Intellectual Property Rights and International Innovation

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Contents

Abstract: This chapter provides a selective survey of the theoretical and empirical literature to date on the relationship between intellectual property rights (IPR) and measures of innovation and international technology transfer. The chapter discusses the empirical implications of theoretical work, assesses the theoretical work based on the evidence available, and identifies some gaps in the existing literature.

1. Introduction

As discussed elsewhere in this volume, intellectual property (IP) reforms have occurred on a global scale during the past decade. This has generated much academic interest in the costs and benefits of stronger intellectual property systems. From an international point of view, it is of particular interest to know whether developing countries (the 'South') derive any benefits through increased technology transfers from developed countries (the 'North') or through increased local innovation. The reason is that arguments about increases in innovation and technology transfer are used to persuade countries to participate in multilateral IP reform.

In this chapter, I survey some of the recent theoretical and empirical research on the effects of intellectual property rights (IPR) on innovation and technology transfer. I focus on the international dimensions, examining the differential mechanisms by which IPR affect North and South. As this chapter will show, the theoretical impacts tend to be ambiguous, either because different studies draw opposing conclusions or because some find the effects to be conditional on certain factors. The empirical work helps shed light on which effects tend to be likely, but the evidence too is diverse. My primary purpose in this chapter is to weigh some of the available evidence, to illustrate common threads, and to reconcile differences where possible. Taking stock of this evidence should help illuminate which aspects of theoretical work receive empirical support and help us draw some overall lessons about the impacts of IPR on innovation and technology transfer. It also should point to some gaps in our current understanding.

The paper is organized as follows. Section 2 briefly reviews the state of international innovation and technology transfer. Since this chapter focuses on North-

South issues, I show how starkly these activities differ by levels of economic development. Section 3 reviews the theoretical models that motivate or guide much of the empirical research. Section 4 reviews the empirical work, the methodologies, and findings. The concluding section summarizes the key lessons and discusses some issues for future research.

2. State of World Innovation and Technology Transfer

Table 1 provides a recent snapshot of the state of international innovation and technology transfer. The table groups countries by level of economic development and shows each group's share of an activity. As measures of innovation and technology transfer, I focus on research and development expenditures (R&D), patenting activity, international trade, foreign direct investment (FDI), and licensing, as these are the most common measures used in empirical work.

Developed countries account for more than three-quarters of the world market (using GDP to measure market size) and account for the bulk of enterprise R&D and patentable inventions, as measured by resident patent filings and US patent applications. Nonresident patent filings represent patent applications received by a country from foreign nationals. Cross-national patenting helps measure the extent of international technology diffusion. Developing and least developed countries account for nearly three-quarters of patent counts received from nonresidents partly because there are more developing and least developed countries than there are developed countries, but also because the global Patent Cooperation Treaty (PCT) system has made it easier to designate multiple countries in an international patent application.[1]

Developing and least developed countries receive a greater share of technology transfers than they contribute to world innovation. For example, they account for about a third of world imports and FDI inflows. They account for a smaller share of technologies transferred through licensing agreements (as measured by payments of licensing fees for the use of technology). Thus, innovation and technology flows are concentrated in the North. The question is what role, if any, IPR play in determining these patterns.

3. Theoretical Background

The theoretical literature identifies a number of different channels or mechanisms by which IPR could affect innovation and technology transfer. These channels or mechanisms can have opposing influences. In this sense, the impacts of IPR on innovation and technology transfer are, *a priori*, ambiguous.

In this section, I first provide some comments about some modeling assumptions adopted in parts of the literature. Models are valuable in helping to focus on the key explanatory channels or mechanisms, but some of the abstractions are not suitable and predictions that rely on them should be viewed critically. I then review and critique North-South models of IPR, innovation, and technology transfer. Next, I discuss other models of innovation (with no international technology transfer) and models of international technology transfer (where innovation is exogenously given). I end with a discussion of the empirical implications of the models reviewed.

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[1] For example, due to the reduction in filing costs, inventors can seek protection not just in the developed countries but also in developing countries.

3.A. On Modeling Assumptions

Models make simplifying assumptions (by definition), but certain assumptions do more than just simplify the analyses. They can contribute to misconceptions about how intellectual property systems work. Chief among these is the assumption that IPR, particularly patent rights, create monopolies. Generally, patent rights give the holder the right to exclude others from practicing the invention. They do not create a monopoly *per se*, in the sense of a single firm in an industry. As Merges et al. (2003, p. 997) point out:

"This presumption that intellectual property rights confer market power has little basis in fact. Patents grant the right to exclude in a tightly defined technological domain. In most cases, this does not translate into what an economist would call a "monopoly," since the technological domain is rarely coextensive with an economic product market."

A patent typically relates to a specific technological component of a product (e.g. a gas pedal in a motor vehicle). It does not give the holder the power to exclude others from making the overall product or designing an alternative component. The holder has exclusive rights only over a specific type of component (or underlying process) and over some close technological substitutes, depending on the scope of the patent. Thus, no monopoly in the product or component market is created, unless we define a very narrow product class. In some situations, where inventions are foundational or non-modular, a patent could cover an entire product but these are exceptions and not the rule.[2]

Another misconception is that patent protection reduces access to knowledge. In some theoretical work, stronger patent protection is modeled as a factor that reduces knowledge spillovers.[3] On the contrary, through disclosure, patents make knowledge open to the public. Instead, patents restrict others from practicing the protected invention,

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[2] For example, a drug patent where the chemical compound is the invention as well as the whole product.

[3] See, for example, Zigic (1998) and Lapan and Kim (2006).

say commercially, but allow other agents (researchers) access to the underlying inventive knowledge.[4] Romer (1990) models this distinction appropriately. In his model, the stock of patentable knowledge "A" is a public good (which generates knowledge spillovers). Each piece of knowledge is a design for a durable capital good, which a patent holder has the exclusive right to produce and sell.

3.B. North-South Models

In these models, innovation typically occurs in the North. Technologies diffuse to the South either via imitation by Southern agents or through such formal technology transfer mechanisms as licensing or FDI. Profits earned in the South in turn affect Northern incentives to innovate. Innovation is reflected in increases in either the *variety of goods* or the *quality of existing goods*. The equilibrium rates of innovation and technology transfer depend on incentives (e.g. value-maximization conditions) and the stock of economic resources. Labor is often assumed to be the only factor of production, used in both research and manufacturing.

On the demand side, consumers solve a two-stage budget problem: a dynamic one and a static one. The dynamic problem is to choose the time profile of their overall expenditures, E. The static optimization problem is to spread their expenditures E either among differentiated goods (in the case of variety-growth models) or among a fixed continuum of goods of different quality levels (in the case of quality-ladder models).

[4] Moreover, basic scientific knowledge is not patentable. In principle, patents cover inventive knowledge or technologies that are industrially applicable or have utility. Patents also do not protect "ideas" but the good or technology in which the ideas are manifested. That said, current controversies exist over whether patents have recently been granted for mere ideas, basic principles, or technologies with no express utility, especially in the United States (Jaffe and Lerner 2004).

On the production side, producers all face a constant returns technology in which one unit of labor is needed to produce one unit of a good. Some goods are produced in the North and others in the South. The total measure of goods is $n = n^N + n^S$, where n^N is that measure produced in the North and n^S that measure in the South.[5] Consumers in each region consume quantities of each of the goods available in the world. It is not the case that consumers in one region consume goods produced only in that region (as in location models). Northern and Southern firms all compete for the same consumers.

I first discuss some contrasting results on the effects of IPR in variety-growth models, then do the same for quality-ladders models. Throughout I focus on the intuition behind the results, and refer the reader to the original papers for the full details.

3.B.1 Variety-Growth Models and IPR

Helpman (1993) develops a model in which stronger IPR in the South could lower the long-run rate of innovation in the North via a *production shifting effect*. To see this, consider the Northern labor-market resource constraint:

$$\overline{L}^N = L_R + L_M \tag{1}$$

where $\overline{L}^N$ denotes the fixed supply of labor in the North, L_R the labor in research, and L_M the labor in manufacturing. Goods produced in the South result only from imitation of Northern goods. Stronger IPR, indexed by θ, reduce imitation (i.e. $n^S = n^S(\theta)$, where $n^{S\prime}(\theta) < 0$). Thus a tightened IPR regime shifts production back to the North. As a result, labor in manufacturing, L_M, increases. Given a fixed supply of Northern labor, wages in the North rise, thereby increasing the cost of research and reducing resources available for innovation, L_R. Hence the rate of innovation in the North would decline.

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[5] In quality-ladder models, n is fixed.

Lai (1998) modifies the above model to allow some Northern firms to become multinational firms that produce in the South. In this case, stronger IPR in the South attract FDI from the North. This enables production to occur in the South within local subsidiaries of Northern firms. Importantly, this possibility *reduces the demand for manufacturing labor* in the North and frees up resources for innovation. To see this, consider the Southern labor-market constraint:

$$\overline{L}^S = L_I + L_F \tag{2}$$

where $\overline{L}^S$ is the endowment of Southern labor, L_I the labor used in imitation, and L_F the labor employed by multinational firms. A Northern firm benefits from becoming a multinational because wages are lower in the South, but imitation risks are higher in the South. Thus stronger IPR in the South reduce risks of imitation and increase the expected returns to being a multinational firm. As a result, more production is transferred from the North to the South. Production shifting to the South relieves pressure in the Northern labor market and more labor is available for innovation. In other words, L_I decreases, L_F increases, L_M decreases, and L_R increases. Hence in this model stronger IPR are associated with higher rates of long-run innovation and technology transfer.

