The Role of Foreign Direct Investment in International Technology Transfer

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International Handbook of Development Economics
Amitava Dutt and Jaime Ros, editors

I. Introduction

International technology transfer (ITT) refers to any process by which a party in one country gains access to technical information of a foreign party and successfully absorbs it into its production process. The importance of ITT for economic development is widely recognized and it has been argued that barriers to technology adoption help explain the income gap between developed and developing countries (Parente and Prescott, 1994). Such barriers include regulatory an institutional constraints that entrepreneurs must overcome, and low levels of human capital. However, the technology frontier is a moving target – new technologies are continually being introduced. To close the technology gap, developing countries must adopt new technologies, at a faster rate than they are being created. Both market forces and government policies have an important role to play in accomplishing this formidable task.

At the heart of ITT is the exchange of information and knowledge. Technology may be codified (e.g., in blueprints) or uncodified (e.g., know-how of engineers). It may be embodied in products or people, or disembodied in ideas or services. ITT often occurs between unrelated partners in market-based transactions. However, information also flows internationally between related parties on a non-market basis, within the boundaries of firms and joint ventures. Given the multi-faceted nature of technology transfer, there exist numerous channels through which technology flows across international boundaries. One major channel is trade in goods and services. All exports bear some potential for transmitting technological information. Trade in capital goods and technological inputs can directly improve productivity by being integrated into production processes. Another major channel of ITT is direct trade in knowledge via technology licensing, which may occur within firms, among joint ventures, or between unrelated firms. The focus of this chapter is the channel of foreign direct investment (FDI).

All these channels may facilitate imitation and reverse engineering. Because imitation does not require compensating technology owners, it can be an attractive option for developing

economies. As Hoekman, et al (2005) note, the temporary migration of students, scientists, and managerial and technical personnel to universities, laboratories, and conferences also plays an important role in encouraging ITT. Furthermore, ITT can also result from the temporary movement of professionals and other service suppliers who enter a developed country to perform specific services and in the process acquire additional knowledge and skills that are transferred back to the home country upon completion of the contract. While such channels of ITT are no doubt of crucial importance, we do not discuss them here in order to limit the scope of this paper.

Although use of the word 'transfer' in the phrase 'international technology transfer' seems to suggest that the process of ITT is somehow smooth and automatic, nothing could be further from the truth. The fact that developing countries lag behind the technology frontier merely creates the *potential* for ITT. For ITT to actually occur, providers and acquirers of new technologies have to undertake deliberate and often significantly large investments.

Actual investment costs are not the only hurdle facing ITT. The very market for technology is hampered by at least two significant market failures: the presence of asymmetric information and/or market power. In fact, the superior information possessed by sellers when protected by intellectual property rights is often what creates the latter market failure. By keeping transactions within one firm, technology transfer via FDI can lessen some of difficulties that confront arms length exchange of technology, yet many difficulties remain. Even within the same firm, Teece (1976) finds the costs of transferring technology to a foreign plant average twenty percent of the total investment required for the plant.[1]

Fuller benefits for local technological capacity are realized if the technologies introduced from abroad diffuse locally. The first step – getting the technology into the country – is international technology transfer (ITT), and the second step – getting the technology into the possession of local firms – is what we call technology diffusion. While the first step is typically a deliberate act, the second step can often be an unintended consequence. What makes the role of FDI especially important is that multinational companies dominate global research and development (R&D) and are therefore act as important conduits of ITT. Yet multinationals are in the business of maximizing profit, not the economic development of host countries. However, available models and empirical studies argue that achieving a balance between the objectives of multinationals and host countries is not as difficult as it may appear on casual observation.

II. FDI as a channel of ITT

[1] See also Mansfield and Romeo (1980) and Ramachandran (1993).

