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**INTERNATIONAL TECHNOLOGY TRANSFER: AN ANALYSIS FROM THE PERSPECTIVE  
OF DEVELOPING COUNTRIES**

*commissioned by the Secretariat*

1. The Annexes to this document contain (i) a Study on International Technology Transfer: an Analysis from the Perspective of Developing Countries, undertaken in the context of the Project on Intellectual Property and Technology Transfer: 'Common Challenges – Building Solutions' (CDIP/6/4 Rev.), by Dr. Keith Maskus, Professor, University of Colorado, Boulder, Colorado, USA and Dr. Kamal Saggi, Professor, Vanderbilt University, Nashville, Tennessee, USA, and (ii) a Peer Review of the above Study by Dr. Walter Park, American University, Washington, DC, USA.

2. *The CDIP is invited to take note of the information contained in the Annexes to this document.*

[Annexes follow]

**Note: The views expressed in this study are those of the author and do not necessarily reflect those of the WIPO Secretariat or any of the Organization's Member States.**

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FROM DEVELOPING COUNTRIES

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## CONTENTS

<b>EXECUTIVE SUMMARY.....</b>	<b>3</b>
1. INTRODUCTION.....	5
2. HISTORICAL AND INSTITUTIONAL CONTEXT.....	7
3. THEORETICAL PERSPECTIVES AND EMPIRICAL EVIDENCE.....	8
3.1. The Nature of Technology as an Economic Good.....	9
3.2. Trade, Economic Growth, and Technology Transfer.....	10
3.3. Empirical Evidence on Technology Adoption and Spillovers.....	12
3.4. Trade in Capital Goods.....	13
3.5. The Salience of Foreign Direct Investment and Multinational Firms.....	13
3.6. Horizontal Technology Spillovers from FDI.....	16
3.7. Newer Elements of ITT.....	18
3.8. The Role of Intellectual Property Rights.....	19
4. POLICY PERSPECTIVES.....	22
4.1. Enhancing ITT through Standard Channels.....	23
4.2. Mandating Technology Transfer via FDI: The Chinese Case.....	25
4.3. Deploying Flexibilities in IPRs.....	27
4.4. Enhancing ITT through Newer Channels.....	27
5. POLICY RECOMMENDATIONS.....	30
<b>REFERENCES.....</b>	<b>33</b>

## EXECUTIVE SUMMARY

1. This paper focuses on international technology transfer (ITT), with a particular emphasis on the concerns of developing countries in gaining greater access to global technology. The first issue addressed is the benefits from, and impediments to, effective ITT.

- It is imperative that developing countries take full advantage of ITT to maximize learning potential and ensure that their scarce resources are not wasted on inefficient production technologies.
- Evidence indicates that cross-country differences in the timing of adoption of new technologies can account for a significant proportion of the observed disparity in per-capita income across countries.
- In addition to facilitating productivity gains and raising income levels in recipient countries, ITT also provides means for addressing specific social and environmental problems with technical solutions available from abroad.
- Impediments to ITT arise from several general factors: information problems deterring technology transactions, market power associated with advanced technologies and facilitated in part by intellectual property rights (IPRs), unfavorable economic and governance conditions in recipient countries, and an inability of scientific and technical personnel in those countries to establish meaningful linkages with global research and innovation networks.

2. International tensions about tradeoffs in access to, and control of, ITT have influenced IPRs for centuries but the most recent trends, especially the foundation at the WTO of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), are the most sweeping and important to date.

3. Reforms undertaken by emerging and developing economies in patents and other types of IPRs in response to TRIPS and other pressures have been significant.

- These reforms have stimulated greater flows of high-technology trade, foreign direct investment (FDI), and technical licensing across borders. Such reforms also have facilitated the technology-oriented activities of affiliates of multinational enterprises in major emerging countries.
- However, this positive evidence is based almost entirely on data pertaining to large and middle-income developing countries. To date econometric studies have not found impacts on the poorest and smallest countries. This may be due to difficulties in measuring the relevant variables but IPRs likely play a modest role at best in the poorest countries. The ability of such countries to attract international technologies is determined by a variety of other factors that constrain their ability to absorb and assimilate foreign technologies.

4. Multinational firms play a major role in ITT because they conduct a larger proportion of the world's research and development (R&D) and often transfer such technologies to their subsidiaries. In this regard, it is encouraging that the share of the global stock of FDI residing in developing countries has increased from 25% to 33% during 1990-2012.

- While convincing evidence of positive horizontal spillovers from FDI to local firms is lacking, there is strong evidence that multinationals willingly transfer technology to their local suppliers. Thus, developing countries can benefit from implementing policies that help local firms secure a firm footing in global production and innovation networks.

- Policy interventions in ITT must take into account the incentives of private sector participants. Since multinational firms, global production chains, and global innovation networks are the driving forces behind innovation and ITT, government policies in developing countries need to be compatible with their incentives.
  - Technology transfer requirements on FDI imposed by China and some other countries only partially account for these incentives. As a result, multinationals forced into joint ventures with local partners may withhold key technologies or take other actions that hamper the learning of local agents.
  - For smaller developing countries, policies that force multinationals to share technologies with local firms could prove self-defeating, for if the local market is not sufficiently large, multinationals may pull out or not invest. A country can then find itself detached from critical production and innovation chains.
5. Developing economies can undertake important initiatives to encourage inward technology flows and connections to the global system.
- Investments in better infrastructure, construction of transparent and competitive tax regimes, and improvements in public governance are clearly important to global firms seeking to locate production and R&D facilities. They are important complements to investments in human capital, training, and research capacities in universities and research laboratories, which support linkages to global innovation networks and emerging forms of open innovation.
  - Fiscal incentives to domestic enterprises for undertaking meaningful R&D programs can make such firms more attractive affiliates or partners in technology contracts.
6. Establishing a transparent, reliable and enforceable system of intellectual property protection, tailored appropriately for countries at different levels of development, is important for several reasons.
- By resolving information problems and reducing contracting costs, IPRs make multinational firms more likely to transfer advanced technologies and associated know-how.
  - Multinationals need assurance that the inputs they procure at various stages of their supply chains are legitimately produced and reliable, which is more certain with a transparent regime.
  - IPRs can help allocate rights and obligations among partners in research networks.
7. Increasing global openness to the temporary migration of skilled technical and entrepreneurial labor is crucial for facilitating international technology flows.
- Developing countries could gain from unilateral liberalization in this regard but could combine their weight in an international push to relax barriers to such migration.
  - There is scope for using principles of the General Agreement on Trade in Services (GATS agreement) of the WTO to reduce inefficient barriers to the provision of research services and to encourage development of “innovation zones” supporting long-term visas permitting free circulation of skilled and technical personnel.
8. A more ambitious proposal is to begin deliberations on negotiating some form of Access to Basic Science and Technology Treaty (ABST), whether at the WTO, WIPO, or other venue.

## 1. INTRODUCTION

1. Technology transfer is a complex and multi-faceted phenomenon. While it can be given a simple definition – the flow between two or more participants of technological information and its successful integration into production by the recipient(s) – the concept encompasses a vast array of market activities. These include migrating basic research results to marketable inventions, investing in adaptive R&D, forming contractual relationships among headquarters and affiliates and among joint venture or licensing partners, and training in the application of blueprints and knowhow.<sup>1</sup> The potential participants also span a wide range, from universities and research laboratories to private and public foundations and NGOs and from start-up firms and technology brokers to established multinational enterprises (MNEs) and their production and R&D partners. New technologies and products are developed and transmitted for a variety of reasons, ranging from anticipated profitability to humane interventions or often mixed motives. Increasingly in recent years these complex actors have formed themselves into global innovation and production networks, with technology transfer playing a central role. As this description suggests, we take a broad conception of what the term “information” entails. Some analysts make a distinction between “knowledge” and “information”. They conceive of the former as encompassing the outcomes of primary reasoning, basic science, and sheer intellectual creativity. The latter then encompasses specific applications of knowledge to solve well-defined commercial problems. Put differently, knowledge is the basis from which innovation springs (Barton, 2006). The distinction largely turns on whether the intellectual contribution has direct utility in the marketplace (Maskus, 2012). Indeed, the vast majority of economic analysis of technology transfer focuses on transactions in applied commercial information, which is more conformable to contractual terms regarding rights to use patents, trademarks, and know-how. Much of our analysis has this emphasis as well.

2. For purposes of this report, however, we use the words knowledge and information almost interchangeably, because we discuss the full range of technology diffusion, including through access to basic research results. However defined, both knowledge and information are classic public goods in the sense that they are non-rival in consumption, even if they may differ in natural and legislated forms of exclusion through imitation costs, exercise of market power, or intellectual property rights. Moreover, any distinction between them is becoming increasingly blurred as universities and private enterprises work in areas of science that are both fundamental and capable of immediate application, so-called “Pasteur’s Quadrant”. Questions of knowledge transfer are as important as those surrounding information transfer and both are discussed here.

3. In this context, a complex array of public policies and regulations affect technology transfer, whether within a country or across national borders. Such policies include tax advantages, fiscal subsidies, regulations encouraging or discouraging international flows of information, and, most prominently, intellectual property rights (IPRs). Broader policy environments also matter considerably, including competition regulation, the efficiency and depth of capital and labor markets, investments in education and human capital, limitations on the domestic or international circulation of skilled labor, openness to international trade and investment, and the quality of governance and institutions. With such complexity, it is generally not possible to depict simple and unambiguous relationships between incentives for technology transfer and economic conditions and policies that support it.

4. This paper focuses on concepts of international technology transfer (ITT), with a particular emphasis on the concerns of developing countries (DCs) and least-developed countries (LDCs) in gaining greater access to global technology. The importance of having access to a portfolio

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<sup>1</sup> A related, and equally important, concept is technology diffusion, or the transmission through various mechanisms of information outside the direct market transactions into broader uses in the economy. Imitation of new technologies and learning by doing are central elements of technology diffusion, as are sharing knowledge within networks, reading patent applications, and the migration of skilled labor among rival firms and across borders.

of international technologies, establishing relationships within which ITT can flourish, and effectively implementing new processes and methods of production can scarcely be exaggerated. For developing countries, this issue is doubly critical. Not only do they lag further behind the technology frontier, they are also confronted with more stringent resource constraints. As a result, it is imperative that they take full advantage of ITT to ensure that scarce resources are not wasted on inefficient production technologies.

5. Economic evidence suggests that as much as two-thirds of the productivity gains experienced by smaller OECD economies can be attributed to importing and implementing technical information from the major technology-producing nations (Eaton and Kortum, 1996). This relationship is presumably at least as strong with respect to technical change among developing economies (Saggi, 2002). In this context, as they expand their capacities for innovation and adaptation, such emerging economies as China, Brazil, India, and Mexico will become increasingly important sources of productivity-enhancing technical information relevant for implementation in the LDCs.

6. In addition to facilitating productivity gains among firms in recipient countries, ITT plays a second critical role: it provides means for DCs and LDCs to address social and environmental problems with technical solutions available from abroad. This is most evident in the areas of medical technologies, science-based agricultural inputs, and methods of improving energy efficiency and mitigating climate change. Each of these areas requires a mix of incentives for research into new solutions for particular needs, support for global technology transfer and diffusion, and means for adaptation to local conditions. The role of technology transfer is so central that one of the present authors in a recent book called for the technologically advanced and high-income nations to make an "Affirmative Declaration on Technology Transfer" in order to help meet such public challenges (Maskus, 2012).