3.B.2. Quality-Ladder Models and IPR

The previous two models assumed negligible costs of imitation. In Glass and Saggi (2002), imitators incur fixed costs in order to imitate successfully and multinational firms face additional costs of adapting their technologies to the South. Imitators in the South target both Northern firms' goods and multinational firms' goods for imitation. The Northern labor-resource constraint is similar to (1), while the Southern labor-resource constraint is:

$$\overline{L}^S = L_I + L_F + L_A + \alpha(\theta), \qquad \alpha'(\theta) > 0 \tag{3}$$

Here L_A is the labor absorbed by multinational firms to adapt Northern goods to the Southern market and $\alpha(\theta)$ the labor used to make imitations of foreign goods and is a positive function of θ, the stringency of IPR.

An increase of θ reduces incentives to imitate but raises the total resources devoted to imitative activities. Because Southern imitators incur greater resources to invent around foreign goods, stronger intellectual property protection in the South results in greater resource scarcity. Less FDI occurs due to the higher costs of production and adaptation. With less FDI, Northern workers manufacture more goods since less production is transferred to the South. Consequently, less labor is available for innovation and this model predicts a decline in Northern innovation and FDI.

In contrast, Yang and Maskus (2001b) develop a model in which stronger IPR increase long-run innovation and technology transfer via licensing. Stronger IPR in the South increase Northern incentives to license in two ways. First, the *contractual costs* of license negotiation and enforcement are reduced. Second, due to reduced imitation risk, the Northern licensor can command a larger share of the rents. Under weaker IPR, the licensor would have yielded a higher share to deter imitation or defection.

The Northern resource constraint is

$$\overline{L}^N = L_R + L_M + L_C(\theta), \qquad L_C'(\theta) < 0 \tag{4}$$

where L_C denotes the labor employed in licensing negotiations. In the South, goods are produced under Northern licensing agreements. Stronger IPR in the South increase the returns to licensing there so that more production is transferred. As a result, production labor in the South rises while Northern manufacturing employment, L_M, falls.

Furthermore, fewer resources are absorbed in licensing negotiations so that L_C falls. Hence, more resources are available for innovation (i.e. L_R increases). Thus both steady-state licensing and innovation are higher when IPR are stronger.

Typically, in these North-South models, the innovation production function exhibits scale effects: a higher rate of innovation is associated with a larger labor force. Two quality-ladder models relax this specification. In Dinopoulos and Segerstrom (2006), scale effects are removed by assuming that R&D becomes increasingly difficult as the quality of products increases. They find that tighter IPR in the South have no long-run effect on innovation in the North. Sener (2006) removes scale effects by introducing lobbyists in both the North and South that favor strong IPR laws. Their rent-seeking activities absorb scarce resources. In this model, tighter IPR exacerbate resource scarcity and reduce the long-run rate of innovation and rate of multinationalization.

3.B.3. Critique of North-South Models

Before policy implications can be drawn for global IP reform, it is important to note some limitations of such North-South models. First, these models do not contain a Southern innovation sector. One of the key empirical and policy debates is that IPR reforms would stimulate local innovation or innovative capacity. However, North-South models do not yield any implications for Southern innovation. Second, the models examine how the strength of IPR in the South feeds back on Northern innovation. As Table 1 shows, the Southern market constitutes a relatively small share of the world market from the vantage point of the North. If we focus on developing countries that have little or no innovative capacity, the South constitutes even a smaller share of the

Northern firms' world market. Thus the contribution of Southern IPR to overall Northern incentives to innovate is likely to be small (a point made in Deardorff 1992).

Third, Southern imitators are able to imitate Northern goods because of weak IPR in the South. The Southern imitators end up supplying those goods to consumers in both the North and South. Yet, presumably the North has strong IPR. To the extent that the imitated goods in the South infringe upon Northern IPR, those goods may not be importable into the North. If so, this would disrupt the role of imitation in product cycles or production shifting.

Fourth, North-South models typically examine one form of technology transfer, such as FDI or licensing. The models ignore the composition of technology transfer, among say exporting, FDI, and licensing. The strength of IPR in the host country can affect not only the volume of technology transfers but also the mode of entry. For example, stronger IPR may appear to reduce subsidiary production but actually increase technology transfers overall if another mode of entry is expanded (say licensing).

3.C. Innovation and Optimal IPR

To address additional channels by which IPR can affect innovation and technology transfer not explicitly incorporated in the North-South models, I turn to other important papers in the literature. I first describe models of innovation (ignoring technology transfer) and discuss how the impact of IPR on innovation can depend on the initial strength of protection and stage of economic development. I then turn to models on technology transfer (that treat innovation as given) and discuss how IPR can affect the volume and composition of technology transfer.

3.C.1. Nonlinearities

Because stronger IPR can have both positive and negative effects, the rate of innovation can vary positively or negatively with stronger IPR depending on the initial level of IPR, thus giving rise to non-monotonic or nonlinear relationships between IPR and innovation. In particular, recent theoretical work suggests an inverted-U relationship between innovation and patent strength.

This inverted-U relationship can be between the rate of innovation and *patent life*. For example, in Cadot and Lippman (1995), longer patents increase the ability of a firm to appropriate its R&D investments. But they also reduce rival entry and reduce the firm's incentive to generate new products that would only render existing ones obsolete. The latter effect dominates after patent life reaches a critical length. In Horowitz and Lai (1996), the rate of innovation equals the size of innovation multiplied by the frequency of innovation. The size (or economic importance) of an innovation is a positive function of the length of patent life, τ. If imitation does not occur until after a patent fully expires, the frequency of innovation is $1/\tau$. Hence a longer patent life has two opposing effects on the rate of innovation: it increases the size of jumps but causes jumps to occur less frequently. Initially, the first effect dominates the second, but when patent duration is very long, the quality distance between a patent holder's good and that of generic producers is so large that further increases in τ have only incremental effects on the incentives to innovate.

This inverted-U relationship can also exist between the rate of innovation and *patent breadth*. O'Donoghue and Zweimuller (2004) distinguish between lagging breadth, which determines the range of inferior products that infringe, and leading breadth, which determines the range of superior products that infringe. For example, if a patent holder has a patent on a good with quality level λ^*, a leading breadth of κ means that any future innovations with quality $\lambda \in [\lambda^*, \kappa\lambda^*]$, for $\kappa > 1$, would infringe upon the patent holder's right. Increasing leading breadth, κ, has two opposing effects on R&D incentives. On the one hand, the patent holder enjoys larger markups and has greater incentives to do R&D. On the other hand, the new patent holder has a weak bargaining position vis-à-vis incumbent patent holders early in the life of a patent. The new patent owner's innovation is likely to step on existing patent rights, requiring various licensing fees to be paid. It is only later in the life of a patent, when the patent rights of competing inventions expire that the patent holder is in a stronger bargaining position with respect to the next generation of patent owners. In this sense, the payoffs to a patent are backloaded, arriving later in time. Thus, a larger κ increases the bargaining power of incumbent patent holders and weakens that of new patent holders, reducing the latter group's R&D incentive. Overall R&D increases only if the payoffs to a patent are not excessively backloaded. Hence, R&D may have an inverted-U relationship with respect to leading breadth (rising initially and falling after κ reaches a certain point).

These models all suggest that at very strong levels of IPR, innovation may be adversely affected. Recent theoretical work on patent thickets could also explain why innovation could be (eventually) adversely affected when patent protection is too strong (see Shapiro 2000). The argument is that the stronger patent rights are, the greater the incentive to file patents. The more patents that are issued, the more permissions innovators will have to seek in order to build on previous technologies. This increases the transactions costs of licensing and cross-licensing negotiations. It also increases the likelihood of blocking (e.g. where patent holders refuse to grant those permissions in order to stave off competition). These increased transactions costs and blocking patents should negatively affect R&D and innovation.[6]

3.C.2. Stages of Development

Strengthening IPR in developing countries also involves tradeoffs similar to those in the North. On the one hand, it increases the ability of innovators to appropriate the returns to their innovations. On the other hand, it increases the costs of innovation because technological inputs will be more expensive when protected by proprietary rights. Cheap imitations or free copies of those inputs will less likely be available under stronger enforcement of IPR laws. But these benefits and costs of stronger IPR are likely to matter differently for developing economies. For instance, a given increase in the cost of R&D may be more burdensome for agents in the South than for their relatively wealthier counterparts in the North. Furthermore, Southern "innovation" tends to be more imitative, adaptive, or incremental in nature. These factors suggest that the IPR needs of the South would generally differ from those of the North. Indeed, recent theoretical work takes into account the different environments and innovative capacities of the former and shows that the optimal level and impact of IPR could vary by stage of economic development.

For example, the optimal level of protection for the South, θ_S, is determined by balancing the marginal costs and marginal benefits of IPR (see Grossman and Lai 2004).[7] The marginal costs (MC) consist of the extra consumer surplus losses that result from giving domestic and foreign patent holders the ability to price above their own marginal

[6] Bessen and Maskin (2000) and Boldrin and Levine (2002) offer related models based on the transactions costs of patents in the context of sequential innovation.

