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THE ECONOMICS OF TECHNOLOGY TRANSFER

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The Economics of Technology Transfer

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The Economics of Technology Transfer

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Introduction

Sanjaya Lall

In its current usage, 'technology transfer' largely refers to the movement of commercial technologies across, and to a lesser degree within, countries. Technology (and knowledge more generally) has moved across enterprises and countries from the earliest days of productive activity. Much of this movement has been informal, through migration, imitation, reverse engineering and buying capital goods. In the past century or so, the transfer has become more formalized. There is a large body of literature on how transfers have taken place through history, and on how governments sought to promote and prevent them (see Jeremy, 1994). The current literature on technology transfer has a more limited focus. Though there are important parts dealing with the diffusion of technology within economies, its main concern has been the international arena where enterprises from different countries enter into formal contracts to buy and sell productive knowledge. It also has a strong policy dimension. The technology market has imperfections that can raise the cost to buyers and limit their technological progress, leading the governments of technology importing countries to try and improve their positions. Such problems are particularly important for developing countries, anxious to obtain access to new technologies while building indigenous capabilities to absorb and build upon them. This introduction treats some of the problems confronting developing countries before describing the structure of the collection.

The Technology Market

While the technology market has elements of markets for both pure knowledge and physical goods, it differs from both. The market for 'pure' knowledge has public goods characteristics; the transfer of knowledge is costless in so far as the original stock does not diminish as others gain access to it and use it in production (we can allow for patent protection without affecting the remainder of the argument). However, the market for technology, while having some public goods features, differs from this conception in important ways. For instance, theory assumes that the absorption by new recipients of new information, once created, is easy, costless and rapid. This does not apply to productive technology: the transfer of technology can have several costs. Technology has to be embodied in specific items of equipment and processes, which generally have to be engineered for the scale, climatic, material and skill needs of the new environment. Technological knowledge also has strong 'tacit' elements that cannot be embodied fully in equipment, blueprints or instructions (Nelson and Winter, 1982). As a result, the recipient has to invest in the new information, skills, technical and organizational capabilities necessary to use technology effectively.

As technology is implemented in a new location, moreover, further adaptations are generally needed. The costs of transfer continue over time, since technical progress may

render the original infusion redundant before the plant has depreciated and further transfusions of technology may be required to keep the knowledge economically viable. Thus, the costs of transfer can be substantial over time. According to one study (Teece, Chapter 4 this volume), transfer costs can range between 20 and 60 per cent of total project cost. The costs of transfer tend to rise with 'technological distance', given by technological specialization, corporate tradition, skill levels and the like. The distance also varies within similar countries, leading to different transfer costs – however, when countries have very different levels of technological capabilities, the costs of transfer are much larger.

The technology market also differs from the market for physical goods. It is not easy to define the technology 'product' or its price. The international technology market is fragmented and ill defined, and searching for the optimal technology at the best price can be costly and difficult. The technology transfer can take many different forms (the product is not well specified). Much depends on how much technical and other information the seller includes (or the buyer asks for) and how it transmits this information and modifies it over time. The seller knows more about the 'product' than the buyer does (otherwise it would have nothing to sell, Arrow, 1962): the buyer thus operates under an information asymmetry, largely absent in transactions in physical products. Even with full information, the two parties can have different valuations of the technology depending on their market positions, expectations and technological capabilities. Since technological information is constantly changing, the valuation also depends on which vintage is being transferred and how its future evolution is foreseen. For these reasons, the price and terms of technology transfer are subject to bargaining and the accompanying uncertainty and nontransparency.

The benefits of technology transfer are difficult to measure, particularly in the long term and on the economy as a whole. While in the narrow and immediate sense, the benefits comprise the recipient access to better productive knowledge (and so higher productivity, new products and/or lower costs), this does not capture all important effects. Much depends on the local context and the mode of technology transfer. These issues are taken up below.

