

Intellectual Property Rights and International Technology Diffusion*

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Abstract

The TRIPs agreement does not appear likely to alleviate any wealth differences arising from the existing North-South technology divide. Open-economy endogenous growth models suggest a dynamic shift towards further concentration of industrial R&D in the Northern countries. While production of goods developed as an outcome of this R&D may shift to Southern countries through the actions of multinationals, empirical evidence indicates this technology transfer will not likely lead to such benefits as productivity growth in the host country. Essentially, this means that stronger IPRs lead to technology transfer that benefits the North but not the South.

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* The views expressed in this paper are those of the author, and do not necessarily represent the views of the Federal Trade Commission or any individual Commissioner.

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I. Introduction

This paper approaches the broad subject of technological development and division from the perspective of international impacts of IPRs. A striking global technology divide exists, even greater in its disparity than in wealth. This carries strong welfare implications, since technology can serve both as a tool for current production and an investment for future growth.

Section II discusses the huge gap between the North and the South regarding technology. Since the economics of intellectual property provide context to technological development, Section III describes theories of IPRs in both national and international settings. Section IV focuses on the economic evidence of technology transfer. I define the terms innovation, imitation, and diffusion, and analyze the various channels in which these activities occur. In particular, I highlight the significant role multinationals play in technology transfer, and the different results depending on whether the transfer is intentional, or whether it includes a shift in control of proprietary knowledge.

Section V considers the impact of the WTO's Trade-Related Agreement on Intellectual Property (TRIPs) on this technology divide. Article 7 of TRIPs focuses specifically on impacting welfare and the dissemination of knowledge, a tradition of policy on IPRs dating back 500 years. The recent history of the negotiations that lead to TRIPS, however, shows significant unilateral activity by the United States for reasons not entirely limited to knowledge dissemination and welfare. The section also discusses the impact of IPRs on intentional technology transfer.

Section VI affirms how industry differences are important for both innovation and for diffusion. Industries in the chemical sector, and in particular pharmaceuticals, are those that rely on patents as a general means of appropriation and are most responsive to IPRs with regard to international transfer.

II. The technology divide

The global economy of the twenty-first century features a stark technological divide between the wealthy and the rest of the world, a divide that may be growing and contains at its center the control of intellectual property. This divide has a loose geographical demarcation that gives rise to the popular distinctions between a wealthy “North” and a less-wealthy “South”. As a matter of convenience, I adopt this terminology in the present paper.

The economic models analyzed below assume the simple existence of this demarcation, while economic evidence indicates the geographical line may not be a coincidence of historical accident. Gallup, Sachs and Mellinger (1998) suggest that location and climate have large effects on income levels and income growth through transportation costs, human health, agricultural productivity, and access to natural resources. They show that wealth density, measured by GDP per square kilometer, is concentrated in coastal, temperate, Northern-hemisphere economies. Between the Tropic of Cancer (23.45 degrees N) and the Tropic of Capricorn (23.45 degrees S), only the city-states Hong Kong and Singapore had GDP per capita among the top thirty in the world in 1995. Moreover, the core economic regions of the world lie within 100 km of coastline in the United States, Western Europe, and temperate-zone East Asia