[7] A model of this kind is set out in the chapter by Edwin Lai in this volume.

production cost. However, this cost is reduced by any increase in the share of world profits from innovation that domestic firms earn. The foreign share of profits is excluded because they accrue to agents abroad. The marginal benefits (MB) consist of the increased innovation incentives provided to firms worldwide. Equalizing these factors yields a condition for welfare maximization:

$$MC(\overset{-}{\mu_S}) = MB(\overset{-}{\theta_S}, \overset{-}{\theta_N}, \overset{+}{M_S}, \overset{-}{M_N}) \tag{5}$$

Note that the marginal costs are a negative function of the South's share of world profits from innovation, μ_S. The intuition is that the greater the South's share, the greater the offset to consumer surplus losses. Due to diminishing marginal benefits of IPR, MB are a negative function of IPR levels in both the North and South. The larger the Southern market, (M_S), the greater is the incentive to innovate, and the greater the marginal benefit of IPR in the South. Using the above condition, we can see that if $\mu_S < \mu_N$ and $M_S < M_N$ – that is, if the South has a weaker capacity to innovate and a smaller market size – then the optimal strength of IPR in the South should be lower than that in the North (i.e. $\theta_S^* < \theta_N^*$). The intuition is that if Northern markets are larger, most innovators will earn their returns in the North. Thus, a given increase in Northern IPR has a larger impact on world incentives to innovate than the same increase in Southern IPR. If the South has a lower capacity to innovate, the North will have a greater share of the world returns to innovation and enjoy greater offsets to the deadweight losses from strengthening Northern IPR.

This theoretical result has important empirical implications, as it could explain why we observe the impact of patent strength on innovation to vary by level of economic development. Specifically, if they are obliged to adopt Northern standards of protection, Southern economies would have a level of protection that exceeds their optimal level – a level which should take into account their *limited market size* and the *imitative, adaptive nature* of their R&D. Hence innovation could be adversely affected in the South if their IPR are raised to Northern levels.

Another important component to the development dimension of IPR is that there may be *threshold effects* at work. Eicher and Penalosa (2006) construct a model in which a critical market size is required before IPR can positively influence innovation. Below this threshold size, the model predicts no significant relationship between patents and innovation. Above the threshold, a two-way causation emerges. The positive feedback mechanism involved is that, on the one hand, high innovation is possible if patent rights are strong, but, on the other, IPR would be made strong if research activity is vibrant enough to create vested interests in such a system. To generate this feature, Eicher and Penasola (2006) introduce two sectors, one undertaking imitation and the other performing R&D. The R&D sector consists of two types of labor: research workers and institution building agents (i.e. lobbyists). If patent rights are too weak, the returns to R&D are low and few funds are available to invest in institution building, let alone innovation. If IPR are sufficiently protective, the returns to R&D are high and sufficient funds are available to maintain strong institutions and drive innovative activity. Going from the low-level equilibrium to the higher one requires a critical minimum market size. Market size affects the value of innovation, and thereby the impetus for institution building. This model also explains why the impact of IPR on innovation could vary by level of economic development.

In related work, Chen and Puttitanun (2005) derive a theoretical model which yields a U-shape relationship between the optimal strength of IPR and economic development. In choosing the strength of IPR protection, a government weighs two factors: first if protection is weak, high quality foreign innovations can be more easily copied and diffused via local imitation; second if protection is strong, local innovators have stronger incentives to engage in research and innovation. In less developed economies, the first factor is more prominent since the quality of local innovation is low; hence governments choose weaker IPR protection. In more developed economies, the quality of local innovation is higher and governments choose stronger IPR protection.

3.D. Technology Transfers and IPR

Technology transfer is the act of shifting technological know-how and the rights to production or sales from one entity to another, whether within a country or across borders. Several decisions must be made by a firm considering whether to transfer an element of technological knowledge, including whether to enter at all and the form of entry.

3.D.1. Market Entry

Maskus and Penubarti (1995) identify two opposing effects of stronger IPR on trade: *a market-expansion effect* and *a market-power effect*. These effects could also be present in other forms of technology transfer activities. Consider a firm in country A that exports patentable commodities to country B, and suppose country B strengthens its IPR. On the one hand, the firm perceives an expansion in its market due to a reduction in imitation by local firms. The demand curve it faces in country B shifts out. On the other hand, stronger IPR in country B increase the firm's market power, reducing the elasticity of the demand it faces. The market-expansion effect is likely to dominate in countries where the market environment is competitive, and the market-power effect in regions where local competitors pose a weak threat of imitation.

Timing is also an important variable. Stronger IPR may delay the introduction of new technologies to a market. As argued in Takalo and Kanniainen (2000), stronger IPR increase the option value of "waiting." As the threat of rival entry is reduced, the innovator may choose to commercialize later. This *value of delaying* may explain an inverted-U relationship between technology diffusion and IPR. Specifically, when IPR are too strong, the incentives to delay may outweigh the market-expansion effects.

3.D.2. Modes of Entry

Next, I analyze the different modes of entry (export, FDI, and licensing) jointly, rather than in isolation. The advantage of this is that we can take into account how changes in host country factors, like IPR, could affect not just the volume of technology transfer but also its composition in terms of the different modes of entry.

A useful starting point is the *Ownership, Location, and Internalization (OLI)* framework of Dunning (1980). The *ownership* factor influences a firm's decision to enter a foreign market. A firm selling a good abroad has a disadvantage competing with producers who know the local market better. To compensate, the firm needs to have some advantages, such as the ownership of a superior technology. The *location* factor influences a firm's decision to enter via exports or FDI. For example, exporting may involve lower agency costs or setup costs than a subsidiary abroad. To compensate, the foreign market needs to provide some location advantage, such as lower factor costs. The *internalization* factor influences a firm's decision to produce the good in its subsidiary or to license the production to another party (affiliated or unaffiliated). The firm chooses to internalize production if there are advantages to controlling the production process, such as the avoidance of transactions costs.

Stronger IPR in the host country can affect each of these factors – the ownership value of technology, the attractiveness of locating production abroad, and the incentive to deal with agents external to the firm. The ambiguity, however, is in how the composition of the different modes of entry is affected. Thus, further theoretical factors are needed to explain firms' choices and strategies.

One factor is the cost of setting up multinational plants. Following Nicholson (2003a) and Vishwasrao (1994), consider a firm choosing between FDI and licensing.[8] Let δ be the imitation risk associated with a multinational plant (in terms of the rate of dissipation of profits) and ϕ the probability that a licensee will defect to operate a rival business. It is assumed that $\phi > \delta$, since a plant is better able to control information. However, establishing a plant involves fixed *setup costs*. Let F denote these costs as a percentage of profits. Licensing has the advantage of avoiding these costs. Both δ and ϕ are functions of the strength of IPR, θ, such that $\delta'(\theta) < 0$ and $\phi'(\theta) < 0$. The firm is indifferent between licensing and FDI if:

$$\phi(\theta) = \delta(\theta) + F \tag{6}$$

If θ^* solves equation (6), FDI is the preferred mode of technology transfer for $\theta < \theta^*$ and licensing for $\theta > \theta^*$.

[8] The firm chooses either FDI or licensing over exports as long as sufficient factor cost advantages exist abroad.

Moreover, the critical value, $\theta*$, varies inversely with F. The setup costs of plants are higher for technologies that are more complex. Indeed such costs act as a natural barrier against imitation. The critical value, $\theta*$, is lower for industries where technologies are relatively hard to reproduce. For technologies that are relatively easy to replicate, the threshold value of IPR that would induce licensing would be much higher.

Another factor affecting the choice between FDI and licensing is the industry or economy-wide *rate of innovation* (see Maskus *et al* 2005). Consider a second type of fixed cost (in addition to plant setup costs), namely a contractual cost. This cost can relate to the cost of transferring knowledge or establishing a legal relationship. Both licensing and FDI involve a contractual fixed cost.

The market value of a firm depends on whether FDI or licensing (LIC) is chosen as the mode of technology transfer and equals the present discounted value of the stream of profits less the fixed costs:

$$V^{FDI} = \frac{\pi^{FDI}}{\iota + \phi(\theta) + r} - C^{FDI}(\theta) \tag{7}$$

$$V^{LIC} = \frac{\pi^{LIC}}{\iota + \phi(\theta) + r} - C^{LIC}(\theta) \tag{8}$$

The discount rate is the interest rate, r, adjusted for the risk of imitation ϕ and the risk of a future innovation ι, which would displace the technology. These risks are assumed to be the same whether FDI or licensing is undertaken. As before, the risk of imitation is lower the stronger IPR are (i.e. $\phi'(\theta) < 0$). The firm chooses licensing if $V^{LIC} > V^{FDI}$ and chooses FDI in the other case. Contractual costs are also lower the stronger are IPR (i.e. $C^{i}{}'(\theta) < 0$, for i = FDI, LIC). Moreover, it is assumed that an increase in IPR reduces contractual licensing costs more than it reduces contractual FDI costs (i.e. $|C^{LIC}{}'(\theta)| > |C^{FDI}{}'(\theta)|$) on the grounds that licensing contracts often involve dealing with agents external to the firm. The other kind of fixed cost – plant setup costs – is assumed to be independent of the strength of IPR. Hence assume plant establishment costs are zero. One further assumption is that the profit flows to licensing are lower than that of FDI (i.e. $\pi^{FDI} > \pi^{LIC}$) on the grounds that licensing involves sharing rents with the licensee.

Assume initially that the firm is indifferent between licensing and subsidiary production. Using (7) and (8), it can be seen that a strengthening of IPR has two effects. On the one hand, it reduces contractual costs, but more for licensing than for FDI. Let ΔC be the difference between the reduction in contractual licensing cost and the reduction in contractual FDI cost. Since $\Delta C > 0$, this increases the propensity to license. But on the other hand, an increase in IPR reduces the risk of imitation and increases the present discounted stream of profits, but more for FDI than for licensing since $\pi^{FDI} > \pi^{LIC}$. Let $\Delta\Pi$ be the difference between the gain in lifetime profits under FDI and the gain in lifetime profits under licensing due to reduced imitation risk. Since $\Delta\Pi > 0$, this increases the propensity to engage in FDI. Thus, if contractual cost reductions exceed profit gains (i.e. $\Delta C > \Delta\Pi$), licensing would be the mode of technology transfer.

