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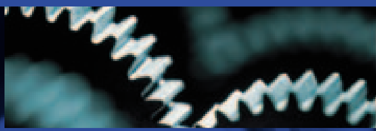

# Encouraging International Technology Transfer

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ICTSD
International Centre for Trade and Sustainable Development

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Issue Paper No. 7

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The Project is being implemented by the International Centre for Trade and Sustainable Development (ICTSD) and the secretariat of the United Nations Conference on Trade and Development (UNCTAD) (Project Number INT/OT/1BH). The broad aim is to improve the understanding of intellectual property rights-related issues among developing countries and to assist them in building their capacity for ongoing as well as future negotiations on intellectual property rights (IPRs).

For details on the activities of the Project and all available material, see http://www.iprsonline.org/unctadictsd/description.htm



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# FOREWORD

The present paper dealing with Encouraging International Technology Transfer is one contribution of the joint UNCTAD-ICTSD Project on Intellectual Property Rights (IPRs) and Sustainable Development to the ongoing debate on the impact and relevance of intellectual property to development.

This report reviews comprehensively the basic theory and evidence regarding how intellectual property protection affects incentives for international technology transfer (ITT). Analysis is provided of market-mediated ITT through trade, foreign direct investment, licensing, and personnel movements, along with informal means through imitation, reverse engineering, and spillovers. The report points out that there are inherent shortcomings in markets for technology that justify public intervention. One form of intervention is IPRs, which can support ITT but also create market power. Empirical evidence suggests that enforceable patents can increase inward flows of ITT in middle-income and large developing countries but probably have little impact in the least-developed countries. Thus, the TRIPS Agreement at the WTO by itself will have little impact on technology acquisition for poor countries. Negotiators recognized this and introduced Article 66.2, which obligates the developed countries to provide positive incentives for ITT to the least-developed countries. This study makes numerous suggestions for improving these incentives by policy changes in recipient countries, source countries, and the global trading system.

Intellectual property rights have never been more economically and politically important or controversial than they are today. Patents, copyrights, trademarks, industrial designs, integrated circuits and geographical indications are frequently mentioned in discussions and debates on such diverse topics as public health, food security, education, trade, industrial policy, traditional knowledge, biodiversity, biotechnology, the Internet, the entertainment and media industries. In a knowledge-based economy, there is no doubt that an understanding of IPRs is indispensable to informed policy making in all areas of human development.

Intellectual property was until recently the domain of specialists and producers of intellectual property rights. The TRIPS Agreement concluded during the Uruguay Round negotiations has signalled a major shift in this regard. The incorporation of intellectual property rights into the multilateral trading system and its relationship with a wide area of key public policy issues has elicited great concern over its pervasive role in people’s lives and in society in general. Developing country members of the World Trade Organization (WTO) no longer have the policy options and flexibilities developed countries had in using IPRs to support their national development. But, TRIPS is not the end of the story. Significant new developments are taking place at the international, regional and bilateral level that build on and strengthen the minimum TRIPS standards through the progressive harmonisation of policies along standards of technologically advanced countries. The challenges ahead in designing and implementing IP-policy at the national and international levels are considerable.

Empirical evidence on the role of IP protection in promoting innovation and growth in general remains limited and inconclusive. Conflicting views also persist on the impacts of IPRs in the development prospects. Some point out that, in a modern economy, the minimum standards laid down in TRIPS will bring benefits to developing countries by creating the incentive structure necessary for knowledge generation and diffusion, technology transfer and private investment flows. Others stress that intellectual property, especially some of its elements, such as the patenting regime, will adversely affect the pursuit of sustainable development strategies by raising the prices of essential drugs to levels that are too high for the poor to afford; limiting the availability of educational materials for developing country school and university students; legitimising the piracy of traditional knowledge; and undermining the self-reliance of resource-poor farmers.

It is urgent, therefore, to ask the question: How can developing countries use IP tools to advance their development strategy? What are the key concerns surrounding the issues of IPRs for developing countries? What are the specific difficulties they face in intellectual property negotiations? Is intellectual property directly relevant to sustainable development and to the achievement of agreed international development goals? Do they have the capacity, especially the least developed among them, to formulate their negotiating positions and become well-informed negotiating partners? These are essential questions that policy makers need to address in order to design IPR laws and policies that best meet the needs of their people and negotiate effectively in future agreements.

It is to address some of these questions that the joint UNCTAD-ICTSD Project on Intellectual Property and Sustainable Development was launched in July 2001. One central objective has been to facilitate the emergence of a critical mass of well-informed stakeholders in developing countries - including decision makers, negotiators but also the private sector and civil society - who will be able to define their own sustainable human development objectives in the field of IPRs and effectively advance them at the national and international levels.

Ricardo Meléndez-Ortiz
ICTSD Executive Director

Rubens Ricupero
UNCTAD Secretary General

## EXECUTIVE SUMMARY

International technology transfer (ITT) is a comprehensive term covering mechanisms for shifting information across borders and its effective diffusion into recipient economies. Thus, it refers to numerous complex processes, ranging from innovation and international marketing of technology to its absorption and imitation. Included in these processes are technology, trade, and investment policies that can affect the terms of access to knowledge. Policy making in this area is especially complex and needs careful consideration, both by individual countries and at the multilateral level.

Markets for exchanging technologies are inherently subject to failure due to appropriability problems, spillovers, asymmetric information, and market power. Thus, there is strong justification for public intervention. However, interests in shaping such intervention are not uniform. Technology developers are interested in reducing the costs and uncertainty of making transfers, along with protecting their rights to profit from such transfers. They argue that effective protection and policy supports for markets are necessary to increase the willingness of innovative firms to provide knowledge of their production processes to firms in developing countries. Technology importers are interested in acquiring knowledge at minimal cost. Some observers argue that this objective is best met by refusing to protect the rights of foreign firms to profit from such transfers, or at least to restrict sharply their exclusive rights to exploit technology.

There is scope for mutually advantageous changes in policy regimes within these extremes. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) within the WTO reflects an important multilateral effort to address these fundamental tradeoffs. However, the Agreement is widely criticized as being overly protective of the needs of technology developers and insensitive to the needs of developing countries. In fact, TRIPS does not address itself in practical ways to issues of ITT, confining its language to general statements.

There are numerous channels through which technology may be transferred across international boundaries. One major channel is trade in goods, especially capital goods and technological inputs. A second is foreign direct investment (FDI), which may be expected generally to transfer technological information that is newer or more productive than that of local firms. A third is technology licensing, which may be done either within firms or between unrelated firms at arm's-length. Licenses typically involve the purchase of production or distribution rights (protected by some intellectual property right) and the technical information and know-how required to make effective the exercise of those rights. In this regard patents, trade secrets, copyrights, and trademarks serve as direct means of information transfer.

There are also important non-market channels of ITT. Perhaps most significant is the process of imitation through product inspection, reverse engineering, decompilation of software, and even simple trial and error. Imitation can be a costly process. A related form of learning is for technical and managerial personnel to leave the firm and start a rival firm. Yet another means is to study available information about those technologies. Patent applications are available for this purpose. Thus, patents provide both a direct source of technology transfer, through FDI and licensing, and an indirect form through inspection. However, there is much debate over whether such patent disclosures provide sufficient information for rival engineers to understand the technologies.

Finally, much technology appears to be transferred through the temporary migration of students, scientists, and managerial and technical personnel to universities, laboratories, and conferences located mainly in the developed economies. Note that in-depth training in science and engineering may be gained this way, suggesting that it is a particularly long-lasting form of ITT. Further, information may be available within the public domain, making it free for taking, although not necessarily absorbed at low cost.

A major reason for protecting IPRs is that they can serve as an important support for markets in technology, including ITT. Without protection from leakage of new technical information, firms would be less willing to provide it on open technology markets. Further, patents and trade secrets provide the legal basis for revealing the proprietary characteristics of technologies to subsidiaries and licensees, supporting the formation of contracts.

However, the idea that weak IPRs reduce inward ITT is not certain and is not accepted by all observers. Limited patent protection and weak trade secrets offer local firms some scope for imitating foreign technologies and reverse engineering products. With intellectual property protection foreign firms may choose not to have any physical presence in a country, preferring to satisfy a market through exports. Similarly, strengthened IPRs provide foreign inventors greater market power in setting licensing terms.

Thus, the question is really empirical. A crude summary of the available evidence is as follows:

- There is strong evidence that patent applications serve as a conduit for learning among OECD economies. Thus, "trade in ideas" is a major factor in world economic growth.

- Patent citations reflect "knowledge flows" across borders in the sense that local inventors learn from them. There is a strongly positive impact of knowledge flows on international innovation, at least among developed regions.

- Stronger patent rights may be expected to raise considerably the rents earned by international firms as patents become more valuable, obliging developing countries to pay more for the average inward protected technology.

- International trade flows, especially in patent-sensitive industries, respond positively to increases in patent rights among middle-income and large developing countries. However, trade flows to poor countries are not responsive to patent rights.

- The evidence on patents and inward FDI is mixed but recent studies find positive impacts among middle-income and large developing countries. Again, poor countries with stronger patents do not attract FDI on this basis.

- There is an identifiable "internalisation effect" whereby strengthening of patent rights shifts ITT from exports and FDI toward licensing. Further, the sophistication of technologies transferred rises with the strength of intellectual property protection.

- Whatever the role of IPRs, they are only one of a list of factors that influence ITT. Important factors include the investment climate, efficient governance, market size and growth, proximity to suppliers and demanders, and infrastructure.

In addition to econometric studies one can look at the histories of such recent developers as Japan and the Republic of Korea. Both pursued IPR policies that favoured local use of international technologies, licensing, and incremental innovation as they moved from being crude imitators to creative imitators and then knowledge-intensive innovators. Developing countries today have much to learn from these histories. However, TRIPS has narrowed the avenues such countries may take toward technological learning and adaptation from foreign technologies.

TRIPS recognizes in Article 7 that the transfer and dissemination of technology is a fundamental objective of the global IPR system. However, most provisions of TRIPS offer little direct assurance that there will be a rise in ITT to poor countries. Thus the negotiators included Article 66.2, which obligates developed countries to offer positive incentives to its firms and institutions to transfer technologies to the least developed countries. Article 67 obligates the developed countries to providing technical and financial assistance to help induce more ITT.

Article 66.2 is not likely on its own merits to achieve significant increases in ITT. There are two essential difficulties. For one, ITT largely relies on private market incentives and this article does little to redress the basic problems mentioned above. Second, even if governments in developed countries were willing to offer substantial incentives they would face domestic political opposition in doing so.

In this regard, the following set of policy recommendations should provide a framework for improving the environment for ITT. I organize them in terms of host-country policies, source-country policies and issues for the global system.

### *Host–Country Policies*

An important determinant of the ability of domestic firms to absorb foreign technologies is the return to investing in at least simple R&D capacity. To the extent that policies discourage such investments, they could be reformed to encourage more innovation.

- Absorption of ITT and its translation into greater competition depend on having an adequate supply of engineering and management skills.
- Backward spillovers from ITT appear to be strongest in countries where multinational firms are capable of working with competitive suppliers in order to increase their productivity and standards. Reducing entry barriers in supplier industries can assist ITT.
- Evidence suggests that FDI and licensing respond to an adequate business environment. Important factors include, among others, an effective infrastructure, transparency and stability in government, and a reasonably open trade and investment regime.
- Governments may reduce the "technological distance" between their firms and foreign firms in order to encourage ITT.
- The intellectual property system is integral to efforts to promote learning from ITT and follow-on innovation. Thus, attention should be paid to selecting IP standards that recognize the rights of inventors but encourage dynamic competition.

### *Source–Country Policies*

- Nothing in Article 66.2 prevents developed countries from providing indirect incentives for ITT. The most powerful incentive would be to provide significant market access in the developed economies for products in which poor countries have a comparative advantage.
- Technical standards play a role in diffusing production and certification technologies. Thus, developed countries could commit to greater access to their own standards-setting bodies for experts from poor countries.
- Governments in developed countries could increase their technical and financial assistance for improving the ability of poor countries to absorb technology and trade.
- Governments could agree to offer identical fiscal benefits to firms transferring technologies to developing countries as to developing home regions.
- Developed countries could offer the same tax advantages for R&D performed abroad as for R&D done at home. To meet the terms of Article 66.2, there might be somewhat greater advantages offered for R&D performed in poor countries.

- Governments could ensure that tax deductions are available for contributions of technology to non-profit entities engaged in ITT. Such contributions could be in the form of money, technical assistance, or mature patent rights.

- Fiscal incentives could be offered to encourage enterprises to employ, at least temporarily, recent scientific and engineering and management graduates from developing countries.

- Public resources, such as those from the National Science Foundation or National Institutes for Health in the United States, could be used to support research into the technology development and technology transfer needs of developing countries. Further, grant programs could be established for research into technologies that would be of greatest productivity in poor countries for social needs. Technologies developed under such programs could be made publicly available if transferred through public resources.

- Grant programs could be devised that offer support to proposals that meaningfully involve research teams in developing countries, presumably in partnership with research groups in donor countries.

- Universities could be encouraged to recruit and train students from LDCs in science, technology, and management. Incentives for setting up degree programs through distance learning or even foreign establishments may be particularly effective.

### *Multilateral Policy Options*

There are essentially two roles that international organizations can play in encouraging ITT. One is to serve as a coordinating mechanism for overcoming problems in private technology markets. The second is to serve as a forum for negotiating additional rights and obligations at the international level in order to reduce impediments to ITT.

- The terms of Article 66.2 could be expanded to include all developing countries, or at least those without a significant domestic science and technology base and extensive university training.

- There may be scope for linking Article 66.2 and Article 67 to Article 7 in terms of obligations. Thus, developing countries could commit to making a good faith effort to improving the environment for ITT if developed countries were prepared to offer much more technical assistance and sustainable funding for such reforms.

- A particular suggestion would be to establish a special fee on applications through the Patent Cooperation Treaty, the revenues of which would be earmarked for improving IP administrative systems in developing countries.

- Through negotiations the WTO could increase the scope for monitoring developed-country efforts in ITT and could add an evaluative mechanism for the effectiveness and extent of technology transferred.
- To reduce information problems, the WTO and technology-related organizations could serve as an intermediary conduit for knowledge about successful technology-acquisition programs that have been undertaken by national and sub-national governments in the past.
- Poor countries face major difficulties in developing the appropriate expertise for developing and enforcing anti-monopoly laws. Thus, one way for governments in developing countries to feel more confident about the system would be for authorities in the developed countries to undertake enforcement actions on their behalf against firms headquartered or located in their jurisdictions.
- In future negotiations over Mode 4 in the GATS (temporary movement of personnel), developing countries could push for additional visa allocations for attending conferences and for professional researchers and students.
- Donor countries and organizations could consider establishing special trust funds for the training of scientific and technical personnel, for facilitating the transfer of technologies that are particularly sensitive for the provision of public goods, and for encouraging research in developing countries.
- Countries are engaged in negotiating a Patent Harmonization Treaty through the auspices of WIPO. At a minimum there need to be regional examination offices with standards that reflect the needs of developing countries.
- There will be strong pressures in the Doha Round to expand protection for geographical indications and to require patentability for biotechnological inventions. Developing countries could tie such changes to significant agricultural liberalization in developed countries.
- Some relief from the need for the poorest countries to meet minimum technical standards could help them acquire mature technologies.