7. Our primary task in this paper is to assess the concerns developing countries face in gaining access to international technologies and knowledge on reasonable terms and to discuss potential avenues for addressing them. Impediments to ITT arise essentially from several general factors: information problems deterring the development of technology transactions, market power associated with advanced technologies and facilitated in part by intellectual property rights, unfavorable economic and governance conditions in recipient countries, and an inability of scientific and technical personnel in those countries to establish meaningful linkages with research and innovation networks.

8. There may be unilateral, regional, and global approaches to resolving these problems. The most significant global approach to date is the establishment in 1995 of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) at the World Trade Organization (WTO). This agreement sets out minimum standards of protection for IPRs that all WTO members must meet and attempt to enforce. In a nutshell, with few exceptions this agreement calls for the harmonization of IPR policies even though economic and technological capabilities vary drastically across WTO members. It has been phased in over time by emerging and developing economies, with some elements still not required of the LDCs.

9. In the next section we offer some historical background on ITT leading to the current international policy structure. In section 3, we offer theoretical perspective on factors that hamper ITT to DCs and LDCs and assess how important these may be in practice in comparison with other factors. We also consider recent empirical evidence on ITT flows to developing countries since the ratification of TRIPS, with some emphasis on key industrial sectors. We also describe the channels through which technology transfer takes place, noting the importance of such "new" factors as the emergence of global innovation networks and the increasing cross-border linkages among basic research institutions, foundations, and private enterprises. In section 4, we consider how governments in both host and source countries might act to remove some of the blockages identified and facilitate positive transfers to poorer countries. A final section offers concluding remarks.

## 1. HISTORICAL AND INSTITUTIONAL CONTEXT

10. Virtually by definition, “technology transfer” is among the oldest of economic transactions. For production to shift from one location to another, or from one time period to the next, requires the dissemination of know-how between agents. Further, productivity cannot readily expand within firms or countries without the application of new techniques. Technology transfer, in various forms, loomed large in the development of imperial China, Renaissance-era growth in western European city-states, and the economic expansion of North America in the 19<sup>th</sup> Century (Mokyr, 2002; Greif, 2006; O’Rourke and Williamson, 1999). Equally, attempts to limit the diffusion of valuable technology to rival firms and locations have been featured for centuries. Prominent early examples include policies to prevent, on pain of significant punishment, the loss of silkworm technology from China and of new mechanized textile weaving techniques in England. Many observers characterize the recent, and ongoing, pressures raised by US and EU trade authorities to increase the scope of intellectual property protection on a global scale as a similar attempt to limit the leakage of technical information to emerging economic powers, at the behest of private commercial interests (Stiglitz and Charlton, 2005; Sell, 2003).

11. Thus, the tradeoff between the needs of technology followers to access new information and the desires of technology developers to control its use and diffusion has long influenced international debates about how policy should shape technology markets. This tension resulted in international policy discussions of various forms at different times in history. We note two prominent episodes prior to the negotiation of TRIPS. First, in the late 19<sup>th</sup> century the major economic powers agreed for the first time on a framework of intellectual property protection, founded in the Paris Convention and the Berne Convention. These agreements offered inventors and authors stronger rights against imitation and copying, with the greatest complaints leveled against unauthorized use of technologies and copyrighted materials in such rising powers as the United States. These agreements, built essentially on a guarantee of national treatment afforded member countries, remained the basic framework of IP protection until TRIPS (Maskus, 2000).<sup>2</sup> Second, in the late 1970s issues of international technology transfer and corporate conduct in the use of technology and market power were central in discussions at UNCTAD about reaching a “New International Economic Order”. Those wide-ranging negotiations achieved little in policy terms but did expose a deep “North-South” divide in attitudes toward the rights to control access to new technologies (Sell, 2003). They presaged much of the current discussion among developing economies about the use of compulsory licensing, research exceptions, policies to accelerate transfers of patent rights, and limitations and exceptions to copyrights.

12. This situation roughly described the global framework in the late 1980s at the outset of negotiations in the Uruguay Round leading to the founding of TRIPS. Initially, the United States, EU and Japan, the primary *demandeurs* of stronger IPRs, sought better disciplines on trademark counterfeiting and copyright infringement. This quickly morphed into a preference for an agreement covering the full range of intellectual property standards in order to afford better and more globalized protection to high-technology firms, especially in pharmaceuticals, agribusiness, biotechnology, software, and entertainment sectors. As has been comprehensively described, developing and emerging economies agreed to comprehensive reforms for a variety of reasons: the single-undertaking nature of the WTO, anticipated gains in

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<sup>2</sup> Historical evidence supports the argument that international treaties over intellectually property encourage technology transfer. Bilir et. al. (2013) examine the effects of the accession of the United States to the Paris Convention in 1887 and find that nationals from original members of the Convention increased their patenting activity in America by more than 40% relative to nationals from other countries. Their analysis also confirms the idea that effects of stronger IPR protection depend crucially on a country’s level of economic development. Specifically, they find that countries with high levels of education and per-capita income responded to greater IPR protection in the United States to a greater extent. A skeptic might argue that patenting is not equivalent to technology transfer. Yet, an important aspect of patenting is the disclosure requirement and this generally facilitates technology transfer.



market access in other areas, growing domestic interests in IPRs, and an increasing perception that protection could be instrumental in attracting FDI (Maskus, 2012; Sell, 2003).

13. Indeed, a fundamental justification put forward for TRIPS is that a stronger and more harmonized system of IPRs would enhance international technology transfer and thereby contribute to economic development. This notion of pro-development IPRs, effected in part via ITT, is enshrined in the TRIPS Preamble and Article 7. It is elevated to an obligation in Article 66.2, which requires developed economies to take measures to encourage ITT to the least developed countries.

14. How effective has TRIPS been in this regard? An exhaustive review by one author offers a mixed message (Maskus, 2012). On the positive side, the reforms undertaken by emerging and developing economies in patents and (to a lesser degree) other IPRs seem to be stimulating significantly greater flows of high-technology trade, FDI, and technical licensing across borders. They also facilitate the technology-oriented activities of affiliates of multinational enterprises in major emerging countries (Branstetter, et al, 2006; 2011). This suggests that TRIPS has improved the underlying plumbing of global technology trade. Further, the new system arguably supports contracting and sharing of IPRs among private and public entities and NGOs working together to resolve key public problems, such as access to new and patented medicines on behalf of poor countries.

15. However, the review found no evidence that TRIPS encourages ITT to the LDCs and other poor countries, whether within Article 66.2 or through broader channels. To date technology providers see those nations largely as sub-standard locations for producing goods in cases where advanced technologies and know-how need to be shared. Put differently, IPR reforms in such countries to date have been unable to overcome other economic disadvantages of LDCs as targets for FDI and ITT.

16. The TRIPS Agreement is hardly the end of global reforms, of course. Since its implementation the United States and EU have pushed for further international policy changes through the negotiation of regional trade agreements (RTAs) and, especially, bilateral investment treaties (BITs) between countries. This process is currently prominent in the confidential negotiations of the Trans-Pacific Partnership (TPP) agreement, which features strong disagreements among partners about achieving significantly stronger IP standards.<sup>3</sup> The “TRIPS-plus” elements of these agreements, such as strict standards for protecting exclusive rights in pharmaceuticals and life sciences and strong deterrents to downloading and sharing online digital products, have been well described in the literature (Maskus, 2012). In addition, BITs recently have tended to state explicitly that intellectual property is an investment asset subject to strong investor protection. However, these arrangements have not attracted much analytical attention. In particular, while BITs seem on average to stimulate FDI (Egger and Merlo, 2012) there is no systematic evidence to date as to whether the IPR provisions in FTAs or BITs specifically encourage ITT.

## 2. THEORETICAL PERSPECTIVES AND EMPIRICAL EVIDENCE

17. The material below is organized as follows. In section 3.1, we discuss the special characteristics of knowledge (and technology) as an economic good and the factors that hamper ITT. Next, we discuss the relationship between international trade and ITT. Section 3.3 provides a critical discussion of the available empirical evidence on the scope of knowledge spillovers. Section 3.4 notes the special role of trade in capital goods in the context of IIT while sections 3.5-3.6 provide a detailed discussion of the role played by multinational firms in the

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<sup>3</sup> See the recently leaked negotiating draft “Secret TPP Treaty: Advanced Intellectual Property Chapter for all 12 Nations with Negotiating Positions” Wikileaks release 13 November 2013.

process of ITT and the available empirical evidence on the possibility of spillovers for host countries.

### 3.1. The Nature of Technology as an Economic Good

18. To set the stage, it is useful to go back to Paul Romer's illuminating discussion of the special properties of knowledge as an economic good. His seminal paper on technological change (Romer 1990) was built on the premise that knowledge is a *non-rival* good: i.e., the usage of a certain type of knowledge by one person does not preclude another from using it. However, this does not mean that technological know-how can be acquired at zero cost. If technology transfer entailed no resource costs, the room for fruitful policy intervention with respect to assimilation of foreign technologies would be quite limited because market forces would ensure that any technology transfer yielding even a minutely positive return to any agent would take place automatically.

19. The non-rival nature of knowledge only implies that if two agents *are willing to incur* the investment cost of adopting a new technology, they can do so without interfering with each other's decisions. Much empirical evidence indicates that ITT indeed carries significant resource costs (Teece 1977; Mansfield and Romeo 1980; Ramachandran 1993). At an intuitive level, this is quite appealing: after all, mastering any activity – be it intellectual or physical – requires a substantial investment of time and effort. Why would it be any different for technology?

20. While economic analysis provides us with a coherent framework for analyzing ITT, several aspects of the process of ITT remain poorly understood. This situation is not necessarily a reflection on the state of economic science – the very nature of ITT makes analytical and empirical progress difficult. At the heart of ITT is the exchange of information and knowledge, both of which are not easy to quantify.

21. In fact, market transactions in ITT are hampered by several problems of which the following three are crucial: (i) asymmetric information; (ii) market power; and (iii) positive externalities. Consider each in turn.

22. **Asymmetric information:** By definition, technology transfer involves exchange of information between those that have it and those that do not. It is well known that the presence of asymmetric information can hamper the efficient working of markets. In simple words, the problem is the following: how does someone possessing useful information convey the value of that information to an uninformed party? The informed party has an incentive to exaggerate the value of its information while the uninformed party has the opposite incentive. Absent third party verification of the value of the information (which is usually unavailable in the context of new technologies), the two parties would have a difficult time reaching agreement. Furthermore, as soon as the valuable information is shared, the basis for trade disappears since both parties know the same thing! This line of reasoning, no doubt, over-simplifies the issues at hand but it does capture something fundamental about the market frictions that arise from the special nature of technology as an economic good.

23. It is widely acknowledged that the presence of asymmetric information can stifle market-mediated technology transfer. In the international context, technology transfer faces additional hurdles: information problems are even more severe and the enforcement of contracts more difficult. In fact, one primary theory of the multinational firm holds that such firms often establish wholly-owned subsidiaries in foreign markets because they find it difficult to profit from deploying their proprietary technologies in those locations simply via licensing with unrelated parties (Markusen, 1995).