If $\Delta C < \Delta\Pi$, the choice of FDI versus licensing will depend on the rate of industry or economy-wide innovation ι. Rapid rates of innovation, by increasing the likelihood that the firm will be displaced by a better product, depress the expected present discounted value of the firm's stream of profits. High values of ι would therefore make the gains from reduced imitation risk appear small, and thus the firm would give less "weight" to $\Delta\Pi$. The contractual cost savings under licensing would appear more prominent and the firm would choose licensing over FDI. However, for low rates of innovation, the gains in FDI profit flows from reduced imitation risk are more significant (relative to the contractual cost savings under licensing) and the firm would choose FDI over licensing. Thus stronger IPR lead firms to choose licensing over FDI as long as innovation is actively occurring in an industry or economy.

Finally, the above theoretical discussions have abstracted from the type of technology transferred. A firm can choose not just the mode of entry but also the vintage of the technology to be transferred (see Fosfuri 2000 and Taylor 1994). For example, if IPR are weak, the firm may transfer an older version of the technology or not transfer its best-practice research technology.

3.E. Relevance for Empirical Work

Collectively, the theoretical literature does not provide unambiguous predictions about the effects of IPR on innovation and technology transfer. In Table 2, I summarize the different theoretical channels or mechanisms identified in the literature and include a judgment as to what the theoretical work seems to be leaning towards most (by region and by type of activity), based on the following reasons.

First, for the North, the literature appears to suggest an inverted-U relationship between IPR and innovation. At low levels of IPR, stronger protection stimulates innovation by increasing an agent's ability to appropriate the returns to investment. At high levels of IPR, the effects of patent thickets, blocking, and reduced competitive pressures may raise the costs of innovation and reduce incentives for innovation. The North-South literature identifies conflicting effects on innovation from global IPR reform, depending ultimately on whether resources are freed up for Northern R&D. Fewer resources are available, for example, if production shifts to the North. However, as I pointed out, the feedback effects may be small if the South constitutes a small share of the world market.

For the South, there are also conflicting effects of stronger IPR on innovation. The South may be on the "left side" (or efficient side) of the inverted-U curve described in the optimal patent literature given that Southern IPR are relatively low. On the other hand, the optimal level (peak) differs for North and South. The South has a smaller market and focuses on adaptive R&D, so that adoption of Northern IPR standards may be inefficient for Southern innovation. On net, the effects of IPR on innovation are likely to be negative in developing countries, particularly in the least developed economies. At best, there may be an insignificant influence due to the possibility of threshold effects. In particular, the size of the Southern market may be below the critical level necessary to yield positive returns on investing in stronger IP institutions.

As for technology transfers, stronger IPR are likely to have a positive effect on the volume of technology diffusion in the North. The market-expansion effect is likely to outweigh the market-power effect (given the greater imitative and innovative capacities in the North and the dynamic, competitive pressures there). However, a possibility exists that excessively strong protection could give firms incentives to delay the introduction of new technologies and enjoy greater rents on existing technologies. For the South, the theoretical literature is divided on whether the South would enjoy increased technology transfers from strengthening their IPR. On the one hand, there are factors, such as reduced imitation risk and contractual costs, that increase Northern incentives to offer more technology to the South. On the other hand, Northern firms could enjoy increased market power as stronger IPR in the South raise the cost of imitation or erect barriers to inventing around patents. On net, I find that the *a priori* prediction is simply ambiguous.

In terms of the composition of technology transfers, the theoretical literature suggests that licensing is likely to be preferred to FDI if the innovation rate (ι) is high, if plant setup costs (F) are high, and if existing IPR are high. These conditions are more likely to be present in the North than in the South, hence licensing is likely to be preferred to FDI in the North – and the opposite is more likely in the South – as IPR strengthen. Either FDI or licensing is likely to be preferred to exports if there are strong location advantages, such as lower factor costs, in the South.

4. Empirical Research

Before discussing empirical evidence, I describe the empirical framework common to most studies. Empirical work requires some measure of the strength of IPR. Various measures of innovation and technology transfer are then regressed on a measure of the strength of protection and other control variables.

4.A. Methodology

4.A.1. Measuring IPR strength

Two types of measures exist: (a) experience-based measures and (b) statutory measures. Both have advantages and drawbacks. Experience-based measures are based on surveys of expert opinion, reports, or cases. For example, Mansfield (1994) surveyed executives from 94 US manufacturing firms to rate the IPR systems of 16 countries on the basis of whether protection was adequate to engage in a variety of technology transfer activities.[9] Sherwood (1997) rates the adequacy of a broad range of IPR (patents, trade secrecy, trademarks, and copyrights) in 18 countries. The World Economic Forum (2000) surveys business leaders in various countries as to whether they regard intellectual property as well-protected, with answers ranging from one (strongly disagree) to seven (strongly agree). The average rating across all respondents in a country gives the index for that country. Park (2005) constructs ratings of enforcement effectiveness based on complaints filed with the United States Trade Representative concerning IPR laws and practices abroad.

The drawback with surveys of expert opinion is that they are usually available for a cross-section of only a small number of countries. The surveys are intensive and it is not surprising to see a limited time-series dimension. The opinions are subjective, even if they are based on experience, and the intensity of opinions is difficult to compare among different experts without a common *anchor* for the perceptions. Also, with the exception of Sherwood (1997), views on the different IPR (such as copyrights, patents, and trademarks) are lumped together. Lastly, based on responses to questions such as "are IPR laws adequate?" it is difficult to ascertain whether a weak system is due to the lack of laws or to poor enforcement or implementation of the laws.

Statutory measures construct an index based on whether various features of IPR systems exist. For example, the state of IPR in country n at time t could equal:

$$\theta_{nt} = \omega_1 \theta_{nt}^1 + \ldots + \omega_J \theta_{nt}^J \tag{9}$$

[9] To form an index, Lee and Mansfield (1996) aggregate the responses to find the percentage of respondents who thought that IPR in a country were adequate.

where $\theta^1, \ldots, \theta^J$ are the different categories of an IP system, and ω_i's the weights of each category. Ginarte and Park (1997) follow this approach to construct an index of patent rights where they examine five major categories (duration of protection, coverage (e.g. what is patentable), membership in international treaties, enforcement mechanisms, and restrictions on patent scope, such as compulsory licensing). They assign equal weights to each of these categories. Rapp and Rozek (1990) use a similar approach to derive an index of patent protection, except that their measure is for one year (1984). Lerner (2002) examines various categories (e.g. existence and duration of patent protection, cost of patent applications, restrictions, and administrative features) for 60 countries from 1850 – 1999 (every 25 years), but does not construct an index, preferring to analyze the effects of separate reforms through event-study methods.

Branstetter et al. (2006) follow a dummy-variable approach, letting $\theta_{nt} = 1$ for $t \geq t^*$ and $\theta_{nt} = 0$ for $t < t^*$, where t^* is the date of a patent-law reform in country n. Some pitfalls with this approach are that reforms are not one-shot but ongoing over time and that not all reforms are equal, with some being major and some minor. Further, a dummy-variable approach does not solve the difficulty of distinguishing between statutory changes and the actual implementation of laws.

A drawback with statutory measures is that there are likely to be deviations between actual practice and what the laws on the books state. Most prominently, a country may allow for extensive judicial and administrative enforcement mechanisms in its law but fail to invest resources in actual enforcement, leading to an effectively weak system. But one should not downplay the importance of statutory provisions. Having laws on the book constitute an explicit obligation on the part of the state to provide certain rights (much like a written contract). Though in practice the enforcement of laws may not always be effective, the presence of laws on the books forms the basis for a grievance against another party or for seeking redress. Statutes and precedent provide guidance for judges and other officials as to how to apply the law.

Table 3 shows the correlation among the various indexes discussed above.[10] To compute the correlations between the different measures, I use the closest year (or years) that matches or overlaps between them. The two main messages of the table are that the statutory-based measures do, in general, correlate well with the experience-based measures. Second, among the experience-based measures, expert opinions can differ quite a bit across different surveys.

4.A.2. Regression Framework

I turn now to a review of econometric studies that relate measures of activity to indexes of IPR strength. Consider the following equation to be estimated:

$$Y_{nt} = \beta_0 + \beta_1 \theta_{nt} + \beta_Z X_{nt} + e_{nt} \qquad (10)$$

where Y is some measure of innovation or technology transfer in country n at time t, θ is an index of intellectual property rights, X a vector of control variables, and e the error term (which may consist of fixed or random effects across n). In many studies, due to limited time-series data, a cross-sectional regression is run where t is some given year or average of years. Fewer studies employ industry-level or firm-level level data on Y.

Empirical studies examine the extent to which variations in Y (across space and over time) can be explained by variations in θ (across space and over time), controlling for other variables. In some specifications, a nonlinear effect of IPR is considered so as

[10] I exclude ratings based on Lerner (2002) because an overall index has not been constructed.

to allow for the possibility that its impact could be negative or positive depending on particular circumstances. In this case, the equation could consist of a quadratic term $\beta_2\theta_{nt}^2$, such that an inverted-U relationship holds if $\hat{\beta}_1 > 0$ and $\hat{\beta}_2 < 0$ and a U-shape relationship if $\hat{\beta}_1 < 0$ and $\hat{\beta}_2 > 0$.

One potential problem is that if all countries in the world adopted the same standards of IPR, i.e. perfect harmonization, such that θ were the same across countries and over time, the above empirical framework could not be used to estimate the effects of protection. In line with this point, Scotchmer (2004, p. 325) addresses a related empirical difficulty:

"Under a system of national treatment, an inventor's incentives to invent do not depend on where he or she is domiciled, regardless of differences in intellectual property laws . . . . Hence, there are reasons to think that the efficacy of intellectual property protection cannot be studied by comparing the success of inventors across countries with different systems. Even if there is heterogeneity in intellectual property protections, there is no heterogeneity in firms' incentives."