A final note on the modalities of technology transfer follows. The transfer of technologies takes place in two broad ways: *internalized* (sold by a foreign company to affiliates under its control) and *externalized* (to other firms). Internalized modes entail direct investment and by definition are the preserve of multinational companies (MNCs). The sale of technology in externalized forms may involve MNCs selling knowledge on a nonequity basis, but there are several other sources: non-multinational enterprises, institutions, research centres or governments. The sale can take a variety of forms: minority joint ventures, franchising, capital goods sales, licences, technical assistance, subcontracting or original equipment manufacturing arrangements.[1]

The role of MNCs in technology transfer depends on the sophistication of technology and the elements of transfer involved. MNCs are very important in technology transfer (by both modes) in high technology activities and in providing entire 'packages' of technology together with management, marketing, brand names and so on. Where only discrete elements are involved, such as process plant or specific items of technical knowledge, specialized engineering and consultants firms play a more important role. Similarly, in activities with stable or simple technologies, where technology is embodied in capital goods and MNCs do not have strong proprietary technological or brand advantages, technologies can flow from buyers, consultants or capital goods suppliers. Policies (mainly in the recipient country) have

also traditionally played an important role, with many governments seeking to encourage externalized transfers to lower the cost of the transfer and promote local capability building. The issues involved are taken up below.

It is difficult to compare the *amount* of technology transfer by different modes, since data on technology transactions are often not available. Even when they are, the sums involved may not be a good reflection of the value of the transfer. As noted, prices contracted for different technology transactions reflect bargaining as well as differences in technology content and conditions. Transfers between related firms may be priced differently from those to unrelated ones for the same technology – they may be lower when elements of the transfer to affiliates are not charged for, or they may be higher to save on taxes. Recent data on technology receipts by the USA suggest that internalized transfers are growing: the share of royalties and technical fees received by US MNCs from affiliates is rising (Kumar, 1998). With policy liberalization and the growing value of innovation to competitiveness, MNCs are shifting towards greater internalization, at least as far as their most valuable technologies are concerned. At the same time, however, sources of externalized technology transfer are growing in number and diversity. MNCs are more willing to part with older, more mature technologies to unrelated firms; smaller enterprises are entering the technology market; there are more specialized engineering firms able to provide turnkey plants; and there are more competent technology suppliers from newly industrializing countries. On balance, independent technology access is probably becoming easier for mature technologies and more difficult for new ones.

Benefits of Technology Transfer by Different Modes

While MNCs are a powerful and growing force in technology transfer the relationship between foreign direct investment (FDI) and local technological development in host countries is not always straightforward or linear. More technology transfer via FDI does not, in other words, always mean correspondingly more local technology development. There are several stages between the import of technology and the development of local capabilities. A body of recent work on technological capabilities in developing countries suggests that the process of becoming and remaining technologically efficient (i.e. competitive in world markets) is fairly complex (Lall, 1992). It involves more than promoting FDI or allowing firms access to technology flows, though both are important.

Most economic analysis tends to assume that the *absorption* and *use* of a technology, once purchased, does not face any further costs or difficulties. On this assumption, enterprises seeking to build competitive technological capabilities should be given free access to all sources of technology (with the choice of mode of transfer left to free market forces).[2] This argument, often implicit, faces certain problems.

The efficient assimilation, adaptation and further development of imported knowledge involve a complex, often costly and risky, process of building new capabilities. Capability development is determined, at the national level, by the policy regime on trade and industry, and by investments in skills, information flows, infrastructure and supporting institutions. At the micro level, it is determined by enterprise efforts to build new organizational and technical skills, generate and tap information and strike appropriate links with suppliers,

buyers and institutions. It generally involves widespread externalities, since information and skills spill over from one enterprise to another. In fact, effective learning often depends on such spillovers. Thus, the social benefits of enterprise learning efforts may far exceed the benefit to the firms themselves.

The *mode of technology transfer can have important effects on the nature and pace of indigenous capability development.* This problem was largely ignored by the early literature, which tended to focus on two issues – the appropriateness of the technology to factor and product markets in host developing countries and the costs imposed by imperfections in technology markets. These concerns have now greatly diminished in policy discussions, to be replaced by considerations of capability building and competitiveness. Needless to say, the pace of technical change and the progress of policy liberalization have added considerable urgency to such considerations. How then do the two broad modes compare?

