4

The Global Effects of Intellectual Property Rights: Measuring What Cannot Be Seen

Despite the obvious practical importance of the question, economists did not attempt until the 1990s to assess empirically the effects of international variations in the strength of IPRs. Without such evidence, the field lay open to strong claims on both sides of the debate—a situation that remains largely true today. Thus, for example, advocates of global harmonization of strongly protective standards made powerful assertions about the trade-distorting effects of weak and variable IPRs in order to buttress the case for their inclusion in the Uruguay Round negotiations. Their opponents argued that strengthening global IPRs would cause monopolization of trade and technology transfer, leading to widespread competitive abuses. These arguments clearly were based on strong assumptions with limited systematic evidence available to support any of them. The situation was even more stark than the earlier acute shortage of information on how patent systems affect innovation and welfare, which had prompted Priest (1986, 19) to lament, "The ratio of empirical demonstration to assumption in this literature must be very close to zero."

In the last decade, a number of economists have made strenuous efforts to help close this information gap. Some analysts developed numerical indices to characterize the strength of patent rights across nations. These in turn were used to study the impact of patent regimes on international trade, FDI, and technology licensing. This chapter reviews the evidence compiled in such studies; it concludes that, in the main, the strength of IPRs is a significant and positive determinant of international commercial activity. Stronger global IPRs could enhance the dynamic efficiency with which resources are allocated internationally, which should help mitigate any adverse distributional consequences.

This literature remains young. There is much room for further work. Moreover, how IPRs affect international business specifically is not well understood by economists. Some of the evidence suggests that they may operate in subtle and indirect ways, prompting analysts to think in broad terms about how to structure IPRs within wider policy frameworks.

Measuring Intellectual Property Rights across Borders

The most fundamental task is to measure the existence and strength of IPRs on a consistent international basis. This is especially difficult; any numerical measures that claim to capture IPRs accurately are subject to sharp criticism. After all, IPRs fall into the category of general rules supporting (or hindering) the legal operation of business, along with competition policies, environmental regulations, and labor standards. Indeed, they may be compared to the characteristics underlying economic structure, such as factor endowments, infrastructure, and the judicial system. Unlike tariffs and taxes, IPRs are not readily measurable; nor do they have obvious price-based equivalents like those used to assess the restrictiveness of quotas. Complicating the picture is that, as fundamental rules governing behavior, IPRs surely interact in complex ways with other policies in reaching their full effectiveness. Thus, identical laws may have quite distinct effects in countries that differ in their market structures and preferences.

Such difficulties render impossible a full accounting of the magnitude and strength of IPRs, especially on a comparative basis; the best analysts can do is to make qualitative rankings of IPRs as measures of inputs into economic and social production. Alternatively, market outcomes, which should be correlated with the underlying laws, may be used as output measures of the stringency or effectiveness of IPRs.

Input Measures

The most sensible approach to quantifying IPRs is to conceive of them as legal entities that serve as fundamental inputs into production. Note that they are public inputs, much like public infrastructural investments, which are available to all users meeting certain legislated requirements. Thus, input measures focus on the laws in place in each country and perhaps on their enforcement as well. This context suggests three distinctive approaches.

First, the most straightforward way to assess a nation's legislation is to list its memberships in international conventions promoting IPRs. Except for the TRIPs agreement, which is a core component of the WTO,

Table 4.1 Membership trends in key intellectual property conventions (number of countries)

Convention	1985	1990	1995	1999
Paris Convention	93	99	136	155
Berne Convention	76	86	116	140
Budapest Treaty	16	23	35	46
Patent Cooperation Treaty	44	49	85	103
UPOV	17	19	29	44

UPOV = Union for the Protection of New Varieties of Plants.

Sources: World Intellectual Property Organization (1999) and UPOV (1999).

and various regional agreements on intellectual property, these conventions are maintained largely under the auspices of the World Intellectual Property Organization (WIPO). There are 23 such pacts, including the recent Copyright Treaty and Performances and Phonograms Treaty, that either establish minimum standards for members or facilitate international cooperation in registering intellectual property. The structure of these conventions has been well described elsewhere (e.g., WIPO 1988; Primo Braga 1996). Many in effect before TRIPs were criticized for advancing weak standards; none was endowed with powers of dispute settlement. These shortcomings were a significant motivation for advocates of stronger standards to incorporate intellectual property into the WTO.

Despite these problems, a country's decision to join any WIPO conventions may be taken as a signal that its laws recognize at least minimal standards, such as national treatment and minimum periods of protection. Moreover, a country that accedes to a treaty setting out cooperative registration procedures envisions enjoying not only the cost savings such arrangements might entail but also an increase in applications for protection in its own jurisdiction. Thus, membership in basic WIPO conventions has been used by a number of analysts (e.g., Ferrantino 1993) as an input measure of the strength of IPRs.

In this context, it is instructive to look at figures for membership trends in five key conventions (see table 4.1).

The Paris Convention covers industrial property of all kinds: patents, industrial designs, trademarks, geographical indications, and trade secrets. It requires national treatment as a main principle, provides for priority of application in the case of patents, marks, and designs, and sets out rules for the administration of these IPRs. After a small rise in the late 1980s, accessions to the convention mushroomed throughout the 1990s. All new members since 1985 have been developing countries and countries in transition, implying a considerable extension of the convention's

requirements into new areas.[1] While several key developing economies, including Venezuela, Singapore, India, and Chile, chose to join in the 1990s, most of the newer members are small and poor or new republics in transition. No doubt much of the increase in membership stems from the need of WTO parties to implement TRIPs, which incorporates by reference the substantive legal provisions of the Paris Convention while not requiring membership per se. In any case, at the present time global membership is comprehensive.

Similar comments pertain to the Berne Convention, which protects literary and artistic works. This convention also rests on national treatment and requires the extension of protection to nationals of all members. It enumerates in general terms the rights covered by copyright laws and exceptions to those rights, and also establishes minimum periods of protection. Membership in the Berne Convention expanded rapidly in the 1990s, indicating growing and globally comprehensive acceptance of traditional copyright protection. Again, virtually all of the new members are small developing economies and economies in transition, though China joined in 1992 and Indonesia in 1997.[2] Like the Paris Convention, substantive provisions of the Berne Convention are incorporated into TRIPs by reference.

The Budapest Treaty is an example of an international cooperative structure in patent mechanisms, in this case those for biotechnological patents. In particular, it allows the deposit of a microorganism into a recognized depositary authority to support patent applications in member nations without the need to make similar deposits with each member. The treaty, concluded in 1977, initially attracted members from only a limited number of developed economies. As biotechnological inventions have multiplied, the cost and security advantages of single deposits have attracted a rising number of developing economies, including China (1995), South Korea (1988), and South Africa (1997).

The Patent Cooperation Treaty (PCT) is also collaborative. It permits an applicant to seek patent protection for an invention in each of many countries by filing one international patent application, designating those nations in which the inventor wishes the application to have effect. A major patent office makes a single international search for prior art, which is preliminary and nonbinding on any member. Because of the considerable cost savings for the applicant and national examination authorities, membership in the PCT rose dramatically in the 1990s, to 103 countries.

Finally, the International Union for the Protection of New Varieties of Plants (UPOV), sets out minimum standards for protecting the fruits of

1. The number actually undercounts true accessions, because several, such as Brazil and Indonesia, joined the Paris Convention earlier but only quite recently adopted the amendments accepted by the 1967 Stockholm conference.

2. The United States joined the Berne Convention only in 1989.

invention in new plants.[3] Rapid technological progress in developing new seeds and hybrids has expanded global interest in such protection; membership in UPOV rose rapidly in the 1990s, again with the greater expansion coming in the latter half of the decade.

The nearly universal international membership in the Paris and Berne Conventions and the WTO requirement of adherence to TRIPS are perhaps the clearest indication that intellectual property protection is pushing forward broadly across the world. Ironically, the fact that few countries remain outside these conventions makes it difficult to use their membership decisions to proxy international differences in the strength of intellectual property protection.

Of course, dummy variables based on membership can be at best only a crude indicator of the strength of a nation's IPRs. The Paris Convention standards for patents, for example, are weak in comparison with those in developed economies and allow wide discretion in limiting patentability, issuing compulsory licenses, and setting opposition procedures. The convention simply requires countries to protect against unfair business competition without setting out procedures for doing so. The Berne Convention does not explicitly cover software; nor does it address the particular problems of other information technologies. Enforcement of standards is implicit in the conventions but effective enforcement varies from country to country, often to the point of absence. Accordingly, some analysts have attempted to capture the strength of IPRs and their enforcement more comprehensively through detailed consideration of each nation's laws. The authors in Gadbaw and Richards (1988) pioneered this effort by analyzing laws and observing enforcement efforts in seven major developing countries as of the mid-1980s. With rich description of policy variations in different functional areas of IPRs the study demonstrated that standards were decidedly weaker in developing than in industrial countries. However, the authors did not construct any comparative indices of strength in IPRs, and the limited country and period coverage precluded much systematic analysis based on their descriptions.

It is possible to use the annual National Trade Estimate Reports of the United States Trade Representative (USTR) to track changes over time in IPRs of major nations as perceived by US business interests. Table 4.2 is a rough overview of the situation as it evolved from 1986 to 1998. The descriptors chosen—weak, moderate, good, and strong—reflect the nature, frequency, and severity of the complaints issued by USTR, though such words cannot precisely describe a country's IPR laws or their enforcement. Thus, for example, while I list significant changes only in patent and copyright laws during this period, there were also changes in trade secrets regulations, plant variety protection, trademarks, and the like.

3. UPOV is a separate entity and is not administered by WIPO. The acronym UPOV derives from its French title.

Table 4.2 Qualitative trends in intellectual property protection, selected countries

Country	1986	1998	Year of major law changes
Argentina			
Laws	Weak	Moderate	Patent 1996; CR 1994
E/A	Weak	Weak	
Brazil			
Laws	Weak	Good	Patent 1997; CR 1996
E/A	Weak	Weak	
China			
Laws	Absent	Good	Patent 1993; CR 1992
E/A	Absent	Weak	
Egypt			
Laws	Weak	Moderate	CR 1994
E/A	Weak	Weak	
India			
Laws	Weak	Weak	Patent 1999; CR 1995
E/A	Weak	Moderate	
Indonesia			
Laws	Absent	Moderate	Patent 1991, 97; CR 1997
E/A	Absent	Weak	
Japan			
Laws	Good	Strong	Patent 1995; CR 1992
E/A	Weak	Good	
South Korea			
Laws	Weak	Strong	Patent 1987, 95; CR 1987, 96
E/A	Weak	Good	
Mexico			
Laws	Weak	Strong	Patent 1991; CR 1991, 93, 96
E/A	Weak	Moderate	
The Philippines			
Laws	Weak	Good	Patent 1997; CR 1997
E/A	Weak	Moderate	
Spain			
Laws	Moderate	Strong	Patent 1986, 92; CR 1987, 93
E/A	Weak	Strong	
Taiwan			
Laws	Weak	Strong	Patent 1993, 95; CR 1985, 95
E/A	Weak	Weak	
Thailand			
Laws	Weak	Good	Patent 1992, 98; CR 1995
E/A	Weak	Weak	
Turkey			
Laws	Weak	Good	Patent 1995, 99; CR 1995
E/A	Weak	Moderate	

E/A = enforcement and administration.
CR = copyright.

Source: Author's inferences from descriptions in USTR, various years.

Moreover, while a word like "moderate" is meant to convey the overall tenor of IPRs protection, it may mask considerable variation in the individual laws covering functional areas of intellectual property.

Keep in mind, finally, that the descriptions summarize the views of USTR, which accord heavy weight to treatment that is parallel to, or even stronger than, the protective standards found in the United States. A law that is "moderate" by American standards may not be unreasonable by the standards of a particular country.

The descriptions in table 4.2 leave the strong impression that the 1990s indeed saw considerable strengthening of the legal structures and enforcement mechanisms for IPRs in many countries. Moreover, the dates given represent only years in which major legislative changes were made; many of these laws continue to evolve through technical adjustments and implementation.

The countries included in the table illustrate a number of avenues toward adopting stronger IPRs. For example, Spain, which had moderate protection for industrial property in 1986, experienced high levels of piracy due to lax enforcement. However, one condition of its entry into the European Union was the adoption of laws harmonized with the (still-evolving) EU standards. Thus, in 1986 Spain revised its patent law to include pharmaceutical products (though protection was phased in only by 1992). Spain adopted the EU software directive in 1993, providing copyrights and the prospect of patents for computer programs.

Turkey resisted changing its laws for some time, but in anticipation of a free trade agreement with the EU recently enacted legislation considerably tightening industrial property rights and copyrights. Similarly, Mexico adopted laws based on highest global standards as early as 1991 and has tightened them further in the context of NAFTA. Indeed, one of the more significant aspects of current regional trade agreements between rich countries and poor countries is that the latter are expected to significantly reform their IPRs regimes.

South Korea and Taiwan are examples of countries that adopted considerably stronger IPRs in the late 1980s and early 1990s, in large part because domestic commercial interests emerged to push that agenda, though American diplomatic and trade pressures contributed.[4] Japan's prior patent procedures—which provided for pregrant opposition, were subject to lengthy delays, and encouraged "patent flooding"—were long an irritant to US multinational enterprises (MNEs). Extensive bilateral discussions led to an agreement in 1994 under which Japan shifted the emphasis of its patent system toward promoting innovation and reduced examination terms.

Argentina, Brazil, the Philippines, and Thailand engineered notable strengthening in their laws only recently. Argentina's 1996 patent law

4. Ryan (1998, chapter 4), provides a trenchant discussion.

revision, since enhanced, retained significant limitations on patentability and patent scope. Brazil has adopted stronger laws in anticipation of meeting its TRIPs requirements. Both countries extended copyright protection to software, though allowing liberal decompilation. The Philippines, despite considerable American pressure throughout the decade, adopted major legislative changes only in 1997, also responding to TRIPs obligations. Thailand's policy evolution was similar. All four of these nations continue to experience significant piracy in copyright and trademark goods. For its part, Egypt updated its copyright law in 1994 and undertook a number of publicized raids on unauthorized distributors of software and electronic entertainment products. However, piracy remains a significant problem and Egypt has yet to update its patent law.

China eagerly embraced IPRs reform in this decade. Beginning from a situation of near absence, China erected laws covering patents (including pharmaceutical patents), trademarks, integrated circuits, plant varieties, unfair competition, and copyrights (LaCroix and Konan 1998; Maskus, Dougherty, and Mertha 1998). China joined nearly all the major international IPR conventions and is also now a member of international procedural treaties on the classification of patents and trademarks and the deposit of microorganisms. The country must make further minor revisions to conform to TRIPs but those revisions are under consideration. China has also made considerable progress in establishing education and training programs in IPRs and in upgrading its administrative and legal enforcement systems. Nonetheless the economy continues to experience massive product counterfeiting, suggesting that enforcement has a long way to go.