National treatment would reduce the significance of cross-sectional variations in IP strength to innovation. Instead, what matters to innovation anywhere in the world is the global level of IPR, say $\theta_t = \sum_{n=1}^{N} \varpi_{nt}\theta_{nt}$, where ϖ_{nt} could be a country's weight in the global level, depending on its share of world output or innovation. Only changes in θ_t over time, for example, would affect innovation (not differences across n). In practice, this criticism does not seriously diminish the value of the econometric framework above. First, national treatment is not widespread and has not been practiced for much of the sample period in the empirical studies. Second, should national treatment be strongly enforced worldwide, only the cross-sectional studies would be affected. Panel-data studies with a time dimension would pick up changes in global incentives over time.

Third, not all firms are global and many file domestic patents only. Typically, international protection is sought for just a fraction of domestic innovations. Thus, national measures of θ remain relevant for these firms. Global firms have a choice of where to locate their production and innovation.[11] For example, firms from both weak and strong IPR countries may choose to conduct their innovation in the country with stronger protection. These choices would be reflected in the data on Y. Thus, higher values of Y_n may be positively associated with higher values of θ_n, even in a world of national treatment. As long as differences in national IPR influence location decisions, international innovation efforts would be sensitive to variations in protection across countries.

Fourth, in addition to innovation investments, cross-country differences in IPR systems would affect incentives for technology transfer. International trade, FDI, and licensing may concentrate more in countries with stronger protection regimes.

In what follows, I organize the review of the evidence by the dependent variable of interest. I first start with measures of innovation and then measures of international technology transfer. Table 4 provides an overview of the empirical studies reviewed here. For each dependent variable of interest, I look for findings related to the following hypotheses or issues, as addressed in the theoretical literature.

- Do stronger IPR stimulate innovation and technology transfer? Are the effects linear (negative or positive) or non-linear (U-shape or inverted-U shaped)?
- How do IPR affect the composition of technology transfer by mode of entry, if at all?
- Does the impact of IPR on innovation and on the volume and composition of technology transfer vary by stage of economic development?

[11] See Cantwell (1995) for evidence on the internationalization of parent-company R&D and for how geographically dispersed innovations are within multinational firms.

4.B. Innovation

As measures of innovation, R&D and patent data are most common. Patents are viewed as the output of innovation, while R&D expenditures are an input. One well-known difficulty with patent data is that increased patenting may merely reflect increased propensities to patent rather than increases in the rate of innovation. Thus, it is useful also to consider R&D as a complementary measure of innovative activity.

4.B.1. Research and Development

Recent studies that examine the relationship between R&D and IPR, controlling for other factors, tend to find a statistically significant positive association (Varsekelis 2001, Kanwar and Evenson 2003, Park 2005, and Allred and Park 2007). In these studies, no evidence exists of an inverted-U relationship between the strength of patent protection and R&D. Indeed in Kanwar and Evenson (2003), a quadratic term (square of the patent-rights index) is incorporated but the coefficient is strongly positive, suggesting that the marginal impact of patent rights is increasing in the level of patent rights. Allred and Park (2007), utilizing firm-level data, instead find a U-shaped relationship between patent strength and R&D (controlling for firm characteristics and national-level factors), so that initially R&D falls with patent strength and rises with it after a critical level of patent strength is reached. Thus, results from these papers show no inverted-U effect as suggested in the optimal patent literature. This does not preclude the possibility that there could be eventually a "peak" effect of patent rights on R&D, since the existing levels of patent strength around the world may still be below the critical point. The measured indexes of patent protection are based on minimum standards established by international agreements (such as TRIPS). The maximum values of these indexes do not necessarily represent the potential upper bounds of IPR strength.

Sakakibara and Branstetter (2001), however, find that patent reforms in Japan in 1988 had negligible impacts on Japanese R&D and patenting. The reforms, among other things, broadened patent scope by permitting multiple claims to be made on a patent. The findings in this study could suggest a diminishing impact of IPR on innovation as IPR increase in strength. Alternatively, because the Japanese patent system may have generally been perceived as fairly strong, the 1988 reforms may have contributed marginally to the overall strength of patent rights. Like the cross-national evidence, the findings in this study do not explicitly suggest an inverted-U relationship between innovation and patent strength..

Developed and developing countries respond rather differently to patent reforms. Allred and Park (2007) find that the nonlinear (U-shaped) relationship between patent strength and R&D applies to developed countries but not to developing. For developed countries with initially weaker (stronger) IPR, stronger patent protection reduces (increases) R&D. This may be because Northern economies with weaker IPR are largely conducting incremental, adaptive innovation. In that case, the higher cost of R&D due to stronger patent protection may have a greater negative effect than the positive impact of enhanced appropriability of R&D investments.

For developing countries, the above study finds that patent protection has a statistically insignificant effect on R&D. Park (2005) concurs in finding that patent protection has insignificant (at conventional levels) impacts on developing-country R&D expenditures. The latter study also examines additional types of IPR, such as copyrights and trademark protection, finding that once patent protection and enforcement are controlled for, these other devices lose statistical significance.

The statistically insignificant effect of IPR on R&D in developing countries may indicate that stronger exclusive rights stimulate some investments that would not have occurred under a weak regime, but crowd out just as much R&D that depended on access to cheap technological inputs or royalty-free imitations. The insignificant result also could reflect the existence of threshold effects. A larger market or a larger research sector is required before stronger IPR provide sufficient incentives for increasing R&D expenditures. Strengthening IP rights from an initially low level to a somewhat higher level may not suffice to provide the necessary incentives or the wherewithal to provide a legal infrastructure to support research and innovation (such as research facilities, a court system, IPR administration, specialized professionals, or market for licensing). Threshold effects imply that a minimum strength of patent laws is needed to generate incentives for R&D and to maintain an effective IPR system.

4.B.2. Resident Patenting

Among cross-national studies using resident (or domestic) patenting, two find that patent reforms have had insignificant effects. Lerner (2002), for example, examines 177 events of patent reforms in 51 countries over nearly a 150-year period. The reforms cover the enactment of patent laws, changes in duration of rights and fees, and limitations on patent rights (such as revocation and compulsory licensing). On average, the number of residential patent filings before reforms was not significantly different from that after reforms. Likewise, Branstetter *et al* (2006) examine patent reforms in 12 developing countries from 1982 to 1999 and find that reforms evoked no significant responses in residential patent filings. Allred and Park (2007), in contrast, find that the strength of patent rights has a nonlinear (U-shape) relationship with residential patent filings, holding other factors constant. The difference in result is likely due to a difference in specification. Allred and Park (2007), for example, also find an insignificant effect of patent rights on domestic patenting if a linear specification is used, but if a quadratic term (i.e. the square of patent rights) is included, a statistically significant U-shape relationship emerges. Moreover, when Allred and Park (2007) use the same sample of countries in Lerner (2002) and Branstetter *et. al* (2006) and impose a nonlinear specification, they again find a U-shaped relationship between residential filings and patent strength.

This means that that we have not (yet) been able to find supportive evidence of the theoretical prediction of an inverted-U effect, in which eventual market-power effects of excessively strong patent rights or patent thickets diminish innovation. Again, it may be that the measured levels of patent strength are below the critical level. Another explanation may be that patent thickets and other related arguments, however valid, apply to a small sector of the economy (e.g. software or biotechnology) or that the transactions costs are actually manageable.[12] On the other hand, the positive effect of patent protection on residential patenting, found in some studies, may not reflect increases in the rate of innovation but in the propensity to file patents. As patent rights get stronger, the demand for patent protection increases. Patent applications for the more marginal innovations may be filed as stronger patent rights increase the value of patent protection.

Returning to the Allred and Park (2007) study, they find stronger patent protection to affect domestic patenting negatively (and linearly) in developing countries.

[12] Thus far, empirical evidence of an "anti-commons" effect of patent rights on biotechnological research suggests that the effects are small (see Murray and Stern 2005 and Walsh et al. 2001).

The question is why, for such nations, we find an insignificant effect of patent protection on R&D but a significantly negative effect on domestic patenting. One possibility is that local patent reforms attract foreign patents which are filed first (i.e. have priority rights) and which cover diverse fields and claims, so that some resident patenting is crowded out, displaced, or pre-empted.

4.B.3. US Patent Applications

Instead of resident patent filings, other studies examine patent filings at the US Patent and Trademark Office (USPTO). If increases in a country's domestic patent strength increase domestic innovation, this could lead local agents to increase their filings abroad, including at the USPTO. Chen and Puttitanun (2005) examine 64 developing countries and find that the larger developing countries that strengthen their patent laws are more apt to file patents in the United States, holding other factors constant. Schneider (2005) finds that stronger home patent rights have a positive effect on US patent filings for developed countries only. For developing countries, patent protection is either negative or insignificant once other variables, like infrastructure and FDI flows, are controlled for. Overall, these results are consistent with studies that investigate domestic patenting. The key difference is that the US patent filings are the foreign patent filings of residents outside the United States. There is a selection bias in that international patent protection is generally sought for the more valuable innovations (given the costs of filing), which may be why the US applications of larger developing countries are more sensitive to patent strength than are those of smaller poor nations.

4.C. International Technology Transfer

Foreign trade, FDI, and licensing are the most common measures of technology transfer because they are the vehicles by which technologies are spread internationally. Less common is the use of international (foreign) patenting data. Firms may not seek patent protection in a destination market if they are transferring technologies that are no longer patentable. The most common reason that inventions may not be eligible for patents is that they were already introduced and practiced somewhere else at least one year prior, placing them into the public domain in locations where patents had not earlier been registered. I first discuss empirical studies that focus primarily on a single mode of technology transfer, and then turn to studies that examine multiple modes jointly. The latter studies address whether stronger IPR increase one particular mode of entry (or service) relative to another.