24. **Market power.** Another serious issue confronting ITT is that owners of new technologies typically have substantial market power that usually results from patents and other IPRs. Such market power necessarily implies that technology will not be transferred at marginal cost – i.e. its price will be higher than the socially optimal price (given that the technology exists). Of course, this divergence between price and cost is what allows innovators to profit from their innovation.
25. **Positive externalities:** The third important problem afflicting ITT is the presence of externalities. Simply put, externalities are said to characterize an economic activity if the costs and benefits of the activity are not fully internalized by those involved in it. For example, if the subsidiary of a multinational firm receives a new technology from which unrelated local agents (say in some other industries) derive some benefit, the parent firm's decision regarding the extent of technology transfer will be inefficient since it will typically fail to account for the positive externalities enjoyed by those local agents.<sup>4</sup>
26. **The cumulative nature of knowledge:** Does the option to engage in ITT imply that developing countries can (or should) rely solely on the fruits of foreign research and development (R&D) and not make any such investments themselves? Alternatively, given that technology can be imported, should a developing country invest its scarce resources in domestic R&D? Following classical trade theory, shouldn't developing countries simply purchase technology from other countries that have comparative advantage in R&D?
27. There are at least two counter-responses to this viewpoint. First, the prescription of efficient specialization based on comparative advantage applies only under a stringent set of assumptions, many of which are not supported by empirical evidence. As was noted above, new technologies are rarely produced under conditions of perfect competition and the market for technology is plagued by transactions costs that stem (partly) from the presence of asymmetric information between buyers and sellers (more on this below). Involvement in R&D by potential buyers of new technologies can facilitate exchange of technology by lowering transactions costs.
28. A second reason for conducting domestic R&D is that technological change is a *dynamic phenomenon* and technology acquisition is not a one-time decision but rather an on-going process. Thus, a dichotomous 'make-or-buy' choice does not adequately capture the complexity of the process of ITT. The decision to not invest in local R&D may not only increase the transactions costs of ITT but also force a country to bear such costs for a long time. The *cumulative nature of knowledge* (and technological change) creates a cross-temporal link between current and future investments in R&D and technology acquisition.

### 3.2. Trade, Economic Growth, and Technology Transfer

29. Traditional economic theory teaches us that international trade yields efficiency gains by improving the global allocation of resources. The more interesting question is whether trade also yields dynamic efficiency gains by improving productivity growth in the world. To answer this question, it is natural to ask how trade affects technological change and global diffusion of new technologies.

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<sup>4</sup> Market failures create the *potential* for governments to play an important role in the process of ITT. However, as we discuss in greater detail below, government policy can be effective only if takes into account the incentives of private agents involved in ITT. Furthermore, the potential for welfare-improving government policy does not always transfer into the effective implementation of such policies. The domestic regulatory and political environment of a country needs to prevent policies from becoming hostage to rent-seeking and lobbying activities. Otherwise, well-intentioned policies can do more harm than good.

30. Standard neoclassical growth models assume costless ITT by positing a common production function across countries. The fact that chosen production techniques vary across countries is not evidence against the neoclassical view: such dispersion in production techniques will naturally result from differences in factor prices (that in turn may be caused by differences in factor endowments across countries).
31. As Parente and Prescott (1994) note, the issue is whether firms in different countries can access the global pool of technologies at the same cost. They emphasize that barriers to technology adoption can be a key determinant of international differences in per capita income. According to this view, some countries make it inherently costlier for their firms to adopt modern technologies, thereby retarding economic development. Following this logic, increased openness may lead to more growth by lowering the barriers to technology adoption.
32. In contrast to neoclassical models that stress capital accumulation, R&D-based models of economic growth assigns a central role to technological change and the accumulation of human capital (Lucas 1988).<sup>5</sup> A brief discussion of the main economic channels underlying the two most commonly used R&D-based growth models – i.e. the *variety-expansion model* and the *quality-ladders model* -- is useful for shedding light on the complex relationships between trade and ITT.
33. In the variety-expansion model, the creation of new products expands the knowledge stock and thereby lowers the cost of future innovation. As more products are invented, both the costs of inventing new products and the profits of subsequent innovators fall because of increased competition created by new products. By contrast, the quality-ladders model posits that consumers are willing to pay a premium for higher quality products. As a result, firms always have an incentive to improve the quality of products. Quality improvements and economic growth result from intentional investments undertaken by profit-seeking entrepreneurs.
34. The important assumption that sustains growth in the quality-ladders model is that every successful innovation allows firms to study the attributes of newly invented products and then improve upon them. Patent rights ensure that production rights reside with innovators, but do not prevent others from using the knowledge embodied in the patented product and from the knowledge disclosure required by the patent granting process. Thus, the creation of a new product adds to the existing knowledge stock of the economy that can be accessed by anyone; such *knowledge spillovers* ensure that anyone can try to invent a higher quality version of the same product.
35. R&D-based growth models contain an important insight: since *new products embody new ideas*, trade in goods can help transmit embodied knowledge internationally. Of course, trade in ideas can also take place *without* trade in goods. Rivera-Batiz and Romer (1991) analyze two different models (the lab equipment model and the knowledge-driven model) of endogenous growth in order to highlight the role of trade in goods versus trade in ideas. An important conclusion of their analysis is that trade in either goods or ideas can increase the global rate of growth if such trade allows a greater exploitation of increasing returns to scale (in the production of goods or ideas) by expanding market size.
36. Multi-country models of endogenous growth have two strands: those that study trade between identical countries and those that have a North-South structure. Although knowledge

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<sup>5</sup> Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1990), and Segerstrom, Anant, and Dinopoulos (1990) are among the pioneers of R&D-based models of economic growth. These models formalize the Schumpeterian notion of “creative destruction” and are built around the idea that entrepreneurs conduct R&D to profit from monopoly power that results from innovation. Grossman and Helpman (1991) provide a unifying framework for two widely used strands of R&D-based endogenous growth models: the varieties model that builds on foundations laid by Dixit and Stiglitz (1977), Ethier (1982), and Romer (1990), and the quality-ladders model developed by Aghion and Howitt (1990), Segerstrom, Anant, and Dinopoulos (1990), and Grossman and Helpman (1991).

spillovers are central to both, technology transfer plays a more important role in North-South models. These models, which emphasize the product-cycle nature of trade, have been particularly useful for understanding ITT and merit some further discussion.

37. In a typical North-South product-cycle model, new products are invented in the North but, due to the lower relative Southern wage, Southern firms can undercut Northern producers by successfully imitating Northern products, provided that they are not prevented from doing so by the local enforcement of intellectual property rights (IPRs). A typical good is initially produced in the North until either further innovation (in the quality-ladders model) or successful Southern imitation (in both the varieties model and the quality-ladders model) makes profitable production in the North infeasible. Consequently, either production ceases (due to innovation) or shifts to the South (due to imitation). Thus, prior to imitation, all products are exported by the North, whereas post imitation they are imported, thereby completing the cycle.

38. What do R&D-based models of growth imply about the effect of trade on productivity and technology transfer? An important conclusion of this line of research is that much hinges on whether knowledge spillovers are national or international in nature (Grossman and Helpman 1995). If knowledge spillovers are international, these models endorse the view that trade is an engine of growth. However, when knowledge spillovers are national in scope, perverse possibilities can arise in such models.

### 3.3. Empirical Evidence on Technology Adoption and Spillovers

39. A comprehensive and long-term perspective on the process of international technology diffusion is provided by Comin and Hobijn (2010) who study the diffusion of 15 specific technologies over the last two centuries (1820-2003). The technologies examined by them range from transportation technologies such as steam and motor ships to information technologies such as personal computers.<sup>6</sup>

40. Their analysis uncovers several important facts. First, the adoption lags are indeed significant: in their sample, the average adoption lag is 45 years. Furthermore such lags vary across both technologies and countries, with the variation across technologies being relatively more important. They also find that more recent technologies have been adopted relatively faster. Somewhat surprisingly, the acceleration in technology adoption predates the digital revolution as well as the rapid expansion of globalization observed during the postwar period.

41. At the aggregate level, Comin and Hobijn (2010) estimate that cross-country differences in the timing of adoption of new technologies can account for about 25% of the disparities in per-capita income across countries. Comin and Hobijn (2010) distinguish between *extensive* and *intensive* technology adoption. The former measure captures whether a technology has been adopted by a country or not while the latter captures the intensity of adoption (or the penetration rate) within the economy – something that speaks to the degree of diffusion.<sup>7</sup>

42. In a recent paper Comin and Ferrer (2013) underscore the importance of the intensive margin for explaining the cross-country variation in per capita income. This channel of technology adoption has been traditionally ignored in past analyses of international technology diffusion (primarily due to data limitations). Using the CHAT data-set, they estimate that the difference in penetration rates between rich and poor countries has widened during the past two hundred years. As a result, even though adoption rates (as captured by the extensive margin)

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<sup>6</sup> An overview of the cross-country historical adoption of technology (CHAT) data-set on which their work is based is provided by Comin, Hobijn, and Rovito (2008).

<sup>7</sup> The findings of Comin and Hobijn (2010) also shed light on the remarkable growth records of Japan during the first half of the 20<sup>th</sup> century and that of the four “East Asian Tigers” -- Hong Kong, Singapore, South Korea, and Taiwan (Province of China) -- during the second half: they find that these periods of rapid growth in these Asian countries coincided with a catch-up in the range of technologies used by them relative to the industrialized countries.

have increased over time, per-capita income has not really converged across countries due to the divergences in the intensive margin of technology adoption.

43. What factors underlie the observed differences in technology adoption decisions across countries? As Comin and Mestieri (2013) note, existing evidence suggests that variation in human capital (as measured by schooling rates at various levels), one's own experience with prior technology adoption as well as that of neighboring countries, local political institutions, openness to trade and investment, as well as the level of local demand all play an important role in generating cross-country variation in technology adoption rates.

44. Earlier studies, especially those using macro data, reached similar conclusions. Several such studies found results suggesting that the benefits of R&D in one country spill over substantially to other countries (Eaton and Kortum, 1996; Coe and Helpman, 1995; Coe, et al, 1997; Bayoumi, et al, 1999).

### 3.4. Trade in Capital Goods

45. In principle, trade in both consumption and capital goods (i.e. goods such as machinery and equipment used to produce other goods) can contribute to technology transfer and empirical studies typically utilize a country's imports of all goods while attempting to measure knowledge spillovers through trade. For example, when a country imports a manufactured consumption good (such as an automobile) local firms can absorb some technological know-how by simply studying the design and the engine of the imported automobile. While such attempts at reverse engineering are no doubt important, they probably contribute less to technology transfer than trade in capital goods that are used in the production of other goods.

46. Today, the world production of capital goods is fairly concentrated: over 80% of the global production of such products resides in just eight countries. Indeed, most developing countries are heavy importers of capital goods and some 85% of the imports of machinery and transport equipment into developing countries come from developed countries (Mazumdar 2001). Xu and Wang (1999) show that although the volume of capital goods trade helps explain cross-country differences in total factor productivity, trade in all other goods does not. This result fits well with the empirical finding that investment in machinery and equipment has a strong association with growth -- see De Long and Summers (1991).<sup>8</sup>

### 3.5. The Saliency of Foreign Direct Investment and Multinational Firms

47. Today, intra-firm trade, that is trade between subsidiaries and headquarters of multinational firms, may account for one-third of total world trade. It is well known that sales of subsidiaries of multinational firms exceed worldwide exports of goods and services so that FDI is now the dominant channel through which firms serve customers in foreign markets. More importantly, the global stock of FDI has grown dramatically during the last decade or so: it increased from roughly \$2 trillion in 1990 to over \$22 trillion in 2012. Over the same time period, sales of local affiliates of multinational firms increased from \$5 trillion to \$25 trillion. On the technology side, over the same time period, the royalties and licensing fee receipts of multinational firms increased from \$27 billion to \$235 billion.

48. While most FDI flows occur primarily between industrial countries (much like most intra-industry trade), developing countries are becoming increasingly important host countries for

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<sup>8</sup> Mazumdar (2001) takes the argument one step further. He notes that due to the presence of trade barriers, investment in imported equipment might generate more growth than investment in local equipment since the true opportunity cost of imported equipment is lower than that of domestically produced equipment, which is produced under trade protection. His empirical analysis supports this argument and also shows that imported equipment matters more for developing countries than developed ones, perhaps because their economies are more open in general.