Today, intra-firm trade (i.e. trade between subsidiaries and headquarters of multinational firms) accounts for roughly one-third of total world trade and sales of subsidiaries of multinational firms exceed worldwide exports of goods and services. Thus, FDI is the dominant channel through which firms serve customers in foreign markets. While much of FDI occurs between industrial countries, developing countries are becoming increasingly important host countries for FDI. Approximately 33% of the global stock of FDI today is in developing countries (UNCTAD, 2003).

FDI is growing in importance as a channel of ITT.[2] Multinational activity occurs primarily in industries that are characterized by a high ratio of R&D to sales and by large shares of professional, scientific, and technical workers (Markusen, 1995). A basic tenet of the theory of the multinational firm is that such firms rely heavily on intangible assets, such as superior technology and well established brand names to offset the logistical and other disadvantages of operating in multiple counties as well as to successfully compete with local firms that are better acquainted with the host country environment.[3] In 1995, of all transactions in royalty and license fees, transactions within the same firm made up in excess of eighty percent, so most explicit trade in technology takes place within multinational firms (UNCTAD, 1997).

Virtually all empirical studies of FDI find that foreign owned plants in developing countries are typically more productive than purely domestic ones. For example, a recent paper by Arnold and Javorcik (2005) provides direct evidence on the impact of FDI. Using data from Indonesia's manufacturing sector during the period 1983-86, the authors focus on the effects of acquisitions of local firms by foreign ones. They find that foreign ownership leads to significant improvements in acquired plants: after three years, the acquired plants outperform the control group in terms of total factor productivity by 34%.[4]

ITT through FDI can be either horizontal or vertical in form. When horizontal, FDI transfers the full technology needed to produce the good. When vertical, different stages of the production process are split across countries so only the technology for the stage (or stages) being produced

[2] That FDI leads to ITT may seem obvious, yet Glass and Saggi (1999) have argued that whether FDI creates ITT in aggregate depends crucially on whether substitute channels of ITT, such as imitation, exist. FDI could merely displace imitation that otherwise would have occurred, leaving ITT essentially unchanged. See also Glass and Saggi (1998) for a model in which narrowing the technology gap induces multinationals to transfer state-of-the-art technologies.

[3] A nice feature of their approach is that they control for the self-selection problem – i.e. while it is true that multinationals typically acquire firms that are relatively more productive, they further contribute to the future productivity of acquired firms.

[4] See Saggi (2002) for an extensive discussion of this literature.

in the host country is transferred. For developing countries, often the more labor-intensive stages are shifted abroad.

Of course, instead of opting for FDI, a firm may sometimes decide to contract with a local firm for production of components in a developing country rather than forming its on production subsidiary there. Due to the participation of local firms, licensing and joint ventures can yield both ITT and technology diffusion. As might be expected, it has been shown that costs of transferring technologies across countries work against FDI (and licensing) as mode choices. Norback (2001) confirms using Swedish data that high technology transfer costs discourage production abroad in favor of exports.

Studies such as Mansfield and Romeo (1980) and Smarzynska (1999) have found that newer technologies are transferred through FDI, whereas older technologies are transferred though joint ventures and technology licensing. Mode choice may be one way that firms attempt to maintain their technological advantage by avoiding modes with high technology diffusion until technologies become somewhat dated. Or perhaps costs of transferring technologies via arms length channels are larger for newer technologies due to greater information asymmetries. Moral hazard considerations can also be important in this context. For example, Ramachandran (1993) has shown that subsidiaries receive greater resources than partially licensor-owned or independent firm once the incentives for both sides to invest in transferring technology are considered. Strategic incentives can also reinforce moral hazard and asymmetric information considerations: Fosfuri (2000) constructs a model with the feature that firms strategically use the vintage of technology to deter imitation by licensees, so that more recent technology is transferred to affiliates than to outsiders (see also Saggi, 1999).

