determine the potential for FDI inflows and the relative bargaining power of the host country government. Large countries like China or India, with a vast domestic market, may be able to impose stronger performance requirements on foreign MNCs than small, African countries with weak infrastructure and shortages of skilled labour. Countries with a favourable geographic location – like the Baltic states – can expect stronger effects of policy reform than countries located further away from the major markets. The differences relating to the level of development are perhaps particularly interesting. There is substantial evidence that strong IPR regimes are particularly important for the ability of middle-income developing countries to attract FDI in high-technology industries (Branstetter *et al*., 2006; Lee and Mansfield, 1996; Nunnenkamp and Spatz, 2004). However, it is not likely that IPRs have equally strong effects on technology flows to low-income countries. The reason is that low-income countries typically lack many of the other resources that would be needed to attract the kinds of technologies that require strong IPR protection. Furthermore, there is a tension between strong IPRs, which aim to restrict the diffusion of knowledge, and the typical objectives of low-income countries, which emphasise speeding up modernisation and technology diffusion, and in which the number of firms or entrepreneurs who own domestic intellectual property is very small. Hence, while IPRs are likely to be of crucial importance for emerging markets that aim to upgrade from assembly operations and other

low value-added activities to more sophisticated industry, they might not be equally urgent in the poorest countries, where more general property rights, infrastructure and general education have higher positions on the list of investment priorities.

## Conclusion

The global production of knowledge and technology is highly concentrated in just a few developed nations – Japan, the United States and the largest EU countries – and in a relatively small number of multinational corporations headquartered in these nations. The top 25 technology-producing MNCs spend more on R&D than the entire non-OECD world. It is therefore not surprising that most countries are dependent on foreign knowledge and technology for growth and development.

There are many different channels for international technology diffusion, ranging from trade and FDI to tourism and international student exchange. This chapter has focused on the role of trade and FDI in international knowledge flows and discussed empirical findings as well as policy conclusions for countries aiming to facilitate the inflows of technology through these channels. Abstracting from the vast diversity of the developing world, which means that specific policy recommendations need to be tailored to the economic conditions in each country, it appears that some conclusions apply more or less across the board.

From the findings of empirical studies, it seems clear that both exports and imports are important from the perspective of technology diffusion. Imports – especially imports of investment goods and services – contribute directly to technology upgrading. The evidence on learning from exporting is somewhat less consistent, but there is no doubt that firms in outward-oriented economies establish stronger contacts with the international market than actors in inward-looking markets. These contacts – whether with customers, suppliers or other business partners – are of high importance for knowledge flows. Foreign direct investment is important, because it results in international technology transfers – affiliates of foreign MNCs typically introduce technologies that are not commonplace in the host economy – and because there is a potential for spillovers of knowledge to local firms. However, spillovers of technology are not automatic consequences of foreign presence, but rather conditional on the capacity and motives of local firms to understand, absorb and adapt foreign technologies to local conditions.

This suggests that outward-oriented trade policies and policies promoting education, training and R&D are important components of any policy package aiming to maximise knowledge flows to developing countries. In addition, there is reason to emphasise the importance of a favourable business environment that provides strong incentives for entrepreneurship, investment and innovation. Infrastructure, strong property rights and other economic institutions, investments in human capital, and in some cases perhaps also incentives for knowledge creation, are assets that promote both the technology imports of foreign MNC affiliates, the ability of local firms to absorb potential spillovers from FDI, and the independent innovation and entrepreneurship of local firms.

In some instances, it is also possible to argue that specific FDI incentives are warranted, to assure that the amount of FDI does not fall short of what would be socially optimal. However, it is difficult to determine what the optimal amount of FDI incentives is, and it is inappropriate to provide incentives to foreign investors if similar incentives are not available to local firms. The reason is that discrimination against local firms will

make it very difficult for local industry to compete efficiently with foreign-owned firms. This is likely to reduce the ability of local industry to absorb the potential spillovers from FDI – in particular, the scope for horizontal spillovers (directed to the industry in which the foreign investors operates) will diminish if preferential treatment of foreign firms puts local industry at a disadvantage. Therefore, to the extent that specific incentive programmes are used, they should probably be designed to target specific behaviour (*e.g.* investment in local human capital) rather than investment in general, and they should be available on equal terms to local firms. For the vast majority of all economies, it is the business environment for local industry that determines long-run development. It is not likely that any preferences or incentives offered to foreign investors can compensate for weaknesses in domestic industry and entrepreneurship.

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