FDI, especially because of the large-scale liberalization undertaken by large countries such as China and India. From 1990-2012, the share of global stock of FDI residing in developing countries increased from 25% to just over 33% (UNCTAD 2013).

49. It is indisputable that multinational firms play a crucial role in ITT. The R&D spending of some of the largest multinational firms in the world exceeds that of many developing countries, even large ones. For example, in 2009 the R&D expenditures of Toyota exceeded that of India, a country of roughly 1.2 billion people (UNCTAD, 2010). Similarly, over twenty multinational firms invest more in R&D than Turkey. It can be difficult to wrap one's mind around such numbers but they are a sharp reminder of the uneven nature of the technology terrain of today's world.

50. When measured by the receipts and payments of royalties and licensing fees, much of the global action in technology transfer is within developed countries and occurs within the boundaries of multinational firms: estimates vary but in a typical year over 80 percent of global royalty payments for international transfers of technology are made between subsidiaries and their parent firms. Of course, royalty payments only record the explicit sale of technology and do not capture the full magnitude of technology transfer through FDI relative to technology transfer via imitation, trade in goods, and other channels.

51. ITT to developing countries via multinationals has increased in magnitude during the last decade or so: from 1990 to 2009 the share of developing countries in global technology payments doubled to 26% (UNCTAD 2010). Multinationals have also been shifting more of their R&D activities to the developing world. For example, Japanese multinationals allocated 38% of their R&D activities abroad to developing countries, a significant increase from 6% in 1993.

52. Developing countries hope not only to import more efficient foreign technologies via FDI, but also to improve the productivity of local firms via technological spillovers to them.<sup>9</sup> The central measurement problem is that spillovers do not leave a paper trail; by definition, they are externalities that the market fails to take into account. Nevertheless, several studies have attempted the difficult task of quantifying spillovers.

53. What are the potential channels through which such spillovers from FDI might arise? At the micro level, the literature suggests the following potential channels of spillovers:

- *Demonstration effects*: Local firms may adopt technologies introduced by multinational firms through imitation or reverse engineering.
- *Labor turnover*: Workers trained or previously employed by the multinational may transfer important information to local firms by switching employers, or may contribute to technology diffusion by starting their own firms.
- *Vertical linkages*: Multinationals may transfer technology to firms that are potential suppliers of intermediate goods or buyers of their own products.

54. ***Demonstration effects***: In its simplest form, the demonstration effect argument states that exposure to the superior technology of multinational firms may lead local firms to update their own production methods. The argument derives from the assumption that it may simply be too costly for local firms to acquire the necessary information for adopting new technologies if they are not first introduced in the local economy by multinationals (and hence demonstrated to succeed in the local environment). Clearly, geographical proximity is a vital part of the

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<sup>9</sup> Not surprisingly, a large literature tries to determine whether host countries enjoy spillovers from FDI. It is important to be clear about the meaning of the word spillover. A distinction can be made between pecuniary externalities (that result from the effects of FDI on market structure) and other pure externalities (such as the facilitation of technology adoption) that may accompany FDI. A strict definition of spillovers would count only the latter, and this is the definition employed here.

demonstration effect argument. Geographical proximity may indeed be crucial for DCs that are not as well integrated into the world economy and that have fewer alternative channels for absorbing technologies.

55. **Labor turnover.** Labor turnover differs from the other channels of technology transfer because knowledge embodied in the labor force moves across firms only through the physical movement of workers. The relative importance of labor turnover is difficult to establish because it requires tracking individuals who have worked for multinationals regarding their future job choices and then determining their impact on the productivity of new employers.

56. The available evidence on labor turnover itself is mixed. For example, although Gershenberg's (1987) study of Kenyan industries finds limited evidence of labor turnover from multinationals to local Kenyan firms, several other studies document substantial labor turnover of this kind. UNCTAD (1992) discusses the case of the garment industry in Bangladesh (see also Rhee 1990). Korea's Daewoo supplied Desh (the first Bangladeshi firm to manufacture and export garments) with technology and credit. Thus, Desh was not a multinational firm in the strict sense; rather, it was a domestic firm that benefited substantially from its connection with Daewoo. Eventually, 115 of the 130 initial workers left Desh to set up their own firms or to join other newly established garment companies. The remarkable speed with which the former Desh workers transmitted their know-how to other factories clearly demonstrates the role labor turnover can play in technology diffusion.

57. Pack (1997) discusses evidence documenting the role of labor turnover in disseminating the technologies of multinationals to local firms. For example, in the mid-1980s, almost 50 percent of all engineers and approximately 63 percent of all skilled workers that left employment at multinationals located in Taiwan (Province of China) left to join local Taiwanese firms. By contrast, Gershenberg's study of Kenyan industry reports smaller figures; of the 91 job shifts studied, only 16 percent involved turnover from multinationals to local firms.

58. In a recent study of Brazilian industry, Poole (2009) provides convincing evidence of the spillovers that labor turnover from multinationals to local firms can generate. She finds that workers in domestic establishments hiring a larger share of former multinational workers earn higher wages, an indication of their higher productivity. Her work also shows that higher-skilled former multinational workers are more effective at transmitting information to local firms, just as higher-skilled incumbent domestic workers are better able to absorb it.

59. In order to synthesize these empirical findings the cross-country variation in labor turnover rates itself requires an explanation. One possible generalization is that in locations such as Brazil, South Korea, and Taiwan (Province of China) local competitors are less disadvantaged relative to their counterparts in many African economies, thereby making labor turnover possible. Thus, the ability of local firms to absorb technologies introduced by multinationals may be a key determinant of whether labor turnover occurs as a means of technology diffusion in equilibrium (See Glass and Saggi, 2002 for a formal model).

60. Furthermore, the local investment climate may be such that workers looking to leave multinationals in search of new opportunities (or other local entrepreneurs) find it unprofitable to start their own companies, implying that the only alternative opportunity is to join existing local firms. The presence of weak local competitors probably goes hand in hand with the lack of entrepreneurial efforts because both may result from the underlying structure of the economic environment.

61. **Vertical technology transfer.** For quite some time, analysts have recognized that multinationals may benefit the host economy through the backward and forward linkages that they generate. However, merely documenting extensive linkages between multinationals and local suppliers or buyers is insufficient for arguing that net benefits accrue to the local economy as a result of FDI.



62. Vertical technology transfer has been documented to occur when firms from industrialized countries chose to buy the output of firms in many Asian economies in order to sell it under their own name (Hobday 1995; Rhee, Ross-Larson, and Pursell, 1984). More recent evidence regarding vertical technology transfer is provided by Mexico's experience with the maquiladora sector and its automobile industry. Mexico started the maquiladora sector as part of its Border Industrialization Program, designed to attract foreign manufacturing facilities along the US-Mexico border. Most maquiladoras began as subsidiaries of US firms that shifted labor-intensive assembly operations to Mexico because of its low wages relative to the US. However, the industry evolved over time and the maquiladoras now employ sophisticated production techniques, many of which have been imported from the US.

63. In the automobile industry, one of Mexico's most dynamic, FDI resulted in extensive backward linkages: within five years of initial investments by US firms, there were hundreds of domestic producers of parts and accessories. US firms and other multinational firms transferred technology to these Mexican suppliers: industry best practices, zero defect procedures, production audits, and the like were introduced to domestic suppliers, thereby improving their productivity. As a result of increased competition and efficiency, Mexican exports in the automobile industry boomed. Thus, although direct competitors of multinational firms may not realize technological benefits (as evidenced by Aitken, Harrison, and Lipsey 1996), suppliers of intermediate goods are likely to benefit substantially.

64. In a broader study, Batra and Ton (2002) use data from Malaysia's manufacturing sector to study effect of multinationals on inter-firm linkages and productivity growth during 1985-1995. Their results show that not only are foreign firms more involved in inter-firm linkages than domestic firms but also that such linkages are associated with technology transfer to local suppliers. Such technology transfers were found to have occurred through worker training and the transmission of knowledge that helped local suppliers improve the quality and timeliness of supply.<sup>10</sup>

### 3.6. Horizontal Technology Spillovers from FDI

65. Early efforts in search of horizontal spillovers from FDI proceeded by relating the intra-industry variation in productivity to the extent of FDI (Caves 1974; Globerman 1979; Blomström and Persson 1983; Blomström 1986). By and large, these studies find that sectors with a higher level of foreign involvement (as measured by the share of the labor force in the industry employed by foreign firms or the extent of foreign ownership) tend to have higher productivity, higher productivity growth, or both. The fact that these studies involve data from different countries (Australia for the Caves study, Canada for Globerman, and Mexico for Blomström) lends a strong degree of robustness to this positive correlation between the level of foreign involvement and local productivity at the sector level.

66. Of course, correlation is not causation and, as noted by Aitken and Harrison (1999) this literature may overstate the positive impact of FDI on local productivity. Investment may have been attracted to the more productive sectors of the economy instead of being the cause of the high productivity in such sectors. In other words, the studies ignore an important self-selection problem. What do empirical plant-level studies find with respect to spillovers from FDI? Haddad and Harrison's (1993) study was the first to employ a comprehensive data set at the level of the individual firm over several years. The data came from an annual survey of all manufacturing firms in Morocco. An important result of this study was that foreign firms exhibited higher levels of total factor productivity (TFP), but their rate of TFP growth was lower than that for domestic firms. In addition, when sectors were divided into high and low tech, the effect of FDI at the sector level was found to be more positive in low-tech sectors. The authors

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<sup>10</sup> See also the evidence in Blalock and Gertler (2008) regarding similar effects of FDI in Indonesia and Smarzynska (2004) for FDI in Lithuania.

interpret this result as indicative of the lack of absorptive capacity on the part of local firms in the high-tech sector, where they may be further behind multinationals and unable to absorb foreign technology.

67. Aitken et. al. (1996) argue that technology spillovers should increase the marginal product of labor and this increased productivity should show up as higher wages. They investigate this idea by employing data from manufacturing firms in Venezuela, Mexico, and the United States. They find that for both Mexico and Venezuela, a higher share of foreign employment is associated with higher overall wages for both skilled and unskilled workers. Furthermore, royalty payments to foreign firms from local firms are highly correlated with wages.

68. Most importantly, the study finds no positive impact of FDI on the wages of workers employed by domestic firms. In fact, the authors report a small negative effect for domestic firms, whereas the overall effect for the entire industry is positive. These findings differ from those for the United States, where a larger share of foreign firms in employment is associated with both a higher average wage as well as higher wages in domestic establishments. Putting the findings of Aitken et. al. (1996) into the context of previous work, it is clear that wage spillovers (from foreign to domestic firms) are associated with higher productivity in domestic plants. Conversely, the absence of wage spillovers appears to accompany the existence of productivity differentials between domestic and foreign firms.

69. Using annual census data on more than 4,000 Venezuelan firms, Aitken and Harrison (1999) provide another test of the spillover hypothesis. Since each plant was observed over a period of time, the self-selection problem of past sector-level studies (that is, FDI goes to the more productive sectors) could be avoided in their study. The authors find a positive relationship between foreign equity participation and plant performance, implying that foreign participation does indeed benefit plants that receive it.

70. However, this own-plant effect is robust for only small plants, that is, those plants that employ fewer than 50 employees. For larger plants, foreign participation results in no significant improvement in productivity relative to domestic plants. More interestingly, they find that productivity in domestic plants declines with an increase in foreign investment.<sup>11</sup> In other words, the authors find evidence of negative spillovers from FDI and suggest that these could result from a market-stealing effect. That is, foreign competition may have forced domestic firms to lower output and thereby forgo economies of scale. Nevertheless, on balance, Aitken and Harrison (1999) find that the effect of FDI on the productivity of the entire industry is weakly positive.