A final proposal is for a multilateral treaty offering access to the results of basic science and technology by putting the results of publicly funded research into the public domain. The agreement could cover inputs, outputs, or both, and would need certain safeguards for reasons of security. To the extent that charges must be paid for research outcomes, a differentiated pricing structure on behalf of developing countries is appropriate.

# 1. INTRODUCTION

The international flow of technological information and its successful integration into domestic production and management processes are central to the ability of developing countries to compete in the global economy and to narrow the technological gaps they face compared to developed countries. Technological change is a principal source of sustained growth in living standards and is essential for transformation and modernization of economic structures. In most instances developing countries find it cheaper and faster to acquire foreign technologies than to develop them with domestic resources. One reason is that such technologies may "spill over" into wider improvements in productivity, generating a multiple benefit.

International technology transfer (ITT) is a comprehensive term covering mechanisms for shifting information across borders and its effective diffusion into recipient economies. Thus, it refers to numerous complex processes, ranging from innovation and international marketing of technology to its absorption and imitation. Included in these processes are technology, trade, and investment policies that can affect the terms of access to knowledge. Policy making in this area is especially complex and needs careful consideration, both by individual countries and at the multilateral level.

International markets for exchanging technologies are inherently subject to failure for reasons discussed in this report. Accordingly, there is strong justification for public intervention. However, interests in shaping such intervention are not uniform. Technology developers, which to date reside overwhelmingly in developed countries, are interested in reducing the costs and uncertainty of making transfers, along with protecting their rights to profit from such transfers. They argue, with some justification, that effective protection and policy supports for markets are necessary to increase the willingness of innovative firms to provide knowledge of their production processes to firms in developing countries. Technology importers, still overwhelmingly in developing and least-developed countries, are interested in acquiring knowledge at minimal cost. Some observers argue that this objective is best met by refusing to protect the rights of foreign firms to profit from such transfers, or at least to restrict sharply their exclusive rights to exploit technology.

There is scope for mutually advantageous changes in policy regimes within these extremes. Thus, the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) within the WTO reflects, in part, an important multilateral effort to address these fundamental tradeoffs. However, the Agreement is widely criticized as being overly protective of the needs of technology developers and insensitive to the needs of developing countries (Commission on Intellectual Property Rights, 2002; World Bank, 2001). As discussed later, TRIPS does not address itself in practical ways to issues of ITT, confining its language to general statements.

The TRIPS Agreement is not the only component of the WTO that affects conditions for ITT. Also relevant are the General Agreement on Trade in Services (GATS), the Agreement on Trade-Related Investment Measures (TRIMS), the Agreement on Sanitary and Phyto-sanitary Standards (SPS), the Agreement on Technical Barriers to Trade (TBT), and the Government Procurement Agreement. More generally, trade policy influences incentives for engaging in technology trade.

Neither is the WTO the only international format in which ITT is addressed. Bilateral investment treaties (BITS) and various preferential trade areas (PTAS) affect incentives and conditions for technology use and marketing.

The investment environment within individual recipient countries may be the most important factor of all. Put simply, because much ITT is mediated through private markets, those countries with inadequate investment climates and poor absorptive abilities are unlikely to receive much inward technology flows under any circumstances.

This report aims to shed light on some of the complexities involved in ITT in order to support positive recommendations for encouraging such flows to developing countries and least-developed countries. Its ultimate goal is to suggest an agenda within which individual and international policies may be structured for this purpose. In the next section I overview relevant theory and evidence on the nature and flows of ITT in order to understand the need for, and appropriate limitations on, public policy in this arena. Attention is paid to market problems, determinants of ITT, channels of transfer, and the scope for spillovers.

Given the central role that intellectual property rights (IPRs) play, in section three I analyse their relationships with ITT. This provides a platform for discussing useful means of limiting the scope of exclusive rights, where such limitations might enhance ITT. However, the analysis also points up the difficulties of attaining benefits from this kind of precise industrial policy.

In the fourth section I turn to the WTO approach to ITT. After discussing the existing WTO provisions in this area I consider the policy options countries have in attracting technology, including regulation of IPRs. This analysis suggests a number of avenues that negotiators might pursue in improving TRIPS as regards incentives for technology trade.

In the final section I provide additional suggestions for multilateral policies that could encourage additional ITT. An important point is that the WTO approach is not the only avenue for achieving this objective.

# 2. THEORY AND EVIDENCE ON ITT

In this section I overview essential theoretical claims about the determinants of ITT and discuss significant empirical evidence about these claims. This is not a comprehensive treatment of these complex issues, which would be beyond the scope of this report.[1] Rather, I highlight the state of knowledge and opinion about key features of ITT in order to set up the discussion of policy issues.

## 2.1 General observations

### *Definitions*

**a. Technology**

It is useful to define central concepts at the outset. First, a technology may be defined as the information necessary to achieve a certain production outcome from a particular means of combining or processing selected inputs. Many technologies may generate the same outcome but they may differ in terms of their efficiency. And a given technology may generate multiple outputs. A technology may be quite specific or it may encompass several sub-processes, such as producing intermediate inputs within an overall value chain. Technologies may be particular production processes, intra-firm organizational structures, management techniques, means of finance, marketing methods, or any combination of these. All contribute to the productivity with which outputs are generated from inputs and to the market value of those outputs.

Technology may be codified in formulas, blueprints, drawings, patent applications, and the like. It may also be uncodified in the sense of requiring implicit know-how on the part of personnel. Often technologies may not be learned solely from codified sources, requiring technology acquirers to gain access to know-how as well. Know-how typically derives from repeated experimentation with production techniques.

Technology may also be classified as embodied or disembodied. Information may be embodied in the form of particular products, which might be reverse engineered to discover the underlying processes. It may be disembodied as codified technology or as know-how. There is a wide variation in the degree of embodiment across products and services. Some products, such as software and pharmaceuticals, wear their technologies "on their face" and are (relatively) easily reverse engineered and copied. Others, such as complex machinery and financial services, carry their technological secrets much deeper.

**b. Transfer of technology**

Technology transfer refers to any process by which one party gains access to a second party's information and successfully learns and absorbs it into his production function. Clearly, much technology transfer occurs between willing partners in voluntary transactions. Thus, there are demanders and suppliers of technology and information is traded in technology markets. As discussed below, markets for information are peculiarly subject to failures, the resolution of which becomes an objective of public policy.

Not all technologies are transferred in private markets between unrelated parties. Much information flows within the boundaries of firms and joint ventures. Further, knowledge about production and management processes may be gained from reverse engineering, reading published materials, training within firms and laboratories, and attending professional conferences. Finally, much information may be available within the public domain, making it free for taking, although not necessarily absorbed at low cost. Note that the public domain may be filled both by public research outcomes and by the decisions of firms not to seek protection or to permit their intellectual property protection to lapse.

Indeed, technology transfer is generally a costly process and these costs are central to how information is traded and between which partners. I will discuss the analytical implications of technology-transfer costs in a later section. At this point, however, it is important to recognize that such costs are an essential component of both private technology markets and other forms of learning. For many developing countries policy must aim at reducing them if effective transfer is desired.

## *Channels of ITT*

It is useful to make a distinction between ITT that flows through market-mediated mechanisms, meaning that some form of formal transaction underlies the technology movement, and non-market mechanisms, which do not involve such transactions. An alternative description would be "formal" and "informal" channels, respectively, reflecting the nature of the information trade.

### a. Market channels

*- Trade in goods and services*

There are numerous channels through which technology may be transferred across international boundaries. One major channel is trade in goods and services. All exports bear some potential for transmitting technological information for they may be studied for design characteristics and reverse engineered. However, trade in capital goods and such technological inputs as industrial chemicals, hardened metals, fertilizers, and software can directly improve productivity by being placed into production processes. In this sense, international trade itself is a central form of technological change.

*- Foreign direct investment*

A second channel is foreign direct investment (FDI) through multinational enterprises (MNEs). MNEs may be expected, in principle, to deploy to their subsidiaries in recipient countries technological information that is newer or more productive than was the case with incumbent firms. This is because the primary motivation for a firm to become multinational is the ownership of some knowledge-based asset (KBA) that provides it with a cost or quality advantage and that can be adapted and employed in multiple locations (Markusen, 1995). The notion of KBAs should be interpreted broadly, for they encompass agribusiness (e.g., livestock management and marketing), manufactures (e.g., chemical formulas, machinery design, and factory-floor management), consumer goods and services (e.g., brand names), and numerous producer services (e.g., financial methods and construction blueprints). Thus, FDI is a major conduit through which firms compete globally in technology.

*- Licensing*

A third major channel is technology licensing, which may be done either within firms or between unrelated firms at arm's-length. Licenses typically involve the purchase of production or distribution rights (protected by some intellectual property right) and the technical information and know-how required to make effective the exercise of those rights. There are important differences between intra-firm ITT and market-mediated licensing. In the first case the MNE retains proprietary control of the intellectual property and know-how, while in the second case access to these assets must be provided to the licensee. Note that in this regard patents, trade secrets, copyrights, and trademarks serve as direct means of information transfer. Where licensing contracts are reached through negotiation between buyer and seller, the transfer is voluntary. However, governments may at time issue orders mandating the surrender of rights to a domestic firm, in which case the transfer is compulsory. It is evident that compulsory licenses may not succeed in acquiring the relevant know-how that is not embodied in patent or trademark rights.

*- Joint ventures*

Licensing and FDI are closely related to the establishment of joint ventures (JVs), which are contractual arrangements between two or more firms in which each provides some advantage that should reduce the costs of joint operations. In this context, international firms may provide technically superior production information through licensing, while local partners provide distribution networks, information about labour markets, unique management techniques, brand recognition, or some other local advantages. Some arrangement is reached for sharing any profits or losses from the JV.

*- Cross-border movement of personnel*

A fifth significant channel of ITT is cross-border movement of technical and managerial personnel. Indeed, many technologies cannot be effectively or affordably transferred without the complementary services and know-how of engineers and technicians that must be on-site for some period of time. An important advantage of MNEs is the ability to shift such skilled personnel among subsidiaries as needed. Markets for temporary movement of skilled workers among unrelated firms may be more restrictive and less flexible, raising the costs of such transfer and absorption.

It is important to note that trade, FDI, licensing, joint ventures, and personnel movements are interdependent processes. These decisions are made jointly by firms seeking to maximize returns on their technological assets. Policy environments affect these decisions, both in overall scope and in their substitution among channels, an important observation to which I will devote some attention later in the report.

The processes described so far may be characterized (save for compulsory licensing) largely as market transactions. In most cases, there are literal buyers and sellers of technology and the role of the market is to facilitate such trade and permit negotiations of mutually advantageous terms of transfer. Technology transfer within multinational firms may not incorporate the same formal terms but ultimately such trades must reflect the true economic value of information to both the parent firm and its subsidiaries. Thus, markets for information play the major role in ITT. To a first approximation, expanding the scope for ITT requires reducing imperfections and impediments in such markets.

*- Trends in market-mediated ITT*

These various flows have grown dramatically in recent years, as shown in Table 1. The figures in that table list nominal exports of capital-intensive goods, skilled-labour-intensive goods, and high-technology goods from the high-income OECD economies to all countries grouped by income levels. They also describe nominal royalty income earned by the OECD countries and net FDI flows from those nations to other countries.

The three categories of merchandise trade capture the forms of exports that should embody considerable technology, though the actual technology content in these flows is unknown. All the merchandise trade volumes are larger than direct trade in technology (i.e., royalties) or FDI flows. Regardless of the channel, low-income countries account for only a small share of total outward flows from OECD countries. Moreover, this share has been falling over time, a trend that is even stronger for sub-Saharan countries.

*Table 1: Exports of Capital-Intensive, Skilled Labour-Intensive and Technology-Intensive Goods, Royalty Income Earned and Net FDI Outflows from High-Income OECD Countries, 1970 and 2001, US$ billion & percent*

| | Capital-intensive exports | | Skill-intensive exports | | High-technology exports | | Royalties | | Net FDI outflows | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Value ($bn)** | **1970** | **2001** | **1970** | **2001** | **1970** | **2001** | **1970** | **2001** | **1970** | **2001** |
| High income | 45.8 | 1,108.0 | 43.7 | 736.7 | 25.8 | 739.3 | 2.8 | 71.2 | 6.9 | 472.1 |
| Low income | 2.8 | 32.8 | 2.4 | 13.1 | 1.2 | 16.1 | 0.0 | 0.02 | 0.3 | 8.1 |
| Lower middle income | 8.4 | 183.4 | 5.7 | 60.0 | 3.5 | 104.3 | 0.0 | 0.7 | 0.9 | 105.6 |
| Upper middle income | 7.7 | 318.0 | 5.2 | 126.9 | 3.8 | 200.0 | 0.0 | 1.8 | 0.6 | 69.4 |
| Sub-Saharan states | 1.5 | 10.6 | 1.5 | 6.0 | 0.7 | 5.6 | 0.0 | 0.02 | 0.1 | 5.5 |
| **Shares (%)** | | | | | | | | | | |
| High income | 70.8 | 67.5 | 76.6 | 78.7 | 75.4 | 69.8 | 99.7 | 96.7 | 79.9 | 72.0 |
| Low income | 4.4 | 2.0 | 4.2 | 1.4 | 3.5 | 1.5 | 0.0 | 0.0 | 3.2 | 1.2 |
| Lower middle income | 12.9 | 11.2 | 10.0 | 6.4 | 10.1 | 9.8 | 0.0 | 0.9 | 9.9 | 16.1 |
| Upper middle income | 11.9 | 19.4 | 9.1 | 13.5 | 11.0 | 18.9 | 0.0 | 2.4 | 7.1 | 10.6 |
| Sub-Saharan states | 2.3 | 0.6 | 2.8 | 0.6 | 2.0 | 0.5 | 0.0 | 0.0 | 1.2 | 0.8 |

*Notes: Country groups are as defined by World Bank; High income—OECD countries minus Mexico, Korea and Turkey; Sub-Saharan states exclude South Africa. Capital and skilled labour-intensive goods are defined on the basis of factor intensity using the SITC classification. [More detail needed..]. High-technology goods are defined on the basis of R&D intensity. Source: UN COMTRADE database (trade); IMF Balance of Payments statistics (royalties) and UNCTAD, World Investment Report (FDI).*

Total trade in technology-intensive goods grew rapidly in the last three decades, with capital-intensive exports to other countries expanding most rapidly. Upper middle-income nations constitute the fastest-growing market for technology-intensive exports from OECD countries. Other conclusions suggested by the data are that licensing and other types of arm's-length trade in technology — measured by royalty income flows — are largely the domain of OECD countries. The flows involved are not negligible, with balance of payments data indicating a total of over $70 billion in 2001. This figure is likely to be a substantial underestimate, given that intra-firm technology and knowledge flows (transfers between parent firms and their foreign affiliates) are not captured by this measure. Upper middle-income countries are the only category of developing economies that have become significant entrants in this market since the 1980s, and these countries still account for less than three percent of total OECD exports.

Among the various channels for ITT, lower middle-income countries have the greatest share in outward OECD FDI flows, a reflection in part of China's role in attracting investment. Indeed, for these countries FDI shares grew faster than technology trade or trade in technology-intensive goods. The same qualitative conclusion holds for low-income countries — FDI grew the most between 1970 and 2001, although the share of low-income countries in various forms of skill-intensive and technology-intensive trade and FDI declined. The shares of Sub-Saharan Africa in all forms of inward technology flows from the OECD economies fell over this period. On this basis it is easy to understand concerns about a divergence in access to ITT between middle-income economies and the least-developed countries.