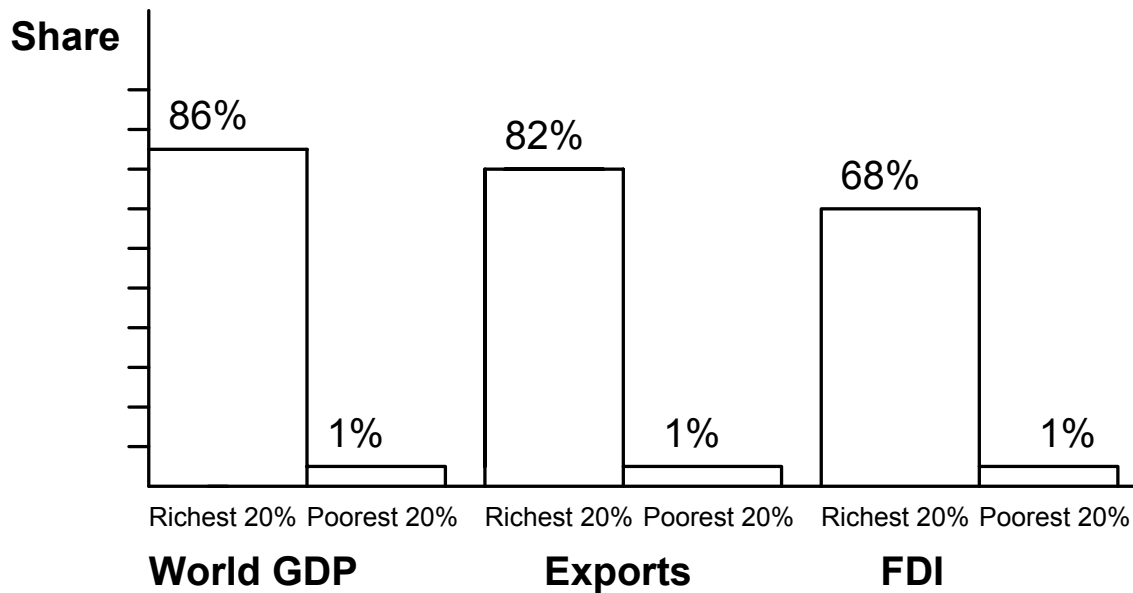
(including China). These areas account for 3% of the world's inhabited land area, 13% of the world's population, and 32% of the world's GDP.

In a historical picture of North-South wealth differences, Diamond (1997) claims that environmental factors are fundamental to the economic dominance of Europe and its former colonies. He argues that historical technological diffusion of plant species and domesticated animals worked most effectively *within* ecological zones, favoring the East-West axis of Eurasia over the North-South axis of Africa and the Americas. These historical advantages of Europe and Asia, combined with the high transportation costs for the landlocked regions of South America, Africa, and Central Asia contribute to the contemporary dichotomy of wealth and technology.

Historical advantages of ecology serve as an analogy to contemporary economic advantages of technology, in which static differences strengthen productivity gaps that lead to dynamic advantages of wealth. Technology serves a dual economic function as both a tool of current production and an investment for future growth. The existing North-South technology divide demonstrates both a static and dynamic differentiation, and the relationship of the regions across this gap entails both the development and the diffusion of technology.

The United Nation's Human Development Report (1999) gives a host of statistics on the current stratification of technology. Chart 1 demonstrates statistics on the split between GDP, exports, and FDI, as well as the elements of global technology captured by internet and telephone lines.

Chart 1: Disparities between the rich and poor in global opportunity



Source: United Nations (1999)

The fifth of the population living in the wealthiest countries have 74% of the world's telephone lines and 93.3% of internet users, versus 1.5% and 0.1 %, respectively, for the fifth in the poorest countries. Investment in research and development (R&D) is similarly concentrated. In 1993, ten countries hosted 85% of global R&D expenditures. Between 1977 and 1996, these ten countries controlled 95% of U.S. patents, but developing countries less than 2%. In addition, residents of industrialized countries controlled more than 80% of the patents granted to developing countries (United Nations 1999).

Statistics on R&D investment show various degrees of concentration at multiple levels of analysis. At one level, R&D is concentrated among industrialized countries. The share in world R&D expenditures by countries in the South was only 4% in 1990, a decline from 6% in 1980 despite well-documented research activity in Southeast Asia (Correa 2000). In 1998, 29 OECD

countries spent \$250 billion in R&D, which is more than the GDP of the thirty poorest countries combined, and accounted for 91% of the 347,000 new patents granted in the world (United Nations 2001).