III. FDI and local technology diffusion: friends or foes?

An important consequence of FDI is that shifting production to a developing country can reduce technology adoption costs for indigenous local firms. The degree to which imitation costs are lowered by FDI might be higher for process than for product technologies. For product technologies, reverse engineering may be the main way that imitation costs are reduced. Since better process technologies tend to be difficult to deduce from inspection of the final good, first hand experience with the technology may be required. Multinational firms bring production to the host country, proving workers with experience using the new technology. Workers then often leave to work for rival local firms or to start their own firms.[5] Either way, such worker

[5] Cheng et al (2005) examine the impact of the ability of workers to absorb foreign technologies on the extent of

turnover generates knowledge flows that may lead to local firm adopting some aspects of the ways in which the new technology better than the old. Also, any degree to which multinational firms adapt technologies to the local economic environment reduces costs of technology adoption for local firms.

Since technology advantages are often needed to survive as a multinational firm, why don't multinationals do anything and everything possible to curtail diffusion of their technologies to rival firms? As argued in Glass and Saggi (2002a), when the gains to local firms are great, the costs of preventing leakage of technologies to rivals (the wage premiums required to keep workers from leaving) are apt to be great as well. Additionally, the presence of multiple multinationals firms in an industry likely leads to positive externalities among them: costly efforts undertaken by any one multinational to curtail spillovers to local competitors would benefit all multinationals. A multinational firm that seeks to protect its technology through litigation, for example, bears the full cost but not the full benefits of its action. As a result, multinationals might very well under-invest in activities that curtail the local diffusion of their technologies.

Focusing on vertical technology transfer from a multinational to its suppliers, Pack and Saggi (2001) have shown that technology diffusion among suppliers can benefit foreign firms sourcing components. Thus, fully integrated multinational firms would be expected to be more adverse to technology diffusion than firms involved in arms-length production deals with local firms. Mexico's maquiladoras appear to have benefitted from the transfer of sophisticated production techniques and backward linkages, especially in the automobile industry. Goh (2005) finds, however, that diffusion of knowledge to other potential suppliers can either encourage or discourage technology transfer depending on the incumbent suppliers's cost of technological effort. Using firm-level data from Lithuania, Javorcik (2004a) finds evidence of spillovers from foreign affiliates to their local suppliers in upstream sectors, but only for projects with shared domestic and foreign ownership (not for fully foreign owned investments).

Evidence regarding whether technologies transferred by multinational firms diffuse to competing local firms is mixed. Finding that sectors with more foreign involvement have higher productivity or faster productivity growth could stem from FDI being attracted to those sectors rather than FDI improving productivity or accelerating productivity growth. Plant-level studies are required to help alleviate any selection bias in industry level studies. Haddad and Harrison (1993) find that foreign firms have higher levels of total factor productivity (TFP) but lower TFP

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production by multinational firms.

growth than domestic firms in Morocco. A stronger positive effect of FDI in low-tech sectors than in high-tech sectors may indicate that local firms in high-tech sectors lack absorptive capacity. Or perhaps multinationals in high-tech sectors take more actions to preserve their technological advantages.

Aitken, Harrison, and Lipsey (1996) explore the idea that technology spillovers ought to increase the marginal product of labor and this increased productivity should show up as higher wages. Their study employs data from manufacturing firms in Venezuela, Mexico, and the United States. For both Mexico and Venezuela, a higher share of foreign employment is associated with higher overall wages for both skilled and unskilled workers. Furthermore, royalty payments to foreign firms from local firms are highly correlated with wages. Most importantly, the study finds no positive impact of FDI on the wages of workers employed by domestic firms. In fact, the authors report a small negative effect for domestic firms, whereas the overall effect for the entire industry is positive. These findings differ from those for the United States, where a larger share of foreign firms in employment is associated with both a higher average wage as well as higher wages in domestic establishments. Putting Aitken, Harrison, and Lipsey's (1996) findings into the context of previous work, it is clear that wage spillovers (from foreign to domestic firms) are associated with higher productivity in domestic plants. Conversely, the absence of wage spillovers appears to accompany the existence of productivity differentials between domestic and foreign firms.