**b. Non-market channels**

*- Imitation*

At the same time, there are important non-market channels of ITT, as mentioned earlier. Perhaps most significant is the process of imitation, in which a rival firm learns the technological or design secrets of another firm's formula or products.[2] Imitation may be achieved through product inspection, reverse engineering, decompilation of software, and even simple trial and error. Whether imitation is legal or illegal depends on the scope of intellectual property protection and the security of trade secrets from unfair competition (Maskus, 2000). What distinguishes it from the earlier channels is that imitation bears no compensation to the technology owner in formal markets. As such, it seems an attractive form of learning and diffusion from the standpoint of developing economies. However, imitation may be a costly process and tends to divert attention from local innovation, so a full accounting of its impacts is more complex.

*- Departure of employees*

A related form of learning is for technical and managerial personnel in whom knowledge of one firm's technologies has been entrusted leave the firm and join or start a rival firm based on that knowledge. Such competition can be a significant form of information diffusion in industries and locations where cross-fertilization of knowledge is important and employees are mobile. Again, the technology is transferred without formal compensation to the original owner and the scope for this activity depends on the legal treatment of labour mobility, "non-compete clauses", and the like.

*- Data in patent applications and test data*

Yet another means of acquiring technology without compensation is to study available information about those technologies. Patent applications, both those registered in a country and (more likely) registered abroad, are available for this purpose. Rival firms in principle can read such applications, learn the underlying technologies, and develop competing processes and products that do not infringe the claims of the original applicants. Thus, patents provide both a direct source of technology transfer, through FDI and licensing, and an indirect form through inspection. However, there is much debate over whether such patent disclosures provide sufficient information that rival engineers can understand the technologies.[3]

A related source of information is confidential test data provided by patent applicants to governments. Government agencies may choose to share such data, possibly after a period of exclusivity awarded to the original applicants, to domestic rivals in order to avoid research duplication costs and accelerate generic competition.[4]

*- Temporary migration*

Finally, much technology appears to be transferred through the temporary migration of students, scientists, and managerial and technical personnel to universities, laboratories, and conferences located mainly in the developed economies. Note that in-depth training in science and engineering may be gained this way, suggesting that it is a particularly long-lasting form of ITT. The challenge for developing countries in this context is to encourage its expatriate students and professionals to return home and undertake local scientific, educational, and business development.

## *Technology spillovers and their main channels*

**a. Definition**

A central characteristic of ITT is the extent of technology spillovers, which may be defined as information learned and absorbed into competition in such a way that the benefits do not fully accrue to the technology owner. Note that the "owner" in this context could be the original seller, the licensed acquirer, or both. Spillover technological benefits refer to lower costs, greater productivity, advantageous follow-on innovation, and other structural elements for which the owner cannot charge full value. They reflect the market externality that technology developers cannot fully recapture the social value of their inventions through private transactions.

Such technology spillovers should be distinguished from pecuniary spillovers, which encompass shifts in prices and market structure, the benefits of which (rents or profits) cannot be extracted by the initiating party. For example, a firm that sells a relatively homogeneous good in different markets may not be able to segment those market prices in order to extract full surplus from each buyer. This is a form of pecuniary externality through trade. Another illustration might be a case in which the entry of a multinational firm reduces competition sufficiently that the remaining local rival firms enjoy higher profits. A central example is the simple case of counterfeiting, in which domestic entrepreneurs apply a copied trademark to their own products in order to profit from the mark-ups paid on status goods. While such impacts are interesting and important, they do not necessarily require a technology transfer, nor do they imply the learning by local firms of new information. In this report I focus on technology spillovers.

**b. Main channels of spillovers**

*- Uncompensated imitation*

It is useful to discuss the main channels of spillovers, which are related to the channels of technology transfer mentioned above. First, the existence of technology externalities is obvious in the cases of uncompensated imitation by local competitors. Successful reverse engineering of a product and legal forms of learning trade secrets are fair means of imitation that achieve technology absorption. Again, this may well be a costly process but it is a central form of technology diffusion and supports dynamic competition in well-functioning markets.

*- Departure of employees*

Second, the departure of technical employees to other firms after they have mastered technological information and know-how from their prior employers is also an important means of diffusion. Note these spillovers may be of two kinds: the use without improvement of prior information to produce competing goods and the adaptation and improvement of that information into new goods and technologies. In general, trade-secrets law will restrict the former activity, at least for some period after the employee's departure date. The latter activity is the basis of much information diffusion and competition in industries for which cross-fertilization of ideas and techniques is common. An obvious example is the agglomeration of information technologies in Silicon Valley in California and the Pudong area in Shanghai. Such spillovers can also arise through attendance at conferences and training in laboratories and universities.

*- Information in patent applications*

A third method of diffusion in this regard is simply for engineers to study patent applications in their own countries and abroad. I will discuss evidence on this channel below. In principle, it is a significant form of learning across borders and, indeed, the diffusion implicit in publishing patent applications is a central social benefit from awarding private exclusive rights to specific claims.[5]

*- Trade, FDI, and licensing: three subcategories of spillovers*

Consider next the technology spillovers that happen largely through trade, FDI, and licensing. To illustrate, a direct trade-related externality arises where a recipient firm imports a capital good and discovers that its costs are reduced by more than it anticipated in negotiating the price of that good. An indirect spillover exists where a machine is imported for use in one product line but the importing firm learns through experimentation that it also works well in another line and may be partially deployed for that purpose.

*Departure of employees*

The operations of MNEs are thought widely to be the source of three important spillovers. One is the movement of technical personnel discussed above. Because MNEs typically arrive in a location with a superior technology or know-how and may be expected also to employ or train some local personnel, the potential for this form of diffusion is large.

*Uncompensated demonstration of new technologies*

A second channel is that by introducing new technologies within its subsidiaries, MNEs may engender an uncompensated demonstration effect as local rivals adopt its best practices. This is really another form of reverse engineering or imitation, albeit at the technology level. Some technologies may be easily observed, such as management, accounting, and marketing techniques or re-organization of production lines. Others may be more difficult to absorb. The argument that MNEs play a particular role in this regard stems from the assumption that it would be too costly for local firms to observe and imitate best-practice foreign techniques (and they may insufficient competitive pressures to do so) unless those technologies are first introduced successfully into the domestic economy by international firms. The "demonstration" arises from the successful use of these technologies by the MNEs, demonstrating that they are effective in the local economy.

*Vertical linkage effects*

Third, and most fundamentally, FDI may generate important spillovers through forward and backward vertical linkage effects. A forward linkage exists where the firm produces inputs that reduce the costs of its customer firms or raises the quality of its products. Note that such a linkage may emerge even within the distribution sector from the insistence by the MNE that products it makes, or that embody its inputs, meet minimum quality guarantees. A backward linkage arises where the firm's operations increase demand for inputs from its local supplier companies and work to improve the technologies and standards used by those companies. This might happen, for example, through sharing blueprints, offering know-how, having engineers visit plants, and commenting on the design and technical performance of supplier products. Backward linkages may be particularly important because MNEs generally would be expected to have higher standards for their inputs, obliging them to share technical information with suppliers in order to achieve those mandates.

For their part, joint ventures and licensing contracts offer similar channels for technology spillovers into the broader economy. The theory is largely the same — demonstration effects, labour turnover, and technology sharing — even if the licensor may be less involved in trying to manage these spillovers.

To summarize, ITT can generate both direct and indirect gains in productivity, cost reductions, product quality, and competition. Some of these gains may be compensated and some accrue as spillovers. Further, these impacts can happen both within sectors and across industries. At the same time, technology transfer incurs costs of contracting, adaptation, imitation, and absorption. These are complex processes that command further analytical attention in the next sections.

## 2.2 Market failures and the need for intervention

Many developing countries have complained for a long time that the flows of ITT through private channels are inadequate for their competitive and social needs. Implicitly the claim is that the volume (and quality) of technology transfers is well below optimal. In principle, this deficiency could be the result of failures in private markets for technology, failures in surrounding factor and product markets, and failures in public policy. All of these are important reasons for limited ITT, perhaps especially the latter two as they may establish an uninviting climate for FDI and licensing. Later in the report I discuss government failures and cross-market distortions. At this point, however, I focus on problems inherent in technology markets.

### *Private market failures*

As mentioned above, the bulk of ITT operates through transactions in private markets or within multinational firms. Markets for developing and selling technologies are naturally subject to distortions that affect decisions regarding how much to invent, what to sell, through which international mode, and the terms of transfer. Indeed, certain information asymmetries and appropriability problems lie at the root of decisions by firms to transact within the enterprise rather than at arm's length. In this section I overview the major issues involved and the policy responses that sensibly address them.

The major problems in technology markets stem from the nature of technology itself. As has been widely discussed, a technology bears important characteristics of a public good (Maskus, 2000). In its purest form, a technology is both non-rival and non-excludable. Nonrivalry is the characteristic that the information may be shared among multiple users without diminishing its productivity for any one user. It is this feature of knowledge that lies at the heart of the modern theory of FDI and licensing (Markusen, 1995). In essence, a firm can generate new technology at one location and share it with other locations, either within the firm or across firms. This process limits the fixed costs of R&D to single episodes at one location and those lower fixed costs may be shared across multiple plants. Non-excludability is the characteristic that an information developer may not be able to prevent others from using it without compensation or authorization. Because technology development is generally a costly activity, firms have an interest in maintaining excludability in order to generate a market return on R&D investments. Of course, excludability is the essence of intellectual property rights, which attempt in principle to balance the returns to innovation against the needs for diffusion.

Our concern here is with international technology transfer rather than technology creation. Indeed, at a basic level many developing countries see little reason to offer protection to foreign technology developers, hoping to free ride on the non-excludability of new processes and products. However, for most developing countries importing technology is a major form of technological change and similar problems emerge from the underlying nature of information. It is useful to enumerate these market difficulties.

#### a. Higher costs through weak excludability

It is rare that technical information is fully non-excludable. Rather, it is costly to learn and absorb technology into local production processes. This may be because the information is difficult to extract from reverse engineering, market lead times, or other factors. While these costs may be unfortunate for poor countries, they are not necessarily inefficient in a global sense because they force imitators to contribute to the costs of innovation. However, to the extent that inventors artificially raise the costs of imitation (e.g., through masqueing or adding technological locks that are difficult to defeat) because of inherent appropriability problems, the flow of technology transfer would be impeded. In terms of policy, governments need to balance the needs of follow-on competition from spillovers (i.e., limit excludability) against the costs arising from restricted technology transfer.

**b. Trade impediments through information asymmetries**

Transfers of technology are subject to asymmetric information problems that can significantly reduce incentives for trade. The essential problem is that the owner of a technology may have complete knowledge about its specifications, effectiveness when deployed under different circumstances, associated know-how, and the like, while the buyer has far less information about it. The buyer would be unwilling to offer a price that would cover all of these claimed benefits before he is sure that such information is correct. But the seller would be unwilling to reveal the information without a contract in place at an acceptable price. To do so would at best alter the negotiating terms in his disfavour and at worst immediately create a competitor based on the revealed knowledge. Accordingly, many otherwise mutually beneficial technology transactions may break down. It follows that policy should aim at two objectives. First, reduce this information asymmetry by increasing access of local buyers to the international stock of knowledge about available technologies. Second, increase the certainty with which technology owners can signal the true value and characteristics of their inventions to buyers without excessive concerns about losing that value without compensation.

**c. Higher costs through market power**

A final problem inherent in technology-transfer markets is that owners of new technical information are likely to have market power because of lead times, brand loyalty, or the exercise of intellectual property rights. Thus, inventors may be expected to sell technologies at a price higher than marginal cost, which is socially less than optimal for the recipient country, at least in a static sense. This wedge between price and cost raises some scope for policy intervention to restrain prices. It should be acknowledged that it is very difficult to implement the kinds of precise intervention that would expand technology transfers at lower cost, rather than simply induce technology developers to exit particular markets. An important variant of this problem is that inventors might transfer technologies under terms that monopolize output markets rather simply extracting rents on the transfer itself. In such cases the exercise of anti-monopoly policies may be in order.

### *ITT as an input for public goods*

The positive case just made for intervention in ITT markets stems from the public-goods characteristics of information and the market imperfections they imply. The analysis may be extended, more controversially, by noting that inadequate flows of ITT associated with those imperfections can impede the ability of nations to acquire public goods, the effective provision of which depends on access to international technologies. Prominent examples include technologies to improve environmental use, medical technologies to enhance public health, and scientific and educational materials.

In analytical terms, the economic difficulty here reflects an externality across distorted input markets (e.g., a patent-protected environmental technology and the poorly regulated use of environmental resources) or between input and output markets (e.g., vague ownership of genetic resources and IP protection on extracted medicines). Optimal policy would aim to use multiple instruments to deal with these multiple distortions, accounting for interactions between instruments. For example, under some circumstances it might be possible to define property rights in natural resources sufficiently to achieve efficient demand for environmental technologies.

However, numerous technical difficulties arise in trying to reconcile such objectives. For example, it is not clear that establishing property rights at both the input and output stages in a vertical technological relationship would generate optimal resource use (Swanson and Goeschl, 2004). Rather, bargaining between vertical monopolists could significantly restrain or distort technology transfer. More generally, the infeasibility of intervening precisely in multiple markets leaves governments with the second-best policy task of reducing impediments to technology transfer for public goods. Indeed, this need for access to public-input technologies in the environment, health, education, science, and infrastructure may be the primary motivation for global interests in enhancing technology transfer to developing nations.

## 2.3. Evidence on determinants of ITT

For purposes of developing policy suggestions, it is important to review evidence from economic studies about the major factors influencing the pattern and volume of international technology transfer. In this subsection I focus on general determinants, leaving a discussion of IPRs to the next section. Because these factors are not the central focus of the report I provide only a brief overview of main results here.[6]

It is evident that no satisfactory direct measures of technology transfer exist. For the most part this is because technology is traded indirectly through trade, FDI, and spillovers. In such cases, the volume of the implicit technology and the terms under which it is transacted are unobservable. Thus, we are forced to consider determinants of these broader and indirect flows. Even in the case of royalties and license fees for intellectual property rights and know-how, a more direct measure of technology transactions, it is difficult to ascertain the volume of technology transferred and the effectiveness with which it is incorporated into local production. Thus, the results of empirical studies need to be approached with caution when linking them with ITT flows.

### *Technology diffusion through international trade*

That international trade may serve as a conduit for international diffusion was established empirically by Coe and Helpman (1995) and Coe, Helpman, and Hoffmaister (1997). Their approach was to estimate the impacts of international (OECD) R&D stocks, weighted by import shares, on total factor productivity (a proxy for technological change) in a cross-section of countries. The latter study is more relevant for this report because the authors found these effects to be significant for developing countries. In particular, a one-percent rise in the share in GDP of imports of machinery and equipment from OECD countries tended to increase total factor productivity (TFP) in developing countries by 0.3 percent per year. Lichtenberg and Potterie (1998) provide additional evidence supporting this view, while the paper by Schiff, Wang, and Olarreaga (2002) finds yet stronger evidence of spillovers when account is taken of indirect influences of foreign R&D through trade with third countries. Finally, Xu and Wang (1999) find evidence of large productivity spillovers through imports of capital goods, which presumably offer both a direct improvement in technology and indirect gains through demonstration impacts and reverse engineering.