In general, internalized technology flows are a very efficient means of transferring a 'package' of capital, skills, information and brand names to developing countries. For many new technologies, internalized transfers are often the only possible mode of transfer, since innovators are unwilling to part with them to unrelated parties (a tendency greatly strengthened by policy liberalization). Even where technologies *are* available at arm's length, internalization may be the most efficient way of transferring the tacit knowledge and skills involved because of the commitment of the transferor and its capability to provide the learning tools needed. This advantage is particularly relevant for least developed countries that find it difficult to master even simple technologies. If the technology is changing rapidly, internalization would provide more direct access to improvements. If the activity is export-oriented, internalized transfers offer the additional (powerful) advantages of international marketing skills and networks, established brand names or, of increasing relevance, access to vertically integrated production structures spanning several countries.

However, foreign investment as a mode of technology transfer has costs: profits are realised by the MNC on the package as a whole rather than just the technology. If the host country already possesses other elements of the package, it would be cheaper to buy the technology separately. In general, the more standardized and diffused the technology, and the more capable the buyer, the more economical will externalized modes be. However, there is a more subtle reason: the existence of learning benefits and externalities may tilt the choice in favour of externalization even for relatively complex and difficult technologies. In such activities, reliance on foreign investment can shorten the learning period and relieve the associated financial stress (most local firms do not have the deep pockets of transnational firms). This may, nevertheless, have other repercussions.

A useful way to analyse this is to divide technological capabilities into four levels. At the bottom are the simplest (operational) ones, needed for running a technology efficiently: these involve basic manufacturing skills as well as some more demanding troubleshooting, quality control, maintenance and procurement skills. At the intermediate level are duplicative skills, which include the investment capabilities needed to expand capacity and to purchase and integrate foreign technologies. Next come adaptive skills, where imported technologies are adapted and improved, and design skills for more complex engineering learned. Finally come innovative skills, based on formal R&D (research and development), that are needed to keep pace with technological frontiers or to generate new technologies.

The advantage of internalized forms lies in the long-term commitment of the foreign

partner to the success of the project, its ability to provide many of the elements of the package needed to operationalize new technologies and its access to world class technologies and markets. At the lowest level, therefore, foreign investment is a very efficient way of transferring technology. Since all technologies need adaptation and improvement to keep them competitive, foreign affiliates, with their base of high level management and technical skills, tend to be in the forefront of such activity in developing countries. In addition, transnational firms have the experience of other affiliates in the developing world to draw on, and can shift knowledge and personnel across countries to help with the upgrading of local capabilities.

As capability development progresses to the fourth level, where local innovative efforts become viable, there can be a conflict of interest between the developing host country and the foreign investor. Internalized technology transfer and local capability development become, in other words, competitive rather than complementary. There are strong economic reasons for the investor to keep innovative work centralized at home or in a few developed countries. At the same time, it is economically desirable for newly industrializing countries to deepen their capabilities in order to mount innovative activity and reap the externalities associated with innovation. MNCs tend to transfer the results of R&D rather than the process itself, whereas the sustained technological growth of developing countries calls for increasing local innovation. There can then be a case for restricting reliance on internalized forms and boosting local R&D based on externalized forms.

At the same time, there can be flexibility in internalized transfers if the host country is able to induce a higher level on innovative activity by MNCs by offering the incentives, skills and infrastructure needed. Singapore is the best example of a country that has been able to do this on a consistent and systematic basis (Lall, 1996).[3] However, there are few other examples of a similar strategy of technology development in other developing countries. The newly industrializing countries that have built advanced local technological capabilities have done so by promoting externalized transfers and restricting free inward FDI, the best examples being Korea and Taiwan.

It is important to note, however, that the current economic environment generates considerable pressures against a proactive government role. Not only are many governments liberalizing on their own, many important tools of intervention used effectively in the past are being ruled out by pressures exerted by aid donors and international agencies. Many new 'rules of the game' constrict the ability of governments to undertake selective interventions to boost industrial or technological development. Many countries rightly welcome such liberalization in reaction to previous strategies of wholesale and inefficient interventions. However, when carried too far, they have to give up legitimate tools of policy, used successfully not just in the developing world but also (further in the past) by many mature industrial economies.