Table 1: National trends in industrial R&D

	1985		Compound real growth rates (%)			
	Billion \$	Percentage of OECD Total	1975-85	1975-79	1979-85	1983-85
United States	78.2	50.4	5.9	4.5	6.7	7.4
Japan	26.8	17.2	9.8	6.6	12.0	12.6
Germany	14.3	9.2	5.6	8.2	3.9	6.5
United Kingdom	9.1	5.8	3.3	5.0	2.1	5.8
France	8.6	5.5	4.6	3.8	5.1	6.7
Italy	4.0	2.6	6.3	2.6	8.9	12.0
Canada	2.7	1.8	9.0	7.6	10.0	9.9
Sweden	2.1	1.3	na	3.9	Na	12.3
Netherlands	1.9	1.2	2.7	0.2	4.4	7.5
Switzerland	1.4 (1983)	1.1	na	0.5	Na	na
Belgium	1.2	0.8	5.0	6.0	4.2	4.8
Spain	0.9	0.6	6.1	0.1	10.3	16.9
Total OECD	155.2	100	6	5	7	8.5

Source: Table 60 in OECD (1989), reprinted from Grossman and Helpman (1991)

R&D is also highly concentrated within industrialized countries. Table 1, reproduced from an OECD study, shows trends in R&D growth throughout the industrialized world. The United States conducted 50.4% of R&D in 1985, and three countries accounted for over 80%. Moreover, even within the United States, the majority of industrial R&D is conducted by firms in a few sectors such as chemicals and electronics.

Through diffusion, however, even a concentrated innovative core can have tremendous impacts on the rest of the world. Eaton and Kortum (1996) trace patenting within the OECD and show that foreign ideas generate more than 50% of productivity growth for the industrialized world. That is, about half of all growth in the industrialized countries can be traced to innovations originating outside their barriers. For countries other than the five leading research economies, the number is over ninety percent.

Such growth generated by foreign innovations demonstrates the salience of the diffusion mechanism. In order for Northern R&D to benefit the South in a similar manner to the intra-OECD exchange, diffusion of technology across regions must occur. The nature of this diffusion grows complicated due to economic characteristics of technology itself. For this reason, technological development and diffusion can be understood within the context of the economics of knowledge or intellectual property.

III. Theories of IPRs

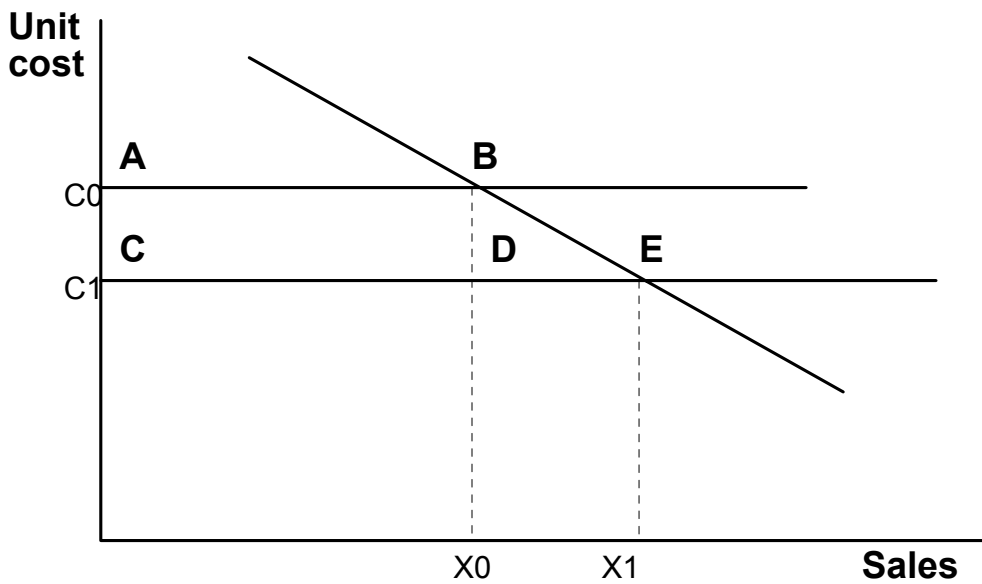
III. A. Incentives for innovation

Technology stems from knowledge, which carries features of a public good, being both non-rival and non-excludable, and thus requires the legal institutions of IPRs to provide

incentives where the market fails. Knowledge is considered non-rival because its use by one individual does not preclude its use by another. This suggests that at any point in time, the optimal situation is for everyone in the world to have access to the stock of knowledge - examples of which include literacy. However, pure knowledge is also non-excludable, which means that anyone who creates knowledge has no way to naturally prevent its dissemination. Legal constructs such as intellectual property rights to provide incentives for the creation of new knowledge.