Using annual census data on more than 4,000 Venezuelan firms, Aitken and Harrison (1999) provide a plant-level test of the spillover hypothesis. They find a positive relationship between foreign equity participation and plant performance, implying that foreign participation indeed benefits local plants that receive such participation. However, this own-plant effect is robust for only small plants, that is, those plants that employ fewer than 50 employees. For larger plants, foreign participation results in no significant improvement in productivity relative to domestic plants. More interestingly, they find that productivity in domestic plants *declines* with an increase in foreign investment – i.e. they find evidence of *negative spillovers* from FDI. The authors suggest that these could result from a market stealing effect: foreign competition may have forced domestic firms to lower output and thereby forgo economies of scale.[6]

However, the results of Haskel et al (2002) contrast with those of Aitken and Harrison (1999).

[6] Nevertheless, on balance, Aitken and Harrison (1999) find that the effect of FDI on the productivity of the entire industry is weakly positive. They also note that similar results are obtained for Indonesia, except that the positive effect on own plants is stronger, whereas the negative effect on domestic plants is weaker, suggesting a stronger overall positive effect.

Haskel et al (2002) use plant-level panel data for all U.K. manufacturing from 1973 through 1992 to re-examine the issue of spillovers from FDI. As the authors note, there can be little doubt that local firms in the U.K. possess sufficient absorptive capacity to benefit from the introduction of newer technologies by multinationals. So if spillovers do not materialize, they cannot be attributed to the limitations of domestic firms. Across a wide range of specifications, the authors find that there are positive spillovers from FDI at the industry level. More precisely, they find that a 10% increase in foreign presence in a U.K. industry raises the total factor productivity of that industry's domestic plants by about 0.5%. However, the authors also note that the large tax breaks and incentive packages given to multinationals seem out of proportion relative to the magnitude of spillovers they generate.

While some studies have cast doubt on the optimistic view that FDI generates positive spillovers for local firms, others have reached different conclusions. Regardless of one's view of these findings, it is worth stressing that domestic firms should be expected to suffer from an increase in competition that often results from FDI; in fact, part of the benefit of FDI is that it can help weed out relatively inefficient domestic firms. Resources released in this process will be put to better use by foreign firms with superior technologies, efficient new entrants (both domestic and foreign), or some other sectors of the economy. However, such resource reallocation does not occur instantaneously. Existing studies of spillovers may not cover a long enough period to be able to accurately determine how FDI affects turnover rates (entry and exit). Furthermore, horizontal studies miss spillovers that may result from FDI in industries other than the one in which FDI occurs.

In a critical discussion of the plant-level studies of horizontal spillovers from FDI, Moran (2004) argues that there is a substantial difference in operating characteristics between subsidiaries that are integrated into the international sourcing networks of the parent multinationals, and those that serve protected domestic markets and are prevented by policy restrictions (such as mandatory joint venture and domestic content requirements) from being so integrated. These different operating characteristics include size of plant, proximity of technology and quality control procedures to industry best practices, speed with which production processes are brought to the frontier, efficiency of operations, and cost of output. He argues that while the former have a positive impact on the host country, often accompanied by vertical backward linkages and externalities, the latter may actually have a negative impact. Drawing upon a wealth of case studies and econometric evidence, Moran (2004) argues this contrast in performance holds across different industries, countries, and time periods. He astutely notes that the failure to differentiate between export-oriented FDI and import-substitution FDI, or between foreign investors free to source from wherever they wish and foreign investors operating with domestic

content requirements, or between foreign investors obliged to operate as minority shareholders and those with whole- or majority-ownership accounts for the inability of earlier studies to isolate the influence(s) of FDI on host country welfare.

We noted earlier that arms length technology transfer is usually of lower quality than its intra-firm counterpart. But is greater involvement of local firms, such as in the form of joint ventures, more likely to lead to diffusion? While this appears plausible, there is little empirical evidence in support of this idea. For example, Blomstöm and Sjoholm (1999) find that the degree of foreign ownership did not affect the productivity of local partners or spillovers to domestic firms in Indonesia for 1991. Yet having any foreign participation at all did matter: plants with no foreign participation were less productive. These findings could represent selection at the plant level – FDI is attracted to more productive plants – or a threshold effect – that foreign participation, not the degree of participation, is what matters most.