Indian law conforms with TRIPs in copyrights and trademarks but is weak in patents. The 1999 revisions to the Indian patent law, passed over considerable and lengthy opposition, meet current transition requirements but remain short of ultimate TRIPs standards. Indonesia's reforms have progressed to the point where legal systems provide moderate coverage of IPRs, though administration of the system remains in its infancy and there are endemic enforcement problems. Looking at the table as a whole, it is no surprise that as the decade ended, the lowest-income economies—India, Indonesia, and Egypt—retained the weakest protection.

Such qualitative descriptions are informative but of limited use for comparisons of large numbers of countries or for statistical analysis. Several researchers have thus undertaken a close analysis of the components of legal structures in order to develop numerical indices of IPRs strength.

The first cross-country index was developed by Rapp and Rozek (RR) (1990). They consulted the legal texts of each country's patent laws and made a rough assessment of their conformity with the minimum standards proposed as guidelines by the US Chamber of Commerce (1987). Their approach considered only the presence or absence of particular features of patent laws, such as working requirements, compulsory licenses, and product patents for pharmaceuticals. It did not consider enforcement ef-

Table 4.3 Indices of the strength of IPRs laws

	RR 1984	GP 1985	GP 1990	GP 1995
Full sample				
N	116	108	109	116
Average	2.90	2.44	2.45*	2.73*
Median	3	2.52	2.52	2.71
CV	0.49	0.39	0.40	0.32
Increases	n.a.	n.a.	9	34
Decreases	—	n.a.	4	3
High-income				
N	27	26	28	30
Average	4.14	3.37	3.43*	3.70*
Median	4	3.32	3.32	3.86
CV	0.26	0.19	0.23	0.17
Increases	n.a.	n.a.	5	15
Decreases	n.a.	n.a.	1	1
Mid-income				
N	33	27	27	34
Average	2.62	2.24	2.29*	2.54*
Median	2	2.26	2.01	2.61
CV	0.41	0.29	0.30	0.23
Increases	n.a.	n.a.	2	13
Decreases	n.a.	n.a.	2	1
Low-income				
N	56	55	54	52
Average	2.46	2.11	2.12*	2.33*
Median	2	2.41	2.41	2.57
CV	0.56	0.44	0.44	0.33
Increases	n.a.	n.a.	2	6
Decreases	n.a.	n.a.	1	1

RR = Rapp and Rozek.
GP = Ginarte and Park.
N = Number of countries.
CV = Coefficient of variation.
n.a. = non-applicable.
*Average scores are computed for an unchanged set of nations between adjoining years.

Sources: Adapted from Rapp and Rozek (1990), Ginarte and Park (1997), and data provided by Park.

fort or effectiveness. Their scale ranged from zero, signifying the absence of a patent law, to five, indicating full conformity with minimum standards. The index was therefore subjective, with each unit increase attempting to capture differences in a large range of complex legal issues.

The first column of table 4.3 provides summary statistics on the RR index for 116 countries in 1984. High-income economies are those with real per capita GDP levels above US $7,000, using 1985 data, taken from the Penn World Tables, for purchasing-power-parity adjusted incomes. Middle-income economies have real per capita GDP levels between $2,500 and $7,000; low-income economies have incomes below $2,500.

It is immediately evident that the strength of patent rights rises with per capita income, though the increase in the average from the low-

income to the middle-income economies is not large relative to the rise from middle-income to high-income countries. This point is explored further in the next section. Moreover, as income levels rise, variation in patent rights falls, as evidenced by the lower coefficients of variation (CV) for richer countries.

The RR approach was extended significantly by Ginarte and Park (1997). They examined the patent laws of a comprehensive number of countries quinquennially from 1960 to 1990, considering five components of the laws: duration of protection, extent of coverage, membership in international patent agreements, provisions for loss of protection, and enforcement measures.[5] Each component was further broken down into important characteristics determining its effective strength. For example, patent coverage refers to the patentability of pharmaceutical products and chemical products and to the existence of utility models. Enforcement measures included the availability of preliminary injunctions, contributory infringement actions, and reversals of the burden of proof in process patent cases. (The authors made no attempt to assess how well the laws in fact were enforced.) Each of these subcomponents was assigned a value of one if present and zero if absent, with the component score being the sum of these values as a percentage of the maximum value. Thus, the minimum possible national score was 0.0 and the maximum was 5.0. Although each subcomponent was binary, the aggregate score was more continuous than the unit-increment approach in the RR index. Thus, the Ginarte and Park index (GP index) is more nuanced to reflect variations in patent laws. Moreover, its computation for different years permits analysis of the index over time.

The GP index is summarized in the final three columns of table 4.3. I present figures for 1985, 1990, and 1995 because of the interest here in recent changes in IPRs. The index averaged 2.44 for all countries in 1985, indicating that roughly half the various subcomponents in patent rights were available in the average nation. Again, the high-income economies had indices that were both considerably higher and less variable than those of the middle-income and low-income economies. Further, the increase in average protection from poor countries to middle-income countries was much less than that from the next progression in incomes.

The late 1980s saw little effective increase in the strength of patent laws, according to the GP index. For example, both the mean and median scores increased almost imperceptibly between 1985 and 1990 across the full sample.[6] While nine countries increased their protection, four weakened

5. These data have now been updated to 1995 and were kindly provided by Walter Park.

6. In the table, the average scores refer to an unchanged set of countries between 1985 and 1990 and between 1990 and 1995 to avoid confusion arising from entry or exit of nations into the database.

their patent laws. Within the high-income economies, the average index rose from 3.37 in 1985 to 3.43 in 1990, suggesting an average increase of 1.5 percent in the index among wealthy countries. Nonetheless, one country (Belgium) in this group registered a reduction in its patent score. Among the middle-income countries, the average index rose from 2.24 to 2.29, or 2.2 percent. Two countries (Mexico and South Korea) strengthened their laws and two (Malaysia and Greece) weakened them. Among the low-income economies there was little improvement in patent laws, with the average index rising only from 2.11 to 2.12, or 0.5 percent. The indices of two nations (Guatemala and Benin) went up while that of one (India) went down.

The GP index for 1995 indicates that there was considerably more strengthening of patent laws in the 1990s than earlier. Of the 109 countries in the sample for both 1990 and 1995, fully 34 engineered more protective patent regulations; 15 of these were high-income countries and 13 middle-income countries. Six of the low-income economies saw rising indices. Across the groups, the average percentage increases in the mean indices were 7.9 percent (high-income), 10.9 percent (middle-income), and 9.9 percent (low-income). From this evidence it appears that in the 1990s many poor and medium-income nations were induced to strengthen their IPRs, whether for internal economic reasons, because of external pressure, or both. Middle-income countries raising their standards were Argentina, Brazil, Chile, South Korea, Malaysia, Mexico, Thailand, and Venezuela, among others.[7]

A final approach to measuring IPRs regimes as inputs into production is to survey MNE managers, who likely are aware of effective differences in systems across countries. These surveys typically ask for the respondents' views on the adequacy of local intellectual property protection. Accordingly, they pay considerably less attention to the structure of laws and considerably more attention to how effectively the laws may be used to protect technological information. Thus, respondents rank their views of patents, trademarks, trade secrets, and copyrights in the aggregate, including not only how the laws operate but also how well they may be enforced. While such surveys are crude in that they ignore technical aspects of the law, they are informative in terms of perceived effectiveness. Unlike indices based on laws, however, the responses likely are endogenous to a host of issues that may not be closely related to IPRs, such as market structure and growth prospects in each country. They also depend on the sensitivity of the firms sampled to IPRs protection, which could vary over time. Thus, they must be treated with caution.

7. I should call attention also to the index developed by Sherwood (1997), who developed a subjective assessment of several components of IPRs, including patents, trademarks, trade secrets, protection of new life forms, copyrights, treaty adherence, and enforcement and administration, in 18 developing countries as of the mid-1990s. Another index was constructed for 33 countries by Kondo (1995).

Table 4.4 Survey indices of perceived strength of IPRs

Country	1990	1995	Percent change
Industrial countries (selected)			
USA	69.2	80.80	16.8
Japan	70.2	66.3	–5.6
Canada	58.4	72.3	23.8
Germany	70.6	78.9	11.8
France	67.2	72.9	8.5
Spain	40.4	58.1	43.8
United Kingdom	59.7	74.4	24.7
Average of 21	*59.0*	*70.5*	*19.4*
Developing countries			
Brazil	36.3	35.3	–2.9
Hong Kong	52.1	63.1	21.1
India	44.3	40.6	–8.4
Indonesia	35.4	45.3	27.9
South Korea	57.1	54.2	–5.1
Malaysia	52.1	62.0	19.0
Mexico	42.0	56.1	33.6
Singapore	71.9	78.8	9.6
Taiwan	53.9	63.8	18.4
Turkey	35.8	25.3	–29.3
Venezuela	32.5	32.1	–1.2
Average of 11	*46.7*	*50.6*	*8.4*
Other developing countries			
Argentina		47.1	
Chile		61.8	
China		33.6	
Egypt		60.0	
The Philippines		37.3	
Russia		15.8	
Thailand		52.1	

Source: World Economic Forum, *World Competitiveness Report* (various issues).

The most familiar survey measure is published by the World Economic Forum in its annual *World Competitiveness Report*. Respondents are asked to provide a subjective answer to the question of whether IPRs in each country are adequate to meet their needs for security and exploitation of proprietary technical information. The answers are compiled into a numerical index ranging from zero to 100, with higher numbers indicating stronger faith in the system of IPRs.

Table 4.4 lists indices for selected countries for the years 1990 and 1995.[8] The most striking aspect of these figures is that MNE managers consider that developed economies have done more to strengthen intellectual property protection than developing economies. Canada's decision to phase out compulsory licenses in pharmaceuticals, for example, seems largely responsible for the 24 percent rise in its index, while Spain's

8. Intellectual property entered the survey in 1989.

adherence to EU standards explains the 44 percent rise in its measure. For 21 industrial countries, the average perceived rise in IPRs protection was 19 percent.

In contrast, for 11 developing countries the average perceived rise was 8.4 percent. Policy in Mexico, Indonesia, Hong Kong, and Taiwan was seen as becoming markedly more protective of foreign intellectual property in this period. However, perceived conditions of protection in Turkey deteriorated significantly in the early 1990s, while Brazil and Korea registered small declines. Thus, it appears that, from the standpoint of MNEs, the ability to protect IPRs improved considerably in the early 1990s in the industrial countries, but considerably less on average in developing economies.

The third section of the table shows the indices for certain developing countries in 1995. By this measure, Chile and Egypt provide relatively strong protection, while Russia, China, and the Philippines do not. Russia's laws are adequate but their enforcement is nil (USTR 1999). China is in a similar position, though perceptions of its protection may be improving: China's index rose by 13 percent between 1994 and 1995.

In summary, together the various measures discussed permit us to draw some conclusions with reasonable confidence:

1. Standards for protecting intellectual property have increased globally, with much of that strengthening coming in the 1990s. Legal reforms in a number of countries, such as Mexico, Taiwan, Thailand, and China, have been especially marked. In many countries such reforms emerged only in the late 1990s, with their adoption mandated by the TRIPs agreement.
2. Enforcement efforts in developing countries tend to lag significantly behind legislative changes.
3. High-income economies continue to strengthen their IPRs. Indeed, it is difficult to determine whether standards in developed and developing economies are converging or diverging, even as minimum standards rise virtually everywhere. This seems especially evident from the survey responses summarized in table 4.4, where on average perceived IPRs protection in the industrial countries rose faster than in developing countries.

While these inferences are reasonable, given various shortcomings the measures discussed here must be treated with caution. Moreover, there are troubling discrepancies among the measures. For example, the qualitative passages in USTR (1999) are laudatory of the modern structure of Mexico's IPRs laws, but the Mexican GP index for 1995 (2.52) remains no higher than the average for middle-income developing countries. Nonetheless, the index rose by 55 percent, which is consistent with the large

Table 4.5 Estimated rates of software piracy and lost revenues

	1994		1998	
	Piracy Rate (percent)	Revenues ($mil.)	Piracy Rate (percent)	Revenues ($mil.)
North America	**32**	**3,931**	**26**	**3,196**
USA	31	3,590	25	2,875
Western Europe	**52**	**2,783**	**36**	**2,760**
Germany	48	671	28	479
Spain	77	191	57	235
Eastern Europe	**85**	**1,101**	**76**	**640**
Russia	95	516	92	273
Latin America	**78**	**981**	**62**	**978**
Brazil	77	294	61	395
Guatemala	94	9	85	9
Mexico	78	192	59	133
Asia/Pacific	**68**	**3,145**	**49**	**2,955**
China	97	364	95	1,193
Japan	66	1,400	31	597
South Korea	75	511	64	198
Thailand	87	68	82	49
Middle East/Africa	**80**	**406**	**63**	**380**
Egypt	84	8	85	11
World Total	**49**	**12,347**	**38**	**10,977**

Source: BSA/SIIA (1999).

increase between 1990 and 1995 in the perceived strength of Mexican IPRs put forward by survey respondents in *World Competitiveness Report*. Thus, despite the differences in approach, there is broad agreement across these measures.

Output Measures

Some analysts attempt to assess IPRs by considering outcomes that may correlate with the underlying effectiveness of intellectual property regimes. The most common approach is to estimate the extent to which rights are violated in different countries. For example, the Business Software Alliance and the Software and Information Industry Association (BSA/SIIA; 1999) publish estimates garnered from their member firms about the degree of copyright infringement in key nations. Similarly, the International Intellectual Property Association (IIPA; 1999) compiles estimates of piracy rates and revenue losses in motion pictures, recorded music, and software for those countries it recommends to receive designations from USTR under the "Special 301" provisions.

Table 4.5 lists estimated piracy rates and revenue losses for US software firms in various regions and countries in 1994 and 1998. The methodology

for estimating revenue losses is simplistic: Firms are asked to report the level of pirated software sales, through any medium, they believe to exist. These sales are considered to displace US revenues, regardless of how markets would react to price and structural changes if copyrights were stronger. In this sense, the estimated revenue losses are excessive, though it is impossible to know by how much. Moreover, the estimated revenue losses are sensitive to business conditions. For example, piracy losses in South Korea are reported to have fallen precipitously by 1998, but this is related foremost to slackening demand there.