While imports provide one channel for learning, it is conceivable that exports are important as well when one considers the need for exporters to offer technical characteristics and quality levels that meet international standards. Bernard and Jensen (1999) and Tybout (2003) discuss the basic economics of this proposition, while Funk (2001) finds evidence of such spillovers for OECD countries.

There is a large empirical literature using the basic Coe and Helpman (1995) framework to look for trade-related spillovers in addition to those studies mentioned above. While differences in samples and techniques leave some room for different interpretations, the preponderance of evidence strongly points to the existence of significant externalities through trade. Accordingly, for countries hoping to benefit from having access to the international knowledge (R&D) stock, becoming more open to trade offers an appropriate route for policy.

However, straightforward liberalization of trade restrictions may not be sufficient in this regard. There are numerous other determinants of a country's ability to absorb and deploy technical information available through trade. One is geographical proximity to both input (e.g., capital-goods) suppliers and customers (Redding and Venables, 2000). Indeed, geographical remoteness may be a force for reducing the information content of trade in a world with agglomeration economies. The policy suggestion here is to find either means of increasing local market size, perhaps through regional trade preferences, or to reduce effective distance by lowering the local costs of trade. The latter may be achieved through liberalization and deregulation of trade-related producer services.[7] A second suggestion is to reduce impediments to internal trade within a country.

A related factor is the technological distance a country lies from the global frontier. Countries that are further from this frontier find it more difficult to absorb information effectively into their production systems

(Keller, 2002). For this reason, countries tend to acquire international technology more readily where their firms are engaged in local R&D programs, there are domestic private and public research laboratories and universities, and there exists a sound basis of technical skills and human capital. Each of these factors reduces the costs of imitation, adaptation, and follow-on innovation.

### *Technology diffusion through FDI*

The evidence that FDI actually generates spillover gains in productivity in developing countries is mixed and depends on the channel studied.[8] For example, spillovers through demonstration effects would largely affect technology in the firms competing directly with MNEs. Haddad and Harrison (1993) used firm-level data for Morocco to study such horizontal externalities. They found that foreign firms tended to have higher levels of TFP but lower TFP growth rates than domestic firms. To the extent that FDI did raise the level of TFP in local firms the result was concentrated in lower-technology sectors. In another study, Aitken, Harrison and Lipsey (1996) argued that spillovers should raise labour productivity and show up in higher wages for employees in both MNEs and local competing firms. Using firm-level data for Mexico and Venezuela they found that a higher share of employment in foreign-affiliated firms was associated with higher wages for both skilled and unskilled workers. However, they could find no evidence of a spillover effect on the wages of employees in domestic firms; in fact there may have been a small negative effect.

Finally, using plant-level Venezuelan data, Aitken and Harrison (1999) discovered that foreign equity participation tended to increase productivity for small establishments, but that productivity of domestic plants declined somewhat with a rise in competition from FDI. Overall, the impact on industry productivity was positive despite this reduction in domestic plant performance. In a related study, Djankov and Hoekman (2000) found that FDI within an industry tended to reduce productivity in domestic firms in the Czech Republic.[9] All of these authors ascribe such negative externalities to the relative inability of domestic firms, arising from weak R&D efforts, in developing countries to adopt the superior techniques introduced by MNEs. Indeed, Dougherty (1998) reports that data for Chinese enterprises are consistent with the claim that such technology absorption and spillovers are positively related to the presence of domestic enterprise-level R&D programs.

There are other studies suggesting a positive externality effect, however. Haskel, Pereira, and Slaughter (2002) studied the productivity performance of U.K. manufacturing firms from 1973-1992. They found that FDI at the industry level had significantly positive impacts on the TFP of domestic plants. In comparing these results one might conclude that the presence of horizontal spillovers depends on the ability of local firms to benefit from the introduction of new technologies through having sufficient technical absorptive capacity themselves, as would seem to be the case with U.K. establishments.

Other studies suggest, however, that FDI spillovers may carry over to developing countries. Park and Maskus (2003) find significant evidence of such impacts using industry-level data for a wide range of developing countries when the regressions are controlled for endogeneity. Aitken, Hanson, and Harrison (1997) found in a detailed survey of Mexican manufacturing plants that proximity to foreign-owned exporting firms generated a positive impact on the probability of the domestic firm being an exporter. Presumably this result suggests that the presence of foreign-owned exporting firms generates externalities through improved local infrastructure.

While the evidence of horizontal spillovers from FDI is mixed, there is considerable indication that vertical productivity spillovers exist from backward and foreign linkages. Major evidence from Hobday (1995) suggests that technology transfer to local firms, in the forms of production processes, standards, and performance and quality levels, emerged in Asian economies when firms from industrialized countries purchased their components.[10] Additional evidence of positive productivity spillovers is provided for Malaysia by Batra and Ton (2002) and for Lithuania by Smarzynska (2002). In the most careful recent study, Blalock (2001) used establishment-level data for Indonesian manufacturing firms and found strong evidence of a positive effect of FDI on the productivity growth of domestic input suppliers.

Perhaps the most persuasive example is simply the history of the Mexican maquiladora program. Over time Mexican-owned firms that began as labour-intensive components producers under contract to U.S. MNEs have become producers of higher-technology goods and engage in considerable sub-contracting with other Mexican firms as well.

Thus, evidence suggests that FDI can be a powerful source of ITT, especially in cases where foreign firms transmit their blueprints, know-how, and quality specifications to suppliers in a vertical relationship. It is, therefore, useful to review briefly the main determinants of location decisions by MNEs, leaving aside for now the role of intellectual property rights. Again, this is an enormous literature and I can only highlight some main results.[11]

First, FDI is attracted by certain macroeconomic factors, including large market size, expected growth in demand, and monetary and fiscal stability (Wheeler and Mody, 1992: Barrell and Pain, 1996; Goldberg and Kolstad, 1995). The role of exchange-rate volatility is less clear, because variations in currency values affect both the relative costs of domestic and foreign production and the value of firm-specific assets (Cushman, 1985; Blonigen, 1997). However, high rates of uncertainty diminish macroeconomic investment incentives.

Second, the preponderance of econometric evidence suggests that corporate tax rates affect location decisions. Other things equal, a country with higher tax rates attracts less MNE activity (Grubert and Mutti, 1991; UNCTAD, 1996; Blonigen and Davies, 2000). To some extent the impacts of taxes are blunted by possibilities for transfer pricing. However, and somewhat inconsistently, there is little evidence to suggest that fiscal incentives have much net impact on the international distribution of FDI.

Trade policy has varied impacts on incentives for inward FDI. Across countries at relatively similar income levels and endowment structures, such as the industrialized nations, higher tariffs seem to attract horizontal FDI to operate behind the trade barrier (Carr, Markusen, and Maskus, 2001). In some degree, high tariff walls have attracted FDI into developing countries in the past as well. However, it must be noted that if such policy generates investment in sectors in which a country has a comparative disadvantage the net welfare costs can be significant (Saggi, 2003a). What may be most relevant for developing countries in the present environment is the proliferation of FDI and joint ventures in vertically organized production networks. Because such networks place a premium on low costs of moving inputs and outputs across borders, protectionist trade environments have become a disincentive for vertical FDI.

The bulk of econometric studies that incorporate measures of investment costs find that they significantly reduce FDI and MNE activity at all levels of development (Brainard, 1997; Carr, Markusen, and Maskus, 2001; Wheeler and Mody, 1992). The primary forms of direct investment costs include restrictions on ownership and control, barriers to short-term movement of technical personnel, limited access to capital markets, and restraints on repatriation of capital incomes. Also important is the surrounding policy environment, including an unbiased and accessible judiciary and transparency and predictability in government. Finally, an effective infrastructure for internal and external transport and communication seems important for attracting FDI (Carr, Markusen, and Maskus, 2003).

It is evident that much vertical FDI seeks relatively low wages, so long as the workers provide acceptable levels of productivity (Carr, Markusen, and Maskus, 2003). Multinational firms are less attracted to the least developed countries in part because of their poor productivity levels in addition to other factors. Rather, affiliate activity tends to be higher in countries with a reasonable supply of technical skills and access to an effective labour force.

As in the case of international trade, proximity to markets matters considerably in determining where FDI will locate. One important reason is the need to communicate with subsidiaries and monitor their activities. Another is that because many MNEs are organized into vertical networks and production may need to be done to order in a short time frame, close access to suppliers and customers is important (Aitken, Hanson, and Harrison, 1997). Note an important implication that FDI may be subject to consider agglomeration economies, particularly if past successful investments are taken as a signal of a good environment for future investments by competing firms (Head, Ries, and Swenson, 1995). Again, the lesson seems to be that if countries are interested in attracting FDI they need to reduce their economic and technological distance from major markets, even if they cannot reduce geographical distance.

More generally, all of these factors — growth, stability, proximity, trade and investment policies, transparency, regulation, and the labour force — make up the "investment climate" for a nation and determine incentives for both FDI and domestic investment. It is perhaps obvious, but nevertheless important, to point out that countries wishing to attract ITT through inward FDI would benefit from focusing much of their policy efforts to these questions.

### *Technology diffusion through licensing*

This again is a highly complex subject that can only be highlighted here.[12] License contracts may exist within the firm, within a joint venture, or between unaffiliated firms. They can cover a variety of transactions, including technical assistance, codified knowledge, know-how, establishment of turnkey operations, and intellectual property rights. Licenses may be offered for a fixed fee, a franchise fee, a royalty schedule (e.g., sliding share of sales), or a share of profits. They may offer rights to produce for, or distribute to, a limited geographical territory for a given period of time. The terms of a license contract may involve performance requirements of the licensee, such as non-disclosure mandates, "no-compete" clauses for personnel, and grant-back provisions on adaptive innovations. Thus, it is difficult to characterize and analyse licensing as a simple transaction.

As noted by Correa (2003), inward technology transfer through various forms of licensing is an important source of innovation and technical transformation for developing countries. However, technology is not just information that can readily be learned by passive buyers. Rather, successful transfer typically requires some capacity to learn and investments to introduce technologies into production processes. As such, countries in which enterprises have substantial engineering skills and active R&D programs for adaptation and learning are more likely to be the recipients of licensing flows than others. This observation seems to be born out in available cross-country licensing data (Yang and Maskus, 2001).

The general determinants of decisions on where to license are not much different from those involving FDI. Thus, market size, anticipated growth, proximity, the stock of human capital, the ability to repatriate licensing rents, and the investment climate all affect licensing flows.

However, two additional factors loom large in the economics literature on licensing. First are the costs of making the transfer and successfully absorbing knowledge by the recipient firm (Robertson, 2001). These costs can take up significant shares of licensing revenues (Teece, 1986; Contractor, 1980). Such costs range from simple translation requirements to developing complex sharing arrangements within joint ventures. Additional costs arise from lengthy judicial or arbitration procedures and regulatory delays.

A second factor is the confidence of licensor firms that knowledge of their proprietary technologies will not leak out into general competition after licensing has transpired. There are a number of natural or market-based means by which such technologies may be held within the licensing contract, even among arm's-length partners. However, to the extent that transferred technologies are easily copied, industrial espionage is common, or that technical personnel can defect from the licensing contract and deploy the technology in their own concerns, foreign firms may choose not to engage in licensing or may transfer lagging technologies (Maskus, 2000). It is evident that IPRs may play a significant role here, as I will discuss in the next section.

From this analysis it follows that if developing countries are interested in expanding the inward flows of voluntary licensing they might focus policy efforts on improving the investment climate and reducing the costs of absorbing technology. The latter task is complex and involves building human capital and expanding national innovation systems.

*Diffusion of public technologies*

As noted early in this report, not all technology is proprietary and not all is transferred through market transactions. Some information is in the public domain, either because it is generated through public research and published or because institutions chose not to patent it or to permit a patent to lapse. In such cases there is no problem with the information being legally accessible. Rather, if there are difficulties in acquiring such technologies they must lie either in the transfer mechanisms or in the ability of local countries to absorb them. In this regard, policy could aim at improving information flows through widespread access to the internet and technical and scientific materials, attendance at conferences, and movement of engineering and scientific personnel. It could also be directed toward improving the ability of local firms to learn and adapt public technologies, including those coming from domestic government laboratories.

It must be noted, however, that there is an increasing tendency within the United States and the EU to encourage private ownership of publicly funded research results and data (Barton, 2003). This trend raises significant concerns about the ability of developing countries to benefit from an information frontier that is simultaneously moving forward rapidly and a public domain taking up a shrinking share of knowledge. Thus, as discussed later, a significant challenge for developing countries is to work to arrest this tendency.

# 3. THE ROLE OF INTELLECTUAL PROPERTY RIGHTS

It is important to begin this discussion by explaining some terminology. It is common in the literature to refer to "weak" and "strong" IPRs and frequently these terms are interpreted as references to the content of laws and regulations. Thus, one might consider a country with rules that do not come up to TRIPS-consistent standards as being weak in this regard, while another that adopts regulations that are more protective than TRIPS mandates to be strong. However, strong "TRIPS-plus" standards are likely to be inappropriate for development purposes in poor countries, so that the words "weak" and "strong" should not be considered as worse or better in a normative sense.

Rather, the real issue is whether a country adequately enforces the laws and regulations it has in place in order to provide transparency and certainty for investors, licensees, and customers. In the discussion to follow, any references to weakness or strength of IPRs should be interpreted in respect of proper enforcement, rather than an implicit statement about the adequacy of laws and regulations themselves. Put more plainly, WTO members must adopt TRIPS-consistent standards at a minimum but would not necessarily benefit from more protective laws. Adequate enforcement is the primary determinant of the incentive effects to which the discussion below refers.

An intellectual property right is a government-protected right granted to an inventor or creator to exclude others from using the technology or product in question. The scope of these rights varies across type of IPR but generally refers to an ability to exclude others from using, producing, selling, or importing for a specific period of time. Intellectual property rights cover patents, trademarks, geographical indications, plant variety rights, copyrights, industrial designs, and layout designs (topographies) of integrated circuits. They are supported by restrictions against unfair industrial practices and such rules are collectively referred to as protection of trade secrets.

Intellectual property rights are granted for three purposes. First, they are society's legal means of providing exclusivity rents to inventors as compensation for their investment costs. Without IPRs, inventive and creative activity would be stifled, an argument that commands wide political support in developed economies but remains under debate within economics (Cohen, Nelson, and Walsh, 2000; Mazzoleni and Nelson, 1998). Second, because some forms of IPRs, particularly the patent, require public disclosure of the technical nature of what is protected, they advance the stock of publicly available knowledge.

The third purpose is most relevant for this report. A central reason for protecting IPRs is that they can serve as an important support for markets in technology, including ITT (Arora, Fosfuri, and Gambardella, 2001). The essential reason stems from the appropriability and asymmetric information problems discussed above. Without adequate protection from leakage of new technical information, firms would be less willing to provide it on open technology markets. Moreover, patents and trade secrets provide the legal basis for revealing the proprietary characteristics of technologies to subsidiaries and licensees, supporting the formation of contracts (Arora, 1996). Trademarks also serve a useful complementary role in this context, particularly where the firm is licensing production or distribution rights and demands minimum quality standards.