Nordhaus (1969) developed the modern approach to deciphering the optimal patent policy. Figure 1 shows the implications of a cost-saving innovation with linear demand and constant marginal cost.

Figure 1: Value of cost-saving innovation¹



An innovation that reduces cost from C_0 to C_1 provides society ABCD annual cost savings. With enforceable IPRs, the innovator captures these rents through monopoly pricing.

After the expiration of the patent, society not only picks up the surplus ABCD, but the shift to competitive output level X_1 provides the increased welfare gains of BDE. The key to the analysis is for the value of ABCD, over time, to exactly match the R&D costs of the innovation. A longer patent life confers social gains by stimulating innovators, but imposes social losses by making consumers wait longer on the BDE triangle. IPRs provide the incentives for innovation by determining the duration ABCD gets appropriated by the firm.

III. B. Innovation and growth

With regard to economic studies concerning growth and human welfare, technological innovation has achieved prominence within the past twenty years. Neoclassical economic theory considered growth an outcome of capital accumulation, regarding technology as an exogenous factor. A branch of theory called “endogenous growth theory” recognizes that technological development is fundamental to the growth process, and describes the market for technology using incentives of supply and demand.

According to Romer (1990), the three underlying presumptions of endogenous growth theory claim that technological development lay at the heart of economic growth, that technological development is excludable and can respond to market incentives, and that technology is a non-rival good that builds on existing levels of technology. Open-economy endogenous growth models use a specification introduced by Krugman (1979) of regional

¹ As drawn, this is based on Scherer's (1972, 1977) geometric interpretation of Nordhaus's theory.

differences in comparative advantages for the innovation or imitation of technology. A key underlying assumption of this literature set holds that the North enjoys a much lower cost for the innovation of a new technology while the South obtains technology through imitation.

Grossman and Helpman (1991) develop a series of endogenous growth models that adhere to the principles of non-rival knowledge that can be excludable through intellectual property protection, usually via trade secrets or patents. Innovations are realized either through expanding product variety (horizontal) or improving quality levels of existing products (vertical), which can also be regarded as a process innovation. Profit-maximizing firms invest in R&D until dynamic rents are exhausted. Whether the innovation is horizontal or vertical, the growing stock of knowledge improves the chances for future growth.

Helpman (1993) extends this framework to include patent protection as tool of government policies. He gives strong theoretical support to the popular notion that stronger IPRs tends to favor Northern welfare at the expense of the South. Moreover, patents may grant enough market power to Northern firms that stronger IPRs may *reduce* the innovation rate. Northern resources are allocated to production, away from R&D.

Helpman's results are not robust to assumptions on the resource constraints of each region. In his model, production of any goods innovated in the North must take place in the North. Lai (1998) shows that if production can shift via FDI, then an increase in the strength of IPRs will lead to a higher innovation rate. Yang and Maskus (2001a) show this also holds if production shifts via licensing.

With technology transfer across regions, the optimal allocation of resources leads to the North engaging primarily in R&D, and the South in manufacturing. Not coincidentally, this

result parallels the neoclassical doctrine of specialization according to comparative advantage. However, this outcome faces political controversies when the specialized goods are not wine and cloth, but non-rival technologies that have dramatic effects on future growth. Developing countries may be inclined to argue that such a result leaves them perpetually lagging the technology frontier. This highlights the important issues of the impact technology transfer actually has on the productive and innovative capabilities of the South, and the extent to which that transfer entails a shift in the control of proprietary knowledge.

IV. Technology transfer

In the above models of open-economy endogenous growth, the methods of inter-regional technology transfer include imitation, FDI, licensing, and a “natural adaptation” where diffusion occurs according to exogenous process. These modes have different characteristics depending upon whether the transfer is made by the intent of the firm. Since technology is non-rival and only partially excludable, quite a lot of diffusion occurs outside voluntary market transactions. With regard to North-South technology differences in the context of IPRs, attention must be paid to whether a shift in control of the proprietary asset occurs. Since stronger protection of intellectual property generally increase the value of existing innovations, if the actual control of the knowledge is not transferred, significant wealth shifts may occur. The single presence of new technology within national borders may not benefit that country without some shift in control.