Subject to such caveats, the reported figures can be instructive. American software firms claimed that globally they lost over $12 billion in sales in 1994 and nearly $11 billion in 1998. The United States is not impervious to piracy. In 1998, 25 percent of software copies put into use here were obtained without copyright authorization; the associated revenue losses were the largest of any country. The period from 1994 to 1998 saw declining piracy rates in most countries, with the overall rate falling from 49 percent to 38 percent. Rates remain high in Russia, China, and Egypt, where unauthorized duplication is endemic. Clearly, piracy rates vary negatively with economic development: higher-income economies, which tend also to be the major software producers, have strong interests in vigorous protection and awareness campaigns.

Similar measures in trademarks and patents are more difficult to come by. Because patent coverage and scope vary widely from nation to nation, it is rarely clear whether particular business actions should be adjudged infringements, which they might be under US law but not in another national jurisdiction. To get an idea of the complexities involved in pharmaceutical patenting, for example, consider the submission of the Pharmaceutical Research and Manufacturers' Association (PhRMA 1999a) to USTR regarding "Special 301" designations. India and Argentina were listed as priority foreign countries largely due to deficiencies in patent coverage. PhRMA tentatively estimated its member firms' annual sales losses to be some $500 million in India and $600 million in Argentina. South Korea was also listed in this category, mainly because of trade barriers and administrative deficiencies in the patent regime, with an estimated sales loss of $500 million. South Africa was placed on this list because its new Medicines Act significantly weakens effective protection of patented pharmaceutical products through aggressive pricing regulations and compulsory licenses. Complaints about other nations included failure to provide retroactive patents (Canada, no estimated damages), discriminatory marketing rights and price controls (China, damages of $1.4 billion), and inadequate treatment of foreign test data along with price regulation (Japan, damages of over $2.5 billion). The report claims that the policies it targets are current or likely violations of TRIPs obligations, an interpretation that must await dispute settlement procedures.

As suggested, estimated rates of copyright, trademark, and patent infringement might be indirect measures of the strength of IPRs if the analyst believes they correlate strongly with weakness in the laws and enforcement. This is true, other things being equal—but unfortunately other things may not be equal. Copyright infringement depends not only on laxity of enforcement, for example, but also on local business conditions, pricing strategies of rights owners, and cultural preferences. In this context, law-based measures are likely more suitable for analytical use.

While these various measures leave much to be desired as indicators of the true strength of IPRs, they are the best available. One reason for using them is to investigate whether their measures of IPRs may be fruitful for analytical work. Two general questions emerge, one relating to IPRs as endogenous policy variables, and the other to IPRs as determinants of economic activity. Thus, economists have analyzed both the cross-country determinants of the strength of patent rights and the impacts of international variations in patent rights on trade, investment, and technology transfer. Because the latter impacts are critical in thinking about the likely effects of stronger global IPRs, they dominate much of the attention in this chapter.

Determinants of Intellectual Property Rights

It is obvious from the figures already given that IPRs tend to strengthen as economic development and incomes rise. That optimal protection of intellectual property is an increasing function of income and technological capacity is easy to explain. As incomes rise, the demand for higher-quality, differentiated products also rises, leading to growing preferences for protection of trademarks and copyrights or, in political economy terms, an increase in the supply of IPRs. As an economy's technological sophistication increases, inventors and creators require stronger protection for their works; thus, demand for IPRs rises. Of course, causation may go both ways, with stronger property rights also contributing to growth in incomes. The latter point remains subject to debate, being not yet well understood in empirical terms. I elaborate these points in chapter 5 on IPRs and economic development.

That IPRs are positively correlated with real GNP per capita was first demonstrated by Maskus and Penubarti (1995), using the RR index,[9] though they corrected it for two econometric problems. First, because the index is subjective, there is significant potential for measurement error. For example, a number of poor nations, such as Ghana and Nigeria, have strong laws on paper because they were British colonies and modeled their

9. Rapp and Rozek (1990) chose to use their index as an explanatory variable in an analysis of income levels; they were not concerned with the opposite causation.

regimes on the United Kingdom Patents Act. However, enforcement difficulties significantly reduce the effective strength of patents in those countries. (This problem may not be of much consequence because few foreign firms are likely to apply for patents in such small markets.)[10] Second, an adjustment problem arises because levels of economic development and trade flows may influence the structure of patent laws and their enforcement.

Maskus and Penubarti used instrumental variables to try to purge the raw RR patent index of these problems. The instruments included prior indicators of the level of economic development (GDP per capita, primary exports as a share of total exports, infant mortality rate, and secondary enrollment ratios for 1965, 19 years prior to 1984, the year of the patent index). They also used dummy variables for former British and French colonies and alternative measures of intellectual property protection, which were highly correlated with patent strength yet presumably were not correlated with trade-regression error terms. Using the instruments to predict patent strength resulted in a corrected index with continuous values from 0.9 to 5.3 (as opposed to the incremental raw index with integral values from 0 to 5). It is worth noting that their approach found that GDP per capita and the secondary enrollment ratio (a proxy for prior human capital development) were strongly positive determinants of this index, as were the dummy variables for colonial identity. While this index was adjusted, it still does not necessarily represent the optimal structure of patent rights.

Figure 4.1 plots the relationship between the corrected patent index, on the vertical axis, and the natural log of real GNP per capita ("income"), on the horizontal axis. Recall that these data are for 1984. A simple regression of the index on current income resulted in this relationship:

$$\text{PATENT}^* = -0.51 + 0.49\log(\text{INCOME}) \quad R^2 = 0.37.$$

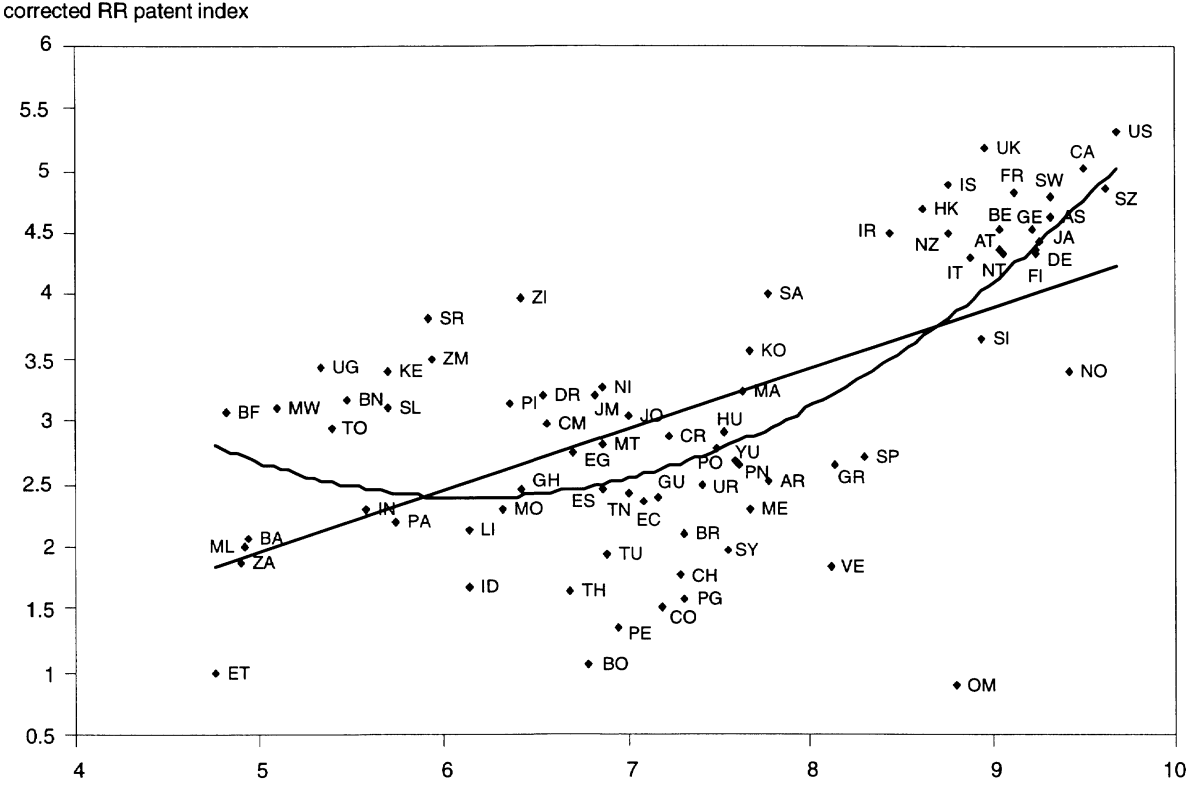
Both coefficients were highly significant statistically. Thus, as real income rises, there is a corresponding increase in patent strength across countries. The calculation suggests that as income rises by $1,000 (a 29 percent increase evaluated at the sample mean), the patent index would become higher by 0.14 units (a 4.5 percent increase). Income alone is capable of explaining 37 percent of the variation in corrected international patent rights.

Figure 4.1 actually suggests that patent rights decline as incomes rise from low levels, then accelerate sharply toward the highest income levels. Thus, there seems to be a quadratic relationship between IPRs and GNP per capita, estimation of which resulted in this equation:

$$\text{PATENT}^* = 10.5 - 2.63\log(\text{INCOME}) + 0.21[\log(\text{INCOME})]^2 \quad R^2 = 0.50.$$

10. I am grateful to Jayashree Watal for pointing this out.

Figure 4.1 Relationship between patent rights and per capita GNP



* = natural logarithm of per capita GNP.
Note: GNP measured in $1000s of 1984 US $s.

Sources: Maskus and Penubarti (1995) and author's calculations.

Adding the squared term lets income explain 50 percent of the variation in IPRs across countries. This specification strongly suggests that countries tend to weaken their patent laws as incomes begin to rise and then strengthen them after a certain point. This U-shaped curve is reminiscent of the "environmental Kuznets curve," which indicated that countries reduce their environmental standards up to some level of per capita income and then raise them continuously after that point (Grossman and Krueger 1993). The plot is shown in figure 4.1. It is interesting that the curve reaches its minimum at log(INCOME) = 6.26, which translates into a per capita GNP of only $523 in 1984. This income level exceeded those of only the 17 poorest nations in the data sample. Somewhat surprisingly, then, accounting for lagged determinants of patent strength, it seems that only for quite poor nations is protection weakened as incomes rise before it rises again. At the same time, it would require a per capita income of $2,750 [log(INCOME) = 7.92] for protection levels to return to the level for a per capita income of $100. In 1984 $2,750 was higher than the per capita income of Argentina, Turkey, Yugoslavia, Brazil, South Korea, Malaysia, and Mexico, as well as other middle-income industrializing economies.

It is interesting to update and extend this analysis. Ginarte and Park (1997) provide an econometric analysis of the determinants of their patent index using a panel of 48 countries for the years 1965, 1975, 1985, and 1990. They relate these patent indices to lagged values of several determinants, among them real GDP per capita, research and development (R&D) expenditures as a proportion of GDP, secondary school enrollment ratios, the Sachs-Warner (1995) dummy variable for an economy's openness to trade, the Barro-Lee (1994) index of political rights, and the Johnson-Sheehy (1995) index of market freedom.

Results from Ginarte and Park's ordinary least squares (OLS) regressions are presented in the first two columns of table 4.6. All variables are in logs except for dummy variables; standard errors of coefficients are listed in parentheses. Ginarte and Park initially ran the log of their index on the log of real per capita GDP, finding a positive and highly significant coefficient over their full sample. However, upon adding other determinants of patent rights, determinants that also influence income levels, they found that while the coefficient on GDP per capita becomes insignificant, there are strong positive impacts from the lagged R&D ratio, trade openness, and the index of market freedom. Human capital, as proxied by the lagged secondary school enrollment ratio, is positive but only marginally significant. Thus, their results seem to suggest that the determination of patent rights is driven in part by the demand for protection because countries with higher R&D intensities and human capital inputs have higher indices.

Their results also suggest that trade openness and market freedom (an index designed to measure how well governments abstain from market interference) expand patent rights. The effect on trade openness is

Table 4.6 Determinants of Ginarte-Park Patent Rights Index

	GP		Maskus	
Variable	**(1)**	**(2)**	**(1)**	**(2)**
Intercept	–1.06* (0.20)	0.68* (0.33)	13.61* (2.09)	10.76* (2.47)
GDP per capita	0.23* (0.03)	-0.03 (0.04)	–3.38* (0.53)	–2.58* (0.64)
(GDP per capita)^2			0.22* (0.03)	0.17* (0.04)
R&D/GDP		0.08* (0.02)		
School		0.06 (0.04)		-0.01 (0.08)
Political freedom		0.07 (0.06)		
Openness		0.10* (0.05)		0.06 (0.08)
Market freedom		0.52* (0.09)		
GDP				–0.01 (–0.67)
S&E/LF				0.08* (0.03)
UKCOL				0.23* (0.07)
FCOL				0.33* (0.13)
Number of observations	192	192	144	144
Adjusted R^2	0.31	0.51	0.33	0.37

(1) and (2) = different specification of regression equations.
S&E/LF = proportion of scientists and engineers in the labor force.
UKCOL = dummy variable for former colonies of the UK.
FCOL = dummy variable for former colonies of France.
* = Indicates significance at 5 percent or lower.
Notes: Standard errors are in parentheses.
Variables are in logs except dummies. Equations estimated by OLS.

intriguing, though difficult to interpret. It could be that citizens are willing to provide more protection in open economies because IPRs help preserve greater consumer choice. It could also be that more open economies find that trade interacts positively with innovative effort, raising the demand for intellectual property protection. (I will return to this in later sections.) Finally, it may be that more open economies could be more susceptible to American pressure for reform.

It is informative to extend the Ginarte-Park analysis in two ways. First, I apply the GP index to specifications similar to the Maskus-Penubarti study. Second, in order to focus on a more recent time period, I perform regressions using a panel of 72 countries in the years 1985 and 1990 rather than the 48 countries in the Ginarte-Park study. Looking at the later years makes it possible to collect data for the R&D variable for additional countries. These figures were taken from the annual UNESCO *Statistical Yearbooks*, supplemented by data on the number of scientists and engineers employed as a percentage of the labor force. Following Ginarte and Park, independent variables were lagged five years to reduce problems with adjustment.

The first specification, listed in the third column of table 4.6, mirrors the quadratic estimation discussed above on the RR index, but it is performed on the raw GP data. It again supports the inverted-U story. Clearly such a specification is simplistic. Thus, I add further explanatory variables that account for other influences on patent rights. One of these is size of the economy as measured by real GDP. It could be hypothesized that countries do not begin to provide strong IPRs until they reach a certain size, because there are fixed costs in organizing and administering a patent system.