The Readings

The present selection of readings largely reflects the concern of the technology transfer literature with international technology markets and the central role of MNCs; it also focuses on development issues, my own area of interest. Part I of the selection deals with basic conceptual issues. It starts with a classic paper by Ed Mansfield (Chapter 1) on the nature and

forms of technology transfer, a clear and brief introduction to the subject. Chapter 2, by Lissoni and Metcalfe, deals with technology diffusion (mainly within developed countries). As noted at the start, while diffusion has traditionally been the focus of the analysis of the 'movement' of technology, the analysis has evolved along different lines from the technology transfer literature (see OECD, 1996). However, it is useful to have this comprehensive review of diffusion, since many aspects overlap with technology transfer. More importantly, Lissoni and Metcalfe set the discussion in terms of a contrast between the textbook neoclassical approach and the more structuralist or evolutionary approach – a distinction that also plays an important role in the transfer literature. Chapter 3, an article published in 1991, by Segafi-nejad provides an overview of international technology transfer, empirical research and policy issues.

Part II concentrates on the role of MNCs in technology transfer. While often cited and reprinted, the paper by David Teece (Chapter 4) is worth having because it remains perhaps the best analytical piece on the costs of technology transfer. Chapter 5, by John Cantwell, describes the process of globalizing innovation by MNCs, and summarizes the valuable data he has collected on the international spread of patenting by international companies. He debunks the common notion that innovative activity by MNCs remains based in their home countries; on the contrary, MNCs from small home countries have been highly international in their patenting for a century or more. While practically all this activity remains within the developed world, MNCs are building international innovation networks that may affect developing host countries.

In Chapter 6, François Chesnais provides a useful theoretical analysis of the role of MNCs in the international diffusion of technology, followed by Chapter 7 by Helleiner describing this role (and its shortcomings) in developing countries. Chapter 8 reprints a paper by John Dunning dealing with the other side of the technology transfer process: the home country of MNCs. He deals critically with common concerns: MNCs reduce competitiveness and employment in the home country by transferring technology overseas, especially to developing countries.

Part III has five papers on technology transfer and development more generally. Chapter 9 contains a comprehensive, analytical review of technology transfer by John Enos, with a focus on the Asia-Pacific region. David Mowery and Joanne Oxley (Chapter 10) examine the role of 'national innovation systems' and technology transfers in East Asia (including Japan). They highlight both the role of domestic technological capabilities in using technology inflows effectively and the link between this literature and the burgeoning set of writings on national innovation systems. They argue that the channel of technology inflow is less important than national receptive abilities, given by the stock of technical manpower, and active domestic competition. Their argument is challenged in the next two papers, both dealing directly with the mode of technology inflows and local technology development. Howard Pack and Kemal Saggi (Chapter 11) and Sanjaya Lall (Chapter 12) argue that the mode of transfer does have an impact on host country learning and capability building; the latter argues for a more interventionist policy. Linsu Kim (Chapter 13) analyses the costs and benefits of technology transfer from a developing country (Korea) perspective, and provides an illuminating conceptual framework for looking at the problem. While it proved too difficult to extract a reading from the book by Radosevic (1999) for this volume, it is a useful recent review of technology transfer and development issues.

Part IV provides a selection of case studies from different developing and transition countries or regions. In Chapter 14, Carlos Correa reviews recent trends and policies in technology transfer to Latin America, while in Chapter 15 Mike Hobday provides a more detailed study of how East Asian 'latecomer' firms learned electronics technology. In Chapter 16, John Mathews analyses how Taiwan used industrial policy to create the 'Silicon Valley of the East', while Poh-Kam Wong (Chapter 17) provides a similar analysis of how Singapore made itself one of the world's leading hubs for hard-disk drives. I find both these case studies fascinating: they illustrate graphically how technology imports can be used deliberately by developing countries to create new areas of comparative advantage in highly advanced activities, Taiwan essentially orchestrating domestic enterprises and Singapore relying on MNC affiliates. For those interested in industrial policy and technology development, Amsden (1989), Mathews and Cho (1999), Pack and Westphal (1986), Westphal (1990) and Wade (1990) are vital supplementary readings. This section concludes with a paper by Slavo Radosevic on technology transfer in Eastern Europe, focusing on strategic changes consequent on economic reform and liberalization.