To put the argument a bit more technically, firms offering their technologies to potential partners in foreign countries may be expected to account for the likelihood of losing control of the information in setting contract terms. In an environment of weak IPRs, they may choose not to transact at all, to offer older-generation technologies, keep the information within the firm by dealing only with subsidiaries, or offer to licensees a larger share of rents (i.e., lower licensing fees) to induce them not to defect with the information. Most of these problems may be expected to reduce overall volumes of ITT, at least through such formal mechanisms as FDI and licensing.

However, the fact that weak IPRs reduce inward ITT is by no means certain, nor is it accepted by all observers.[13] Poorly enforced patent protection or trade secrets offer local firms some scope for imitating foreign technologies and unfettered reverse engineering. The essence of intellectual property protection is to award to inventors the right to decide when, where, and under what terms information will be transacted. Thus, firms may choose not to enter a market at all with FDI or licensing, preferring instead to satisfy a market through exports. Similarly, appropriately enforced IPRs provide foreign inventors greater scope for acting strategically in setting licensing terms, including fees, distribution territories, patent pooling, and grant-back provisions.

Thus, as always in the analysis of IPRs, there are complex tradeoffs that cannot be answered without empirical research, to which I turn next. The evidence overall is reasonably persuasive that patents both increase flows of ITT and shift incentives for investors between FDI and licensing. However, this work is based largely on aggregate data that is subject to various interpretations and not persuasive to all. Further, there is little suggestion of this positive impact in the least developed countries.

## 3.1 International technology diffusion through patent applications

There are two ways that patents can generate ITT. First, and most directly, if inventors in one country register a patent application in another country it signals a willingness to deploy that technology in the recipient nation. In turn, the availability of that information could spill over into higher domestic productivity. Second, if disclosure is a central element of the patent system, there should be evidence that patent applications are read carefully and used by firms around the world to improve their own technologies.

There is considerable evidence that both of these processes are important in spreading technological information among the OECD countries. Eaton and Kortum (1996) estimated a pair of equations explaining, first, the decision of inventors in each country to register patents in all other countries and, second, the impacts of those registrations on productivity in the recipient nation. The first equation took account of innovative characteristics of the source countries and market features and patenting costs in the destination countries. The expected number of bilateral patent applications was then placed into labour-productivity growth equations. Using data from 1988, they found that a significant amount of productivity growth in most OECD nations could be attributed to these international patent flows as a source of technology diffusion. Specifically, every country other than the United States obtained more than 50 percent of its productivity growth by importing technologies (patents) from abroad. Further, for all countries other than the five main research nations (United States, Germany, Japan, France, and the United Kingdom), foreign patent applications accounted for over 90 percent of productivity growth. Thus, "trade in ideas" is a major factor in world economic growth.

As for the second form of diffusion, Peri (2003) estimated a model of ITT across sub-national regions of North America and Europe using 1.5 million U.S. patents and 4.5 million patent citations from U.S. applications filed by residents of those regions, over the period 1975-1996. Patent citations reflect "knowledge flows" across borders that are placed into further innovation by foreign inventors. Peri found that about 15 percent of average knowledge within a region is learned outside the region of origin and only nine percent is learned outside the country of origin. Thus, there is a limited amount of diffusion overall, owing to distance, borders, and differences across regions in technological specialization. However, the most significant (i.e., most cited) patents are widely diffused, as is knowledge in the highly technological sectors. Moreover, the international extent of knowledge flows is greater and travels further than merchandise trade flows as predicted by gravity equations (McCallum, 1998; Anderson and van Wincoop 2002). Most significantly, the statistical analysis found a strongly positive impact of knowledge flows on innovation.

While these studies are persuasive, they leave important questions unanswered. First, both papers (and others like them) focus on information flows among developed countries and we have no analogous evidence regarding the ability of developing countries to absorb technologies through patents. This shortcoming should not be overstated, for some indirect indications exist in the data. For example, the Eaton and Kortum (1996) paper found that the smaller and less technologically advanced OECD countries derived most of their productivity growth from having foreign inventors patent in their economies. Thus, imported ideas are important and this conclusion should extend to developing nations, which remain overwhelmingly net importers of technology. For its part, the Peri (2003) paper highlighted that those technology-recipient regions with low levels of human capital and long distances from information sources tended to receive considerably less spillovers. The latter finding suggests that the poorest and most remote developing countries are unlikely to raise their own innovation profiles from reading foreign patents until their bases of science and technology are significantly improved.

Second, these studies do not consider the implications of enforcing patent rights for the costs of technology transfer. On the one hand, if a developing nation were to establish an enforceable IP regime foreign firms would be expected to take out more patent applications there, implying a higher inward flow of information. On the other hand, the tighter exclusive rights would offer inventors greater market power on future inventions, permitting them to extract higher rents through increased prices and royalty payments. In this regard, McCalman (2001), using the Eaton-Kortum model and 1988 patent applications, studied the potential effects of harmonizing patent regimes at a high level on changes in bilateral rent transfers in a sample of developed and developing countries. He found that such harmonization had the potential to effect considerable net outflows of royalty payments as developing countries increased their patent strength. Overall, the seven developing countries in the sample (Panama, Colombia, South Africa, Korea, Mexico, India, and Brazil) would pay around $2.4 billion more per year simply through the higher patent values predicted. Interestingly, most developed countries also would increase their net payments, with only five nations earning a rise in net receipts. Of these, the United States would be the overwhelming earner, with an increase in annual payments of $4.6 billion.[14]

Overall, these studies offer a mixed message for developing countries and their hopes of attracting ITT through the patent system. To the extent that a better-enforced regime attracts more inward patent applications, especially from technology leading countries, there should be gains in productivity and growth. Moreover, if the tighter regime encourages local innovators to look abroad for inspiration from foreign patent applications, the implied knowledge flows would be higher. However, the costs of acquiring technology through foreign patent applications could rise, perhaps significantly in larger developing countries with domestic competence in imitation. Finally, it is implicit in these studies that positive spillovers depend on other factors, including especially local engineering skills and R&D effort. Because such factors are lacking in the poorest economies, the beneficial spillovers from ITT seem unlikely to emerge for some time.

## 3.2 IPRs and trade, FDI and licensing

As discussed earlier, the bulk of ITT flows through international trade, foreign direct investment, and licensing contracts. Each of these channels may be affected by the intellectual property regime in the recipient country and this possibility has become the subject of numerous recent empirical studies. It should be kept in mind that, with few exceptions, these studies use aggregate data and crude measures of IP protection. Thus, they measure ITT indirectly at best and may mask considerable variation in effects at the industry or firm levels. Nevertheless, a brief review is in order.[15]

Maskus and Penubarti (1995) were the first to relate international trade flows to the cross-country strength of patent laws. They pointed out that if international firms were presented with enforceable IP protection in their export markets, they could either expand trade flows (a market-expansion effect) or restrict them (a market-power effect). This hypothesis was tested using bilateral imports from OECD countries to themselves and to a large group of developing countries in detailed manufacturing categories. The strength of patent rights was measured by an index from one to five across importing nations (Rapp and Rozek 1990). The authors found that import volumes were positively and significantly affected by increases in this patent index across most manufacturing categories, particularly in large and middle-income countries. Maskus (2000) calculated that partial harmonization of patents through TRIPS could increase manufacturing imports into larger developing economies by up to nine percent, which would afford a subsequent gain in TFP growth.

This analysis was refined by Smith (1999), who took pains to distinguish between types of importers. Specifically, countries could present an imitative threat (i.e., an ability to reverse engineer and imitate imported goods) if they have a significant human capital base and poorly enforced IPRs. This situation characterized large and middle-income developing countries prior to TRIPS. However, countries would not be much of a threat if they did not have an engineering base or if they had strong patent rights. Both the least-developed countries and the richer OECD countries would be in this group. By relating changes in trade flows to variations in patent rights with this breakdown, Smith found that international firms indeed would expand their exports to imitative (large and middle-income developing countries) nations significantly in response. However, the responsiveness of trade with respect to patent rights in both the poorest countries and the high-income OECD countries was essentially zero and may have been negative in the former case. Thus, the suggestion from this work is that the poorest countries might not experience rising ITT through imports even upon adopting TRIPS-consistent IPR regimes.[16]

The evidence on patents and inward FDI is mixed. Survey results by Mansfield (1994) suggested that U.S.-based multinational enterprises paid some attention to the perceived enforcement of IPRs in major developing countries in locating facilities abroad. Two major findings were that lagging technologies were transferred to nations with weak IP enforcement and that production and research facilities were less likely to be established than distribution centres in those countries.[17] Lee and Mansfield (1996) subsequently related FDI flows to perceptions of IPR strength and found a positive relationship. Again, this result was confined to the larger and more technologically advanced developing nations.

In contrast, Primo Braga and Fink (1998) could find no statistical relationship between patent rights and international FDI flows or stocks. Their study used the well-known index of patent rights developed by Ginarte and Park (1997). This index is a weighted average of components of legal regimes in place, including provisions for enforcement, in a broad cross-section of countries. The result in the Primo-Braga and Fink paper was consistent with the findings in Kondo (1995) that there was no statistical relationship between various measures of patent protection and FDI.

More recently, Blyde and Acea (2002) estimated the relationship between patent rights (using the Ginarte-Park index) and imports and FDI into Latin American countries. They found that imports are sensitive to variations in the patent index for the higher-income nations but insensitive to patents in the poorer countries. However, the strength of patent laws exerted significantly positive effects on bilateral inflows of FDI from OECD countries even after controlling for institutional variables, infrastructure, and human capital levels.

Empirical studies of licensing behaviour are rare but tend to show a strong impact of patent rights on the volume of royalties and license fees, taken as a measure of technology flows (Ferrantino, 1993). Most recently, Yang and Maskus (2001) regressed the real volume of license fees for industrial processes paid by unaffiliated foreign firms to U.S. firms in 26 countries in the years 1985, 1990, and 1995 on the Ginarte-Park patent index. Controlling for market size, human capital, and openness, they discovered that such fees were positively and significantly affected by patent rules and enforcement, and that a one-percent rise in the index would increase licensing volumes by 2.3 percent on average. Thus, if inflation-adjusted licensing fees truly reflect the volume of underlying ITT, this result suggests that technology flows react elastically to patent rights. However, the study needs to be refined because it did not have a true measure of licensing contracts or content. It is possible that increases in real fees reflect in part the enhanced market power offered foreign licensors.

Recent studies provide more sophisticated treatments of some of these issues because they account for the interrelated nature of decisions regarding trade, FDI, and licensing. In the most comprehensive analysis, Smith (2001) related U.S. exports, sales of foreign affiliates, and licensing fees to the Ginarte-Park patent index in several developed and developing countries. She found significant evidence that better-enforced patents would increase affiliate sales and licensing payments on average. However, these results pertained only for countries with strong imitative capacities (that is, a relatively high ratio of engineers and scientists to population). Further, there was a strong suggestion of an "internalisation effect" whereby strengthening of patent rights would shift activity from exports and FDI toward licensing. In supplementary regressions, Smith showed that patent rights strongly and positively affected the inflows of knowledge, measured as R&D expenditures undertaken on behalf of affiliates. Again, this finding applied only to recipient countries with strong imitative abilities; the impact was absent in countries with weak imitative abilities.

Additional studies include Nicholson (2002) and Puttitanun (2003), both of whom used data on the number of various kinds of contracts (exports, FDI, licensing) to examine the impacts of patent rights on channels of ITT. Similar to Smith, they found that increases in the patent index significantly raised the flows of both FDI and licensing relative to trade. In Nicholson's specification there was a strong indication that stronger IPRs tended to shift contracts from affiliates to licensees, particularly within high-technology sectors. Puttitanun's results were less pronounced but similar.

In summary, while much ITT occurs through trade, investment, and licensing the impacts of intellectual property rights at the aggregate level are still under debate. In my view it is fair to claim that the preponderance of evidence supports the following conclusions.

i. Within those middle-income and large developing economies that both pose an imitative threat to IPR holders and have some domestic innovation capacity, enforceable patents do attract significantly more ITT, particularly through investment and licensing contracts (including joint ventures). In fact, the impacts in some countries might be large relative to existing flows, as noted by Maskus (2000). There is little indication of this effect in the poorest countries, where patents seem to play no significant role.

ii. Within the group of middle-income and large developing countries, as IPR regimes become more protective and are more clearly enforced there is a tendency for international firms to substitute their ITT decisions at the margin toward licensing and away from FDI, even as both flows rise in the aggregate. This finding is consistent with the "internalisation" view of the MNE, under which more certain technology protection encourages transfer of information outside the firm's boundaries.

iii. The quality of technology transferred rises with the strength of intellectual property protection and domestic technological capabilities. That is, as countries enforce their regimes and firms offer enhanced capacities to absorb and improve upon technology, foreign firms become more willing to transact more advanced products and processes.

iv. Whatever the role of IPRs, they seem not to rank very highly on the list of factors that influence ITT, except for advanced technologies and R&D facilities. More important factors include the investment climate, efficient governance, market size and growth, proximity to suppliers and demanders, and infrastructure.

## 3.3 Evidence from individual country experience

Many observers find these aggregate studies to be unpersuasive.[18] An alternative approach is to study the experience of IPR regimes in influencing inward ITT in specific countries. Unfortunately, relatively few such studies have been performed and none, to my knowledge, in the least-developed countries. Again, therefore, the findings should be considered indicative or suggestive.

It is common to argue that a number of countries gained access to critical foreign technologies without offering much intellectual property protection and that this ability to learn and deploy information was central to growth and structural change. A number of now-developed economies, including the United States, Japan, the Republic of Korea, and Taiwan, were "second comers" in this regard and took advantage of foreign technical information while providing at best minimal patent and trade secrets protection. In contrast, some technology leaders in Western Europe, including the United Kingdom and Germany, have had relatively strong protection from the origins of the industrial revolution. Observers of that history tend to argue that IP protection was central to promoting innovation, even if that innovation came importantly from imports.

In light of this mixed history, it is unlikely that a firm historical correlation, let alone causation, could be established between the degree of IP protection and domestic invention or productivity growth. However, it is instructive to consider the results of particular country studies in order to see if any lessons for ITT may be drawn.

Japan is sometimes described as a country that acquired much technology without IPRs in place. This is a misleading characterization; Japan has had a patent policy since the early 1900s at least, though it did not patent pharmaceutical products until 1970. A fairer characterization is that, in the period of Japan's rapid growth and industrialization after World War II, its patent system was designed for both innovation and diffusion (Ordover, 1991). Thus, the regime recognized utility models, permitted single claims only within the patent application, required early (pre-grant) disclosure, and had an active opposition system. This approach encouraged incremental and adaptive innovation by Japanese firms and promoted the diffusion of knowledge, including foreign technologies, into the wider economy. It also strongly encouraged inventive foreign firms to license their technologies to Japanese concerns, a fact that presumably was buttressed by the difficulties in that period of establishing FDI. Extensive econometric analysis suggested that this system encouraged the filing of large numbers of utility model applications for incremental innovations that were based partly on laid-open patent applications (Maskus and McDaniel, 1999). Statistically, utility model filings had a positive and significant impact on Japanese TFP growth from 1969-1993, suggesting that they were a source of technical change and information diffusion.

The Ministry of International Trade and Industry (MITI) was also claimed to have been heavily involved in examining technology licensing contracts and affecting the terms of transfer. Moreover, it also pursued a restrictive approach toward incoming FDI, in part in an effort to encourage domestic acquisition of international technologies (Balassa and Noland, 1988). Whether this type of intervention was itself effective in promoting learning and growth is unclear and remains subject to debate.