In the regression in the final column, market size has no detectable impact on patent rights. This finding is potentially important in policy terms. It suggests that GDP itself is not a determinant of IPRs reform, as opposed to per capita income and economic development. Because US trade authorities are concerned with the strength of IPRs protection in large but poor economies, such as India and China, they have mounted considerable pressure for change. This finding suggests that, despite such pressure, effective patent rights may remain limited until incomes grow well beyond current levels. In other words, the higher standards required by TRIPs may well command limited enforcement attention in many nations.

The school enrollment ratio is not significant, perhaps because published secondary enrollment figures mask huge differences in actual human capital formation. However, the proportion of scientists and engineers in the labor force has a strongly positive impact on the GP index, again suggesting that as economies devote more resources to inventive activity, the demand for intellectual property protection grows. Finally, the dummies for countries that are former colonies of Britain and France are strongly significant.[11]

The notable feature here is that, even controlling for other influences, the inverted-U relationship between patent strength and lagged real per

11. In principle, it would be beneficial to include country fixed effects to control even more tightly for unmeasured, idiosyncratic national factors influencing patent rights. However, such an approach would be difficult with only two years of data.

Table 4.7 1985 income levels and 1990 predicted patent indices

Country	Income	GP Predicted*	GP Actual
India	763	2.21	1.48
Ghana	922	2.09	2.90
Nigeria	1,199	1.98	3.05
Indonesia	1,253	1.97	0.33
Egypt	1,574	1.91	1.99
The Philippines	1,871	1.90	2.67
Thailand	2,149	1.90	1.85
Turkey	2,851	1.94	1.80
South Korea	3,122	1.97	3.94
Malaysia	3,778	2.04	2.37
Brazil	4,249	2.10	1.85
Mexico	5,708	2.30	1.63
Spain	7,496	2.57	3.62
Japan	10,289	3.02	3.94
Italy	10,442	3.04	4.05
USA	15,101	3.84	4.52

* = value of GP Index predicted by the final regression equation in table 4.6.
Note: For all countries, the patent index is computed assuming they were not British or French colonies. Income is measured in US dollars.

Source: Author's calculations.

capita income remains intact. Indeed, the coefficients are similar to those reported for the corrected RR index, except that the coefficient on squared GDP per capita is somewhat lower. This difference actually shifts the parabola to the right in the range of low and middle incomes. As a result, the income at which patent protection becomes weakest is approximately $2,000 per capita in 1985 international dollars. Moreover, the expected patent index is the same for economies with per capita GDP of $500 and $7,750, implying a significant range of income variation before protection becomes stronger.

To illustrate these findings, in table 4.7 I list several countries, their income levels in 1985, and their anticipated and actual GP patent rights indices in 1990. In order to preserve the quadratic ranking across income levels, I compute the predicted indices from the final regression equation in table 4.6 but assume that each country was not a British colony. Colonial status does matter: the actual indices for Ghana and Nigeria considerably exceed their predicted levels. India has been more aggressive in weakening patent rights in food products and pharmaceuticals despite its former status as a colony.

Observe that the predicted GP indices fall as incomes rise through Thailand, then at higher income levels begin to rise. In most middle-income economies, actual protection in 1985 lags behind that anticipated,

as illustrated by Turkey, Brazil, and Mexico. The significant later strengthening of IPRs in the 1990s in Brazil and Mexico surely stemmed in part from indigenous interests in tighter protection. In contrast, Malaysia and South Korea adopted laws by 1990 that seemed stronger than warranted by their 1985 incomes. Spain's accession to the EU also succeeded in raising its patent rights above the predicted level.

The high-income economies uniformly have actual protection levels stronger than the model predicts. It seems likely, therefore, that the simple specification set out here misses important influences on IPRs that rise cumulatively with income. Unfortunately, the dynamics cannot readily be captured with available data.

This analysis has aimed at explaining the determinants of patent laws —input measures, in our terminology. To conclude this section one study should be mentioned that considers an output measure, software piracy rates, as an endogenous variable. Marron and Steel (2000) regressed software piracy rates, averaged over 1994-96, on per capita GDP and a variety of other determinants. They found that piracy rates are negatively related to income levels, a general measure of the strength of contracts, and an index designed to measure the power of individualism in the culture relative to collectivism. An individualistic culture, they claimed, would likely have a stronger need for property rights to avoid collective coercion or misappropriation. Their results are at best questionable, in part because output measures may not provide accurate indications of underlying IPRs. Nonetheless, the study is noteworthy for introducing culture into the determination of property rights.

The Effects of IPRs on International Economic Activity

One essential reason for developing such measures is to use them in analyzing whether the strength of IPRs has detectable effects on economic activity. My main concern is to look at international economic transactions—international trade in goods, foreign direct investment, and licensing contracts—–because they are the subject of considerable debate, and hope, about the effects of stronger global property rights. Clearly, however, IPRs have wider effects—on innovation, market structure, pricing, and economic development, issues I turn to in the next chapter.

Recent empirical analysis tells us much about the international effects of variations in IPRs. I am reasonably confident in the conclusions reached here, while cognizant that much more work could be done to refine the information, given the numerous shortcomings of the available measures of IPRs. Counting the number of legal provisions in a country's regime is informative but cannot readily capture the prevailing business climate within which IPRs operate. Moreover, by their nature, IPRs are territorial

and aggregated. Laws covering patents, trademarks, confidential information, and copyrights apply equally to all sectors and all competitors. Thus, a national aggregate index of the strength of patents, for example, cannot convey the differential impacts they might have across industries and between foreign and domestic enterprises. For such reasons, I advise caution in considering the following.

Are IPRs Trade-Related?

Intellectual property rights originally entered the Uruguay Round negotiations on the grounds that weak and variable standards distort international trade flows and interfere with global economic efficiency. If that were true, IPRs could be labeled "trade-related" and included in the WTO. However, because it is impossible simply to discipline the associated trade distortion, an agreement to modify IPRs regimes themselves was required. These notions gave the ultimate TRIPs agreement both its name and its extensive structure.

That limited protection could distort trade is clear. For example, weakly enforced copyrights generate incentives for domestic firms to copy foreign software and entertainment products, thereby displacing imports with home production. Weak border enforcement could expand trade by indirectly subsidizing exports of imitative products from an infringing country. Weak standards could be associated either with lower or higher trade, depending on demand and on the abilities of other countries to prevent infringing trade.

Suppose a firm in a developing country is awarded a trademark that is registered abroad by another enterprise and widely recognized. The first firm could use its trademark to (1) preclude imports of products from the foreign trademark owner or (2) raise the owner's trade costs, thereby limiting trade opportunities. Similarly, working requirements that mandate local production can reduce trade; on the other hand, requirements recognizing imports as working could induce more imports than the patent owner would choose in their absence.

Highly protective IPRs could also deter legitimate trade or, alternatively, facilitate collusive behavior that would limit competition through trade. Such measures may also be applied in a discriminatory and strategic fashion, as was the case with Section 337 in US trade law (Mutti and Yeung 1997).

Note also the possibility that foreign exporters could alter their behavior in reaction to IPRs policies in importing countries: a firm might decide to exploit a market through exports where it would normally choose to license its technology for local production. The decision could be based on limited trade secrets protection in the import market, where licensing could risk unauthorized loss of proprietary information.

The linkages between trade and IPRs may have important dynamic aspects. In principle, patents directly affect growth through incentives to innovate and to transfer technology. One primary channel through which firms earn returns to invention is international trade with different markets. Variable patent systems would present an array of policy parameters that exporters must take into account in setting trade decisions. Therefore, patent regimes could be an important factor in the relationship between trade and growth (Segerstrom, Anant, and Dinopolous 1990; Taylor 1994; Frankel and Romer 1999).

This wide menu of possibilities demonstrates that trade could be affected by IPRs. It also raises the problem that the meaning of "trade distortion" is inherently ambiguous in the intellectual property context. It is as true in the international arena as domestically that IPRs are second-best solutions to dual static and dynamic market failures. The optimal pattern of production and trade is generally unknown, which makes the normative problem quite different from an analysis of tariffs and quotas. In particular, which standards introduce distortions and which standards correct them varies by circumstance. Empirical analysis to date has therefore posed only the narrower positive question of whether the global distribution of trade depends on an importing nation's system of IPRs.

Identifying how IPRs affect international trade is empirically difficult for many reasons:

- The strength of patents and trademarks will be embedded in the prices at which goods are traded; these price effects cannot be separated from other components of pricing behavior.
- Firms owning a new product or process decide to export to a particular market as they are deciding whether to service markets through FDI or licensing.
- The essence of IPRs is to create market power in the distribution of new goods and technologies, implying that the choice of market structure matters for the analysis.

To illustrate these problems and to facilitate a review of this evidence, I create a simple verbal model of a price-discriminating firm considering the distribution of a patentable or trademarked good to various countries.[12] Consider how patent laws affect trade: weak patent systems do not necessarily deprive innovative firms of all market power because local imitation is costly and takes time, though such costs vary considerably by sector. Further, strong patents do not generally create a full monopoly on

12. This discussion draws on Maskus and Penubarti (1997), who provide further analysis.

a new product, because legitimate substitute products are likely to be on the market. In theoretical terms, therefore, a static model with a dominant foreign firm facing a local competitive fringe makes sense. Assume also that markets are segmented by trade costs or restrictions on parallel trade, allowing the firm to discriminate in price decisions.

In this context, it is easily shown that strengthening the patent regime has an ambiguous impact on the dominant firm's decision to export to a country. The most straightforward reason for the ambiguity is that there is a trade-off between the enhanced market power generated by stronger patents and the larger effective market size created by reduced abilities of local firms to imitate the product. The *market-power effect* reduces the elasticity of demand facing the foreign firm, permitting the firm to cut its exports to the market with stronger patents. However, the *market-expansion effect* would shift the demand curve outward and induce larger sales through export. Moreover, in larger importing markets with significant imitation capabilities, the firm would experience a *cost-reduction effect*, as the stronger patent law reduces the need to engage in costly deterrent activities (Taylor 1993).[13]

This ambiguity exists in all markets. However, as Maskus and Penubarti (1995) hypothesize, the market-expansion effect is likely to dominate in larger countries with highly competitive local imitative firms, while the market-power effect would be stronger in smaller economies with limited ability to imitate. The effects would be expected to vary by sector as well. It is worth noting that this fundamental ambiguity arises in imperfectly competitive market structures, whether they are static or dynamic.

Other factors are important in determining market responses:

First, the reactions of foreign firms to changes in IPRs cannot be considered in isolation from trade policy. It is possible, for example, that the profit-maximizing reaction of an exporter could be either to increase or decrease its volume of trade with a country that strengthens its patent law, depending on the height of the tariff. Similarly, if there is a binding quota on the product, change in the patent law cannot attract more trade. If parallel imports are allowed, the dominant firm faces a different set of competitive trade-offs in setting market prices. Finally, there are complicated interactions between patents on final goods and trade barriers on intermediate inputs.

Second, as noted earlier, the firm may face a choice of entry modes, including exports, FDI, and licensing, that would be influenced by variations in patent laws. As discussed further in the next subsection, patent reform could result in substitution effects among entry modes, in addition to the fundamental ambiguity in the market-power and market-expansion effects.

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13. Private enforcement is common in both developed and the major developing economies (Maskus, Dougherty, and Mertha 1998).

To summarize, theoretical models do not clearly predict the impacts of variable patent rights on trade volumes. Much depends on local market demand, the efficiency of imitative production, and the structure of trade barriers. Also important are the reactions of imperfectly competitive firms. Thus, a clear picture can emerge only from empirical studies.

In a pair of studies, Maskus and Penubarti (1995, 1997) estimated reduced-form equations for 1984 bilateral trade in manufacturing sectors based on the Helpman-Krugman (1985) trade model. The data set incorporated 22 exporting countries, mainly OECD members and therefore home to most of the world's MNEs, and 71 importing nations at all levels of economic development. Explanatory variables included a scaling factor, importer per capita GNP, trade restrictions in the importer, and the adjusted-corrected RR index of patent rights in the importing nations. The patent index was interacted with dummy variables for small and large developing countries in order to capture the effects of market size and technological capacity.

The results are striking. Within the group of large developing economies, which includes nearly all countries in which there have been significant complaints about weak IPRs, the strength of national patent laws exerted a significantly positive effect on bilateral manufacturing imports in many product categories. Thus, in these countries the market-expansion effect of stronger patents tends to be dominant; weak patents in large developing economies are indeed barriers to manufacturing exports from the OECD countries. The impacts were similar, though statistically weaker, in the group of small developing countries, suggesting that net market-expansion effects largely operate in these nations as well. Perhaps as anticipated, the pharmaceuticals sector demonstrated positive impacts of patents on trade flows. This industry is particularly sensitive to patent rights for protecting innovation rents.

It is evident that the strength of patent rights is highly correlated with the effectiveness of IPRs generally. Stronger patents (as a proxy for trademarks) in the study were particularly effective in increasing imports of relatively low-technology goods, such as clothing and other consumer items. This finding suggests that the ease of knocking off such products under weak trademarks limits the incentives of foreign firms to sell them locally.

Effectively, stronger trademarks lower the costs of exporting because a firm has less need to discipline local imitators through lower prices and private enforcement. This is true also of pharmaceutical formulations, though they are more likely to be produced under local license than imported. The study found further that trade in goods that are difficult to imitate, such as certain kinds of machinery, or for which trademarks are not as significant, such as basic metal manufactures, was less sensitive to international variations in IPRs. This result

presumably reflects the limited threat of losing market share to local infringing firms.[14]

These findings may be statistically significant, but the more important question is their economic significance. Thus, the implied increases in international trade flows from simulated changes in patent rights are provided in table 4.8. To make these calculations, an elasticity of imports with respect to the patent index (using mean sample values and assuming fixed expenditure levels in each country) was computed for each sector and for each country group, including small developing countries, large developing countries, and high-income countries.

These elasticities were then applied to informed guesses about the new patent effectiveness that would come about from implementation of TRIPs.[15] In particular, I assume that TRIPs will result in a rise in the average corrected RR index in small developing countries from 2.68 to 3.25, or 22 percent. I entertain two possibilities for large developing countries. First, I incorporate a rise in the average index from 2.86 to 3.25, or 14 percent, to suggest harmonization across all developing countries. Second, I consider an increase in the index from 2.86 to 3.50, or 22 percent, to reflect the possibility that large countries will implement absolutely higher levels in the strength of their patent laws. Finally, I suppose that TRIPs will result in a modest increase in the average patent index in high-income nations from 4.48 to 4.60, or 0.3 percent.