IV. A. Firm-to-firm transfers

Hobday (1995) argues that diffusion of technology across borders primarily occurs by firm-level learning, both between and within firms. This diffusion can be differentiated according to the intent of the firm. Baldwin and Scott (1989) distinguish technology distributed by intent of that firm, “dissemination”, from diffusion by competitive activities, “imitation”. The difference does not lay in legal or ethical claims, but on the appropriation rights of the innovator. Imitation often carries a negative connotation, but the activity itself, as generally defined, entails substantial cost and creativity by the competing firm, and the new products developed via imitation add value to economic growth.

Alternative characterizations of diffusion refer to “spillovers”. Grossman and Helpman (1991) define technological spillovers occurring when firms acquire information created by others without paying for it in a market transaction, and the creators (or current owners) have no effective recourse under prevailing laws to prevent other firms from utilizing information so acquired. This quality highlights the partial excludability of knowledge goods, and serves as a primary theoretical benefit of FDI (Wang and Blomstrom 1992)..

Unintentional spillovers, or “leakages” can occur in a variety of ways across national borders. Reverse engineering, similar to imitation, describes the process of developing a competing product using the original. This method is generally employed in fields in which innovative qualities can be easily mimicked, such as certain chemicals, as discussed in Section V below. Leakages also occur through defection, when a former employee begins working for a competitor, through the emigration of high-skilled workers, or when a firm breaks a licensing contract to produce its own good absent of royalties.

Firms choose to distribute their technology through intentional transfer for a variety of reasons, and a highly developed industrial organization theory considers the value of integration for a firm for such activity. The specifics of this literature do not translate directly to international incentives, providing fertile ground for theoretical investigation. In a brief summary, innovating firms may appropriate the returns from an innovation via in-house sales or through royalty fees of licensing contracts. Coase's (1937) classic theory explains integration as the optimal outcome when the transaction costs of using the price mechanism exceed the cost of organizing through direct control. The choice of integration or licensing reflects market imperfections, technological interdependence within the sector, the returns to economies of scale, and short-run differences in productive capacity or operating costs.

Markusen (1995) succinctly details how these parameters extend to multinationals. Theories of FDI usually assume that the firms undertake a fixed cost to develop a proprietary asset that can support production over multiple plants. Downstream production plants shift overseas either to exploit lower costs, in the case of vertical FDI, or to avoid high transport costs for horizontal FDI.

The economic research that describes the decision for international dissemination, the effect of IPRs on technology transfer, and the impact of imported technology differs considerably from analogous research within a closed economy. A key point involves the relationship between multinationals and their sector-specific incentives to innovate and disseminate technology. I focus on this link in a discussion of transnational transfer, recognizing that important research questions remain.

IV. B. Across national borders

The intentional dissemination by a firm to transfer its proprietary knowledge outside political borders can occur via exporting, FDI, and licensing. Each of these modes differ in its value to the domestic economy, related to the actual extent control of technology is transformed. If an exported product is a capital good, such as in a process innovation, the innovation enhances the technological frontier of the importing country. With consumer products, however, proprietary rights would remain in the hands of the foreign innovator and the domestic industry cannot use the technology for its own production without some form of non-market activity. Consequently, the threat of imitation, which depends on the strength of IPRs, affects the exporting decision. The innovator may simply choose not to export a technology-intensive good or may choose to extend control of its production through FDI.

Multinationals play a crucial role in the transfer of technology across borders. Mansfield et al (1982) show that except for process innovations, FDI is the principle channel of technology transfer, and that technology transferred through multinationals tends to be newer than in licensing or joint venture agreements. According to Dunning (1983), in the period from 1945 to 1965 multinationals centralized technology and limited access by their subsidiaries, buying foreign high-technology corporations and transferring the knowledge to their home parents. Since the mid-1960's, the dissemination of technology via multinationals has accelerated, as various countries in Latin America and Asia, following Japan, have become adept at acquiring technologies. Technology is now being transferred by multinationals through the advice and assistance to local firms. Dunning suggests that the proprietary advantage of multinationals, and

the source of their market power, may no longer be the possession of superior knowledge but the ability to transfer it.