Under pressure from the United States (and some of Japan's largest and most dynamic exporting companies), the government radically strengthened its patent protection over the period 1988-1993. As a result, the focus of learning from ITT has presumably shifted from incremental innovation toward technology sharing arrangements and the higher-cost activity of inventing around stronger patents. It is important to note that econometric evidence suggests that no increase in R&D spending or innovative output by Japanese firms could plausibly be associated with this expansion of patent rights (Sakakibara and Branstetter, 2001). However, foreign firms have increasingly transferred technologies through patent applications, indicating that the incentive effects of patent reform tend to favour international firms. This finding is consistent with that of Lerner (2002), who examined shifts in patent protection across 60 countries over 150 years. He found that strengthening protection had few positive impacts on patent applications by domestic enterprises but often tended to encourage more foreign filings.[19]

Korea represents another case of a "technology follower" that has transformed itself into an increasingly innovative and high technology economy. Kim (2002) provides a cogent description and analysis of the means by which this was accomplished. In its early stages of industrialization, through the 1970s, Korean firms undertook learning via "duplicative imitation" in which they took advantage of mature technologies that foreign firms had permitted to enter the public domain or were willing to provide cheaply because they were no longer cutting-edge. Relatively few foreign firms patented technologies in Korea because of its small market size and limited imitative threat. Industrial property rights were weak and encouraged imitation and adaptation. In this context, Korea was an example of a low-wage economy producing labour-intensive goods at the end of the product life cycle. For this purpose, however, its firms had to import "off the shelf" technologies successfully and adapt them for developing slightly differentiated products. The role of the government essentially was to promote exports and encourage the development of technical and engineering skills through education and workplace training.

Korea's success raised its labour costs in relation to other developing countries and forced it up the product cycle to an economy undertaking "creative imitation" in the 1980s and 1990s. This process involved more significant transformation of imported technologies, increasing domestic R&D, and additional production differentiation in order to generate greater value added. It also required increasing use and development of knowledge-intensive intermediate inputs. Because these are far more complex, the need for in-house research capabilities became central for technology acquisition. Further, Korean firms increasingly ran into difficulties with advanced foreign firms that now considered them to be competitors and became unwilling to offer their technologies without IP protection and licensing contracts. Under pressure from the United States (and again with increasing support from innovative domestic firms) the government undertook major upgrades of the intellectual property system from 1987 to 1993 (Maskus, 2000). It also became more welcoming to formal channels of ITT and there were major increases in royalty payments, capital goods imports, and FDI in the 1980s and 1990s (Kim, 2002). The government also invested in improving university and public research capabilities.

Like Japan, Korea has moved into the rank of technologically inventive nations, at least in some sectors. Korea had the highest growth rate in the world in private R&D expenditure per dollar of GDP in the 1980s and 1990s (Kim, 2002). The growth of patenting by Korean firms in the United States and Japan far outweighed those of other countries in the 1990s (Luthria and Maskus, 2003), while foreign firms increasingly patent in Korea. Thus, there are large flows of two-way ITT now and, indeed, some Korean firms have established R&D facilities abroad in order to learn from frontier-level technological changes.

Unlike Japan, this explosion in domestic innovation accelerated after the patent system was strengthened. Whether this success may be attributed to the policy change is a difficult question to answer. As noted by Luthria and Maskus (2003), the rise in patenting seems also to be due to improved technology management and extensive concentration in Korean industry. Moreover, to date the patenting activity is concentrated in electronics applications covering relatively small and adaptive innovations and product differentiation. In contrast, the Korean biotechnology sector, which must rely more heavily on basic research results, has had far less patenting success.

Brazil, Mexico, Malaysia, and the export-intensive regions of China and India are among other countries that graduated from the imitative stage to that of creative imitation and implementation of knowledge-intensive inputs. In each of these cases IP protection was limited and firms took advantage of available foreign technologies. But as the technological sophistication of production processes matured and the depth and complexity of knowledge for effective absorption grew, firms increasingly have resorted to formal means of ITT and governments have strengthened the IP regime.

From this history it is fair to conclude that both the nature of ITT and interests in IPRs follow a form of "technology ladder" related to basic product-cycle ideas. Many middle-income developing and transition countries are essentially at the duplicative imitation stage, hoping to absorb free or cheap foreign technologies into labour-intensive export production and evolve higher value-added strategies over time. The poorest countries have barely stepped onto this stage of the ladder at best.

In this regard, a strong argument exists that the global system of stronger IPRs required of all WTO members amounts to a significant entry barrier for firms in poor countries (World Bank, 2001; Kim, 2002). In a worst-case scenario, the provision of 20-year patents on technologies that have, in advanced countries, far shorter useful lives before obsolescence, suggests that TRIPS would permit international firms to extract rents on information that would otherwise have lapsed into the public domain. Firms in poor countries may be unable to pay these costs and presumably would have little leverage to negotiate for favourable terms of transfer. Under this dynamic, the poorest countries of the world would find their access onto the bottom rungs of the technology ladder blocked, perhaps permanently.

While this is a valid concern, it should be kept in perspective. First, it remains unlikely that international firms would choose to register patents in the smallest and poorest countries, keeping the associated technologies in the public domain for at least domestic production. Second, the patents that are registered do provide some scope for technological spillovers, as discussed above, though the evidence reviewed suggests that such learning in the least developed countries would be slight. Third, generally there will be multiple technologies available, especially as regards mature products and industries, and even with limited IP protection the owners of those technologies may be expected to compete to transfer them. Fourth, entry into the duplicative industrialization stage might be impeded in any case by the failure of governments to provide appropriate engineering skills, entrepreneurial opportunities, infrastructure, and efficient governance. Again, IPRs present only a part of the story regarding incentives for ITT.

Whether stronger IP systems will slow down learning and diffusion in lower-income developing economies remains an empirical question and it would be useful to have a careful study in representative countries. However, it does seem that some avenues to industrialization will be narrowed significantly unless authorities work carefully within the TRIPS requirements to maximize access to ITT. I turn to this question in the next section.

# 4. TRIPS AND INTERNATIONAL TECHNOLOGY TRANSFER

Discussion over whether TRIPS will increase or decrease flows of ITT is polarized. Advocates see the agreement as establishing a critical and necessary legal framework within which firms can transact in proprietary information with certainty (Sherwood, 1997). As a result, ITT flows should expand markedly and even find their way into high-valued niche production that could favour developing countries. Indeed, those governments (the United States and the EU) that most heavily pushed for TRIPS justified its inclusion in the GATT/WTO on the grounds that it would increase technology transfer.

Critics see TRIPS as a mechanism for enhancing the global market power of information developers, permitting them to act in monopolistic and abusive ways that would slow down ITT, especially to the poorest countries (Correa, 2003). Many developing countries consider the agreement to be unbalanced in this regard and to embody insufficient provisions for ensuring that ITT actually expands. This issue has become central for the Doha Round.

Neither of these views can withstand close scrutiny. The essential reason is that ITT is a complex and multi-varied process and the expected impacts of a trade agreement cannot be characterized or predicted so easily. Whether ITT will rise or fall depends on a host of circumstances that vary across countries and over time. As suggested in this report, among the more important factors are the local investment climate, market competition, governance policies, openness, proximity to markets, human capital (engineering and management skills), and labour mobility. For example, a country that implements strong trademark, patent, and copyright systems in the presence of restrictive entry and distribution laws would be more likely to suffer diminished competition and reduced inward ITT than an identical but more open economy. To a first approximation, then, governments can work on these other factors in order to encourage inward technology transfers. An additional important factor is the extent to which foreign governments choose to place into the public domain the results of publicly funded research.

Put differently, enforceable IPRs are neither necessary nor sufficient to establish robust inflows of technology. Nevertheless, IP standards can be an important factor influencing the volume and quality of ITT inflows. Thus, it is worthwhile to overview the main features of TRIPS that could affect incentives for ITT. It is also useful to discuss aspects of the agreement that offer policy flexibility to developing countries for the purpose of increasing the flows of ITT and its diffusion into the domestic economy. Only an overview is provided here; a detailed discussion would be beyond the scope of this report.[20]

## 4.1 General TRIPS provisions

The Preamble of TRIPS notes the particular needs of developing countries in the context of technological improvement. Specifically it states that:

"*Recognizing* the underlying policy objectives of national systems for the protection of intellectual property, including developmental and technological objectives;

*Recognizing* also the needs of the least-developed country Members in respect of maximum flexibility in the domestic implementation of laws and regulations in order to enable them to create a sound and viable technological base;"

Thus, the agreement recognizes both that technological development is an IPR-related policy objective of all nations and that the least-developed countries (LDCs) have particular foundational needs in terms of creating a technological base. The former point suggests that IP standards may be structured, within the framework of TRIPS, in ways that enhance technology acquisition and diffusion, without regard to development level. The latter point recognizes that the LDCs should deploy "maximum flexibility" in their IPRs in order to benefit sufficiently from foreign technologies that they may be able to establish the kind of manufacturing and marketing competence to permit their entry onto the lower rungs of the global technology ladder.

The phrase "maximum flexibility" needs to be read in the context of obligations accepted in TRIPS. On paper this flexibility is necessarily reduced relative to having no such obligations. In this context, countries that could have benefited from free access to international (even proprietary) technologies by placing them effectively into production have seen their range of options restricted. Nonetheless, the fact that the Preamble mentions creation of a "sound and viable technological base" as one of the basic objectives of TRIPS means that the negotiators meant for effective technology transfer to emerge from its operation.

The language of Article 7 is important in this regard, for it states technology transfer as a basic objective of TRIPS:

"The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations."

Note that this is a positive objective; it states that protecting and enforcing IPRs should contribute to these goals rather than acknowledging that a failure to protect IPRs might also so contribute. However, it suggests that in adopting TRIPS-consistent protection countries should expect the systems they implement to enhance both the transfer and dissemination of technology. How broadly one should interpret the scope of this objective is subject to debate. Presumably the *demandeurs* of protection meant it to cover formal or market-based means of transfer and subsequent dissemination. In this view, informal means of learning through imitation and copying would not constitute permissible transfers and the Agreement would not be structured to promote them. However, technology-importing nations might interpret Article 7 to mean that their own IP systems should encourage a broader view of technology transfer while remaining consistent with TRIPS.

It is also necessary to cast Article 7 as an objective for the global system. Thus, the regimes adopted not only by developing countries but also those by developed countries and those reached in bilateral and multilateral consultations should promote technology transfer and diffusion. The substantive obligations of TRIPS could be read against this objective. If some may be shown to interfere with technology transfer or its dissemination there is scope for revisiting them or complementing them with other obligations.

Note also that Article 8.1 permits countries to take measures:

"…to promote the public interest in sectors of vital importance to their socio-economic and technological development…"

Article 8.2 recognizes that countries may wish to adopt policies:

"…to prevent the abuse of intellectual property rights by rights holders or the resort to practices which unreasonably restrain trade or adversely affect the international transfer of technology."

Any such measures must be consistent with the TRIPS agreement. Nonetheless, the language again recognizes the centrality of technology transfer as an objective for the intellectual property system.

The most direct language on technology transfer arises in Article 66.2, which states:

"Developed country Members shall provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least-developed country Members in order to enable them to create a sound and viable technological base."

There are several noteworthy aspects of this article.[21] First, it requires only developed countries to provide such incentives, and only on behalf of the LDCs. No obligations or rights are created for the developing and transition countries. Second, that it is a positive obligation is indicated by use of the word "shall" and this fact was clarified by the Doha Declaration. Thus, developed nations must find means to define and provide such incentives. Third, while the incentives involved must promote and encourage technology transfer the language does not say they must actually achieve increases in ITT. Indeed, governments cannot coerce private firms to take up these incentives. Firms are presumably more likely to engage in ITT where they can profit from it. In this regard, the LDCs may need to enhance their abilities to absorb ITT. Finally, Article 66.2 does not mention IPRs specifically. Thus, developed countries could establish whatever incentives they find sensible, including limitations on the scope of IP protection, presumably so long as those limitations do not conflict with the TRIPS agreement provisions.

Recognizing that developing countries and LDCs would face considerable difficulties in implementing TRIPS, Article 67 obligates the developed countries to technical assistance covering the entire agreement:

"In order to facilitate the implementation of this Agreement, developed country Members shall provide, on request and on mutually agreed terms and conditions, technical and financial cooperation in favour of developing and least-developed country Members. Such cooperation shall include assistance in the preparation of laws and regulations on the protection and enforcement of intellectual property rights as well as on the prevention of their abuse, and shall include support regarding the establishment or reinforcement of domestic offices and agencies relevant to these matters, including the training of personnel."

There is no mention here of technology transfer or dissemination. Presumably, however, its scope extends to means of making Article 66.2 effective, at least for LDCs. In this context, technical assistance should extend to programs improving the ability of LDCs to attract and absorb ITT.

## 4.2 TRIPS–consistent flexibilities in intellectual property

It should be kept in mind that a well-functioning and balanced IP system can contribute positively to international technology transfer and its diffusion into the economy. For example, trademark protection can enhance the willingness of firms to license production and distribution rights and to extend their marketing efforts across space.[22] An efficient allocation of copyrights (authors' rights, performers' rights, mechanical rights) can sort out the complex contracting problems inherent in literary and music creation. Patents and know-how are often the central components of technology transfer and legal certainty in how the rents to these assets are to be shared can reduce contracting costs, thereby raising the volumes of information transacted. Protected geographical indications can provide incentives for foreign technology leaders (e.g., in the wine industry) to bring new technologies to local regions.

As always, however, IPRs are a two-sided sword for technology importing nations and firms. I have discussed earlier the problem that even mature technologies, available for simple imitation at low investment cost prior to TRIPS, could command significant license fees in the future. With the bottom rungs of the technology ladder thus raised, especially for the poorest countries with a skill basis that is too limited to manage the initial jump, the scope for imitation is narrowed. More broadly, TRIPS affords technology developers greater leeway to refuse to license a protected technology or product, to demand markedly higher licensing fees and prices, and to impose restrictive conditions on licensing contracts.

TRIPS offers countries avenues to limiting the scope of intellectual property protection in order to pursue certain objectives, including technology transfer and dissemination. Again, it is beyond the scope of this report to undertake a detailed examination of the legal and economic basis for these procedures.[23] Fundamentally, Articles 27.2 and 27.3 permits countries to exclude certain important technologies from patentability, including plants and animals (except microorganisms). Countries are permitted to protect plant varieties with a *sui generis* system that could be based on the UPOV model.

Application and renewal fees for patents and trademarks could be set to promote innovation and dissemination of IPRs. It is possible to set lower patent application fees for small and medium-sized enterprises than for large firms. Further, patent renewal fees may rise over time to encourage firms to let protection lapse on mature and less-valuable inventions. Governments in developing nations could require rapid publication of patent applications (most of which will have been published elsewhere already), with the fullest feasible disclosure of the technical processes involved and how to reduce technologies to commercial practice. Allowable claims could be narrow and limited to single technologies or applications. Further, countries could set high standards for the inventive step in order to prevent routine discoveries from being patented. In combination with a system of utility models and design patents, local firms would be encouraged to invent around patents and improve their manufacturing methods. Pre-grant opposition or active opposition procedures after grants are made would help invalidate inappropriately awarded patents. Developing countries could permit oral prior art to defeat claims of novelty. They could award a limited grace period in order to maximize the inventions available in the public domain to domestic firms.