Note that while these scenarios involve significant hikes in the patent indices of developing countries, they do not envision full harmonization of those indices with laws in the developed countries. As discussed elsewhere in this book, though TRIPs requires minimum standards, it comes well short of effective harmonization. Finally, the computed trade impacts should be considered to be long-run, taking place only after TRIPs standards are phased in and markets adjust to the new policy regimes.

Consider first some implications for sectoral trade. Some of the implied elasticities are negative, as for tobacco products and petroleum and coal products in all country groups. These goods likely are not responsive to patents; in fact, the underlying elasticities are not significantly different from zero. However, among the high-income countries there is a negative impact of tighter patents in professional goods, suggesting that a slight increase in patent rights would generate lower trade volumes (the market-power impact would dominate). This holds as well for pharmaceutical products. While the positive impacts on pharmaceuticals

14. Such inferences raise many questions that could be considered in further work. For example, it would be interesting to employ a different specification to look at how IPRs affect net trade by sector, distinguishing between effects on goods imported for final consumption and effects on goods traded through production sharing. Further, it would be interesting to see if weak IPRs could have export-enhancing impacts.

15. Details of these calculations are available on request.

Table 4.8 Simulated increases in total imports by sector into developing countries resulting from strengthened patent laws (millions of 1984 dollars)

Sector	Small DCs	Large DCS (1)	Large DCS (2)	HICs
Food products	111	1,070	1,762	386
Beverages	82	416	686	398
Tobacco products	–4	–42	–69	–102
Textiles	111	731	1,204	205
Apparel	106	711	1,171	435
Leather and products	19	145	239	53
Footwear	26	162	266	75
Wood products	12	201	331	7
Furniture and fixtures	41	240	395	147
Paper and products	106	560	922	247
Printing and publishing	35	206	340	156
Industrial chemicals	132	–18	–30	–364
Other chemical products	33	345	568	164
Pharmaceuticals	3	9	14	–51
Petroleum refining	162	862	1,420	720
Petroleum and coal products	–0.7	–25	–42	–58
Rubber products	36	194	319	120
Plastic products	31	183	301	113
Pottery and china products	13	59	97	33
Glass and products	27	165	271	108
Nonmetal products, nec	36	188	310	112
Iron and steel	180	1,005	1,656	1,027
Nonferrous metals	132	890	1,466	818
Metal products	92	485	798	193
Industrial machinery	356	1,623	2,673	730
Electrical machinery	175	869	1,432	0
Transport equipment	556	2,837	4,673	2,036
Professional goods	24	206	340	–111
Other manufactures	70	460	758	263
Total (dollar value)	2,699	14,727	24,257	7,913
Total (percentage of imports)	6.2	5.4	8.9	0.6
Total (percentage of GNP)	1.4	1.1	1.7	0.1

DC = Developing country.
HIC = High-income country.
nec = not elsewhere classified.
Notes: This table assumes that national expenditure levels remain unchanged after patent law changes. Assumptions on patent law changes include

- A 22 percent increase in average effective strength for small countries (from 2.68 to 3.25 on a five-point scale)
- Either a 14 percent or a 22 percent increase in strength for large countries (from 2.86 to 3.25 and 3.50, respectively in cases (1) and (2))
- An 0.3 percent increase in strength for industrial countries (from 4.48 to 4.60).

Sources: Calculated from Maskus and Penubarti (1995) and International Monetary Fund, *International Financial Statistics Yearbook 1987*.

trade with the developing countries are statistically significant, the implied volume increases are small: only $3 million for small countries and between $9 million and $14 million for large countries. There is also a negative impact in industrial chemicals in the large developing countries and the high-income countries.

Taking all manufacturing goods together, across the small developing economies perhaps $2.7 billion in additional annual imports would be created in the long run. While this amount seems modest, it comes to 6.2 percent of total 1984 merchandise imports of this group of countries and 1.4 percent of their combined GNP. Similarly, manufacturing imports into the large developing countries could expand by between $14.7 billion (5.4 percent of 1984 imports) and $24.2 billion (8.9 percent) per year—again indicating that stronger patent rights would engender important increases in import demand. In sectoral terms, these impacts would be concentrated on transport equipment, machinery, and food products. Finally, the small policy change simulated in the high-income countries would procure an additional $7.9 billion (perhaps 0.6 percent) in merchandise imports.

Because these results are based on 1984 activity, they may be outdated. The data review in chapter 3 showed that trade in IPR-sensitive goods has risen rapidly since 1984. Thus, it is interesting to see if this additional trade bears a more economically significant relationship to international patent rights. An important study posing this question is by Smith (1999), who updated the Maskus-Penubarti studies by analyzing sectoral 1992 manufacturing exports of US states to 96 countries. These data were compiled from the two-digit Standard International Trade Classification (SITC). She used a gravity-equation framework, accounting for per capita incomes, populations, geographic distance, trade restrictions, and the RR index of patent rights. Note that one advantage of using US state-level exports as the dependent variable is that their distribution across exporters does not depend on the trade policy of the United States, which treats each state equally.

Smith's particular focus was the identification of market-power and market-expansion effects in groups of countries identified by their ability to imitate products. Consider a classification of four country groups:

- The industrial countries tend to have strong technological capabilities and might therefore represent a competitive threat through imitation. However, they also have strong patent rights that considerably dampen this effect. Thus, Smith hypothesizes that within this group there would be an ambiguous balance between market-power and market-expansion effects.
- A similar conclusion applies to poor economies that have both weak patent rights and weak imitative capacities.

- In contrast, industrializing economies with weak patents but effective imitation threats, such as China, Turkey, and Venezuela, should find a dominant market-expansion effect. That is, other things being equal, within this group those countries with stronger patents should absorb higher import volumes.
- Finally, nations with strong patent rights but weak imitative abilities should absorb a net market-power effect, or lower trade volumes, as the strength of IPRs expands.

Smith's econometric results were remarkably supportive of these hypotheses. Taking each country group in turn, she discovered first that US exports to countries with high R&D ratios and strong patent laws depended positively and significantly on variations in IPRs. That is, the market-expansion effect dominates among the industrial countries, attesting to the effectiveness of their IPRs in deterring imitation. This was especially true of patent-sensitive industries, such as chemicals and instruments. In contrast, US export volumes depended negatively and significantly on patent strength in the group of countries with weak property rights and limited imitation threat. In that group, the market-power effect dominated.

As expected, the market-expansion impact was particularly pronounced in trade with middle-income economies that had weak patent rights and strong imitation. This result confirms that of Maskus and Penubarti (1997), who found that industrializing economies could attract more trade by limiting local imitation through stronger IPRs.

Finally, also as expected, the market-power effect dominated among the group of nations with weak imitation and strong patent regimes.

Smith calculated the implied elasticities of US exports to patent rights in each group for the aggregated patent-sensitive industries. These elasticities were large, reflecting in part the small average trade volumes of states to each foreign trading partner. She applied these estimates to the counterfactual experiment of assuming that TRIPs would succeed in harmonizing global standards at the level represented by 4.0 on the RR index. The results suggested that US exports to countries with weak imitation and relatively strong patents would fall slightly, by 1.4 percent ($1.7 billion in 1992 values). However, exports to those countries with weak patents and weak imitation would fall by 16.5 percent ($103 billion), as a result of additional market power. In contrast, exports to the middle-income economies with weak patent rights and strong imitation would rise by 12.5 percent ($43 billion). Trade with the industrial countries would not be affected under this scenario because their patent rights would not be changed.[16] Overall, Smith's static estimates suggest that US export

16. These calculations demonstrate an obvious weakness of partial-equilibrium simulations. Clearly, any changes of this magnitude in the distribution of global trade volumes

volumes would be quite responsive to strengthening of patent rights but would fall on net as a result of TRIPs. This finding is in contrast to the calculations reported above that global trade volumes would rise in most sectors and to each country group.

Smith's findings must be approached with caution. One particular problem is that her designation of imitative abilities came from considering solely each country's ratio of R&D expenditures to GDP. In the developing economies R&D data are highly suspect and not comparable to those in developed countries. This choice led to a number of anomalous designations: Brazil and Argentina, for example, are presumed to pose lesser imitation threats than Bolivia and Tonga. A more refined designation might push larger countries into the threat group, suggesting a larger positive trade response. Note also that Smith computed only the trade response for the United States; analysis for other manufacturing exporters might find net positive impacts. And, of course, many other static and dynamic factors could influence the responses of trade volumes to the TRIPs accord.

In summary, there seems to be convincing evidence from these studies of two claims:

1. Weak patent rights are significant barriers to manufacturing trade, particularly in IPR-sensitive goods. However, this phenomenon occurs mainly within industrializing economies that pose credible imitation threats. It is no surprise that these countries have been the main focus of complaints about weak IPRs. As these countries strengthen their IPR regimes they should attract rising import volumes of high-technology goods, which may have a beneficial growth effect, as discussed in the next chapter.

2. Because poor countries without much current ability to imitate new products do not pose a competitive threat, their weak patent rights are of limited concern to technology developers.[17] Indeed, their adoption of stronger IPRs could expose them to negative market-power effects on their terms of trade, although these studies cannot support computation of how much prices would change. Indeed, the same inference could be applied to high-income economies with a comparative disadvantage in developing new products and technologies. Taken alone, this factor would imply that TRIPs could be harmful to both

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would have important interindustry and international trade effects that would spill over across borders and affect the trade volumes of all countries. To date, however, no one has assembled a computable general-equilibrium model for assessing global trade impacts.

17. Clearly, this conclusion should not be applied to copyrighted goods, which are easily copied in all countries, including those without much human capital.

country groups. Of course, in an overall assessment of harmonization, many other factors must be balanced against this scenario.

IPRs and Foreign Direct Investment

Multinational enterprises (MNEs) make multifaceted decisions about how they can serve foreign markets. They may decide to undertake FDI, which requires selecting where to invest, in what kind of facilities, whether to buy existing operations or construct new plants, which production techniques to use, and how large an equity position to take with potential local partners. They may prefer a joint venture with a defined share of input costs, technology provision, and profits or losses. Finally, they may opt to license a technology, product, or service, leading to complicated bargaining over license fees and royalty payments.

These decisions are jointly determined. For any firm, the outcome depends on a host of complex factors regarding local markets and regulations. In this section I discuss the most significant of these factors for attracting FDI and review the econometric evidence.[18] IPRs clearly play an important role in these processes, though their importance varies by industry and market structure.

MNES may undertake horizontal FDI, in which the subsidiary produces products and services similar to those produced at home, or vertical FDI, in which the subsidiary produces inputs or undertakes assembly from components. In the latter case, international production is fragmented across borders, taking advantage of location considerations and input costs (especially wage differences) at various stages of production. Incentives for horizontal and for vertical FDI are different. Horizontal FDI tends to characterize the investment decisions of MNEs operating across borders within the industrialized nations, while vertical FDI is more prevalent among MNEs that invest in developing (low-wage) economies. Horizontal subsidiaries tend to produce for local or regional markets only, without exporting much to the host country. In contrast, the output of vertical subsidiaries is more likely to be exported within the MNE, both to the host country and to countries with similar demand characteristics.

Foreign direct investment embodies two distinctive assets: (1) capital and (2) technology or some intangible advantage. While the capital for financing FDI may come from the host country or from global financial markets, it may also be raised on the local capital markets of the recipient nation. Indeed, this is by far the most common approach for financing horizontal investments among industrialized nations. Thus, FDI may or may not be associated with a net external addition to the local capital

18. This section draws on Maskus (1998b).

stock. External financing more commonly characterizes FDI in emerging countries.

In this light, FDI should be viewed less as a source of finance (global FDI flows are in any case small in relation to flows of portfolio capital) and more as a source of investment in capital and technology or related assets. These variables are capable of improving productivity and wages in a recipient economy.

With these comments in mind, consider how a firm decides to engage in FDI. For a firm to become an MNE, it must have a sufficient cost advantage or technical product superiority over firms in the host country to overcome the disadvantages it faces in international management, including language and cultural barriers, jurisdiction-specific tax treatments, distance from headquarters, and monitoring local operations. Thus, MNEs must enjoy some efficiency advantages; economic theories of FDI begin with a description of such advantages.

A convenient framework for thinking about this question is the ownership-location-internalization (OLI) paradigm developed by Dunning (1981). In this approach, MNEs are characterized by an *ownership advantage*, which could be a tangible asset, such as a proprietary claim in facilities producing key natural resources. Far more commonly, however, the advantage is an intangible asset, such as a trademark, a reputation for quality, or a product or production process to which other firms do not have access and which is protected by a patent or maintained as a trade secret. Such advantages provide market power and cost efficiencies that are sufficient incentives to undertake multinational organization and operation.

That ownership advantages are strongly associated with technology development, information management, and marketing strategies is borne out by key characteristics of MNEs. Such firms tend to be important in industries with high R&D intensities, large employment of professional and technical workers, significant reliance on new and technically sophisticated products, and considerable amounts of product differentiation and advertising.[19]

Thus, FDI is more likely to be important in industries in which intangible, knowledge-based assets (KBAs) specific to each firm are significant for two key reasons. First, informational advantages can be transferred easily across borders at low cost. Second, knowledge is similar to a public good in that a particular technology or trade secret can be used in several production facilities without reducing its availability for others (as is the case with labor and capital). Such knowledge is embodied in blueprints, software, chemical formulas, and managerial or engineering manuals, which may be used numerous times at low marginal cost.

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19. Considerable evidence supporting these points may be found in Brainard (1993), Caves (1996), Grubaugh (1987), Markusen (1995), and Morck and Yeung (1992).

The important implication of this characteristic of knowledge is that MNEs enjoy scale economies from multiplant production, sometimes called economies of scope. A multinational firm can produce its technical knowledge in one location and use it in several plants in different countries, spreading the investment cost of technology development and marketing across numerous facilities (Markusen 1984). In contrast, two independent firms, each of which must make this investment, operate at a cost disadvantage. Thus, we should observe significant multinational activity in industries in which transferable knowledge and product quality are a key focus of strategy. Indeed, this is consistent with the available evidence. Possibilities for exploiting multiplant economies are now considered perhaps the most important determinant of a firm's decision to undertake FDI.

This argument is particularly relevant for horizontal FDI, in which firms base strategies for penetrating markets on the economic value of their KBAs, such as superior production processes, reputations for quality, performance, and service, and even lifestyle images. MNEs find it crucial to be able to support their investments with complementary operations, including service contracts. Economic value is increasingly related to performance of systems, including products, services, information, maintenance, technical upgrades, and close relations between producers and clients. As amplified below, this means that, in today's world, FDI is less attracted by protectionist tariff walls and more attracted by economies with open access to global markets. It also suggests that strong IPRs are taking on increasing importance as a determinant of inward FDI.