Mansfield and Romeo (1980) survey executives for 31 U.S. based firms in order to understand the nature and extent of technology being transferred by multinationals, and the benefits conferred upon the host countries. They find that the mean time of leakage of technology by multinationals was about four years after its initial introduction into the United States, but in most cases may have leaked even without its transfer. Executives said that in about one-quarter of the cases leakage was advanced 2.5 years because of FDI, but in general leaks would have occurred as quickly. Seventy large British firms say those leaks are how they gained some technological capabilities, but only 20% said they were “important”. Note, however, that most competitors obtaining the technology were not usually headquartered in the host country; in the sample, the majority were headquartered in West Germany. Technology primarily leaked through reverse engineering, with important roles also played by information revealed in patents and defection in personnel. For 80% of leaked technologies, leaks led to cost reductions for users, and for 40% of the technologies they led to supply savings.

In a detailed study, Hobday (1995) shows the impact of FDI on technological change in East Asia. He interviewed company directors and engineers to determine learning mechanisms for firms in the region, specifically concerning latecomer firms with technological disadvantages and in undeveloped local markets. These firms engage in numerous channels in order to acquire technology and overcome technical barriers to entry. Hobday outlines theoretical stages of technology development. The progression moves along: 1) basic production capabilities, 2) reverse engineering, 3) product design capability, 4) product innovation capability, and finally to

5) advanced product/process innovation. Examples of this development carried to fruition include Samsung and Goldstar of South Korea, and ACER and Tatung of Taiwan.

Hanson (2001) reviews the substantive economic literature on the impact FDI may have on the host countries. Empirical evidence provides weak support that FDI generates positive spillovers, but suggests that domestic plants in industries with a large multinational presence realize lower rates of productivity growth. In particular, Haddad and Harrison (1993) find weak plant-level productivity growth negatively correlated with foreign presence in Morocco, and Aitken and Harrison (1999) find similar results for Venezuela. Kokko (1994) finds that spillovers are less likely in “enclave” sectors with large technology gaps and high foreign shares. The overall results imply that FDI may reflect a technology transfer that fails to generate technological development for the recipients.

Scherer (1977) discusses the impact compulsory licensing may have on innovation and patenting. Multinationals often patent their products in many jurisdictions but produce in few, forcing developing countries to pay high prices for imported patented products while they are unable to use frontier technology. The response is that some governments use “working” requirements on patents or subject these technologies to compulsory licensing.

Licensing can have the same financial consequences as exclusive exploitation if no scale economies are present in the production or distribution of goods, the cost of license enforcement is minimal, and a competitive royalty rate can be assigned. However, a royalty rate equivalent to potential monopoly rents can be difficult to obtain, and thus mandatory licensing may be analogous to weakening or shortening a patent.

Scherer analyzes the impact of compulsory licensing in U.S. antitrust litigation, and finds

that patenting by companies impacted by mandatory licensing decrees declined, but finds no significant impact on R&D efforts. Firms appear to be protecting their proprietary knowledge through alternative means, a foreshadowing of the sector-specific analysis discussed in Section VI. He cites survey evidence that suggests the response to licensing at a reasonable royalty receives a much stronger reaction in pharmaceuticals, relative to mechanical or electrical engineering, or to other chemicals. Explanations of this result follow a consistent theme regarding pharmaceuticals that high research intensity, unique product features, and absence of other means of protection cause its dependence on patenting. Firms also mention the great difficulties in finding a “reasonable” royalty in the pharmaceutical sector.

IPRs are an important determining element in the activity of FDI and licensing, as well as with other forms of technology transfer. While IPRs may tend to increase direct forms of transfer, they also leave proprietary control in the hands of the innovators. Consequently, the impact may be that IPRs diminish the transfer of *usable* technology. The next section describes the political backdrop for TRIPS, and then discusses the potential impact this agreement may have on the dissemination of technology.