The final section consists of two papers on technology transfer and globalization in the industrially advanced countries. Keith Pavitt (Chapter 19) provides a review on transfers among these countries and Daniele Archibugi and Jonathan Michie (Chapter 20) close appropriately with an analysis of the changing nature of technological globalization. They show that technologies are being increasingly exploited on a global scale and that innovators are being compelled to collaborate with each other similarly to retain competitiveness, particularly in fast-growing activities. They question how rapidly MNCs are spreading innovative activities internationally.

Research Issues

Let me conclude with some important research issues in the field of international investment and technology transfer – the list, being subjective, reflects my interests in development policy.

- The *scope for effective policy* on FDI and for *bargaining* between MNCs and host countries. The trend of policy liberalization, reinforced by the World Trade Organization and new rules like Trade Related Investment Measures (TRIMS), is towards reducing the power of host governments to intervene in the market-determined investment process. How much scope will be left if something like the failed Multilateral Agreement on Investment by the Organization for Economic Cooperation and Development (OECD) is concluded in the future? How will such agreements affect bargaining between governments and MNCs? Will they affect governments of countries of different sizes and incomes differently? What tools of FDI attraction, guidance and control on FDI will be left to governments?
- The *impact of technological changes* on FDI and MNC strategies. Technical change is altering patterns of national and corporate comparative advantages constantly, shifting some activities back to advanced countries and others to developing ones. There are large shifts under way within the developing world, with increasing divergences

between a few newly industrializing countries and least developed countries. A number of important issues arise. To what extent is FDI accelerating these shifts? Can it be made to reduce divergences rather than exacerbate them? What are the effects on developing host countries of the trend to strategic alliances between the leading MNCs? Will technical change and increased competition lead to more technological effort being located in developing countries or less? At the corporate level, how do new information and communication technologies affect the location of strategic activities? Do they lead to greater centralization or otherwise?

- The new drivers of *FDI location*. It is clear that in a liberalized world the factors attracting MNCs are different from before, but what are the main motive forces in investment location? How important are large domestic markets, the availability of skilled manpower, physical infrastructure, investment incentives, belonging to large regional groups? Answers to this set of questions are vital to the formulation of FDI and technology transfer policies in developing countries.
- *FDI promotion*. The examples of Ireland and Singapore are often cited as 'best practice', and the broad nature of their strategies is known. However, the details are less well understood, and the steps that less advanced countries need to take to set up efficient promotion agencies are not clear. What are the emerging best practices in promotion and targeting? What sorts of skills are needed? What sort of information? How is investor targeting and monitoring operated? Which MNCs respond best to promotion? Which industries are most amenable?
- The impact of FDI on *domestic technological effort and entrepreneurship* remains a controversial and important area. The 'stylized fact' is that the countries that have built up the strongest domestic technological capabilities have restricted FDI. However, countries like Singapore and Ireland are attracting considerable R&D effort from MNCs; there are indications that Malaysia and Mexico are following some distance behind. What are the trade-offs between attracting FDI and deepening technological activity? What are the limits of depending on MNC-led R&D especially if the domestic technological base is weak? There are also issues related to linkages between MNC affiliates and local suppliers and buyers. Are these growing stronger or weaker with trade liberalization and the removal of local content rules? What can be done to raise the intensity of vertical linkages?
- The nature and scope of emerging *integrated production systems*. This raises perhaps the most important, interesting and difficult set of issues. At this time, such systems are expanding very rapidly in a few industries, but will they continue to do so? Which countries will they embrace and which not? What are their linkages with the economies of the host countries? What are their industry-specific characteristics? How much of world trade will be covered by these systems? What can host governments do to break into these systems?

Notes

1. MNCs dominate the transfer of technology in contractual forms, and the bulk of royalty payments in the world are from affiliates to parent companies (OECD, 1999, p. 96).

2. The case for free technology markets in all forms is reinforced by the accelerating pace of technical progress, which raises the cost and risk of being 'left behind' but this is incidental to the underlying theoretical argument.
3. Ireland is a comparable example in the developed world.

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