To summarize, MNEs are essentially exporters of KBAs, including technology, engineering, management, marketing, and financial services. The importance of human capital skills in generating these KBAs is evident. MNEs also license the rights to use devices that protect the value of their KBAs, including patents, trademarks, trade secrets, and copyrights. Indeed, it is common to refer to IPRs themselves as the relevant KBAs. Local subsidiaries pay for these services with royalties, license fees, shared outputs, and profit repatriations.

Even given some ownership advantage, MNEs still must decide on investment destinations. These decisions depend on the *location advantages* of particular countries. Such advantages make it profitable for the firm to produce abroad rather than stay at home and export the good. Obvious examples of location advantages are market size and growth, local demand patterns, transport costs and distance from markets, low wage costs in relation to labor productivity, abundant natural resources, and trade protection that could encourage "tariff-jumping" investment. Also important are an adequate and modern infrastructure and transparent government regulatory procedures.

Recently, location characteristics that enhance the value of KBAs have taken on greater importance. Among these are an adequate supply of

highly skilled labor in order to facilitate use of technology and management techniques, close proximity to customers and unimpeded ability to build supplier-customer networks, and a vibrant business-services sector that can handle localized needs for marketing and finance. Further, the strength of each country's IPRs is a location factor of growing importance, as discussed further below.

Location advantages matter for both vertical and horizontal FDI, but they are especially important for vertical FDI, in which firms build production networks, with engineering, design, and marketing operations in the headquarters country, and resource extraction, assembly, and data processing in host countries. Indeed, the most significant recent trend in vertical FDI has been such vertically integrated networks, a process also referred to as "production fragmentation," "delocalization," or "outsourcing" (Hanson 1996). This process underlies the rapid expansion of intrafirm trade in goods and services between developed and developing economies. Investment of this kind is most attractive in low-wage, high-growth economies with markets large enough to support scale economies in assembly. While outsourcing is of concern to low-skilled workers in high-wage economies, in generating overall efficiency gains in both the source and host countries it is a critical component of modern competitive strategies.

In this context, it is interesting to observe that the volume and character of inward FDI change dramatically as countries develop (Zhang 1996). The least-developed countries attract virtually no FDI (except in extractive sectors) due to extremely low productivity, education, and skills. Further, such countries tend to have underdeveloped infrastructures, are relatively closed to trade, and maintain poorly designed, intrusive, and nontransparent government regulations that encourage corruption.

When such countries can marshal effective investments in infrastructure, capital, and education and skill, their per capita income levels rise over time. As this happens, MNEs find these economies attractive locations for vertical FDI in labor-intensive assembly operations. Intrafirm trade grows. This process expands until real wages rise sufficiently that the economies lose their competitive advantages in assembly production (the FDI itself plays a positive role in raising wages). As vertical FDI falls off, however, horizontal FDI tends to move in, because such countries achieve income levels that make them attractive markets for high-quality differentiated consumer and capital goods and even for local R&D programs. Indeed, these countries may well become sources of FDI.

Interestingly, as horizontal FDI grows it tends to displace both interfirm and intrafirm trade (Markusen 1995). Thus, so-called "North-South" investment tends to be vertical, while "North-North" investment is horizontal.[20] Rapidly developing economies like South Korea, Singapore, and

20. The horizontal-vertical distinction is blurred in a number of sectors, such as pharmaceuticals and chemicals. In those industries, chemicals may be produced in headquarters

Mexico may move through this investment cycle in a single generation. Thus, there is an important dynamic element to growth and investment.

Key location characteristics for horizontal MNEs include market size, income levels and growth, transport costs, and the availability of complementary business services and regulation. As noted earlier, the more horizontal the investment, the more important IPRs are. In this sense, it is not surprising that countries moving up the FDI cycle find a growing economic interest in adopting stronger IPRs, an interest congruent with their own expanding abilities to produce new products and technologies.

Finally, ownership and location advantages together may not fully explain FDI because they do not account for the advantages of internal organization over selling goods and licensing technologies on the open market. MNEs also have *internalization advantages*, which relate to gains from exploiting their KBAs within their own international operations (Rugman 1986). It is this aspect of the process that explains the decision to acquire a subsidiary rather than to license an asset to an independent foreign firm.

There are numerous reasons why the costs of international transactions may be lower if performed within a single firm rather than at arm's length. Most of these relate to the difficulties of writing and enforcing contracts between independent firms when licensing is costly and information is imperfect. For example, because the KBA that is the potential subject of a licensing contract is valuable but perhaps easily copied, the original firm may not wish to reveal its technology to an unrelated licensee during contract negotiations for fear that the latter could simply decline the contract and copy the technology. The licensee, on the other hand, would be unwilling to sign a contract and agree to royalty terms unless it knows the particulars and value of the technology. In such cases, it may be impossible to draft a satisfactory contract, forcing the original firm to acquire a subsidiary to which it transfers the KBA (Teece 1986).

This informational imperfection in the market for technology implies, other things being equal, that firms would be more likely to engage in FDI in countries with weaker IPRs and contract enforcement. An implication is that as IPRs in a particular nation become stronger, firms will tend to choose more technology licensing and joint ventures and less FDI. This is the one identifiable theoretical case in which the strength of IPRs would be negatively associated with FDI flows. It applies most readily to firms that have proprietary technologies that have been expensive to develop but are easily copied, such as pharmaceuticals, agricultural chemicals, and computerized processes. A similar phenomenon is that MNEs may find it easier to retain technical and managerial employees who might otherwise defect from a licensee after learning the technology and form their own competing firms.

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locations, then shipped in bulk to processing plants for final formulations. These formulations are sold largely on domestic markets rather than shipped back to the parent country.

An additional contracting problem is that a potential independent licensee may attempt to convince the MNE that the market is smaller than it really is or will grow to be, thereby limiting its royalties and fees. If there is wide uncertainty on this point, the MNE may prefer to avoid having to share any potential profits by engaging in FDI and controlling local management and sales. This situation also helps explain why some firms set up complementary foreign distribution and servicing facilities (Zeile 1993).

MNEs usually experience higher costs of transferring technology through arm's-length transactions because aspects of the technology that are tied up in the firm's human capital, management, know-how, and corporate culture are not easily transmitted (Teece 1977, 1986). This factor becomes more important the more complicated the technology or management process is, helping to explain the prevalence of MNEs in high-technology industries. Transfer costs also depend on the recipient country's ability to absorb the technology efficiently, suggesting that more technology for complicated products and processes would be licensed as the human capital base of the economy rises. Also important are the transparency and certainty of the legal and regulatory systems.

Where the firm's KBA is a reputation for high quality, an additional incentive for FDI arises. Once a contract is signed, local licensees may not have sufficient incentive to maintain the quality of the product or service, tarnishing the licensing firm's reputation and profitability. Similarly, licensees may shirk their marketing or distribution efforts, degrade product quality, or contract with competing firms to whose products they devote more attention. These problems are most significant in economies where monitoring is costly and difficult, the supply of technologies and products to licensees is highly competitive, and contracts are not well enforced. While many contracts are designed to deter such behavior, firms may find it easier to exercise control through FDI.

This analysis suggests strongly that internalization issues favor the development of MNEs in industries where KBAs are important. Thus, MNEs tend to be associated with intensive R&D programs, advertising efforts, and frequent introduction of complex products. In such sectors, technology transfers are likely to be internal, especially when there are contracting, monitoring, and enforcement difficulties. Thus, internalization issues characterize horizontal MNEs.

There are also internalization advantages for vertically integrated MNEs. Largely, these relate to difficulties in setting contract prices when a single buyer (the MNE) proposes to purchase inputs or services, such as a natural resource or assembly operation, from a single seller. Where markets may be oligopolistic on both sides of the transaction, firms are likely to find it advantageous to integrate the activities and establish profit-maximizing internal pricing.

This review of the determinants of FDI leaves much room for IPRs to

affect investment flows and the operations of MNEs. The means by which IPRs influence FDI are subtle and complex. Seen in the proper policy context, IPRs are an important component of the general regulatory system, including taxes, investment regulations, production incentives, trade policies, and competition rules. As such, what matters overall for FDI is joint implementation of a procompetitive business environment, as I discuss further in a later chapter. In this section, I focus strictly on mechanisms by which the strength of IPRs could affect FDI decisions, as seen by economists, in light of theories of why investment takes place.

Exports are likely to be the primary mode of supply when transport costs and tariffs are low in comparison to the costs of FDI and licensing. FDI is likely to supplant direct exports of a good where trade and transport costs are high,[21] the fixed costs of building foreign plants are low, local productivity is high relative to wage costs, the size of the host market is large, and the R&D or marketing intensity of the product is substantial. The last factor is critical for horizontal FDI in differentiated goods and advanced technologies in that it is the knowledge basis, or intellectual component, of the firm's advantage that induces it to become an MNE.

FDI exists because firms with an ownership advantage prefer to exploit it through internal organization of multinational activity, with the location of activity depending on local market characteristics. IPRs are thus likely to take on different levels of importance in different sectors with respect to encouraging FDI. Investment in lower-technology goods and services, such as textiles and apparel, electronic assembly, distribution, and hotels, depends relatively little on the strength of IPRs and relatively much on input costs and market opportunities. Investors with a product or technology that is costly to imitate may also pay little attention to local IPRs, though the fact that imitation has become markedly easier over time in many sectors points to the rising importance of IPRs. Firms with easily copyable products and technologies, such as pharmaceuticals, chemicals, food additives, and software, are more concerned with the ability of the local IPRs system to deter imitation. Firms considering investing in a local R&D facility would pay particular attention to local patent and trade secrets protection.

This perspective is consistent with results reported by Mansfield (1994), who surveyed 100 major US firms with international operations in 1991. Intellectual property executives in firms representing six industries were asked (1) their opinions of the importance of IPRs in their FDI and licensing decisions and (2) their assessments of the adequacy of IPRs in

21. This is a relative comparison only. I do not mean that raising trade barriers would attract FDI, but rather that high tariffs in relation to fixed costs are associated with FDI. In general, however, significant trade liberalization tends to attract FDI for reasons discussed elsewhere.

Table 4.9 Percentage of firms claiming that strength or weakness of IPRs has a strong effect on whether direct investments will be made, by type of facility, 1991

	Sales and distribution	Basic production and assembly	Components manufacture	Complete products manufacture	R&D facilities	Average
Chemicals	19	46	71	87	100	65
Transport equipment	17	17	33	33	80	36
Electrical equipment	15	40	57	74	80	53
Food products	29	29	25	43	60	37
Metals	20	40	50	50	80	48
Machinery	23	23	50	65	77	48
Average	20	32	48	59	80	48

Source: Mansfield (1994).

16 countries. Table 4.9 reproduces his results by type of investment facility.[22]

In no industry was there much concern about IPRs protecting the operation of sales and distribution outlets. In the chemical industry, which includes pharmaceuticals, 46 percent of firms were concerned about protection for basic production and assembly facilities, 71 percent for components manufacture, 87 percent for complete products manufacture, and 100 percent for R&D facilities. This tendency to be more concerned with IPRs the higher the stage of production carried over to all sectors. Overall, the chemical industry was the most affected in its decisions to invest, though in all sectors there was a strong concern about local IPRs in siting R&D operations. In a companion paper, Mansfield (1995) demonstrated that these findings held also for Japanese and German firms considering foreign investments.[23]

Table 4.10 presents additional results for selected countries with weak IPRs in 1991. India elicited the greatest concern about patents; fully 80 percent of the chemical firm respondents indicated they could not engage in joint ventures or transfer new technologies to subsidiaries or unrelated firms due to weak protection. Interestingly, in chemicals there was little difference between joint ventures and subsidiaries in this regard. Both evidently provided foreign firms with approximately the same level of security about their technologies (though there was more concern about joint ventures in Mexico and Indonesia). However, across all countries licensing to unrelated firms was seen as riskier because of weak IPRs. This situation was also true of machinery firms. In the other sectors, however, weakness in IPRs made little difference in the willingness to transfer technology through various modes.

That licensing is seen as insecure relative to investment in the high-technology sectors in countries with weak IPRs confirms a subtle aspect of intellectual property protection. Recall that firms are more likely to undertake FDI than licensing when they have a complex technology and highly differentiated products and when costs of transferring technology through licensing are high (Teece 1986; Davidson and McFetridge 1984; Horstmann and Markusen 1987). Under these circumstances, it is efficient to internalize the costs of technology transfer through FDI in a wholly owned or majority-owned subsidiary. As IPRs improve, other things being equal, licensing costs should fall because it becomes easier to discipline licensees against revelation or appropriation of proprietary technology and against

22. These results should be viewed cautiously; surveys do not control for numerous other potential influences on investment and licensing decisions.

23. This suggests that the measures of the weakness of intellectual property protection marshaled from USTR reports and discussed above may not be unduly biased by their US perspective. I am grateful to Jack Mutti for pointing this out.

Table 4.10 Percentage of firms claiming that intellectual property protection is too weak to permit types of investment, 1991

Country	Chemicals	Transport equipment	Electrical equipment	Food products	Metals	Machinery	Average
Panel A: Joint ventures with local partners							
Argentina	40	0	29	12	0	27	18
Brazil	47	40	31	12	0	65	32
India	80	40	39	38	20	48	44
Indonesia	50	40	29	25	0	25	28
Mexico	47	20	30	25	0	17	22
South Korea	33	20	21	12	25	26	23
Thailand	43	80	32	12	0	20	31
Average[a]	49	34	30	19	6	33	
Panel B: Transfer of newest or most effective technology to wholly owned subsidiaries							
Argentina	44	20	21	12	0	14	18
Brazil	50	40	24	12	0	39	28
India	81	40	38	38	20	41	43
Indonesia	40	20	31	25	0	23	23
Mexico	31	20	21	25	0	22	20
South Korea	31	20	28	12	40	22	26
Thailand	60	80	31	12	0	18	20
Average[a]	48	34	28	19	9	26	
Panel C: Licensing of newest or most effective technology to unrelated firms							
Argentina	62	0	26	12	0	29	22
Brazil	69	40	29	25	0	73	39
India	81	40	38	38	20	50	44
Indonesia	73	20	33	25	0	37	31
Mexico	56	20	28	25	0	36	28
South Korea	38	20	34	12	40	29	29
Thailand	73	80	36	12	0	25	38
Average[a]	65	31	32	21	9	40	

a. Average over the seven countries listed.

Source: Mansfield (1994).

misuse of a trademark. Thus, at a given level of complexity of innovations, we would expect to see licensing displace FDI as IPRs are strengthened.