Although the extent of technology diffusion resulting from FDI is unresolved, that FDI stimulates economic growth in the host country enjoys strong empirical support. Balasubramanyam et al (1996) find the growth stimulating effects of FDI are stronger for countries that pursue export promotion rather than import substitution policies. So trade policy seems to affect the benefits of FDI, although trade orientation could proxy for other unmeasured differences across countries. For export promoting countries, FDI stimulated growth more than domestic investment. Borensztein et al (1998) find that FDI contributes more to economic growth than domestic investment for countries that have a sufficient stock of human capital. Countries with insufficient human capital presumably lack the ability to absorb technologies. Xu (2000) finds that countries need to achieve a minimum level of human capital in order for the technology transferred by U.S. multinational firms to contribute to productivity growth, but most less developed countries do not satisfy the required threshold.

IV. Policy options for acquiring and absorbing new technologies

Separating the concept of ITT from that of local technology diffusion is especially important for analyzing policy choices. When assessing the impact of a policy option, the effects on both ITT and technology diffusion should be considered. Some policies might promote ITT but not technology diffusion. Others might promote technology diffusion but then adversely affect ITT through discouraging FDI. Multiple policy instruments are likely to be needed to achieve the ideal combination of ITT and technology diffusion. Too much technology diffusion, and there may not be much technology to diffuse since the potential for local spillovers may deter FDI. Too much ITT, and few of the advanced technologies may ever be used by indigenous firms.

Many countries such as Japan, South Korea, and China have historically restricted FDI, often to favor of technology licensing or joint ventures. Foreign firms were often required to share technologies with local firms in order to conduct business in Japan. It is difficult to judge whether countries restricting FDI performed better or worse than if they took a more liberal approach since the counterfactual is not observed. The findings that newer technologies are transferred through FDI rather than though joint ventures and technology licensing call into question the wisdom of policies that favor technology licensing or joint venture over FDI. Even if more technology diffusion results, the technology obtained may be far below state-of-the-art. It is possible that policy interventions could act to improve the terms of licensing contracts for local firms by removing alternatives (or making the alternatives far less desirable) for the foreign firm.

More recently, developing countries have become quite eager to attract FDI. Part of this eagerness may stem from enhanced awareness that FDI can serve as an important channel of ITT, although employment issues surely also play a role. Many countries, both developed and developing, offer fiscal and financial incentives to attract FDI. Eliminating restrictions on FDI is likely to be beneficial, at least at the world level, since foreign firms are freer to choose between modes without interference. However, when it comes to promoting FDI, a few words of caution may be in order. You can have too much of a good thing. Similar to free trade being best and export subsidies being distortionary, care is needed to avoid overstimulating FDI. Incentives could lead to FDI being attracted to the wrong countries – countries where costs will be higher than alternative locations. Excessive competition for FDI between locations could bid away all potential benefits.

As noted above, empirical evidence on technology spillovers from FDI is mixed, so benefits to local firms might not be realized. If governments use incentives to try to obtain the right kind of FDI, one has to question whether the government can indeed pick industries with the best potential for spillovers. Adequate human capital and infrastructure are needed for absorption, and any bureaucratic impediments to technology adoption should be minimized. So much focus on FDI risks overlooking opportunities to improve the diffusion of technologies.