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

72. To recapitulate, several studies have cast doubt on the view that FDI generates positive spillovers for local firms. But such findings need not imply that host countries have nothing significant to gain (or must lose) from FDI. Domestic firms should be expected to suffer from an increase in competition; in fact, part of the benefit of inward FDI is that it can help weed out relatively inefficient domestic firms. Resources released in this process will be put to better use by foreign firms with superior technologies, efficient new entrants (both domestic and foreign),

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<sup>11</sup> See also Djankov and Hoekman (2000).

or some other sectors of the economy. However, such reallocation of resources cannot take place instantaneously. Existing studies of spillovers may not cover a long enough period to be able to accurately determine how FDI affects turnover rates (entry and exit).

73. Furthermore, spillovers may be of an entirely different nature: local firms may enjoy positive externalities from foreign firms that make it easier for them to export. Such externalities may come about because better infrastructure (transportation, storage facilities, and ports) emerges in regions with a high concentration of foreign exporters.<sup>12</sup>

### 3.7. Newer Elements of ITT

74. The foregoing analysis refers to theoretical perspectives on the traditional forms of technology transfer: trade in high-technology and capital goods, FDI, and licensing/joint ventures. These flows are now complemented by a major change in world production structure, the growth of global production chains within (and across) multinational firms. The vertical fragmentation of production into stages involving various forms of design, assembly, production, and marketing, has opened an additional complex channel of information flows across borders.

75. Parallel to this trend, yet somewhat broader, is another element that has significant implications for ITT, i.e., the emergence of global innovation networks (GINs) within the globalization of R&D (Maskus and Saggi, 2013). The term refers narrowly to the establishment within a global firm of one or more R&D facilities at different locations and the associated management decisions and exchange of information among them and the parent company.

76. More broadly, GINs incorporate many actors, including multinational firms (which may cooperate in some R&D programs), startup companies, universities and public research laboratories, and even foundations, NGOs, and government agencies. Within these networks there are potential gains from specialization (e.g., basic research versus commercialization) and collaboration (e.g., in licensing, pooling information and intellectual property, and cross-border research alliances). These broader networks have multiple goals, ranging from basic revenue generation through efficient knowledge creation and use to the solution of global problems requiring complex research programs (Maskus, 2012). Both private firms and government authorities increasingly see participation in GINs as important boosts for competitiveness, growth, and technology transfer.

77. In recent years there has been substantial growth in investments of international firms in research facilities in different countries (OECD, 2008). Most occur among the developed economies but China and India recently have entered top ten recipients of such facilities within enterprises and among research collaborations. These research affiliates and contract R&D facilities have several purposes: modifying products for local markets, situating R&D close to growing markets, using lower-cost research personnel, and establishing centers of original innovation.

78. Equally important, there are increasing numbers of cross-border basic research collaborations among universities, government laboratories, and foundations, while private companies participate in the development of final products (NSF, 2010). This reflects growing capabilities in science and technology (S&T) around the world, emerging in concert with the policy perception that international competitiveness depends on innovation and access to

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<sup>12</sup> Aitken, et al (1997) provide direct evidence on this issue. They conducted a detailed study of 2,104 manufacturing plants in Mexico. In their sample, 28% of the firms had foreign ownership and 46% of the foreign plants exported. Their major finding is that the probability of a Mexican-owned plant exporting is positively correlated with its proximity to foreign-owned exporting plants. Such spillovers may result from informational externalities and are more likely to lower fixed costs rather than marginal costs of production.

knowledge. Thus, governments increasingly emphasize S&T as part of long-term national strategies and invest additional funds in S&T infrastructure, including education, facilities, and fiscal incentives for R&D. One important outcome has been more cooperation among multinational teams, involving both public and private partners, focusing on specific research questions. That such collaborations are growing may be seen in the rapidly increasing numbers of joint patent applications and scientific publications (OECD, 2008). Further, recent research with these data highlights the importance of personal and professional interactions in expanding research productivity within affiliated networks and creating associated knowledge spillovers (Montobbio and Sterzi, 2011).

79. Global innovation networks offer considerable scope for enhancing ITT and increasing access of developing countries to both basic knowledge and applied outcomes. Although empirical studies are not yet available, GINs seem likely to facilitate collaborative research and information sharing among small and medium-sized enterprises (SMEs). Thus, they could act as a potentially powerful and leveraged international tool for innovation. Unfortunately, however, there is very little systematic data available on the emergence of inter-enterprise and cross-border research collaborations (public or private). Nor is there much information on research arrangements among universities, private firms, and foundations. In this regard, it would be useful for international organizations and scientific agencies to invest in better statistical flows about the nature and activities of innovation networks.

80. A final important element is the emerging focus of private enterprises on open innovation, or the policy of firms to collaborate in research and make at least a portion of the results of their R&D work available (whether free or at some upfront access charge) to others, even as they otherwise may acquire and exploit private IPRs on the balance of their intellectual assets. There are good reasons for this strategy. First, collaboration can significantly cut costs and avoid duplication of research efforts.<sup>13</sup> Second, offering open access can encourage a collaborative pooling of knowledge in which multiple firms participate. This offers real gains since at some points in time a firm may contribute knowledge while at others it may be seeking technical solutions. Third, to the extent open access encourages users to adopt a firm's technology the latter can benefit from selling complementary products and services. This approach is common, for example, in the area of open software development.

81. Thus, both GINs and open innovation offer exciting prospects for new forms of technology transfer through active collaboration, even if the extent of such prospects is currently unknown. The question remains how scientists and firms in DCs may be better linked into such networks. Much of our thinking is presented in the policy analysis in Section 4. To presage that, however, we believe that part of the answer lies in the standard policies of investing in technology infrastructure, improving education, facilitating research, and enhancing public and private governance institutions. However, we also argue that a critical path to increasing such linkages is to significantly reduce barriers to the international migration, even if temporary, of scientific, technical, and entrepreneurial personnel.

### 3.8. The Role of Intellectual Property Rights

82. It is clear that the scope and enforcement of IPRs play strong, albeit somewhat cross-cutting, roles in ITT. This has been a central consideration in international trade research since the ratification of TRIPS in 1995. Rather than reviewing a large literature, we list the key insights from various studies of policy reforms since TRIPS.<sup>14</sup>

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<sup>13</sup> An extreme version is the emergence of crowd-based innovation, in which individual computer users may make available capacity for working on complex numerical problems in such areas as biotechnology or astrophysics. This endeavor can involve both public research institutes and private enterprises.

<sup>14</sup> See Park (2008) and Maskus (2012) for recent reviews.

### *General insights*

83. There is strong evidence that strengthened patent rights causally attract significantly more imports of high-technology goods and capital inputs from the technologically advanced OECD countries to major emerging economies (Ivus, 2010). The increase amounted to over \$35 billion in annual trade (in 2000 US dollars) after 1994 in the 18 countries undertaking the largest policy changes. Additional analysis found that these increases came largely in quantity increases rather than monopolistic price increases. Similarly, in a current working paper, Maskus and Yang (2013) find that patent reforms, including a measure of enforcement, in major reforming economies after TRIPS account for as much as 20-percent rises in sectoral manufacturing exports from those countries to the United States. The logic here is that IPR reforms would attract more technology transfer and ultimately expand export capacities.

84. This finding is consistent with the firm-level evidence in Branstetter, et al (2011), which analyzed the post-reform technological activities of local affiliates of U.S. multinational companies in a selection of large emerging economies. They found significantly positive increases in local affiliate sales, plant and equipment, and employee compensation, especially for technologically advanced MNEs. The authors also discovered that affiliates' local value added rose significantly, especially in technology-intensive sectors. In addition, using detailed U.S. import data there was strong evidence that firms in these countries expanded the range of their exports.

85. Regarding the effects of IPRs on the type of technology transfer, the findings are generally quite consistent across the literature (Smith, 2001; Nicholson, 2007; Park and Lippoldt, 2005). Stronger patent regimes tend to shift aggregate and firm-level activity away from exports toward FDI and licensing. This effect generally occurs only above some level of per-capita incomes, suggesting that firms are willing to supply countries with limited imitative capacities via trade. As incomes rise even higher and host countries become more technologically sophisticated, increases in patent strength cause FDI to give way to licensing and JVs, since the risk of imitation and opportunism falls. Licensing avoids much of the fixed costs of FDI, so IPR reforms shift firms' strategies toward external partners.

86. As this last comment would suggest, the effects of IPR reforms on ITT would be expected to vary, depending on the sector of activity and sophistication of the technology. Ivus et. al. (2013) argue that to better understand the overall effect of TRIPS on multinational activity and technology transfer one needs to account for the fact that there is variation in imitation risk across industries. For example, patent protection is relatively more important for the pharmaceutical industry because the cost of imitating a typical medicinal drug is small relative to the cost of inventing one. As is well known, the relative ease of imitation and the lack of protection of foreign product patents allowed India to successfully establish a local generic pharmaceutical industry prior to the ratification of TRIPS. On the other hand, most developing countries have found it difficult to establish industries by imitating complex manufactured goods such as automobiles and airplanes

87. Thus, a more nuanced understanding of the consequences of changes in IPR protection in developing countries necessitated by TRIPS can be obtained by accounting for the fact that imitation risk (or the value of patent protection) varies across industries. Yet, existing theoretical analyses of IPR protection in an international setting have generally tended to ignore the variation in imitation risk across industries -- see, for example, the classic works of Grossman and Helpman (1991) and Helpman (1993) and the more recent contribution of Branstetter and Saggi (2011). However, several economic analysis that allow for the effects of IPR protection to be industry dependent have recently become available.

88. In a North-South model where the risk of imitation varies across industries, Ivus et. al. (2013) study how the extent and industrial composition of multinational activity is affected by changes in Southern IPR protection. They show that licensing occurs in industries where the

risk of imitation is low and FDI where it is of intermediate magnitude. Furthermore, in their model, stronger IPRs in the South alter the industrial composition of multinational activity towards licensing at the expense of FDI.

89. In an insightful contribution, Bilir (2013) develops and empirically tests a model in which the FDI decisions of firms depend upon the respective life cycles of the products sold by them. She argues and empirically confirms the idea that firms selling products with shorter life cycles are less sensitive to imitation risk created by FDI because imitation is less likely to occur before obsolescence.

90. To summarize, there is a reasonable consensus among international economists that reforms in IPRs, measured almost entirely by patent rights, can significantly expand trade, FDI and licensing. However, this finding must be balanced by an important caveat: the evidence exists almost entirely in samples of large and middle-income developing countries. To date econometric studies have not found impacts, whether positive or negative, on such variables in the poorest and smallest countries. In part, this may be due to difficulties in measuring the relevant factors in such countries. Most likely, however, it suggests that intellectual property rights play a modest role at best in the poorest nations. Their ability to attract international technologies is determined by other factors, such as proximity to markets, costs of doing business, and policy coherence (Hoekman, et al, 2004).

#### *A specific perspective on know-how*

91. As the discussion in this section suggests, economic analysis of international technology transfer largely adopts the view that IPRs constitute a single instrument with uniform effects. That is, IPRs may be thought of as patent rights, which have straightforward impacts: they expand incentives for ITT (most readily by permitting multinationals to safeguard technologies within firm boundaries and by reducing the costs of achieving and enforcing contracts), raise the costs of imitation or reverse engineering for local competitors, or both.