V. Role of TRIPs

V. A. Does TRIPs care about welfare?

The modern Western tradition of protecting intellectual property began in fifteenth century Venice when they were instituted to protect the incentives for innovation to facilitate competition with neighboring Florence. This tradition moved northward through Europe, reaching Germany and England in the 1540's and 1550's. Whereas 18th century France

developed the “natural rights” view of patents, which considered the fruits of creativity in the domain of the inventor and not subject to public intervention, the English codified laws to stimulate innovation. The U.S. followed suit, and from its inception in 1781 the stated goal for U.S. patent policy has been to promote public welfare, recognizing the fundamental trade-off that trade secrets are exchanged to the public domain in exchange for a limited exclusivity (Ryan 1996). The modern multilateral agreement of the WTO, TRIPs, adopts this language of welfare-based protection of intellectual property. Article 7 focuses on “technological innovation” and the “transfer and dissemination” of technology (Watal 2000).

TRIPs found its way into negotiations during the Uruguay Round of GATT almost entirely due to unilateral actions by the United States, by far the largest producer and seller of technology goods. In the early 1980s, multinationals based in the U.S. mobilized to improve IPP internationally. A divergence existed at that time between the North and the South, especially in Latin America and Southeast Asia, for product and process patents. This held especially true in food, agriculture, chemical, and pharmaceutical patents. As of 1988, the World Intellectual Property Organization identified 31 developing countries that excluded pharmaceuticals products, 8 that excluded pharmaceuticals processes, and 12 that excluded chemical products. Finland, Greece, Iceland, Monaco, Portugal, and Spain also excluded product patents for pharmaceuticals at that time (Watal 2000).

Correa (2000) says numerous factors converged to motivate the activity on intellectual property protection, including the growth of technology in importance to international competition, high externalities in the production of knowledge with limited appropriability, the increasing elimination of trade barriers, and a perception in the United States that its

technological supremacy was being challenged by Japan and the newly-industrializing countries. Pfizer and IBM, leading a consortium of firms in pharmaceuticals, electronics, and entertainment, initiated a proposal at the GATT for multilateral actions to strengthen IPRs (Ryan 1996). In a 1984 amendment to Section 301 of the 1974 Trade Act, the U.S. Congress gave the U.S. Trade Representative the legal right to tariff impositions on intellectual property (Watal 2000). With a mandate for “adequate and effective protection” of IPRs, the USTR began bilateral diplomacy. Successful Section 301 bilateral actions against Brazil and the Republic of Korea showed credible threat by the United States, and by 1994 the Treaty of Marrakech was signed, giving life to TRIPs (Ryan 1996).

V. B. Impact of TRIPs on Technology Transfer

TRIPs alters the landscape of international activity in technology. Welfare transfers specific to TRIPs have been estimated to be as high as \$20 billion.² A crucial element behind these results on welfare is the technology transfer between the North and the South. Global welfare depends on the overall innovation rate, as well as the access by much of the population to those innovations. The economic evidence with regard to the impact of stronger IPRs on technological dissemination suggests that stronger IPRs increase international transfers. This research has not yet been applied to unintentional transfers, but as discussed below some ancillary results support theoretical projections that they are prevented by stronger protection.

Maskus (1998) observes that stronger IPRs have a positive and statistically significant impact on U.S. bilateral FDI in developing countries. The sales, exports, and assets respond

² World Bank estimate

positively to increased IPRs for affiliates of U.S.-based multinationals in developing countries, although the number of patent applications declines. Maskus suggests that the contrast may be due to substitution from FDI to licensing taking place after a threshold level of patent protection.

Smith (2001) finds support for theoretical suggestions that stronger IPRs enhance the advantages of FDI relative to exporting, but may diminish them relative to licensing. She shows that stronger IPRs have a positive effect on both FDI and licensing, especially in countries with strong imitative capabilities. McDaniel (2000) suggests that *weak* IPP may be an internalization disadvantage that encourages licensing, and finds some support that the proxies for inventing around encourage licensing to substitute for FDI in Japan.

Yang and Maskus (2001b) investigate the general-equilibrium theoretical result that IPRs have an ambiguous effect on licensing.³ Although strong IPRs increases the incentives for licensing by weakening the internalization effect on FDI and increasing the royalty fees, they may tend to cause a lower overall innovation rate that decreases the rate of new technologies to be licensed. They find that stronger IPRs have a positive and statistically significant effect on both the royalty fees from unaffiliated foreigners and for the licensing of industrial processes but not on the royalty and licensing fees from affiliated subsidiaries.