Under limited circumstances set out in Article 31, governments may resort to compulsory licensing to promote public health, welfare, security, competition, and other objectives. However, if governments take advantage of this procedure, compulsory licensing procedures should be transparent and well-defined in order not to discourage entry of foreign firms and development of new technologies by domestic firms. It should be noted that the restrictions imposed on compulsory licensing are seen by some observers as so rigorous as to eliminate nearly all prospects for effective technology transfer (Correa, 2003). In particular, requirements for compensation, the need for non-exclusive licensing, and the inability to compel transfer of know-how significantly restrict the ability of local firms to benefit from this policy. Indeed, there is little evidence that countries have successfully used this tool to gain access to international technologies.[24]

There remains debate among legal scholars about whether TRIPS permits countries to require local production in order for patents to be "worked" sufficiently to remain valid. On the one hand, it may be argued that the language in Article 27.1 making "…patent rights enjoyable without discrimination as to …whether products are imported or locally produced" makes working requirements for the maintenance of IPRs impermissible. On the other hand, it has been observed that, as long as a local working requirement is maintained for *bona fide* purposes (such as the satisfaction of compelling public interests, as opposed to the sole purpose of conferring an economic advantage on a local producer), there is by definition no "discrimination", but only "differentiation".[25]

From an economic point of view, however, it should be noted that, especially for small and poor developing countries, local working requirements are likely to discourage foreign firms from entering in cases where local production for small markets is uneconomic. Meanwhile, as discussed earlier, imports can serve as important channels of ITT. Thus, it is at best debatable whether resort to working requirements could actually increase net technology transfer.

For purposes of encouraging dynamic learning and competition, it is important for developing countries to encourage reverse engineering as a fair competitive practice, consistent with TRIPS. This permits local rivals to use unpatented information but only at the cost of undertaking their own incremental R&D activity, which in itself can contribute to future technology transfer. Indeed, a regime protecting confidential business information but with liberal principles of reverse engineering could promise dynamic benefits for developing countries.

TRIPS Article 40 sets out a general right for countries to establish and enforce anti-monopoly policies for purposes of combating abusive technology licensing practices. Remedies may include a variety of restrictions on behaviour and the exercise of IPRs, including compulsory licensing to expand competition, a practice that is central to U.S. competition policy. However, relationships between IPRs and their potential abuse in technology markets are complex and require considerable expertise in diagnosis and treatment. Moreover, the scope for abusing IPRs depends on the competitive nature of distribution markets and entry possibilities. There is scope for developing nations to improve their competition regimes and to benefit from technical assistance in this regard. To rely on this avenue for enhancing ITT may require a broad policy approach to expanding dynamic competition.

In copyrights, TRIPS offers flexibility for defining fair use of unauthorized copies for purposes of achieving social and economic objectives. Countries can permit limited copying for teaching, research, libraries, museums, and charitable organizations. Reverse engineering of computer programs for purposes of developing competing software is permissible under TRIPS. Such decompilation is central to the development of software industries in many developing countries.[26] A policy preference for encouraging use of open-source software in education and industry can matter here as well.[27] Finally, developing countries could insist upon a high standard of creativity before extending protection to databases beyond the copyright.

More could be said about competitive standards and limitations on IPRs that have some potential to enhance ITT into poor countries. Governments could benefit from considering such policies carefully and embedding them in the broader competitive and technological environment. However, it is difficult to argue persuasively that patience and the surgical exercise of IP policy offer the promise of significant increases in ITT. Accordingly, it is important to set out a broader policy agenda that might assist in this objective.

# 5. POLICY SUGGESTIONS FOR ENHANCING ITT

The analysis in this report supports the following justifications for policy interventions, including through WTO negotiations and operations, in order to increase the incentives for, and reduce the costs of, international technology transfer to developing nations. First, there are inherent problems in markets for technology, including spillovers from weak excludability, asymmetric information, and market power. Second, the flow of ITT may be impeded by virtue of related difficulties, including a weak host-country environment for absorbing technology, distance from markets, and poor infrastructure. Third, such flows may be similarly impeded by related policy restraints, including host-country restrictions on service provision, technology-transfer requirements, and domestic innovation systems (including IPRs) that fail to promote diffusion and follow-on innovation. Fourth, impediments to ITT arise from trade restraints in the developed economies. Such restraints are both formal trade barriers and informal restrictions in the form of technical standards. Fifth, a considerable amount of publicly generated research results fail to be transferred, either because they are (sub-optimally) excluded from the public domain or because there is insufficient information available about their characteristics. Finally, the development needs of poor countries support a conscious effort at expanding ITT, which is the spirit within which Article 66.2 was negotiated.

Article 66.2 has a laudatory intention but it is not likely on its own merits to achieve significant increases in ITT. There are three essential difficulties. For one, ITT largely relies on private market incentives and this article does little to redress the basic problems mentioned above. Second, private firms cannot be compelled to increase their ITT activities and they may choose not to take advantage of incentives offered. Third, even if governments in developed countries were willing to offer substantial incentives they would face domestic political opposition in doing so.

In this regard, the following set of policy recommendations should provide a framework for improving the environment for ITT. I organize them in terms of host-country policies, source-country policies and issues for the global system, including the WTO.[28]

## 5.1 Host-country policies

It is evident that developing countries could do much on their own to encourage inflows of ITT and their effective use in the domestic economy. In short, their challenge is to improve the local environment for ITT and its diffusion. Because the issues are discussed elsewhere in the report, a brief listing should suffice here.

An important determinant of the ability of domestic firms to absorb foreign technologies is the existence of an in-house R&D capacity, even if it is a relatively limited one. Thus, prospects for ITT are enhanced where there is an expected positive return to investing in at least simple R&D capacity. To the extent that technology policies, restrictions on capital markets, and tax policies restrict this return or discourage such investments, they should be reformed to encourage more innovation. For example, because investments in innovation and technology acquisition are liable to be sub-optimally low, tax credits or deductions could be applied to domestic R&D expenditures and technology licensing payments. Further, it may be desirable to link relative tax advantages to firm size in order to encourage such activity in small and medium enterprises, which might otherwise be excluded from the technology marketplace, given the fixed costs of entry and licensing.

Similarly, absorption of ITT and its translation into greater competition depend on having an adequate supply of human capital, including engineering and management skills. In this regard, domestic education and technical training policies are an important component of national innovation strategies. For this purpose, investments in secondary education to increase access of students to essential literacy and mathematical skills should have a high payoff in poor countries. Tax advantages for R&D could extend as well to firm-level technical training programs.

Over the medium term formal higher and graduate education in science and engineering may require the continued movement of students to educational institutions and enterprises abroad. Countries have scope for quickly expanding the scope of educational opportunities at home through the use of internet services in order to tap into on-line training services.

To benefit from foreign training in the long term, it is important to induce trainees to return to their home countries, as opposed simply to repatriating income. Thus, programs to establish a domestic entrepreneurial environment that attracts skilled workers who reside in developed countries to come home can rapidly increase the deployment of international technologies and capital.

Technology spillovers from ITT appear to be strongest in countries where multinational firms are capable of working with competitive suppliers in order to increase their productivity and standards. Such backward linkages are central to diffusion and learning within increasingly vertical production networks. They are also important in developing competitive strength in small and medium-sized suppliers. Thus, policies aimed at reducing entry barriers in supplier industries can increase ITT and maximize the follow-on information benefits. In this context, punitive tax systems that keep entrepreneurs in the informal sector need reforming. Governments might consider targeted loan guarantees for supplier firms in order to overcome weak capital markets and inadequate loans stemming from risk aversion.

There is little evidence that extensive government monitoring of technology license contracts, with associated requirements for full disclosure of proprietary information to public agencies or other performance mandates, has positive impacts on inward ITT or on productivity growth. Such mandates are likely to deter foreign firms from transferring their newer technologies to all but the largest or higher-income economies. Thus, intervention of this kind may be counterproductive in contrast to setting a transparent set of licensing and FDI policies. Typically the proper role for governments is not to restrict licensing terms ex-ante but to be vigilant for anti-competitive abuses of licensing agreements.

Evidence suggests that FDI and licensing respond to an adequate business environment. Important factors include, among others, an effective infrastructure and transparency and stability in government. For example, recent evidence suggests that the most significant impediment to inward flows of capital and FDI may be inadequate governance and economic institutions (Kalemli-Oczan and co-author, 2003).

Governments may be able to do little about geographical distance but they can take steps to reduce the "technological distance" between their firms and foreign firms in order to encourage ITT. This is the main argument for establishing national or regional innovation systems that encourage local R&D, transfer knowledge from universities and public laboratories to domestic firms, and promote use of telecommunications, e-commerce, biotechnologies, and other cost-saving technologies.

A role remains for governments to engage in research programs that may be aimed at meeting domestic and regional public-goods needs and at encouraging the movement of these technologies into commercial use. Research into agricultural, medical, and environmental problems of local interest may best be based in public research laboratories or university-based incubators, with a commitment for licensing results on a reasonably open basis.

The intellectual property system is integral to efforts to promote learning from ITT and follow-on innovation. In this regard, attention should be paid to selecting IP standards that recognize the rights of inventors but use the flexibilities in TRIPS to encourage dynamic competition, as discussed earlier. Thus, governments should consider carefully their standards regarding utility, novelty, fees, utility models, competition policy, and compulsory licenses.

This list offers little that is new to policymakers in developing countries, which have been advised continuously to improve their investment and technology climates. Indeed, some of the suggestions may be of limited relevance to the poor and least-developed countries because they require resources that might be better spent on other development needs. Therefore, the more relevant lists for this report are those following.

## 5.2 Source-country policies

Article 66.2 is a positive obligation on developed countries, the overwhelming source of new and even mature technologies, to provide incentives to their firms to transfer these technologies to the least-developed countries. To date, the only response to this obligation is the ongoing exercise in which each developed country has reported to the TRIPS Council its incentives for technology transfer. Upon reading these reports, it is fair to describe them as follows. First, few new initiatives have been reported; virtually all are continued from prior policy decisions. Second, there are virtually no programs aimed specifically at the LDCs, rather their benefits are available to all developing countries (or even developed countries). Third, the programs are largely in the form of technical assistance and capacity building, with payments typically made to source-country consultants for this purpose. Fourth, where assistance payments are made to developing countries for the purpose of technology acquisition, it is generally for recognized regional development purposes, such as within the EU or NAFTA. Fifth, measurement of the extent of technology transfer is typically restricted to the dollar value of the assistance provided rather than some meaningful measure of effectiveness or results in transferring information. Of course, it must be acknowledged that precise measurements of technology transfer are extremely difficult to make without revealing proprietary information. Sixth, some countries make available for transfer the results of certain public research programs, though the extent of active efforts to share that information varies widely.

Reports of this kind, while useful for increasing transparency about available benefits, are hardly sufficient for expanding technology flows. The following suggestions for a more positive approach may be considered.

Nothing in Article 66.2 prevents developed countries from providing indirect incentives for ITT. Perhaps the most powerful such incentive available would be to provide significant market access in the developed economies for products in which poor countries have a comparative advantage. In the case of textiles and apparel, such access presumably is forthcoming with the expiry of the Multi-Fibre Arrangement in 2005. This commitment could be made more credible if the developed countries were to agree to negotiate a less intrusive set of contingent protection (anti-dumping) rules that would restrain their freedom to limit imports.

In the case of agriculture and food, the potential for increasing trade through lower trade barriers and reduced subsidies is obvious. Estimates from the World Bank (2001) suggest that the agricultural output gains in developing countries from agricultural liberalization could amount to several hundred billion dollars per year, much of it exported. An increase in market activity of that size unquestionably would encourage the transfer of IP-based agricultural inputs, including genetically engineered crop technologies and biotechnological plant varieties.

The linkage between ITT and market access could be easily made by recognizing the role that market size and growth play in attracting trade and FDI, while recognizing that both international enterprises and domestic firms in developing countries would be more willing to invest in new technologies if export markets were more assured.

In recognition of the role that technical standards play in diffusing production and certification technologies, developed countries could commit to greater access to experts from developing countries in deliberations of their own standards-setting bodies. Access to technical specifications defining key regional and global standards in information technology goods, food products, and other areas can be central to achieving effective ITT (Maskus and Wilson, 2001). Indeed, learning technical standards is often tantamount to learning technology.

Governments in developed countries need to increase their technical and financial assistance for improving the ability of poor countries to absorb technology and trade. There are several key issues in this context. First, capacity building in IPRs should emphasize less the specification of protective laws and regulations and emphasize more the technical, judicial, and legal expertise underlying effective ITT. Thus, rich-country governments could encourage a repository and publication of best practices by firms headquartered there in foreign licensing contracts with subsidiaries, joint ventures, and arm's-length partners, Training programs in how technology is transferred through modern technology markets would be beneficial. Second, governments could provide financial and technical support in establishing public and public-private research facilities in developing countries. Third, competition authorities in rich countries could help their counterparts in poor countries to develop appropriate anti-monopoly regimes as regards IPRs and technology transfer.

An alternative form of assistance could recognize that poor countries face major difficulties in developing the appropriate expertise for developing and enforcing anti-monopoly laws. Yet the main concern expressed about stronger IPRs as regards ITT is the potential for abuse of exclusive rights in those markets. Thus, one way for governments in developing countries to feel more confident about the system would be for authorities in the developed countries to undertake enforcement actions against firms headquartered or located in their jurisdictions (Saggi, 2003b). One could consider this to be a form of "reverse extraterritoriality" in which developed countries would agree to issue sanctions in home markets on the basis of malfeasance in poor countries, until that malfeasance is remedied. For this to have any chance of success there would need to be considerable cooperation between competition authorities in the developed and developing economies for purposes of defining and recognizing licensing abuses. In itself, this goal may require an agreement at the WTO over multilateral disciplines in competition policy, with enforcement to be shared between developed and developing countries.

It would be difficult for developed-country governments to envision fiscal incentives for transferring technology, which might ultimately result in jobs transferred overseas, without offering similar incentives to firms to locate in or provide technologies to lower-income areas within their own countries. However, such discrimination typically works in the other direction. Thus, federal governments could agree to offer identical fiscal benefits to firms transferring technologies to developing countries as to developing home regions. In a form of "special and differential" treatment for the least-developed countries, consistent with Article 66.2, these benefits could be made larger for LDCs.

Similarly, in the spirit of non-discrimination at the WTO, developed countries could offer the same tax advantages for R&D performed abroad as for R&D done at home. To meet the terms of Article 66.2, there might be somewhat greater advantages offered for R&D performed in poor countries.

Governments could ensure that tax deductions are available for contributions of technology to non-profit entities engaged in ITT. Such contributions could be in the form of money, technical assistance, or mature patent rights. It is conceivable that non-profit organizations of this kind would be more efficient in locating developing-country recipients by virtue of their specialization in such activities.

Fiscal incentives could be offered to encourage enterprises to employ, at least temporarily, recent scientific and engineering and management graduates from developing countries. If such employment were to happen in the donor countries, some coordination with immigration policies would be required, including presumably requirements for the personnel to return to their countries for some time period.