92. While this perspective is useful for generating important insights, it misses important elements of the granularity of IPRs and ITT. On the one hand, the IPRs relevant for technology trade include not just patents but also trademarks and trade secrets, though the latter is more properly considered an element of unfair competition regulation.<sup>15</sup> On the other, “technology transfer” involves multiple layers of transactions that may be differently affected by IPRs. The most basic would be simply to sell production rights, with or without a trademark, excluding blueprints, formulas or know-how. The most advanced would be a full transfer of know-how to a local affiliate or licensing partner, including franchise or trademark use rights, or installation of an R&D facility. Between these extremes ITT transactions could range from simple installations of turnkey plants and production processes to extensive technical training and two-way sharing of technologies. In this context, the basic economic conception of ITT as a standard transaction is flawed.

93. This issue matters most in thinking about the determinants of know-how transfers, which are important for recipient firms and countries seeking to achieve the fullest extent of technology access. Put differently, patents typically cover only embryonic and (perhaps minimally) codified R&D results and licensing patent-use rights may not be adequate to support commercialization without also offering the associated proprietary know-how, especially in developing countries. While they are not the same thing, know-how, or tacit information, is typically protected by trade secrets. Thus, the question is how an IPR regime can facilitate development of hybrid licensing agreements including both patents and trade secrets embodying know-how.

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<sup>15</sup> Of course, other elements could matter, including copyrights on software and technology manuals, plant variety rights, and design protection.

94. The essential challenge in licensing know-how is the double moral-hazard problem mentioned earlier: licensors may not fully reveal the tacit information without knowing local demand conditions and recipients may try to renege on a contract after learning the know-how. This uncertainty can deter licensing, particularly when there are high transactions costs in transferring know-how and limited enforcement capacities.<sup>16</sup> Technology owners either would choose not to license to countries where such problems are severe, diminish the quality of the technologies offered, or keep their information in-house through FDI. The primary insight from the economics literature is that stronger IPRs helps resolve these problems by changing tradeoffs and facilitating fuller licensing to external partners (Vishwasrao, 1994; Markusen, 2001).

95. This broad view can be usefully supplemented by insights from the literature on hybrid licensing, however. This literature generally finds that composite licensing involving both patents and know-how can increase the efficiency of technology markets. First, because know-how is tacit and hard to contract, simple licensing arrangements make it difficult for either participant to appropriate returns to innovation and transfer. However, where there is a strong complementarity between patents and know-how, meaning that the information in the former cannot readily be implemented without the latter, bundled licensing can garner those rents (Arora, 1995). This is because access to the know-how can be credibly linked to the enforceable patent license.

96. Second, licensors are more willing to sell know-how in arm's-length contracts where it can be bundled with other technology inputs, such as equipment and intermediate materials and technical services (Arora, et al, 2001). Generally it is easier to enforce contracts on these inputs, since their use is readily monitored and prices are more transparent than is the case with invisible and tacit knowledge. In this context, tied sales between inputs and know-how can encourage ITT and be pro-competitive, despite a general policy caution in this area. Indeed, evidence from Indian technology contracts supports the view that bundled contracts support know-how transfer (Arora, 1996). This logic and evidence suggest that authorities in developing economies should exercise caution in mandating or even subsidizing know-how transfers without recognizing potential linkages between formal IPRs (e.g., patents) and incentives to license tacit knowledge. Hybrid contracts can increase the efficiency of technology markets and expand effective transfers.

#### 4. POLICY PERSPECTIVES

97. When discussing policy it is important to begin with a statement of objectives. In the context of diffusing technological information to developing countries we can imagine three proximate objectives, which may support varying policies. First is to increase the access of agents in developing countries to international stocks and flows of technology. Second is to enhance means of actually transferring technologies, including know-how, and implementing them into local production and management processes. Third is to expand and cement the connections of key players in developing countries to the global system of innovation and information transfer. Taken together, these intermediate objectives support the ultimate goals of encouraging structural transformation, raising productivity and economic growth, and facilitating solutions to key socioeconomic problems.

98. Equally, it is important to identify whose policies are considered. Among the major groups to consider we would list first the government authorities of developed countries (who may be expected to offer incentives for more outward ITT), developing countries (recipients) and emerging technology leaders among middle-income economies (who could play both roles). A second group would be non-governmental actors, whether universities, private enterprises,

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<sup>16</sup> Recall that successfully transplanting know-how is a costly process involving significant investments on both sides (Teece, 1981; Mansfield and Romeo, 1988).

foundations or NGOs. Finally, we would list a composite group, the “global community” as governments and international organizations with common concerns in finding solutions to public problems. Obviously, these groupings are not mutually exclusive and their policies and actions may share elements in common, though they may also be in conflict.

99. Fully fleshing out each of these three objectives, and their manifestation in the preferences of multiple actors, into policy proposals would take at least three major studies and could support many conferences and scholarly volumes. Since the focus of the present paper is on drawing lessons from theory and empirical evidence to support concrete proposals, we limit the discussion here to primary principles. First, we offer policy lessons about facilitating ITT through markets in subsection 4.1. Subsection 4.2 then considers building blocks for enhancing knowledge transfers through less formal means, such as GINs. In subsection 4.3, we provide a critical discussion of China’s technology transfer policies with respect to FDI. All of this sets up our list of concrete policy suggestions in the concluding section of the paper.

#### 4.1. Enhancing ITT through Standard Channels

100. In light of the literature discussed earlier, it seems clear that developing countries should ensure that local firms have undistorted access to capital equipment and imported inputs that embody foreign knowledge. But they should not take too limited a view of this since the case for open markets extends to other products as well.

101. Many studies indicate that absorptive capacity in the host country is crucial for obtaining significant spillover benefits from trade or FDI. Without adequate human capital or investments in R&D, spillovers may simply be infeasible. This is among the most robust findings of the literature. The implication is that liberalization of trade and open FDI policies need to be complemented by appropriate policies with respect to education, R&D, and human capital accumulation, if developing countries are to take full advantage of these channels of ITT.

102. Of greatest relevance to the subject of ITT is the role that subsidies can play in facilitating learning, technology acquisition, and dynamic comparative advantage that cannot be appropriated by private agents and hence will not be paid for by any individual firm. Commentators such as Amsden (1989) and Wade (1990) argue that interventions, including implicit or explicit subsidies, lay behind the economic ‘miracles’ in Korea and Taiwan (Province of China). Their case is that by carefully targeted subsidies, these governments were able to stimulate key sectors, which both became efficient in their own right and provided positive spillovers to other sectors. In other words, the government was able to provide critical coordination of a sort not available through market-generated interactions.

103. It is important to differentiate between sector-specific subsidies and general policies facilitating learning and the development of enterprise. The case made by analysts such as Amsden (1989) and Wade (1990) for specific subsidies has been challenged by, for example, Porter et al. (2000), Lee (1996) and Kim (2000), who argue that specific interventions reduced growth and technical progress. In a comprehensive retrospective on the East Asian development experience, Noland and Pack (2003) argue that such interventions do not show up in high rates of TFP growth for manufacturing. In the case of places such as Korea and Taiwan (Province of China), TFP growth was not much higher than in the OECD (Bhagwati, 1999). In India, selective interventionist policies were associated with declining TFP growth rates during 1960-80 (Ahluwalia, 1985), while the opening of the economy led to an increase in TFP growth rates (Krishna and Mitra, 1998).

104. That said, the case for general, not industry-specific, subsidy policies—incentives for certain types of activity, e.g., innovation, education, transport infrastructure and similar public



goods—is uncontroversial.<sup>17</sup> Policies aimed to promote socially beneficial activities are also justified. Markets do fail and there may be good rationales for governments to provide incentives for firms and agents to undertake activities that would otherwise be undersupplied. An important example that has a direct bearing on the subject at hand is the learning externality analyzed by Hausmann and Rodrik (2003), where the market undersupplies investment by firms in new (nontraditional) activities because of appropriability problems—as soon as an entrepreneur is successful in identifying a profitable new opportunity of line of production, entry by imitators prevents recouping of costs. If so, a subsidy or similar incentive can help expand innovation and risk taking.

105. An efficient use of subsidy instruments requires that governments be effective at both identifying cases that justify subsidies and at implementing them appropriately. In practice, governments may fail at doing so, so that the policy problem is to assess the relative sizes of government and market failure. Among the potential problems are that subsidies can serve to support inefficiency; that firms may behave strategically (by under-investing, for example) in order to win subsidies; and that subsidies can result in corruption, bad corporate governance and rent-seeking behavior. The biggest challenge of implementing subsidies is that they are difficult to control and that the government needs to establish an effective (credible) exit strategy that weeds out successful efforts from unsuccessful ones.

106. Since the ratification of TRIPS in 1995 and the expiry of the lag periods granted to developing countries before they had to become TRIPS compliant, the enforcement of IPRs in the global economy is now backed by the potent dispute settlement procedure of the WTO. In some senses, developing countries no longer have a choice in the matter: they have to offer IPR protection at the level of industrialized countries or risk retaliation at the WTO. However, it is important to bear in mind that the interests of developing and developed countries are not necessarily opposed to each other. Even in the highly controversial domain of TRIPS, there is room for common ground.

107. A major reason for protecting IPRs is that they can support markets in technology, including ITT.<sup>18</sup> Without protection from leakage of new technical information, firms would be less willing to provide it on open technology markets. Patents and trade secrets provide a legal basis for revealing the proprietary characteristics of technologies to subsidiaries and licensees, supporting the formation of licensing contracts. In setting contract terms with firms in countries with weak IPRs, technology owners may choose not to transact at all, to offer older-generation technologies, to keep the information within the firm, or accept reduced fees from licensees to induce them not to defect with the information. These problems may be expected to reduce overall volumes of ITT.

108. The available evidence suggests that patent protection both increases flows of ITT to countries with technological capacity and shifts incentives for investors between FDI and licensing. As we noted earlier, patent applications serve as an important conduit for learning even among industrialized economies. Patent applications from foreign nations are strongly associated with productivity growth in recipient countries.<sup>19</sup> Every country other than the United States derives a majority of its productivity growth from imported technologies (patents). Furthermore, to some degree, patent citations reflect "knowledge flows" across borders. While there is a limited amount of diffusion overall, owing to distance, borders, and differences across regions in technological specialization, the most significant patents are widely diffused, as is knowledge in the highly technological sectors.

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<sup>17</sup> High of rates of investment in South-East Asian nations can to a large extent be explained by prior high levels of public investment in public goods such as infrastructure (Bhagwati, 1999).

<sup>18</sup> See Arora, Fosfuri, and Gambardella (2001) and Maskus (2004 and 2012).

<sup>19</sup> See Eaton and Kortum (1996).

109. International trade flows and FDI, especially in patent-sensitive industries, respond positively to increases in patent rights among middle-income and large developing countries. An important reason is that these countries represent a competitive imitation threat with weak IPRs and stronger patents expand the market for foreign exporters (Smith, 2001).

110. However, as one might expect, trade and FDI flows to poor countries are not particularly responsive to patent rights. Indeed, a common finding of the literature is that the poorest countries are unlikely to benefit from strong IPRs (e.g., McCalman, 2001). Stronger patent rights may be expected to raise considerably the rents earned by international firms as IPRs become more valuable, obliging developing countries to pay more for the average inward flow of protected technology. These are also countries where ITT-related spillovers are likely to be small at best, given limited absorptive capacity. The implications are that policy in such countries should aim at lowering costs of imports of IPR-intensive goods and technology, and raise capacity to absorb and adapt technologies.

#### 4.2. Mandating Technology Transfer via FDI: The Chinese Case

111. In countries that historically emphasized import-substituting industrialization, restrictive trade policies were often complemented by restrictions on inward FDI (in part to prevent tariff-jumping investment). Thus, Brazil, Japan, Korea, and Taiwan (Province of China) all imposed restrictions on FDI at various points in time. However, policies were often more lax toward other modes of ITT, including trade policies affecting machinery and equipment, and licensing of foreign technology.<sup>20</sup> More recently, national FDI policies have generally become more open, while some countries differentiate between joint ventures and fully owned subsidiaries of multinational firms. For example, in the service sector, restrictions on the degree of foreign ownership essentially imply that foreign investors are forced into forming alliances and joint ventures with local companies in order to be able to sell in the local market. Such policy restrictions are also used in the manufacturing sector.