It is useful to summarize the predictions about IPRs, FDI, and technology transfer:

- Investment and technology transfer are relatively insensitive to international differences in IPRs in sectors with old products and standardized, labor-intensive technologies. Here, FDI is influenced by factor costs, market sizes, trade costs, and other location advantages.
- Other things being equal, FDI representing complex but easily copied technologies is likely to increase as IPRs are strengthened, because patents, copyrights, and trademarks increase the value of KBAs, which may be efficiently exploited through internalized organization.
- To the extent that stronger IPRs reduce licensing costs, FDI could be displaced over time by efficient licensing.
- Whatever the mode, the likelihood that the most advanced technologies will be transferred rises as IPRs are strengthened.

One implication of this analysis is that rapidly developing countries, as they move up the "technology ladder" to an ability to absorb and even create more sophisticated innovations, should find a natural interest in improving their IPRs. This is perhaps the strongest argument to make in favor of stronger protection in nations such as Korea, Brazil, Mexico, Malaysia, China, and India. In the early stages of their industrial growth, such countries have an interest in being able freely to imitate imported technologies, which calls for limited protection. As they evolve, however, they should become increasingly interested in tightening IPRs, both in order to attract the most modern technologies and to encourage their own innovation. Indeed, this prediction is borne out by the pattern of patent protection across countries, as evidenced by the U-shaped relationship between patent rights and income levels (see figure 4.1).

A final comment about the emerging system of global IPRs should be mentioned because it is little appreciated in the policy arena. To the extent that *different* levels of IPRs acts as a location determinant of FDI and technology transfer, the trend toward harmonization of IPRs within the TRIPs agreement will offset such advantages. That is, it will increase the attractiveness of countries that are strengthening their IPRs but reduce the *relative* attractiveness of those that already have strong IPRs. In conjunction with rising *absolute* protection levels, this partial convergence of global minimum standards presents great opportunities for innovative firms. Absolute increases in protection could afford a positive scale effect on all forms of IPR-sensitive activity. Further, the relative convergence implies that firms will no longer have to pay as much attention to localized protection and enforcement problems in safeguarding their proprietary

information. In turn, they can focus their R&D programs on those areas with the highest global payoffs. Ultimately, however, this means that IPRs could play a smaller role in determining location choice.

As with international trade, this theoretical review indicates, that the relationships between IPRs and FDI are subtle and complex. While the weight of theory seems to lie on the side of a positive impact, overall it is ambiguous. Finding evidence on the nature of these relationships ultimately requires empirical analysis. Yet, despite the obvious importance that IPRs could play, few recent studies have included measures of their strength in different countries as a potential determinant of FDI.

Two early studies (Mansfield 1993, Maskus and Eby-Konan 1994) could not find any relationship between crude measures of intellectual property protection and the international distribution of FDI by US multinational enterprises. These articles suffered from limited specification of models and employed poor measurements of IPRs. Their results should be largely discounted. A more recent paper by Primo Braga and Fink (1998) could not find significant effects of patent rights on FDI in a gravity framework. This was a substantive piece of work, employing an extensive database and accounting for some determinants of investment other than patents. It raised doubts about the ability of econometric studies to find impacts of IPRs on FDI, or indeed whether such impacts existed.[24]

The results of two other recent studies bring this negative finding into question, however. Lee and Mansfield (1996) used survey results to develop an index of perceived weakness of IPRs in destination countries for US firms. They regressed the volume of US direct investment in various countries over the period 1990-92 on this index, along with measures of market size, the past investment stock, the degree of industrialization, a measure of openness, and a dummy variable for Mexico to control for its special investment relationship with the United States.

They found that weakness of IPRs has a significant negative impact on the location of American FDI. Further, in a sample of chemical firms, the proportion of FDI devoted to final production or R&D facilities was negatively and significantly associated with weakness of protection. The weakness of IPRs had much less impact on the decisions of firms with limited ownership (less than 50 percent) of local affiliates because such firms would be unlikely to transfer their frontier technologies in any case. From these results, it appears that both the volume and quality of investment are diminished in countries with limited property rights.[25]

Maskus (1998a) took an extended approach. It was argued that much of the prior literature is poorly specified in that it does not recognize the

24. See also Kondo (1995).

25. See also Moran (1999). Primo Braga and Fink (1998) discuss a number of shortcomings of the Lee and Mansfield approach.

interconnected decisions made by MNEs. In particular, MNEs may choose to export, raise sales from existing foreign operations, increase investment, or transfer technology directly in response to stronger patent rights. A simultaneous set of equations were to capture these joint impacts, controlling for market size, tariff protection, the level of local R&D by affiliates, distance from the United States, and investment incentives and disincentives provided by local authorities. This was done for 46 destination countries, using annual data from 1989-92. The index of patent strength was the corrected RR index, taken from Maskus and Penubarti (1995), and was interacted with a dummy variable selecting developing economies. The interaction term was included to examine whether IPRs affect FDI differently according to level of economic development.[26]

Table 4.11 lists the results from the preferred specifications. All four commercial flows—patent applications, sales by local affiliates, exports from the United States to the host country, and level of affiliate investment assets—are strongly attracted by large markets, as measured by real GDP. A high average tariff tends to diminish FDI, as measured by assets. Local R&D performance is positively associated with each commercial flow. It also appears from this specification that investment incentives have a positive impact and disincentives a negative impact on the level of FDI assets deployed across destination nations.

Average patent strength is strongly associated with patent applications, though the sum of the coefficients on Patent and Patent*DD suggests that the effect is rather weak in developing countries. Exports to affiliates are positively affected by patent strength in developing economies. While average patent strength has little apparent effect on affiliate sales across all nations, the effect is significantly positive in developing countries.

Taken together, these results suggest that if an average developing country were to strengthen its patent index by one unit, local sales of US affiliates would rise by $243 million, or about 2 percent of average annual sales. It is also interesting to note that the coefficient of the patent variable is negative and significant in the assets equation, but the impact in developing countries is significantly positive. Indeed, the results suggest that a one-unit increase in the patent index of the average developing economy would raise the asset stock of US multinational affiliates by $1.9 billion, or about 16 percent of average asset stock.[27]

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26. The equations were estimated with corrections for unequal error variances within each year and for serial correlation over time (in order to account for temporal dependence in the observations). The equations did not include country fixed effects.

27. The elasticity of sales with respect to patents in developing countries was 0.05, while the elasticity of assets was 0.45. At the mean patent index, a one-unit increase would represent a 36 percent rise in the index number. Remaining elasticity estimates from this analysis are listed in Maskus (1998b).

Table 4.11 Simultaneous equations model of the impact of patent strength on the international exploitation of intellectual assets (46 countries, 1989-92)

Variable	Applications	Sales	Exports	Assets
Constant	0.27* (2.77)	0.46* (5.13)	0.60* (7.51)	0.14 (1.46)
GDP	3.66* (26.79)	31.19* (27.23)	1.07* (10.02)	26.26* (10.13)
Tariff rate	–6.34* (–4.89)	–3.19 (–0.26)	–3.95* (–4.92)	–108.88* (-3.34)
Affiliate R&D	1.78* (3.42)	42.80* (19.42)	1.74* (23.86)	40.76* (6.17)
Distance	0.012* (3.08)	–0.057* (–2.32)	–0.008* (-5.01)	–0.95* (-9.02)
Patent	1703.15* (10.24)	–76.05 (–1.26)	–21.23* (–5.19)	–1,585.41* (–6.70)
Patent*DD	–1690.37* (–10.13)	319.53* (4.50)	53.99* (8.63)	3,516.62* (11.62)
Incentives	43×10^{3}* (12.2)	340×10^{3}* (13.85)	15×10^{3}* (11.14)	$1{,}389 \times 10^{3}$* (16.29)
Disincentives	–3489.02* (–4.41)	-23×10^{3}* (–2.32)	2423.17* (4.29)	-354×10^{3}* (–7.80)
R^2	0.90	0.97	0.97	0.90

Applications = Number of US patent applications filed in host country.
Sales = Total sales of foreign affiliates of US parents (US$ millions).
Exports = US exports shipped to affiliates (US$ millions).
Assets =Total assets, foreign affiliates of US parents (US $millions).
GDP = Real GDP in host country (US$ billions).
Tariff rate = Import revenues divided by total dutiable imports.
Affiliate R&D = Expenditure on R&D by foreign affiliates of US parents (US$ millions).
Distance = Distance from US to host country (kilometers).
Patent = Instrumented patent index.
Patent*DD = Index interacted with a dummy variable for developing countries.
Incentives = Number of affiliates that received tax concessions in host country divided by number of affiliates that received tax concessions in any of the countries.
Disincentives = Number of affiliates that employ a minimum amount of local personnel in host country divided by number of affiliates that employ a minimum amount of local personnel in any of the countries.
* = Significance at the 1 percent level.
Note: The equations are run in a SUR framework corrected for heteroskedasticity and autocorrelation. Figures in parentheses are t-statistics.

Source: Maskus (1998a).

The finding that patent strength does not attract more applications in developing nations but does increase affiliate sales and asset stocks is intriguing. While precise interpretation is difficult, it is possible that MNEs, in allocating their investment funds, are sensitive to improvements in IPRs in developing countries, even if they choose not to incur the expense of applying for local patents to the same degree as in developed countries. However, the substitution effect between FDI and licensing noted earlier may become dominant once patent protection exceeds a particular level. In conjunction with the results in Lee and Mansfield (1996), these findings indicate that levels of FDI are responsive to IPRs in developing nations. It should be noted that these tentative conclusions are based on aggregate FDI data and may not pertain in some sectors in some countries.

To see whether such results carry over into other empirical modeling contexts, I performed the regressions reflected in table 4.12. The approach stems from a two-country, general-equilibrium theory of foreign direct investment, as detailed in Carr, Markusen, and Maskus (2000). In that model three fundamental determinants of FDI are emphasized:

1. The public-input nature of R&D, management, and marketing ("headquarter services") permits economies of scope in horizontal FDI. This encourages such investment in countries of similar size and income levels.
2. Differences in skills encourage parent companies in skill-abundant nations to invest in vertical FDI in labor-abundant nations.
3. Trade barriers in the host country should induce more FDI, other things being equal, for purposes of jumping tariffs, though the likelihood of this outcome would diminish with the technological sophistication of the commodities produced.

Various interaction terms are added to account for nonlinearities in the model. Geographic distance appears in the equations to account for monitoring costs, which should reduce FDI. Finally, the model adds a variable measuring how MNE managers perceive the adequacy of intellectual property protection in host countries. The notion is that weak intellectual property rights would deter FDI because they raise the costs of maintaining secrecy and of monitoring local operations. However, as we have discussed, the theory could support a prediction of higher FDI in nations with weak IPRs.

The dependent variable in the regressions is the real sales volume of majority-owned foreign affiliates of US manufacturing enterprises and, similarly, the real sales volume of foreign-owned US subsidiaries. These data are taken from the US Department of Commerce annual publications on activities of US affiliates abroad and foreign affiliates in the

Table 4.12 Estimates of the general-equilibrium knowledge capital model

Variable	GLS1	TOBIT1	GLS2	TOBIT2
Constant	–25,911* (–2.48)	–46,739* (15.9)	–17,093 (1.63)	–42,590* (13.7)
Sum GDP	13.56* (12.5)	15.65* (208.3)	12.98* (12.1)	15.66* (216.8)
(GDP differences)^2	–0.0013* (–10.6)	–0.0011* (71.4)	–0.0012* (-9.83)	–0.0011* (72.2)
Skill differences	49,048* (3.32)	60,682* (13.9)	26,001* (2.19)	56,002* (12.25)
Trade cost	13.77 (0.21)	142.6* (3.90)	43.83 (0.68)	132.9** (3.52)
IPR	–113.4 (–1.29)	–167.8** (3.23)	–199.1* (-2.57)	–163.2** (3.19)
(GDP differences) × (Skill differences)	–0.61 (–0.23)	–4.82 (2.57)	–2.83 (–1.24)	–4.67 (2.51)
(Trade cost) × (Skill differences)^2	–1,363 (–0.97)	–3,114* (4.23)	–1,237 (–0.89)	–2,593** (3.02)
Distance			–0.86* (–5.10)	–0.66* (15.41)
Number of observations	513	671	513	671
Adj. R^2	0.87		0.87	
Log likelihood		–5,496		–5,489

Notes: Figures in parentheses are t-statistics for GLS regressions and chi-squared statistics for TOBIT regressions.
*Significance levels of 5 percent or lower
**Significance at 10 percent.

Source: Author's calculations.

United States. There are 36 countries in the sample, with a panel of bilateral observations over the period 1986-94. Not all countries provided full data for each year. Independent variables include the sum of the two countries' real GDP, the squared differences in their GDP levels, a measure of skill endowment differences, and indicators of trade barriers and intellectual property protection. Labor skill is measured by the percentage of each country's labor force that is employed in managerial, technical, and professional occupations, with bilateral skill differences simply being the difference between the skill ratio of the parent country and that of the host country.

The measure of trade barriers is an index of national protectionism, defined as efforts to prevent importation of competitive products, constructed from a survey of MNE managers and reported in the World Economic Forum (1995). Finally, the index measuring the inadequacy of IPRs was taken from the same survey. These last two variables are transformed so that higher values indicate higher trade protectionism and weaker IPRs.

The regressions included country fixed effects and embodied two techniques. The first is a generalized least squares (GLS) procedure accounting for heteroskedasticity in the error terms. The second accounts for the fact that, for many small developing economies in the sample, the data do not list any foreign affiliate sales. It is likely that these cases reflect the absence of any investment. To incorporate these zero observations for FDI into the dependent variable, I perform Tobit regressions, thereby increasing the sample size and including more developing countries.

These results again are interesting. Joint market size, as given by the sum of GDP, exerts a powerful and positive impact on affiliate sales. In theory, the squared term in the difference in GDP levels should be negative, for as market sizes diverge, incentives for horizontal FDI fall.[28] The positive and highly significant coefficient on skill differences provides strong evidence of an endowment basis for FDI, referring largely to vertical investment. The trade cost variable, a measure of local protectionism, is uniformly positive but does not often attain significance in the GLS equations. However, it *is* significant in the Tobit equations, which embody more observations for developing economies. Thus, the tariff-jumping argument for FDI seems to hold more strongly for investment going to, and coming from, developing economies than for investment between developed economies.

As anticipated, the intellectual property coefficients are consistently negative and significant in three of four cases. For the GLS specification, adding distance raises the magnitude of the coefficient considerably and also its statistical significance. Thus, controlling for distance, which may act as a proxy for the administrative difficulty of monitoring and controlling foreign operations, MNEs pay significant attention to the local protection of IPRs in their decisions on sales volumes of foreign affiliates. Using the GLS2 estimate, a one-unit increase in the IPR index in the average country in the data sample would raise affiliate sales by $199 million. Since sales volumes correlate positively with FDI, this finding provides further support for the notion that direct investment reacts negatively to the weakness of intellectual property protection.[29]

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28. See Markusen (1995) and Helpman (1987).