Stronger protection of intellectual property (IP) has been often been suggested as a means of attracting FDI. The thought is that firms will avoid FDI in favor of exports to countries with weak protection of IP (although they may also shift from licensing to FDI). Theoretical studies such as Glass and Saggi (2002b) and Glass and Wu (2006) based on the quality ladders model of growth cast doubt on the idea that FDI rises with stronger IP protection, once the repeated nature

of innovation is captured. Taylor (1993) has suggested that poor protection of IP may lead firms to mask their technologies in order to make them harder to imitate.[7]

However, in a recent paper Branstetter et. al. (2006a) have argued that in a variety expansion North-South product cycle model with endogenous Northern innovation, Southern imitation, and FDI, IPR reform in the South leads to increased FDI from the North, as Northern firms shift production to Southern affiliates. Furthermore, this increased FDI drives an acceleration of Southern industrial development, as the South's share of global manufacturing and the pace at which production of more recently invented goods shifts to the South both increase. In addition, their empirical results show that U.S.-based MNCs expand the scale of their activities in reforming countries after IPR reform, and this effect is disproportionately strong for affiliates whose parents rely strongly on patented intellectual property as part of their global business strategy. Furthermore, they also provide evidence from highly disaggregated trade data that suggests that the expansion of multinational activity leads to a higher net level of production shifting to developing countries, more than offsetting any possible decline in the imitative activity of indigenous firms.[8]

Several other empirical studies find some support for IP protection encouraging FDI. Using data on U.S. FDI, Lee and Mansfield (1996) find that a country's choice of IP protection influences the volume and composition of FDI it receives. Smith (2001) finds that stronger IP protection encourages affiliate sales and licensing for countries with imitative capacity. Javorcik (2004b) finds weak IP protection deters FDI in technology-intensive sectors for transition economies. Nunnenkamp and Spatz (2004) find evidence of IP protection spurring higher quality FDI.

Stronger IP protection may be more important for technology licensing than for FDI due to the risk of opportunistic behavior and difficulty enforcing contracts. Yang and Maskus (2001) consider a model in which stronger IP protection increases the licensor’s share of rents and reduces the costs of licensing contracts. Thus, better IP protection may indeed stimulate licensing and technology transfer.

V. Concluding remarks

International technology transfer is a complex, multi-faceted phenomenon. In this short survey, we have chosen to highlight the role foreign direct investment and multinational corporations

[7] See also Taylor (1994) for the effects of IP protection on technology transfer.
[8] In a related paper, Branstetter, et al (2006b) have shown that there is a significant increase in technology transfer following reforms among affiliates of firms that make extensive use of the U.S. patent system.

play in the process of international technology transfer, paying little attention to international trade of goods and service, movement of workers and professionals, and other related phenomenon. While we do feel that FDI is the most important channel, we do not mean to imply that the other channels are not of considerable importance as well.

That multinational companies are pivotal in introducing new technologies to host countries is fairly well established. However, lagging countries need not only to obtain foreign technology but to learn how to use it to its fullest potential. In this context, we have found it useful to make a distinction between initial international technology transfer and subsequent technology diffusion within host countries. This distinction can be important since some policies could promote technology transfer but deter technology diffusion, or promote technology diffusion but deter technology transfer. With respect to the contribution of FDI, there is some good news and bad news. First the bad news: multinationals will usually lose from further horizontal diffusion of their technologies and should be expected to take actions that thwart that process. T he good news is that technology transfer to local suppliers is incentive compatible for multinationals and a plethora of empirical evidence indicates that vertical linkages between multinationals and their local suppliers play a crucial role in the industrial development of host countries.

An important policy conclusion of this analysis is that host countries are better off facilitating processes that are incentive compatible for multinationals. In other words, a developing country should perhaps be less concerned about being able to produce an automobile of its own and more concerned about developing a competitive network of suppliers that can serve (and gain from) firms. It is in this mutually beneficial exchange that the most productive policy intervention might lie. Of course, if both sides are indeed willing participants, policy intervention required would be ‘light’ as opposed to ‘heavy’. Furthermore, it would not be targeted in nature. Instead it would ensure that local businesses have access to adequate infrastructure and skilled workers and their expansion or downsizing decisions are not hampered by burdensome regulations. In our view, this is another plus of pursuing policies that takes proper account of the incentives multinational firms have (and don’t have) to encourage industrial development in host countries.

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