4.C.1. International Trade

Recent empirical studies find a positive influence of IPR on trade flows, particularly for developing countries. Maskus and Penubarti (1995) introduce this subject into the empirical literature, finding that an index of patent rights in importing countries had a significantly positive effect on industry-level manufactured imports.[13] Smith (1999) and Co (2004) develop similar results, but issue the qualification that the impact of stronger patent protection on trade depends on the importing country's capacity to imitate (using R&D/GDP ratios as an indicator of this capacity). In countries that have a weak imitation capacity, stronger patent rights exert a greater market-power effect than a market-expansion effect.

[13] See also Fink and Braga (1999).

A common finding in these studies is that stronger patent rights have either an insignificant or negative effect on trade in high-technology, R&D-intensive, or patent-sensitive goods. This seemingly paradoxical outcome may be due to the fact that if foreign IPR levels are weak, firms find it safer to export sensitive goods rather than produce them abroad. Thus, as patents become stronger firms become more open to other servicing options, tending to diminish trade. Another reason is that firms in patent-sensitive industries may already possess some market dominance from their technological superiority. Stronger patent protection would then largely create market-power effects, also reducing the volumes of trade.

4.C.2. Foreign Direct Investment (FDI)

Empirical evidence on the effects of IPR on FDI is mixed. I first describe results using US data, and then those using other data. Braga and Fink (1998) examine the stocks of outward US direct foreign investment in 42 countries in 1992 and find that they weakly correlate with the strength of patent protection in those countries, holding other factors constant. In contrast, Lee and Mansfield (1996) examine a panel of 14 developing countries around the same period. They find that the strength of IPR rights (as perceived by managers in the Mansfield (1994) survey) is a significant determinant of the volume of US outward FDI flows. They also show evidence that weaker IPR can affect the composition of FDI, making firms more likely to invest in sales and distribution outlets rather than manufacturing plants or R&D facilities.

More recent studies have used more current US data. Nunnenkamp and Spatz (2004) find that protection of intellectual property rights is a significant determinant of US outward FDI stocks, particularly in developing countries. A reason that IPR may matter more for FDI in such countries is that technology protection is generally weak in developing regions, so that a given change in an IPR index represents a relatively major policy development. In larger and richer countries, the environment for FDI is conducive for other reasons, such as market size, strong contract enforcement, infrastructure, and labor skills, so that IPR may matter relatively less. As I will argue later, in more developed countries a further strengthening of IPR permits firms to consider other options, such as licensing, rather than expanding their subsidiaries.

Branstetter *et al* (2005) examine the activities of US multinational firms in 16 countries during the period 1982 to 1999. They consider multiple dependent variables associated with FDI activity, such as local affiliate sales, employment, capital stock, R&D, and industry output. The reason for examining a comprehensive set of variables is to ensure that IPR reforms did not merely increase firms' market power but led to "quantity" effects, such as increased production, employment, and investment in capital and technology. Their results indicate that episodes of stronger IPR have been followed by expansions in multinational sales, employment, investment, production, and technology transfer, and that these effects are disproportionately stronger where the parent firms are heavily dependent on patents.

Thus, evidence from US multinational enterprises suggests a positive effect of IPR on FDI, particularly in developing countries. Moreover, this effect appears to be stronger with more recent data, samples with a longer time-series and microeconomic firm-level observations.

I now turn to evidence using FDI data from outside the United States. Using French multinational firm data, Mayer and Pfister (2001) find that stronger patent rights have a negative influence on the location decisions of multinational firms. When they split their sample into developed and developing host countries, they find that the strength of a developing country's patent laws has a statistically insignificant influence on the probability that a French multinational firm will locate in that country. The strength of a developed country's patent laws has a quadratic (inverse-U) effect on the firm's probability of locating there, implying first an increase and then a decline after some critical level of patent law strength is reached.[14]

It is important to note that Mayer and Pfister (2001) study location decisions, a yes or no dichotomous variable, rather than FDI flows or stocks. For firms already located in a country, the intensity of technology transfer in response to changes in patent laws is not captured in the location data alone. A difficulty with interpreting their results is that they can be consistent with both the market-power and market-expansion hypotheses. If firms exercise greater market power, they would reduce the flow of new branches or affiliates being opened up so as to enjoy greater rents from existing outlets. Otherwise, if firms take advantage of expanded markets, they may be exploiting alternative modes of marketing their goods and services, such as licensing or joint ventures. Thus a key limitation with focusing on single entry modes like this is that it makes it difficult to draw decisive conclusions about whether stronger IPR enhance or reduce technology transfer.

Using firm-level data for Eastern Europe and the former Soviet Union states, Javorcik (2004) finds that stronger patent rights have a positive and statistically significant effect on the probability of foreign investment in high-technology sectors and

[14] Mayer and Pfister (2000) also obtain an inverse-U relationship for developing countries if the level of corruption and political rights in the host country are not controlled for. They argue that patent indexes may be picking up the effects of institutional factors and the regulatory climate.

an insignificant effect in other sectors. Moreover, foreign investors are more likely to invest in sales and distribution outlets rather than in manufacturing or R&D facilities when patent protection is weaker. This propensity is found in all sectors, not just in high-technology. These findings conflict with those of Mayer and Pfister (2001) but are consistent with those of Lee and Mansfield (1996).

Using Japanese firm-level data, Belderbos *et al* (2006) study the decisions of 605 Japanese multinational firms in 42 countries regarding where they invest in R&D facilities. Their survey data allow for a rough separation of R&D investments into research-related investments (R) and development-related (D) investments. Both R and D abroad are found to be positively influenced by a host country's strength of patent laws. This supports Javorcik's (2004) conclusions as well.

Thus the non-US evidence on the effects of IPR on FDI is also mixed. However, the breakdown of FDI by function and sector is valuable in indicating that the effects vary, depending on whether FDI is largely for purposes of sales and distribution outlets, or for production and R&D, or whether the investment is in technology-intensive industries.

4.C.3. Licensing

Recent studies on licensing find a positive association between patent strength and licensing, holding other factors constant. Using US firm-level data, Branstetter *et al* (2006) examine the determinants of the value of licensing fees and royalty payments made by affiliates in 16 countries to their American parents. They find that patent reforms contribute to a rise in affiliated licensing fees and royalties to US parents, and that the rise is especially significant from affiliates whose parents patent extensively. Of course, the value of such fees and payments is the product of price (fee per transaction) and quantity (number of transactions). If stronger patent rights largely increase market power, the increase in the value of payments may be driven largely by the higher prices charged. Thus, to assess whether more actual technology transfers occurred (i.e. the quantity effect), the study explores whether R&D by affiliates and patenting by US firms increased in the reforming countries. I will discuss the foreign patenting results later. As for R&D, the study finds that such spending by affiliates is significantly higher after reform than before reform (holding other factors constant).

Note that this study focuses on one particular mode of technology transfer, that of affiliate licensing. It is possible that increases in affiliate licensing come at the expense of licensing to unaffiliated firms. If increased patent strength increases the market power of the licensor, that firm may have an incentive to exploit the technology through subsidiaries or affiliates rather than through arm's-length parties. Thus, it would be useful to determine if total licensing -- affiliated plus unaffiliated – increases after significant patent reforms.

Yang and Maskus (2001a) examine both affiliated and unaffiliated licensing by aggregate US firms in 23 countries. In contrast to Branstetter *et al* (2006), they find that stronger patent rights have an insignificant impact on licensing fees and royalties from affiliated parties. One explanation may be that since these transactions occur internally within the multinational organization, licensing to affiliated parties may be less sensitive to patent protection levels. Another is that the imitation risk associated with affiliated licensing is likely to be less than that with unaffiliated licensing so that stronger patent rights enhance the licensor's market power over affiliated parties.

As for unaffiliated licensing and IPR, Yang and Maskus (2001a) find a nonlinear (U-shaped) relationship between those flows and the strength of patent rights, holding other factors constant. The intuition is that at low levels of patent strength, destination countries have limited imitative capabilities. Stronger patent rights have a greater market-power effect than a market-expansion effect in that situation. At higher levels of patent strength, the destination countries have more innovative activity and pose greater imitation risks. In this situation, the market-expansion effect of stronger patent rights tends to dominate.

As for studies exploring non-US multinational-firm data, Wakasugi and Ito (2005) examine the affiliated licensing, and Nagaoka (2004) the unaffiliated licensing, of Japanese companies. Both studies find that stronger patent protection enhances Japanese foreign licensing (affiliated and unaffiliated). Because the unit of analysis in Nagaoka (2004) is individual licensing contracts, his study is able to demonstrate the existence of a positive "quantity effect" of stronger patent rights on arm's-length technology transfers.

4.C.4. Joint Modes of Entry

Thus far I have considered the effects of IPR on one mode of entry at a time. But firms have a choice among alternative modes. These alternatives are not perfectly substitutable for there may be costs of adjusting among them. For example, if a firm already has a subsidiary, it would be a drastic change to shut it down and license production to a third party. However, given the right incentives and opportunities the firm can decide to vary its mode of entry or its means of servicing foreign markets in response to changes in host-country conditions.