The impact of IPRs on international technology transfer depend on the sector of the firm. Mansfield (1994), in a survey of 100 U.S. firms in six manufacturing industries found within particular countries there was no relationship between two different industries as to the importance of the IPR regime, but that each industry generally felt a similar dependence on IPRs for all countries. For example, the percentage of chemical firms that said IPP is too weak to

permit licensing of their latest technology was highest or second-highest among the six industries for all 14 of the developing countries listed. For the same question, the percentage of metals firms was the lowest of the six for all but one country.

VI. Industry-specific impacts of IPRs

The impact of IPRs on the innovation and diffusion of technology can be characterized by sector-specific effects. In a survey by the U.S. International Trade Commission (1988), 42% of firms (concentrated in the high-technology fields) said patents were “very important” to their business, while 27% of firms said patents were only of “moderate” importance. How firms decide between these modes is determined in large part by the salience of each potential leakage. Mansfield’s survey shows that firms in the chemicals and electronics industries are particularly sensitive to protection of intellectual property when deciding whether and how to transfer technology.

Mansfield, Schwartz, and Wagner (1981) indicate that patents have different impacts on unauthorized imitation in these industries. Using data on 48 product innovations, they show that patents increase the cost and timing of an innovation. They find that imitation costs are on average 65% of innovation costs, and that the median estimated increase due to patenting was 11%. These increases were differentiated across industry, with patents raising imitation costs by 30% in drugs, 20% in chemicals, and 7% in electronics. Using data from 37 innovations in plastics/semiconductors/pharmaceuticals, they find that patents were a prerequisite for the introduction of about one-half of product innovations, and that about 36% of R&D would not

³ Yang and Maskus (2001a)

have been invested without adequate patent protection. Market concentration delayed leakages in pharmaceuticals but shortened leakages in plastics, while R&D performed by the foreign country the imitation lag for plastics and semiconductors but did not have an effect for pharmaceuticals.

Levin et al (1987) demonstrate that these industries carry dramatically different responses to the incentives offered by patents. They survey high-level R&D executives in more than 100 manufacturing industries to see how appropriation differs across those industries. The dominant methods for new innovations are secrecy and lead time. The surveyed executives felt that patents lost much of their effectiveness due to the ability by competitors to invent around data embedded in the patent. Duplicate research, listed as independent R&D in the study, rated the highest method of inter-firm technology transfer. Survey respondents next listed licensing, then reverse engineering, then hiring R&D employees as a means of transfer. In chemicals, however, patents served as the primary method of appropriation. Overall, the sectors that gave the highest ratings to patents were: petroleum refining, drugs, plastics, inorganic chemicals, and organic chemicals.

Cohen et al (2000), in an update of the Levin survey, discuss the characteristics of R&D in the chemical industry that may explain this ambiguous dependence on patents. They stress a distinction between “discrete” product industries such as drugs, chemicals, and biotechnology, as opposed to “complex” industries such as electronics and scientific instruments, a classification introduced by Merges and Nelson (1990). The key difference involves the number of separately elements in an innovation subject to patenting. In the complex industries, patents are generally devices used to block a rival’s innovation with complementary technologies. In discrete

industries, each new innovation enjoys a unique patent, and thus patents are the dominant method of appropriation. Note that since the Levin survey, secrecy has become more important as a means of appropriation, especially for process innovations and for small firms, but secrecy lends itself *least* to RD spillovers.

VII. Conclusion

The TRIPs agreement does not appear likely to alleviate any wealth differences arising from the existing North-South technology divide. Open-economy endogenous growth models suggest a dynamic shift towards further concentration of industrial R&D in the Northern countries. While production of goods developed as an outcome of this R&D may shift to Southern countries through the actions of multinationals, empirical evidence indicates this technology transfer will not likely lead to such benefits as productivity growth in the host country. Essentially, this means that stronger IPRs lead to technology transfer that benefits the North but not the South.

These conclusions offer substantive opportunities for future research. Industrial organization theories of internalization in a closed economy are not yet directly applicable to existing theories of the multinational. Moreover, no existing research investigates the difference impacts of North-South FDI and licensing on the host countries. Such studies could prove very useful in discerning appropriate policy responses to the global technology divide.

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