29. Again, such results raise as many questions as they answer. One fruitful avenue for further research would be to incorporate into the FDI equations measures for corruption and tax burdens across countries, because such variables have been found to matter in

IPRs and International Technology Transfer

Some of the discussion in the last section hinted at a theory of how IPRs affect the transfer of technology by altering incentives to choose between FDI and licensing contracts. The issue is far deeper than that, of course, and requires further discussion before we look at some basic evidence.

"Transfer of technology" covers a vast array of complex transactions that can only be summarized here. At the most basic level, it means the successful learning of information and the know-how to use it by one party from another party. The transfer may be unintentional and uncompensated, intentional and fully compensated, or somewhere in between.

The distinction between information and know-how is important. Gaining access to blueprints for a complex technology is of little competitive advantage in itself unless there is also a way to determine how to use it efficiently. Clearly, the ease of mastering production technologies varies considerably across products and sectors.

It is convenient to think of the channels through which technology may be transferred, for IPRs influence how these channels may be used. Technologies may be effectively misappropriated through straightforward imitation or copying without compensation to their developer. In this context, copying should be distinguished from reverse engineering. The technology for copying software or music is available to anyone with a computer and a supply of storage devices. Similarly, it is easy to produce toys, apparel, and related goods that copy the designs of trademark owners. Though little effective technology is learned this way, significant amounts of revenue may be generated.

Reverse engineering is more difficult. The classic examples are software and pharmaceuticals. Competitors may decompile computer programs in order to learn their structure; once learned, the program language may be used to launch competing products, but this process can be difficult and expensive. In pharmaceuticals it is typically neither costly nor difficult to determine chemical formulas simply by decomposing the drugs. It is then possible to sell competing compounds. Thus, it is difficult to protect the technical secrets embodied in these products through purely private mechanisms. More complex technologies, such as automotive engineering, avionics, and medical devices, bear their secrets more deeply; these cannot be duplicated without considerable cost. Still, the basic acts of exporting goods or producing and selling them locally through FDI risk imitation.

Even without literal attempts to copy technologies or products, there may be a remarkably rich flow of uncompensated information among potential competitors through trade shows, publications, patent applica-

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investment decisions. IPRs may proxy for such influences, but that possibility has not yet been assessed.

tions, and movement of technical employees between firms. For example, the needs of a firm to share know-how with its suppliers could spill over into design improvements that are beneficial for competing firms using the same suppliers. Channels of this kind were found by Mansfield (1985) to be important in explaining the relatively rapid dissipation of US industrial technologies into public knowledge. Mansfield found that technological secrets leaked into competitors' hands typically within one or two years. Such diffusion also seems to be rapid across borders (Krugman 1987); it is likely that this transfer has accelerated with improvements in communications technologies.

However, even though such information may be available to competitors quickly, turning it into competing products may be costly and time-consuming. For example, another survey by Mansfield, Schwartz, and Wagner (1981) discovered that average imitation costs totaled some 65 percent of innovation costs and that imitation time equaled about 70 percent of innovation time. Again, however, these figures are likely outdated. They would, in any case, vary sharply by sector.

Intentional technology transfer comes through three channels: FDI, joint ventures, and licenses.[30] Because FDI aims largely to exploit proprietary technological advantages, it represents a critical source of technology trade. At the same time, intrafirm transactions complement the productivity advantages of MNEs and expand technology learning in host countries. MNEs may ship advanced material inputs to subsidiaries that help reduce production costs. They also share, in addition to blueprints and product designs, the inputs of skilled producer services, such as engineering and management. In typical production joint ventures, partners share technologies or provide technology in return for access to marketing networks or some other competitive advantage.

In arm's-length licensing one firm leases rights to another, unrelated firm to (1) use a technology that is protected by patents and trade secrets or (2) produce and market a copyrighted or trademarked good or service. Terms may include a fixed franchise fee, royalty payments based on sales volumes, or both. As discussed earlier, there are extraordinarily difficult problems in designing licensing contracts, not least of which is assigning a market-specific value to the patent or trademark being leased. The value depends on, among many other things, market size, demand characteristics, age of the technology, availability of substitute products, and the strength of local IPRs. Some of these variables cannot be known at the time contracts are made.

Whatever the form, technology transfer costs money (Teece 1986). The costs range from trivial, in the case of software and music piracy, to extensive, in the case of complex interrelated technologies. If there is considerable uncertainty about such factors as future demand and the

30. For an extensive review, see UNCTAD (1995a).

ability of licensees to absorb new technologies, and if information is weakly available or asymmetric between parties, the associated market imperfections will likely result in inefficient licensing. Such problems are magnified in the international context, where different legal systems and information reporting requirements may interfere.

IPRs have an important effect on the costs of transferring technology. At one extreme, strong IPRs eliminate the ability to copy products slavishly (or otherwise to develop functional equivalents) and significantly raise the costs of imitation through reverse engineering or inventing around patents. Thus, IPRs raise the costs of competing through uncompensated and unauthorized learning, thereby limiting information spillovers through those channels.

At the other extreme, IPRs tend to reduce the costs of *authorized* technology transfers. For example, patents and trade secret protection may encourage arm's-length licensing in two ways: (1) well-understood rights allow a clearer revelation of technological advantages and market size, permitting contracts to be struck more efficiently, and (2) strong IPRs make it more certain that the licensee will not misappropriate the technology or debase the trademark and that technical employees will not defect to form competing firms. As for FDI, there could be both an expansion effect as the costs of transferring and protecting know-how within the firm are reduced, and a substitution effect as MNEs shift away from FDI toward external licensing. The evidence in the previous section suggests that the expansion effect strongly dominates in developing economies.

Thus, IPRs play a role in international technology transfer that is parallel to their role in promoting innovation and limiting imitation within an economy. By providing additional certainty about the enforceability of contracts, IPRs could encourage firms to trade technology across borders through making costly investments in FDI and licensing.[31] And by raising the costs of imitation, IPRs might limit international diffusion through unauthorized means. As ever in this area, a balance must be struck in setting policies, a balance that would, other things being equal, favor weak IPRs in poor countries but continuously stronger IPRs in nations approaching the technological frontier.

Recent theoretical treatments of how IPRs affect technology diffusion bear mixed messages. In some models, technology is transferred through imitation by firms in developing countries. When the global IPRs system is strengthened by the adoption of minimum standards and as foreign patents are enforced, imitation becomes harder. As the rate of imitation declines, contrary to what might be expected, it slows down the global

31. IPRs may not be strictly necessary for this task; strong contract laws could in principle achieve the same purpose. However, the contracts would have to provide protection from imitation and defection that would be essentially equivalent to patent and trade secret rights.

rate of innovation. This outcome emerges because if innovative firms expected slower loss of their technological advantages they could earn higher profits per innovation, reducing the need to engage in R&D (Helpman 1993; Glass and Saggi 1995).

This result, which is sensitive to model assumptions, may not hold up to alternative specifications. Indeed, Lai (1998) found that product innovation and technology diffusion would be strengthened by tighter IPRs if production were transferred through FDI rather than through imitation. This points to the need for developing economies to remove impediments to inward FDI as they strengthen their intellectual property systems. Vishwasrao (1994) demonstrated in a game-theory setting that, while the mode of technology transfer is affected by IPRs protection, with internalization through FDI the preferred mechanism in countries with weak patents, the quality of technologies transferred would rise with stronger IPRs. Taylor (1994) also showed theoretically that technology transfer would expand with stronger patents when there is competition between a foreign and a domestic innovator. Failure to provide patents removes the incentive for the foreign firm to license its best-practice technologies. Rockett (1990) found that where local imitation requires knowledge that is available only through licensed technology, the foreign licensers make available lower-quality technologies. This reduces the licensee's incentive to imitate the technology, reducing both the quality and extent of knowledge transfer. Yang and Maskus (2000a, 2000b) developed dynamic North-South models in which the rate of technology transfer could be enhanced by stronger IPRs in the South to the extent that cost reductions in licensing contracts would outweigh cost increases in imitation. Markusen (2000) found a similar possibility in a duopoly setting.

Once again, empirical analysis must be brought to bear. Studies that ask a variety of questions are relevant. First, there is evidence that a policy of weak IPRs in technology-recipient nations reduces the quality of technology transferred. Drawing on a study of collaboration agreements between British and Indian firms, Davies (1977) concluded that difficulties in securing rights over the profits accruing to technical information raise powerful barriers to information trades between developed and developing economies. Contractor (1980) studied a sample of 102 technology licenses provided by US firms; his regression results supported the hypothesis that returns to a technology supplier increase with patent protection in the recipient nation. He found that technologies transferred to developing countries tended to be significantly older than those transferred to industrialized economies. While these findings may be dated, they point to the significance of patent regimes in attracting technology through licensing.

There is also evidence that the effectiveness of IPRs protection in inducing technical innovation and technology transfer depends on the trade orientation of an economy. In a survey of more than 3,000 Brazil-

ian companies, Braga and Willmore (1991) found that the propensities of firms both to develop their own technologies and to buy them from foreign sources were negatively related to the degree of trade protection they enjoyed. Thus, in closed economies, protecting IPRs may not expand innovation much because the competitive conditions are inadequate to stimulate it. Gould and Gruben (1996) found in an econometric study that patent strength was an important determinant of economic growth and that this effect was stronger in relatively open economies. I return to this important finding in the next chapter, on IPRs and economic development.

Further, in an important study of international patenting behavior, Eaton and Kortum (1996) discovered that significant amounts of technology are transferred across borders through the patenting system. The value of patent rights varies by country and technology field but is typically significant in important developing countries, suggesting that stronger patents would induce further R&D, patent applications, and patent exploitation. There appear to be considerable spillovers of technological knowledge through patenting and trade in patented products. Indeed, Eaton and Kortum claim that, except for the United States, the OECD countries have derived substantial productivity growth from importing knowledge through patents.

The importance of technology transfer through trade in technologically advanced inputs (machinery, chemicals, software, producer services, and so on) should also be emphasized. There is evidence that such trade is responsible for significant productivity gains across borders and is a crucial part of technology convergence among the developed economies in recent decades and the diffusion into developing countries (Coe and Helpman 1995; Coe, Helpman, and Hoffmaister 1997). This suggests that emerging economies have a joint interest in trade liberalization and linking their IPR systems with those of the developed countries. The resulting productivity spillovers could easily outweigh the costs associated with additional market power.

Two studies have related data on US licensing receipts to the strength of IPRs in licensee countries. Ferrantino (1993) included memberships in the Paris and Berne Conventions along with duration of patent length in each of 75 countries as determinants of production and licensing fees of overseas affiliates of US MNEs in 1982. The results suggested weakly that stronger IPRs, measured in this way, favored local production over intrafirm exports from the United States and also expanded licensing payments by affiliates.

Yang and Maskus (2000c) regressed the real volume of license fees for industrial processes paid by unaffiliated foreign firms to US firms in 26 countries for the years 1985, 1990, and 1995. The measure of IPRs was the GP patent rights index. Other independent variables for licensee nations included real GDP, population, secondary enrollment ratio, and the

Sachs-Warner index of openness. In their preferred estimation, they found that with country fixed effects unaffiliated royalties and license fees were positively and significantly affected by the strength of patent rights. The coefficient suggested that a one-percent rise in the GP index would expand licensing volumes by around 2.3 percent in the average licensee country. To the extent that license fees reflect the value of underlying technology, this result supports the view that technology transfer would rise with stronger patent rights. However, despite its use of license volumes (values deflated by a price index) the approach does not adequately distinguish between the higher valuation associated with additional or higher quality technology flows and higher fees associated with additional market power for licensers.

Summary

As the world continues to undertake unprecedented policy changes in IPRs, economists strive to peel away the veil of darkness surrounding the likely effects on global economic activity. The evidence reviewed in this section is not definitive. It would benefit from further study and better measurement of IPRs. Nonetheless, I am sufficiently comfortable with the work to draw some confident conclusions:

1. There is no doubt that international differences in intellectual property rights have statistically and economically important effects on international economic activity.
2. Trade flows into large developing economies with significant capacities for imitation are restricted by weak IPRs. Adoption of the TRIPs standards bears the potential to raise their imports of technologically sophisticated goods by significant amounts.
3. However, as small poor nations strengthen their IPRs, they may find some of their markets becoming more monopolized by foreign exporting firms, a conclusion that holds as well for rich economies that are net importers of intellectual property. In this context, competition authorities may need to be more vigilant. Unfortunately, the poorest countries rarely have competition regimes in place; the process of installing them will be complex, as I discuss later. More fruitfully, such economies would do well to ensure that competitive processes thrive on their markets, so that the availability of substitute products can blunt monopoly pricing impacts.
4. FDI is also sensitive to variations in IPRs. The amounts of possible additional investment as a result of patent reforms could be large. Imports and FDI both embody technological advantages that can spill

over into domestic economies, even under strong patent regimes. Thus, a dynamic benefit from rising activity flows could outweigh losses in the terms of trade for such countries. The likelihood of such an outcome depends on complementary factors, such as the ability to absorb and commercialize technologies, openness to trade, and maintenance of competition. These observations are at the core of the discussion in chapter 7.

5. Finally, a feature of IPRs that is underappreciated, at least by economists, is that they can undergird an efficient system of contracts to promote formal technology transfer through licensing. Again, the potential increases in licensing volumes from strengthening such rights could be significant and the quality of the technologies should rise. Seen in this light, it is inevitable that technology importers will pay higher costs to absorb more and better technologies as a result of tighter IPRs. Note that this outcome would not be by any means universal. Stronger property rights could also permit firms to choose not to license their closely held technologies except in cross-licensing or patent-pooling arrangements. Thus, a trade-off likely will emerge between stronger licensing incentives and greater prerogatives to maintain technologies under close control. Such trade-offs are the essence of intellectual property rights and call for some balance in achieving an appropriate mix of incentives.

These conclusions are important for the ensuing discussion. However, keep in mind that they follow from limited econometric analysis. Two shortcomings of this analysis are particularly troublesome. First, either the studies adopt aggregate approaches, failing to consider impacts across sectors, or the sectoral approaches are partial equilibrium. It would be useful to estimate interindustry linkages through a computable general equilibrium approach, which has yet to be done. Such an approach would also permit consideration of international trade effects across countries more readily. Second, while the studies to date permit tentative conclusions about dynamic effects of IPRs, there are no explicitly dynamic analyses. This is unfortunate in light of the inherently dynamic trade-offs that IPRs embody. This oversight surely implies that the effects of stronger IPRs are being underestimated.