Recent empirical work has explored both the volume and composition of technology transfers, and how each mode varies relative to another in response to stronger IPR. The results are often conditional on other factors being present. Using US aggregate data, Smith (2001) finds that stronger patent rights in recipient countries expand the scale of all technology transfer activities considered (exports, FDI, and licensing) but have relatively large impacts on licensing and FDI. This appears to support the OLI framework, wherein greater IPR strength enhances location advantages and alters internalization considerations. The effects found by Smith depend, though, on the imitative capacity of the host country (measured by whether there are sufficient R&D scientists and engineers per million people). Weak capacity itself provides *de facto* protection against imitation so that patent protection matters less when the threat of imitation is weak.

Nicholson (2003b) works with count data on the number of US multinational firms engaged in FDI or licensing in 1995, broken down by industry. Count data help provide a perspective on the quantity effects of IPR changes, but leave out information on the value of transactions. As discussed earlier, firms in capital-intensive industries are likely to enjoy *de facto* protection from imitation due to their complex, hard-to-replicate inputs. This is reflected in the empirical results: in countries where capital costs are high and patent protection strong, firms prefer licensing to FDI. But where capital costs are high and patent protection weak, firms prefer to keep production internalized within their affiliated subsidiaries. Thus how IPR influence the choice of mode is conditional on the capital intensity of firms. For destination countries outside the richer nations of the Organization for Economic Cooperation and Development (OECD), this study finds patent protection to have no significant influence on FDI or licensing counts, regardless of the capital intensity of an industry. This could suggest that much of the positive effects on technology transfer (especially licensing) in developing countries may be price effects, reflecting market power, not quantity increases.

Maskus et al. (2005) use data similar to Nicholson (2003b). The industries are put into two groups: low R&D-intensive and high R&D-intensive, where the intensity is considered high if the R&D/sales ratio exceeds three percent. Consistent with the theory discussed earlier, stronger patent protection increases the probability of FDI and lowers the probability of licensing in low R&D-intensive industries, and does the opposite in high R&D-intensive industries. This evidence supports the view that the transition from FDI to licensing, as IPR get stronger, applies to industries or economies where the external innovation rate is high.

The above studies use data from US multinationals. Fosfuri (2003) examines plant-level data for the global chemical industry. The data set tracks the technology-transfer investments of 153 US, Japanese, and European firms. The investments refer to the costs of establishing a wholly-owned subsidiary, a joint venture, and a licensing deal. The finding here is that patent protection plays no role in any of the three technology-transfer investments. One qualification is that if patent protection is interacted with a variable representing imitative capacity (i.e., average years of schooling), stronger patent rights are found to reduce investments in licensing in countries where the imitative capacity is weak.

These results, however, are difficult to compare to those of previous studies because Fosfuri (2003) uses a different measure of licensing, namely the cost of licensing.

Other studies use the value of royalties and fees (or counts of contracts) as measures of licensing. Another consideration is that the sample of chemical plants largely consists of firms with process innovations. For such innovations, patents may not be the most effective mechanism for appropriating the returns to innovation. The results therefore do not preclude the importance of other kinds of IPR, such as trade secrecy.

These empirical studies do not explicitly treat North-South issues.[15] For different country income groups, Park and Lippoldt (2003, 2005) study the relationship between IPR and various modes of technology transfer, including trade, FDI, and affiliated and unaffiliated licensing, using both aggregate and US firm-level data. They also consider various kinds of IPR, including patent protection, copyright laws, and trademark protection. For this purpose, indexes of copyright laws and trademark regulations, analogous to those for patent rights set out in Ginarte and Park (1997), were developed. Consistent with most other studies, they find that stronger IPR increase FDI or licensing relative to exports in both developed and developing countries. The response of FDI to stronger patent rights is larger in developing countries (where IPR regimes are relatively weaker) than in developed countries (where IPR regimes are relatively stronger). Thus, patent rights appear to have a positive, but diminishing association with FDI as the strength of patent rights increases, controlling for other factors. The diminishing association is consistent with findings that firms prefer licensing in relatively richer countries, where IPR are stronger.

These authors also demonstrate that patent rights are a positive and statistically significant determinant of unaffiliated licensing by US firms in both developed and

[15] Nicholson (2003b) examines non-OECD countries, but for one period only. Moreover, among this group there exist countries of different income classifications.

developing countries, controlling for other factors. The quantitative effect is larger in developed countries, where the capacity to imitate is higher, so that a given reduction in the risk of imitation produces a larger effect on arm's-length licensing. On the composition of licensing between affiliated and unaffiliated parties, the study finds that stronger IPR enforcement raises the share of unaffiliated licensing in developed countries but insignificantly affects the composition in developing countries. One reason unaffiliated licensing may be preferred in developed markets is that firms may not be able to meet the increased demand in larger markets via their own operations. With stronger IPR, arm's-length licensing enables the firm to exploit the market more efficiently and to reap profits indirectly through rent-sharing arrangements.

As for other types of IPR, copyright laws have a positive effect on licensing in developed countries but a negative effect in developing nations, particularly for the licensing of such creative works as books, music, and film. In developing countries, where domestic imitative capacity is less, stronger copyright laws appear to enhance the market power of licensors. This would increase the return on each license while reducing the overall number of licenses issued. Trademark rights have a negative influence on licensing in both developed and developing countries. Unlike patents or copyrights, stronger trademarks are not direct incentives to investments in innovation but rather guarantees to consumers of the true origin of goods. It may be that trademarks protect the value of goods imported, while allowing the holder to exercise existing intellectual property rights more strongly with respect to domestic licensees. Such interpretations need to be investigated with additional empirical analysis.

4.C.5. Nonresident Patenting

Nonresident (or foreign) patenting data could complement data on trade, FDI, and licensing. If technology transfers involve new patentable technologies, firms typically would file patent applications in the destination country. Hence, foreign filings could help assess the extent to which new technologies are introduced to a market. Branstetter et al. (2006) and Lerner (2002) find that nonresidential patent applications respond positively to local patent reforms. However, Lerner (2002) qualifies this by pointing out that the effects of patent strength on nonresidential filings are weaker if patent protection is already strong, suggesting an inverted-U relationship between patent strength and nonresidential patent filings. Allred and Park (2007) concur that an inverted U-relationship exists between nonresident patent applications and patent strength. This inverted U-relationship suggests that at very strong levels of patent rights, firms have an incentive to delay the introduction of new technologies and exploit existing assets longer.

However, Allred and Park (2007) find this inverted-U result only for developed countries. For developing economies, a statistically insignificant relationship exists between nonresident patenting and patent rights, holding other variables constant. Recall that some studies do find that stronger patent protection increases FDI in developing countries. In this context it seems surprising that foreign patenting is affected only insignificantly by patent rights. The explanation might be that technologies transferred to the South are relatively older or that FDI was largely geared towards sales and distribution rather than R&D and production. Transferring older vintages obviates the need to file foreign patent applications, since the technologies are prior knowledge. Thus, to the extent that developing countries receive transfers of older vintages or second-tier research technologies, foreign patenting would be less sensitive to variations in patent rights in developing countries.[16]

6. Conclusion

The theoretical and empirical work on international innovation and intellectual property rights is quite diverse, yet some general findings do emerge. In this section, I first summarize the main observations made in the review of recent empirical work, discuss the implications of the evidence for theoretical work, and offer some suggestions for future research.

On innovation, the evidence suggests that the effect varies by initial levels of intellectual property rights and stages of economic development. For the South, stronger IPR have an insignificant effect on R&D and a negative effect on patenting. For the North, stronger IPR have a negative effect on R&D and patenting among relatively weaker IP countries and a positive effect among relatively stronger IP countries.

On technology transfer, the studies seem to suggest that when we look at the different modes of technology transfer jointly, stronger IPR expand FDI or licensing relative to trade (e.g. exports). This can be seen especially in patent-sensitive or high-technology industries, where stronger protection reduces the imitation risks of FDI or licensing. But stronger patents in the South may initially attract technology mainly

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[16] Contractor (1981) provides evidence that US firms tended to transfer older technologies to unaffiliated parties in developing countries compared to those transferred to agents in industrialized economies. The commercial age of a technology is defined as the time from commercial introduction to the inception of a licensing agreement. In Mansfield (1994), chemical and manufacturing firms report that they would not transfer new technologies to countries with weak IP laws. More recently, Nunnenkamp and Spatz (2004) find that weaker IPR are associated with lower quality FDI as judged by the small increases in local R&D, employment, and value added.

through trade in goods if developing countries initially have weak protection. The initial increases in IPR may not be sufficient to attract FDI or licensing, however.

There are some disputes as to whether stronger IPR can stimulate FDI in developing countries, but the evidence suggests that the composition of FDI can be affected. In particular, higher protection standards can increase the ratio of production and R&D facilities to sales and distribution outlets. In developed countries, stronger IPR appear to have an inverted-U effect on FDI. This suggests that when a high level of protection is reached, multinational firms exercise greater market power and reduce output (or the number of subsidiaries). Alternatively, the inverted-U effect could reflect market expansion, but via licensing rather than through increased subsidiary activity. Though firms have to share rents with licensees, this channel may be more efficient than expanding subsidiary plants. There may, for example, be diseconomies of scale associated with monitoring and coordinating a larger number of geographically dispersed plants.

But this preference for licensing over FDI as IPR strengthen is not unconditional. In cases where the industry or economy-wide rate of innovation is slow, there is less profit destruction due to the arrival of new innovations. Hence, as long as profits from subsidiaries are greater than that from licensing, multinational firms may want to maintain its market presence via subsidiary production. Also, if capital setup costs are low, or copying is fairly easy, the technology owner would not consider licensing unless IPR are sufficiently high. For IPR below that critical level, strengthening such rights would not expand licensing relative to FDI.

Data on foreign patenting complement the above measures of technology transfer in that firms with patentable technologies may seek patent protection in destination markets. The evidence suggests that stronger patent rights increase foreign patenting in the North (up to some point, beyond which stronger patent rights reduce foreign patenting), but has no effect on foreign patenting in the South, holding other factors constant. The lack of correlation between technology transfers to the South and foreign patenting in the South may reflect the possibility that the technologies transferred are dated or not best-practice.