112. Perhaps the most widespread and aggressive use of such policies has been undertaken by China. Holmes et. al. (2013) provide a detailed discussion of the current Chinese policy environment for FDI and then estimate a computational model of its impacts. A brief summary of their findings is as follows. Starting in 1994, China implemented a policy that imposed specific technology transfer requirements for foreign firms wishing to enter its local market. For example, under certain circumstances foreign firms were required to form a joint venture with a local partner. In other cases foreign entrants were expected establish local R&D facilities.

113. Holmes et. al. (2013) dub this to be a *quid pro quo* policy of exchanging local market access for technology transfer. While one might have expected that China's entry into the WTO would make it impossible for it to pursue such "technology mercantilism", the authors note that the "widely held view – in government reports and throughout the business community – is that China continues to impose technology transfer requirements" on foreign firms. Most interestingly, they note that such requirements do not provide local Chinese firms with property rights over the technology transferred in markets outside of China. Thus, the explicit bargain offered by policy is access to the local market in China in return for technology transfer to the local joint venture, with the understanding that foreign firms would not thereby create competition in their existing markets abroad. The authors' computations suggested that China has successfully captured more technology and productivity for its local firms, with a consequent rise in domestic welfare, albeit at the expense of lower profits for multinational firms.

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<sup>20</sup> Maskus and McDaniel (1999) offer econometric evidence that Japan's post-war patent system strongly encouraged inward technology licensing, which positively increased the productivity of local firms.

114. Assuming that the Chinese policy is beneficial for the local economy, as the calculations of Holmes et. al. (2013) indeed suggest, should and can other developing countries follow suit and impose similar technology transfer requirements as a precondition for market access? The Chinese quid pro quo policy with respect to FDI is a manifestation of long-held belief among policymakers that *involvement of local agents* with foreign technologies is essential for future technological progress and economic growth. Yet this is too simplistic a perspective. After all, even if foreign firms were to establish wholly owned subsidiaries local workers and managers would still be employed by them. Perhaps the degree of local involvement might vary somewhat between FDI and joint ventures but it is hard to believe that the difference could have

such major implications for local technological learning and growth. Indeed, existing evidence (collected over decades) shows that multinational firms typically transfer higher quality technologies to wholly owned subsidiaries in comparison with joint ventures with local partners.

115. Another problem with the Chinese policy is that it seems likely to discourage FDI into China. This criticism may ring hollow considering the fact that China has been the largest recipient of FDI in the developing world in recent decades. Even though the elasticity of inward FDI into China to local policy restrictions may not be high (due to the size and growth of the Chinese market), there are margins along which foreign investors can adjust (such as by lowering the quality of technologies that they transfer to China under such forced sharing or being less cooperative than would be optimal for maximizing local learning).

116. It is worth bearing in mind that what China has achieved in terms of economic growth during these recent decades has simply not been witnessed before in human history: smaller countries might have matched or exceeded Chinese growth for shorter time periods but no country of such massive size has ever grown this fast and for this long. The closest example to China is India but its economic growth during this period, while robust in its own right, pales in comparison to that of China.

117. The upshot of this remarkable and unprecedented economic growth in China is that the Chinese government is in a unique position and has substantial market power when it comes to implementing policies that allow it to extract technology transfer from foreign companies without destroying their incentives to operate in its market. Smaller developing countries, or larger ones not experiencing similarly rapid growth, do not have the same leverage. Therefore, they cannot readily expect to increase technology transfer by imposing similar conditions on foreign investors. Any such attempts on their part run the risk of lowering foreign investment as well as the quality of technology transfer undertaken by foreign investors.

118. Such countries would be better served by investing in human capital and infrastructure (something China has done also), in implementing policies that improve openness to trade and investment, and in establishing a business climate that does not unduly hinder private enterprises. Nevertheless, the Chinese policy of forcing technology transfer is surely preferable to a policy that completely rejects FDI and insists on reverse-engineering and self-reliance, an approach India and Brazil pursued vigorously in the past. A more sensible approach for the larger developing countries is to use their “market power” to improve the quality and extent of ITT to the local economy.

119. In this context, considerable evidence exists that multinational enterprises are keen to transfer technology to their local suppliers.<sup>21</sup> Policies that facilitate this process, as opposed to those that force foreign firms to engage in ITT to local competitors, have a greater likelihood of being successful. In practice, of course, many countries actively seek to attract foreign investors through up-front subsidies, tax holidays, and other inducements. For there to be a

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<sup>21</sup> The authors in Moran et. al. (2005) discuss several case studies documenting this preference.

rationale for such investment incentives host countries must enjoy externalities from inward FDI, as described earlier.

#### 4.3. Deploying Flexibilities in IPRs

120. The caution about China's experience notwithstanding, developing countries do retain policy flexibility in IPRs that can be effective in facilitating inward technology flows in cases where international firms may be hesitant or even act anti-competitively. Such policies have been widely described under the rubric of "TRIPS flexibilities" and so we just mention them here.<sup>22</sup> We caution that our reading of the available evidence supports the view that a

transparent and enforceable system of IPRs generally facilitates market-mediated technology flows. Thus, excessive limitations on patent scope or the use of trade secrets may backfire in this context. Subject to this proviso, however, the following elements may be fruitful.

121. First, technologies that remain in the public domain may be freely reverse engineered if domestic firms have the capacity to do so. Thus, rigorous eligibility standards for patents can sustain a more vigorous pool of information available in the public domain. Similarly, governments could require adequate disclosure in patent applications of the best means of implementing a patented technology. Second, countries are free to retain in their laws a research exception permitting domestic firms to experiment with patented technologies so long as the outcome does not infringe other use rights. This can be especially helpful in areas where such experimentation helps build technical capacity or understand the scientific basis of public goods.

122. Third, while the treatment of working requirements of patents remains somewhat unsettled in TRIPS, refusals to supply the market or license a technology of critical interest can be construed as anti-competitive. Competition authorities may deploy government-use orders or even compulsory licenses as available remedies, as is done in developed economies. Finally, given the importance noted earlier of labor turnover for technology diffusion, policy could place limits on contractual obligations, such as lengthy non-compete clauses, deterring such mobility.

123. While such flexibilities can be important, we note three important caveats. First, none of them are relevant in countries where firms do not register patents. In these cases, local entities are free to copy, though this approach is unlikely to garner the requisite know-how. Second, some of these limitations, such as competition regulation and compulsory licenses, are technically demanding and require administrative skills that may not be available. Third, frequent recourse to compulsory licenses, working requirements, and technology mandates can discourage entry of foreign firms in the first place. All of these caveats point to the importance of building technical and managerial capacity within poor countries in order to both build markets that encourage inward transfers and to manage competition problems appropriately.

#### 4.4. Enhancing ITT through Newer Channels

124. As suggested above, innovation networks and open innovation offer developing countries new opportunities for better access to technological information. The question is how researchers and firms in such countries might take advantage of these opportunities. This is a difficult question to answer, not least because there is little evidence about the determinants of innovation network behavior in poor economies. However, we offer some thoughts about building conditions that should facilitate useful linkages.

125. Despite the lack of systematic evidence, casual observation suggests that GINs develop among entities in countries with significant research capabilities, efficient supply sectors, and

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<sup>22</sup> Maskus (2012, chapter 5) offers an extensive discussion.

strong public governance (OECD, 2008). Indeed, to date the partners in GINs abide substantially in the advanced industrial economies, with growing participation from larger emerging economies, such as China, Mexico, and Brazil. Similarly, firms and universities with scientific and technical personnel operating within existing research programs are more likely to absorb information made available through open innovation. This underlines the importance of making investments in such capacities and skills in countries seeking to garner stronger linkages with international innovation. Thus, while it is hardly a novel observation, the primary policy suggestions in this area parallel and complement those in attracting technologies through more standard channels. Improve the economic and governance infrastructure, including IPRs, in order to facilitate connections between domestic and foreign research entities. Invest in building human capital and technical skills, along with appropriate incentives for engaging in domestic basic and applied research.

126. There are additional elements that countries could consider which aim at improving the chances of meaningful engagement with research networks and open innovation. First, governments could critically review their regulatory restrictions on the provisions of domestic and foreign research services to assess whether they impede technology flows and skill acquisition. For example, limits placed on clinical research services, whether in medical trials or testing of new agricultural varieties and bioengineering products, may inefficiently restrict the ability of firms to engage in important intermediary research. Relaxation of such barriers could encourage more inward investments of such testing services, while helping to build a local industry. A second example would be to review certification and testing protocols that may excessively raise costs of domestic testing services and limit investments in such technical capacity.

127. A third area would be to review immigration and visa policies with a view to relaxing those that unreasonably restrict the flow of skilled labor, both into and out of the economy. Prior research highlights the importance of incoming engineering and entrepreneurial talent, often within multinational firms, for building local technical capacities and procuring related spillovers (Montobbio and Sterzi, 2011; Kerr, 2008, 2013). This finding extends as well to the contribution of highly skilled international students (Stuen, et al, 2012). We caution that such empirical results to date have been found largely in cases of skilled migrants working in the developed economies. However, the basic principle, that the contributions of talented technical personnel are complementary to the development of local skills and research capacities, should operate even more for workers located even temporarily in a welcoming developing economy

128. It is important to note that these ideas could be taken up also by multilateral or plurilateral agreements within the WTO or within regional cooperation agreements (Maskus, 2004; Maskus and Saggi, 2013). Specifically, for purposes of enhancing connections among and between researchers in technologically advanced developing countries, we encourage the global community to consider pursuing the following options.

129. The principles of GATS could be extended to liberalize trade in research services. Thus, countries could bring research services into GATS (or regional) negotiations. R&D services could include such elements as equipment purchases and testing protocols, grant management and accounting, and the ability to employ research workers and students across borders. These services are often heavily restricted in favor of domestic providers. Commitments to open such services to competition, whether through GATS, the emerging Trade in Services Agreement (TISA), or preferential trading arrangements, could offer efficiency gains and improve innovation and research network linkages.

130. Perhaps more important would be to expand GATS to encourage greater temporary mobility of skilled and entrepreneurial workers. The essential idea is to increase "brain circulation," in part to avoid perceived drawbacks of "brain drain" in depriving developing countries of talent. As noted above, a significant channel of ITT is the temporary -- though not brief -- relocation of skilled personnel from countries where production technologies and R&D

are lagging to where those skills can be fully utilized. The reverse flows contribute to technology transfer as well. The development of GINs is facilitated by the unimpeded flow of such personnel among R&D and production facilities for temporary stays. Similar comments would apply to research professionals, faculty, and graduate students moving between universities and public research labs and also migrating to spend time in private R&D facilities.

131. Compared to the current world of tightly limited visas and short stays, a more efficient system would link skilled workers together in an “innovation zone” in which countries would agree to permit longer-term work visas, perhaps for ten years, that could be valid in all participant countries. The concept would be to facilitate free circulation of technical and entrepreneurial talent among the member nations, permitting them to be deployed freely within the associated innovation networks.

132. Thus, WTO members could move toward a plurilateral agreement for significantly liberalized skilled-labor flows under the framework of an innovation zone work visa. The agreement would need to consider how the certification of skills acquired in different professions and in different countries would be recognized by the members, though a basic preference for mutual recognition would seem most efficient. Consistent with GATS principles, countries could reserve certain sensitive professions or perhaps enact safeguards, for example to ensure that security-sensitive positions in public agencies or research labs are ineligible.