Public resources, such as those from the National Science Foundation or National Institutes for Health in the United States, could be used to support research into the technology development and technology transfer needs of developing countries. Further, grant programs could be established for research into technologies that would be of greatest productivity in poor countries for social needs, such as water treatment, energy, and the environment. Technologies developed under such programs could be made publicly available if transferred through public resources. If such transfer requires investment by private firms, they could enter the public domain after an agreed-upon period of exclusivity.

In a similar vein, grant programs could be devised that offer support to research proposals that meaningfully involve research teams in developing countries, presumably in partnership with research groups in donor countries.

Universities could be encouraged to recruit and train students from LDCs in science, technology, and management. Incentives for setting up degree programs through distance learning or even foreign establishments of university campuses may be particularly effective in this context.

## 5.3 Multilateral policy options

There are essentially two roles that international organizations can play in encouraging ITT. One is to serve as a coordinating mechanism for overcoming problems in private technology markets. The second is to serve as a forum for negotiating additional rights and obligations at the international level in order to reduce impediments to ITT. Neither of these roles necessarily involves the WTO, though that institution is likely to be integral to any policy changes. Following are a series of suggestions that might be pursued at the multilateral level.

The terms of Article 66.2 could be expanded to include all developing countries, or at least those without a significant domestic science and technology base and extensive university training. The designation of 49 "least developed countries" leaves out many truly poor countries for no evident reason.

There may be scope for linking Article 66.2 and Article 67 to Article 7 in terms of obligations. Specifically, developing countries could argue that building a "sound and viable technological base" (Article 7) requires institutional reforms (including implementing and enforcing IPRs), infrastructure, and an effective science and technology policy, all of which are costly. Thus, developing countries could commit to making a good faith effort to improving the environment for ITT if developed countries are prepared to offer much more technical assistance and sustainable funding for such reforms. In the absence of marked increases in such assistance, the LDCs could be permitted to suspend or delay the costly enforcement of technology-related IPRs. This is a subtle and complicated issue for the threat of such actions could deter private ITT.

Because costs are a central problem, a particular suggestion worth exploring would be to establish a special fee on applications through the Patent Cooperation Treaty, the revenues of which would be earmarked for improving IP administrative systems in developing countries. The logic here is that the primary beneficiaries of stronger patents in the developing world will be firms and shareholders in developed economies. The poor countries have little incentive to fund these institutions, especially in light of other development needs. Thus, to resolve the collective-interest problem here (ie, that beneficiaries do not pay the costs), a special administrative fee at the PCT (or other international patent organizations) is sensible.

The WTO could increase the scope for monitoring developed-country efforts in ITT and could add an evaluative mechanism for the effectiveness and extent of technology transferred.[29] Over time this approach should build up useful information about problems and effective practices in transferring technologies.

The WTO can do little to resolve the asymmetric information problem in private transactions between technology buyers and sellers. However, to reduce the information problems overall, the WTO and technology-related organizations could do more to serve as an intermediary conduit for knowledge about successful technology-acquisition programs that have been undertaken by national and sub-national governments in the past (Saggi, 2003b). That is, the WTO could serve a useful role in encouraging collaboration and information sharing among member governments. Such programs could involve, for example, detailed information from Japan, Korea, the United States, China, and Brazil about past policies and effective partnerships between agencies and domestic firms in acquiring technologies and the terms involved, such as royalty rates and contract clauses that resulted in actual local absorption. They could also describe the most effective roles for public research facilities and universities in facilitating technology transfer. Because these would be descriptions of history involving generally outdated technologies, there should be relatively little private opposition to their use.

Once enough information of this type has been compiled and studied, the WTO (in conjunction perhaps with WIPO and technology-related organizations) could attempt to develop a model technology transfer contract that could serve as a guideline for ITT and would represent the legitimate interests of both buyers and sellers (Saggi, 2003b).

In future negotiations over Mode 4 in the GATS (temporary movement of personnel), developing countries could push for preferential visa allocations for attending conferences and for professional researchers and students.

Donor countries and organizations could consider establishing special trust funds for the training of scientific and technical personnel, for facilitating the transfer of technologies that are particularly sensitive for the provision of public goods, and for encouraging research in developing countries (Roffe 2002).

Countries are engaged in negotiating a Patent Harmonization Treaty through the auspices of WIPO. While such a treaty offers certain benefits in terms of costs and certainty, developing countries should not agree to protection standards as they exist in the United States and the European Union regarding patentability, novelty, and utility. At a minimum there need to be regional examination offices with standards that reflect the needs of developing countries.

As regards TRIPS itself, developed countries are unlikely to accept any significant rollback in its provisions. Indeed, there will be strong pressures to expand protection for geographical indications and to require patentability for life forms, especially those developed in biotechnological research. Each of these changes would pose some additional potential for increasing ITT flows to developing countries as the relevant technologies are deployed there. However, they also may raise costs and for some countries could be harmful in the intermediate term. Accordingly, developing countries could tie such changes to significant agricultural liberalization in developed countries. The linkages are direct in any case.

Going beyond TRIPS, it is possible to argue that technical standards and regulations act not only as non-tariff barriers to trade but have the effect of limiting technology transfers to poor countries (Maskus and Wilson, 2001). In this context, some relief (perhaps for a defined period) from the need for the poorest countries to meet minimum technical standards could help them acquire mature technologies.

The agreement reached by WTO members on August 30, 2003 on access of poor countries to essential medicines through compulsory import licensing and effective market segmentation recognizes that, for some IP-intensive goods there are benefits from price differentiation across countries. The notion of trade-policy arrangements to encourage cheaper prices in poor countries for medicines, software, educational materials, agricultural inputs, and other technologies is attractive from the standpoint of ITT and Article 66.2. Thus, an extension of the basic approach, perhaps combined with subsidies for provision of such technologies in the LDCs, could be beneficial. It should be noted that some developing countries may choose to refrain from joining such arrangements due to concerns that cheap technology imports could damage prospects for local industrial development.

## 5.4 A Multilateral Agreement on Access to Basic Science and Technology

The suggestions made above range from simple and practical to complex and of questionable political feasibility. In my view, action on all of these fronts could provide more incentives for ITT while representing the interests of both buyers and sellers.

However, it is worth concluding this report by reviewing a broader suggestion, first set out by Professor John Barton.[30] One important way to help build a "sound and viable technological base" in poor countries is to increase the size of the pool of technologies available in the public domain or widely accessible at affordable costs. Thus, in this proposal an agreement at the WTO could be negotiated in which all signatories would place into the public domain, or find other means of sharing at modest cost, the results of largely publicly funded research. The idea is to preserve and enhance the global commons in science and technology, while setting out a public mechanism for increasing the international flow of technical information, especially to developing countries, without unduly restricting private rights in commercial technologies.

As noted above, the essential purpose is to expand the public domain in scientific and technological information, when that information is publicly developed. A related question is how to extend this concept to underlying processes for purposes of sharing the technologies. The agreement could cover "input liberalization," which would permit researchers from other countries to participate in, or compete with, local research teams for grants and subsidies. This could be combined with increased opportunities for temporary migration of scientific personnel and additional student visas. Thus, particular provisions could prohibit preferences for national firms and institutions as regards publicly funded research consortia and access to research-based tax advantages. Commitments could be reached banning visa restrictions that inhibit the ability of students to study at universities in another nation or restrict the scope for scientists and engineers to participate in conferences or training programs. However, governments could choose to reserve their research results for preferential use by local firms and the registration of intellectual property rights, much as happens in the current U.S. system. While this approach could expand research efficiency and transfer more skills abroad, its scope for raising access to new information would be limited.

Second, "output liberalization" would entail offering researchers in other countries access to nationally generated science and data, without increasing their ability to use underlying funding or research facilities. This approach would usefully expand the public commons and increase knowledge transfers but would not directly expand efficiency or transfer research skills. A key provision here would promote access to scientific databases and would ensure that intellectual property regulations not limit access to basic scientific knowledge. Finally, "full liberalization" would combine these regimes, both expanding international flows of research contracts and personnel and increasing global access to outcomes.

The most effective approach would be full liberalization to the extent it is politically feasible. In getting there, however, it may be necessary to adopt something like a GATS approach, permitting governments to reserve sensitive areas of technology and to designate different levels of commitment to open access.

Consistent with other WTO agreements, national treatment would be a key legal provision of the treaty, requiring that, in as many ways as possible, foreign scientists and firms be treated the same way as national ones with respect to access to a country's scientific and technical support programs and outcomes. Like TRIPS, this agreement could also adopt an MFN commitment, unless there were compelling reasons for regional preferences.

A treaty of this kind would need to be balanced by safeguard clauses. One issue involved in international scientific and technological collaboration relates to the equitable and efficient distribution and management of intellectual property that could emerge from subsequent applied innovation. Another is that concerns regarding national security and technology proliferation would need to be addressed. For example, the United States has moved to establish new security classifications for biological data and restrict some foreign students form studying particular areas of biotechnology. Such restraints need to be balanced with the advantages of promoting the scientific and technological commons.

In recognition of the need for encouraging a "sound and viable technological base," it would be possible to build in preferential advantages for the developing economies. For example, to the extent that data and research results are to be made available at some cost, differential pricing schemes for governments and institutions in poor countries could be encouraged. Efforts to encourage research participation by scientists and engineers from developing countries could be written into proposal solicitations. Marginal visa allocations could be aimed at students and researchers from poor countries. More generally, developed countries could commit themselves to help developing nations build capacity for improving educational and scientific processes, including their ability to benefit from available international information. Assistance in development and use of electronic resources, especially the Internet, could be particularly valuable.

# 6. CONCLUDING REMARKS

The strong interest developing countries have in expanding their access to international technologies is understandable in light of rapid technical changes in the global economy. An ability to learn from foreign technologies and adapt and absorb them into domestic competition is critical for achieving sustained economic transformation and productivity growth.

The TRIPS agreement in the WTO commits member countries to implementing and enforcing relatively strong minimum standards for technology protection, though it retains some room for flexibility. There are good reasons to think that over time these changes in IP protection will support expanded market-mediated ITT. However, these impacts will depend on numerous national and industry characteristics. In general, developing economies with a good basis in skills, a competitive economy, good growth prospects, effective infrastructure and the like are more likely to see these flows increase. The LDCs are likely to find relatively little expansion in inward technology flows for some time to come.

In this report I have analysed the nature and determinants of ITT for the purpose of setting out a more positive agenda for increasing information flows. To achieve this objective, while sustaining the interests of both technology importers and exporters, will require significant efforts on both sides. Moreover, a multilateral approach to greater collaboration in this area may be justified both in terms of market difficulties and the public interest. It is hoped that the suggestions offered here offer a sound basis for discussion and negotiation over the medium term.

# END NOTES

[1] A number of recent studies cover these issues. See in particular OECD (2003), Saggi (2003a), WTO (2002), and Maskus (1998).

[2] The most straightforward form of imitation is to produce a competing good under a rival's trademark, a process often called counterfeiting. While such imitation is attractive to firms wishing to free ride on a well-known brand, it rarely involves actual absorption by the rival of new or improved technologies, which is the focus of this report.

[3] See the UNCTAD-ICTSD Resource Book on TRIPS and Development Part 2.5.7 (sub-Sections 3 and 7) [hereinafter Resource Book], (available at *http://www.iprsonline.org/unctadictsd/ResourceBookIndex.htm*).

[4] Note that with respect to test data, there exists considerable controversy among legal experts whether Article 39.3 of the TRIPS Agreement obligates Members to actually provide the original applicant with a (temporary) right of exclusivity. For details on this interpretative issue, see the Resource Book, Part 2.7 (sub-Section 3).

[5] See the Resource Book, Part 2.5.7 (sub-Section 1).

[6] Recent surveys may be found in Markusen and Maskus (2003), Saggi (2003a), World Bank (2001).

[7] This is a highly complex question that goes beyond the scope of this report.

[8] This sub-section draws in part on Saggi (2003).

[9] Interestingly, they found a significantly positive impact of imports on domestic firm productivity, suggesting again that trade is an important channel of learning.

[10] Moran (1999) provides considerable anecdotal documentation of such effects in many developing countries.

[11] See Markusen (1995) and Markusen and Maskus (2003) for reviews.

[12] See Arora, Fosfuri and Gambardella (2001), Contractor (1980), and Teece (1986) for extensive analysis.

[13] For example, Correa (2003) argues that strong intellectual property protection is liable to stifle ITT as firms exploit their market power.

[14] The World Bank (2001) updated these calculations to 1995 patent data, finding that net outflows from developing countries could be as much as $19 billion per year. However, these figures should be treated with caution.

[15] For a more lengthy discussion see Maskus (2000).

[16] However, imports were sensitive to openness to trade, suggesting that simple trade liberalization would be a more affirmative route to ITT.

[17] Heald (2003) criticizes the Mansfield results on the basis that one-dimensional survey perceptions cannot capture the complexities of patent law, a criticism that could be aimed at many such studies.

[18] See Correa (2003) especially.

[19] However, Kanwar and Evenson (2003) find a positive statistical impact of patent protection on R&D expenditures across both developed and some developing countries over the period 1981-1995.

[20] See Reichman (1996/1997) and Correa (2003) for fuller discussion.

[21] Becker (2003) provides a comprehensive textual analysis.

[22] Maskus (2000) extensively discusses these innovation and dissemination issues.

[23] See World Bank (2001) and Reichman (1997/1997). For a detailed analysis of the flexibilities existing under the provisions of the TRIPS Agreement, see the respective chapters of the Resource Book.

[24] See Reichman and Hasenzahl (2003) for more discussion on the law and practice of compulsory licensing.

[25] See the interpretation in the Resource Book, Part 2.5 (Patents, sub-Section 2.5.8 on Article 31 TRIPS), referring to the WTO panel in *Canada-Patent Protection of Pharmaceutical Products,* WT/DS114/R, 17 March 2000.

[26] Reverse engineering of computer programs is legal under TRIPS because copyright is limited to the protection of the expression as such and does not extend to the underlying ideas (see Article 9.2 of the TRIPS Agreement). It is therefore permissible to decompile computer software to study its method of operation for the purpose of creating new, competing software (i.e. a new expression of the same idea). On the other hand, the pure copying of copyrighted software does not represent a new expression and is therefore prohibited under TRIPS. Note that reverse engineering is not permitted under patent law: contrary to copyright, patents protect the idea underlying the protected good or service. Therefore, in jurisdictions permitting the patentabilty of computer programs, it is not legal to decompile patented software with a view to using the underlying operational concept for the creation of competing software. However, WTO Members under the TRIPS Agreement remain free to refuse the patentability of computer software, see Part 2.5 of the Resource Book (Section 2.5.1 on patentability criteria).

[27] It should be noted that there is little theoretical literature on the long-run development implications of different software models and clear predictions are difficult to make. For a detailed discussion of the advantages offered to developing countries by the use of open source software, see A. Story, "Intellectual Property and Computer Software: A Battle of Competing Use and Ownership Visions for Countries of the South", forthcoming at *http://www.iprsonline.org/unctadictsd/projectoutputs.htm#resource.*

[28] Becker Consulting (2003) and Saggi (2003b) offer related suggestions.

[29] Indeed, in February 2003 a mechanism to monitor compliance with Article 66.2 was established by the Council for TRIPS. However, procedures for information dissemination and evaluation are also important.

[30] See Barton (2003) and Barton and Maskus (2003). Becker Consulting (2003) makes some similar points without spelling out the mechanisms involved.

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