133. These basic concepts – facilitating international cooperation in research and innovation networks and expanding the circulation of skilled workers – lie at the heart of the long-term proposal for an international Treaty on Access to Basic Science and Technology (ABST), set out initially in Barton and Maskus (2006).<sup>23</sup> The fundamental notion of an ABST, which would reside within WIPO or the WTO, is to complement the global IPRs system and preserve and enhance the global commons in science and technology without unduly restricting private rights in commercial technologies. The approach would be to place into access pools the patented results of publicly funded research that develops knowledge capable of supporting applied science and R&D. This mechanism would be particularly valuable in areas of common global concern, such as climate change and medicines. In essence, funding agencies in participating nations would state that, to qualify for a research grant in specific areas of science, the university and scientists must agree to place any resulting patents into common-resource pools. These patents would then be available for license to all competent agents from other member countries under terms worked out in advance.

134. One model would be to license at “fair, reasonable and non-discriminatory” (FRAND) terms. In the ABST, however, there should be provisions for concessional terms to researchers from poor countries without discrimination among applicants within graduated country bands. Moreover, the agreement could encourage researchers from member countries to participate in, or compete with, local research teams for grants and subsidies, combined with increased opportunities for temporary migration. It would also give researchers in other countries access to scientific knowledge and data produced from publicly funded research.

135. Several structural issues would form the basis of the treaty. First would be its scope in terms of subject matter and processes. It is difficult to draw any dividing line between basic and applied research. One definition of basic knowledge is that which is truly non-rival, has limited commercial utility, and is an input into other science. Another class of basic technologies would be those supporting the provision of global public goods, such as environmentally sound inputs and essential medicines. There is no clear sense in which these characteristics might be universally defined. One way to manage the distinction would be to include research processes and findings and data that are both fundamental knowledge inputs and largely publicly funded.

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<sup>23</sup> Maskus (2012, chapter 5) offers a detailed explanation of what an ABST could entail.

This idea is natural because basic and public-goods technologies require public financing in any event.

136. Second would be the nature of liberalization, or the forms in which access is to be granted. In principle, there could be three levels of commitment. First, input liberalization would permit researchers from other countries to compete with, or participate in, domestic research teams for public grants and subsidies. This could be combined with increased opportunities for temporary migration of scientific personnel. However, governments might prefer to reserve their research results for preferential use by local firms and the registration of IPRs. This approach would expand research efficiency and transfer more skills abroad, but its scope for raising global access to knowledge would be limited.

137. Next, output liberalization would simply offer researchers in other countries access to nationally generated science and data from public funding. This approach could significantly expand the public commons and increase knowledge diffusion but would not directly expand efficiency or transfer research skills. Important provisions would promote access to scientific databases and ensure that intellectual property regulations do not limit access to basic scientific knowledge deposited in commons pools. The United States, for example, could meet terms of an ABST by modifying the Bayh-Dole Act to require non-exclusive licensing of publicly funded basic research results.

138. Finally, full liberalization would combine these approaches, both expanding international flows of research contracts and personnel and increasing global access to outcomes. As an economic matter, we favor full liberalization to the extent it is politically feasible. To achieve that goal, 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.

139. The treaty also would need to be balanced by safeguard clauses. One issue would be the equitable and efficient distribution of intellectual property from subsequent applied innovation. To what extent would originator universities depositing basic research results be able to benefit from downstream applications? Another is that concerns regarding national security and international technology proliferation would need to be addressed.

140. Importantly, an ABST could build in preferential advantages for poor economies. For example, where research results are made available in licensing pools at some cost, differential pricing schemes for governments and institutions in poor countries could be encouraged. Efforts to increase research participation by scientists and engineers from developing countries could be written into proposal solicitations.

## 5. POLICY RECOMMENDATIONS

141. Fruitful policy intervention needs to recognize that market agents play a crucial role in the process of ITT but that the environment in which ITT occurs is shaped by a range of government policies. The ability to absorb foreign technologies is critically dependent on the level of local human capital stock. Our policy recommendation here is as simple as it is fundamental: governments of developing countries must play their part in strengthening the local education systems at all levels (from the primary to post-secondary). From an economics perspective, strengthening local education systems is a necessary pre-condition for effective ITT to occur.

142. Openness to trade, particularly in capital goods trade, is crucial for updating local technologies. By contrast, policies aimed at reverse-engineering complex capital goods behind stiff trade and investment barriers are likely to be counter-productive.

143. Any policy intervention must take into account the incentives of private sector participants involved in the process of ITT. As we have stressed throughout the paper, multinational firms, global production chains, and global innovation networks are the driving forces behind innovation and the diffusion of technology. Government policies in developing countries need to be *compatible with the incentives* of these entities. For example, considerable empirical evidence shows that while spillovers from FDI to competing local firms are elusive, such is not the case for spillovers to local suppliers and other agents involved in vertical relationships with multinationals and other foreign investors.

144. The practical lesson here is that rather than trying to reproduce complex industrial goods (such as cars or computers) entirely on their own, developing countries need to ensure that their firms fit into the production and innovation chains of such products to the mutual advantage of all sides. This is not to say that the role a developing country plays in a given production or

innovation chain is immutable. Far from it: evolving market conditions would naturally call for adjustments over time. But policy intervention should look to ease such adjustments as opposed to working against them.

145. Within this context, consider the technology transfer requirements on FDI that have been imposed by China (and to a lesser degree by some other countries in the past). Such policies take into account some of the incentives of market agents but not all: they recognize that multinationals keen to enter the Chinese market would be willing to share technologies but do not account for the fact that they also have incentives not to create strong competitors for themselves. As a result, one would expect multinationals forced into joint ventures with local partners to withhold key technologies or take actions that limit the learning of local agents.

146. For smaller developing countries, implementing Chinese type technology transfer policies could prove self-defeating: if the local market is not sufficiently large, multinationals may completely opt out. If this happens, a country can find itself shut out of the global production and innovation chains that drive economic activity in today's global economy – an outcome that would be highly detrimental to improving local productivity and growth.

147. Despite this observation, developing economies can undertake important initiatives to encourage inward technology flows and connections to the global system. Investments in better infrastructure, construction of transparent and competitive tax regimes, and improvements in public governance are clearly important to global firms seeking to locate production and R&D facilities. In this sense, they are important complements to investments in human capital, training, and research capacities in universities and research laboratories, which are critical for linkages to global innovation networks. Similarly, fiscal incentives to domestic enterprises for undertaking meaningful R&D programs can help position such firms to be more attractive affiliates or partners in technology contracts. All of these form components of a dynamic national innovation system, itself important for facilitating technical change.

148. We also note the importance of establishing a transparent, reliable and enforceable system of intellectual property protection. This policy, conditioned on improvements in the economic climate in the prior paragraph, can help three objectives regarding ITT. First, by resolving information problems and reducing contracting costs, IPRs make multinational firms more likely to transfer advanced technologies and associated know-how. Second, multinationals need assurance that the inputs they procure at various stages of their supply chains are legitimately produced and reliable, which is more certain with a transparent regime. Third, intellectual property rights can help allocate rights and obligations among partners in research networks. Note that procuring these gains does not require adopting IPR systems that replicate the highly protective regimes of the United States or other advanced countries. Rather, it is a question of establishing transparency within a system of standards and limitations that are appropriate for countries at different levels of development.



149. Finally, we reiterate our view that increasing global openness to the temporary migration of skilled technical and entrepreneurial labor remains a key input for facilitating international technology flows. Developing countries could gain from unilateral liberalization in this regard but combining their weight in an international push to relax barriers to such migration could be especially powerful.

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[Annex II follows]



**REVIEW OF STUDY (E): KEITH MASKUS AND KAMAL SAGGI, “INTERNATIONAL TECHNOLOGY TRANSFER: AN ANALYSIS FROM THE PERSPECTIVE OF DEVELOPING COUNTRIES”**

**REVIEWER: PROF. WALTER PARK, AMERICAN UNIVERSITY, WASHINGTON, DC, USA**

This study provides a comprehensive coverage of international technology transfer (ITT) issues as they pertain to developing countries. The study takes us through the conceptual issues and framework for analysis, provides critical commentaries on previous academic research and policy reports, and discusses policy recommendations for improving the process and environment for ITT.

The study stresses the importance of ITT not only for private sector productivity but also for the pursuit of social objectives, such as health and environmental goals. At present, a critical hurdle for the less developed countries is their ability to access global technologies on reasonable terms. The study points out that, to the extent that there has been success at international technology transfer owing to reforms in policy, such as intellectual property rights (TRIPS), the impact is largely felt in large and middle-income developing countries. For the poorest economies, there are major impediments to in-bound ITT, which tend to be structural; for example, governance problems, lack of linkages with global innovation networks, and underdeveloped absorptive capacities, due to inadequate levels of human capital, infrastructure, and other factors.

The study discusses traditional sources of ITT, such as foreign direct investment (FDI), licensing, joint ventures, and trade in capital goods, as well as newer channels, such as open innovation, global innovation networks (GIN), and an innovation zone, within which researchers and scientific personnel can more easily move from country to country on a special work visa. Such circulation of human capital can better facilitate knowledge transfers, sharing, and participation in research projects, and strengthen GIN among companies, universities, and research centers. Furthermore, in my view, these channels (open innovation, GIN, migration) may possibly enable poorer economies to better develop their indigenous innovative and absorptive capacities than traditional ITT activities. While traditional ITT can generate technological spillovers, via labor turnovers and local imitation, these newer channels appear to work more directly at providing access to knowledge and opportunities for capacity-building. In some sense, ITT should be viewed as a means and not an end insofar as local technological development is concerned. Possessing stronger local capacities helps fill some gaps with ITT. For example, ITT usually provides local economies with products that already exist elsewhere, but in many instances, there are product-needs specific to local economies, relating to health, geography, climate, and customs. Local innovative capacities and participation in open innovation and GIN can help tailor research to local needs. ITT may also be subject to business cycles in source countries; for example, flows of FDI from the U.S. and Europe fell after the 2007-8 financial crisis. Stronger indigenous capacities help ensure that local economies meet technological needs with minimal disruption from global market fluctuations.

In the concluding section, the study emphasizes the importance of local human capital stock to the ability of developing economies to absorb foreign technologies, and strongly recommends that governments of developing economies improve their educational systems, which “is a necessary pre-condition for effective ITT to occur.” Going forward, IPRs, particularly copyrights, will play an important role. This area of IPRs has not been explicitly treated in the study, but will be important for the education of poorer economies. At present, many developing economies do not create their own educational materials, such as textbooks, even for primary and

secondary education.<sup>24</sup> They are largely dependent upon the publishing industries of developed countries. Even local publishers turn to American and British companies to act as intermediaries for marketing their works. There are also complex territorial licensing practices, laws, and pricing that may be impeding access to knowledge (books, journals, software, and databases) for poorer economies.<sup>25</sup> Open educational resources, parallel importation of copyrighted works, and collective licensing reforms, should be among the topics for further debate as we consider ways to enhance human capital development in the less developed world.

[End of Annex II and of document]

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<sup>24</sup> See Amalia Toledo, Carolina Botero, and Luisa Guzman (2014), "Public Expenditures in Latin America. Recommendations to Serve the Purposes of the Paris Open Educational Resources Declaration," *Open Praxis*, Vol. 6, Issue 2, pp. 103-114

<sup>25</sup> See Eve Gray, Andrew Rens, and Karen Burns (2010) *Alternative Licensing Models in Africa* (IDRC Project Report), Association for Creative Research and Development.