Furthermore, given that domestic innovation in developing countries responds insignificantly to stronger IPR (at least in the short to medium term), Southern firms will not generate as many new patentable technologies to file for international protection (relative to their Northern counterparts). This means that global patenting will be dominated by Northern enterprises for some time to come and that the Southern share of profits from world innovation is likely to decline. This situation should raise the costs of policy harmonization for the developing world.[17]

The evidence gathered thus far can be used to reflect on the theoretical work reviewed early in the chapter. First, the empirical work does not support North-South models that predict stronger IPR will reduce Northern innovation and technology transfers to the South. The market size of the South may be too small to have a feedback effect on Northern innovation in any case. Stronger IPR may reduce certain modes of technology transfer, like exports or FDI, but the evidence (especially using US data) suggests that either FDI or licensing is likely to increase in the South. The worst

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[17] Recall the argument in Grossman and Lai (2004).

potential outcome seems to be that unilateral and global IPR reforms will have an insignificant effect on FDI in developing nations, but will not reduce such flows. The evidence also does not support predictions of an inverted-U effect on domestic innovation in the North. This may be because the measured indexes of IPR across countries lie below the potential "peak" levels of strength.

The empirical evidence does support theories arguing that stronger IPR may not be conducive to patentable innovation in developing countries or that Southern protection rights need to reach a threshold level before R&D is responsive to reforms. The evidence also supports the hypothesis that stronger IPR have an inverted-U effect on the volume of technology transfer within developed nations and affect the composition of technology transfer in favor of licensing. Though the summary in Table 2 noted that it was ambiguous, *a priori*, whether stronger IPR would increase technology transfers to the South, most of the recent studies employing a long panel of data and examining a variety of measures of multinational activity suggest that enhanced protection does have the potential to stimulate trade, FDI (initially in sales and distribution), and licensing (initially affiliated).

There are a number of issues associated with IPR and international innovation that this chapter did not address, while those that were covered could use further discussion and refinement. I will mention a few key areas for further research. First, the weak response of innovation in developing nations to stronger domestic IPR may be due to time lags. It would therefore be useful to better understand the sources and structure of such lags. Moreover, if there are threshold effects, what kind of big push would be needed to get the R&D sector in such countries up to the critical size, and how long would that take? Likewise, are there lags or adjustment costs in technology transfer? How easily can firms shift from one entry mode to another? What are the threshold values of profitability before firms switch among modes? It is unlikely that firms can adjust instantaneously due to setup and contractual costs.

Second, the chief benefit of stronger IPR in the South, at least in the medium run, seems to be the potential to attract inward technology transfers from the North. If so, what types of technologies are being introduced? Are they high-value or best-practice technologies? What types of facilities are being established in the developing world and does this vary among countries depending on income and other factors? It would also be useful to know more about the costs of adapting technologies to local production conditions and business climates.

Third, studies that examine technology transfers via licensing typically work with data on royalties or fees paid by the licensee to the licensor. As discussed in the text, stronger IPR may merely increase the bargaining power of the licensor so that higher payments reflect higher fees and not increased contracts, deals, or transactions. Future work should provide a better decomposition between the price and quantity effects of increased IPR. An added complication is that if firms shift toward licensing higher-value technologies as a result of stronger patents, fees could rise for reasons that go beyond market power. Thus, some quality adjustments in characterizing licensing contracts need to be incorporated into such analysis as well.

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Table 1. World Shares of Innovation and Technology Transfer

	Developed Countries	Developing Countries	Least Developed Countries
GDP (1999-2000)	76.1%	23.3%	0.6%
Business Enterprise R&D (1995-1998)	94.3%	5.7%	0%
Resident Patenting (1999-2000)	81.9%	18%	0.001%
Nonresident Patenting (1999-2000)	26.1%	49.9%	24%
Foreign patenting in the US (2000)	84.7%	15.2%	0.002%
Imports (1999-2000)	67.6%	31.7%	0.7%
FDI Inflows (1993-1998)	63.7%	36.2%	0.2%
Licensing Payments (1998)	77.8%	22.2%	0%

Sources: UNIDO (1999/2000), World Bank *World Development Indicators* (2005), and US Patent and Trademark Office. The classification of countries by level of development is that of the United Nations (see UNIDO).

Table 2. Summary of Theoretical Predictions on Innovation and Technology Transfer

Influences of Stronger Intellectual Property Protection on:

Region:	Innovation	Technology Transfer	
		Volume	Composition
North	Reduced Demand for Manufacturing Labor (+) Appropriability Effect (+) Production Shifting to North (-) Costs of R&D (-) Patent Thickets, Reduced Rivalry (-)	Ownership, Location, and Internalization OLI (+) Market Expansion Effect (+) Market Power (-) Value of Delaying (-)	Licensing preferred to FDI if existing IPR are strong, if set up costs are high, and if innovation rate is high
	Net Effect? Nonlinear (Inverted-U)	Net Effect? Positive, or Nonlinear (Inverted-U)	Net Effect? Licensing favored
South	Appropriability Effect (+) Costs of R&D (-) Imitative, Adaptive R&D (-) Limited Market Size (-)	Market Expansion Effect (+) OLI (+) Reduced Imitation and Contractual Costs (+) Market Power Effect (-) Resource Absorption Effect (-)	Licensing preferred to FDI if existing IPR are strong, if set up costs are high, and if innovation rate is high
	Net Effect? Negative or Threshold Effects	Net Effect? Ambiguous	Net Effect? FDI favored

Note: Each entry indicates the theoretical channel or mechanism by which IPR affect technological activity in a region. The predicted signs are in parentheses.

Table 3. Correlations among different measures of IP Strength or IP reform

		GP	RR	BFF	M	S	P	WEF
Statutory Measures	GP	1						
	RR	0.73 (110)	1					
	BFF	0.57 (49)	0.65 (16)	1				
Experience-Based Measures	M	0.53 (15)	0.45 (16)	0.56 (12)	1			
	S	0.71 (18)	0.38 (18)	0.92 (5)	0.14 (6)	1		
	P	0.78 (45)	0.75 (45)	0.49 (39)	0.80 (13)	0.63 (12)	1	
	WEF	0.75 (70)	0.76 (67)	0.22 (16)	0.58 (16)	0.78 (17)	0.81 (44)	1

Notes:

Each entry shows the correlation between the row index and column index. The number of observations is in parentheses. Correlations between indexes were calculated for the closest dates that were common to the indexes.

GP – Ginarte and Park (1997) covering patent protection levels in various years (1960-2000)
RR – Rapp and Rozek (1990) covering patent protection levels in 1984
BFF – Branstetter et al. (2006) covering patent reforms before and after a given year (1982-1999)
M – Mansfield (1994) covering IPR ratings for 1991
S – Sherwood (1997) covering IPR ratings for the mid-1990s
P – Park (2005) covering patent enforcement effectiveness reports for 1990-2000
WEF – World Economic Forum (2000) covering IPR ratings for the late 1990s.

Table 4. Selected Empirical Studies

Measure of Innovation	**Study**	**Sample**	**Indexes**	**General Findings**		
				Pooled	**North**	**South**
R&D	Varsekelis (2001)	Cross-Section, 50 Countries, 1995	GP	+	n/a	n/a
R&D	Kanwar and Evenson (2003)	Panel, 32 Countries, 1985-1990	GP	+ (nonlinearly)	n/a	n/a
R&D	Park (2005)	Cross-Section, 41 Countries, 1980-1995	GP, P	+	+	0
R&D	Allred and Park (2007)	Panel, Firm Level, 35 Countries, 1990-2000	GP	U-shape	U-shape	0
Resident Patents	Lerner (2002)	Cross-Section, 177 Reform Episodes in 60 Countries, 1852-1998	Dummy Variables	0	n/a	n/a
Resident Patents	Branstetter et al. (2006)	Panel, Firm Level, 12 Countries, 1982-1999	BFF	0	n/a	n/a
Resident Patents	Allred and Park (2007)	Panel, 100 Countries, 1965-2000	GP	U-shape	U-shape	−
US Patents	Chen and Puttitanum (2005)	Panel, 64 Developed Countries, 1975-2000	GP	n/a	n/a	+ (in larger developing)
US Patents	Schneider (2005)	Panel, 80 Countries, 1970-1990	GP	+	+	−

Technology Transfer	**Study**	**Sample**	**Indexes**	**General Findings**		
				Pooled	**North**	**South**
Trade	Maskus and Penubarti (1995)	Cross-Section, 22 OECD Country exports to 77 Countries, 1984	RR	+ , 0 in patent sensitive industries	+	+ (in larger developing)
Trade	Fink and Braga (1999)	Cross-Section, Bilateral trade 89 Countries, 1989	GP	+, 0 for high-tech goods	n/a	n/a
Trade	Smith (1999)	Cross-Section, US State exports to 96 Countries, 1992	RR	+ , − in patent sensitive industries	−	+
Trade	Co (2004)	Panel, US Exports to 71 Countries, 1970-1992	GP	+, − in high R&D sectors	n/a	n/a

FDI	Lee and Mansfield (1996)	Panel, US flows to 14 Countries, 1990-1992	M	n/a	n/a	+
FDI	Braga and Fink (1998)	Cross-Section, US and German Stocks in 42 Countries, 1992	GP	0	n/a	n/a
FDI	Nunnenkamp and Spatz (2004)	Cross-Section, US Stocks in 58 Countries, 1995-2000	GP, WEF	+	0	+
FDI	Branstetter et al. (2005)	Panel, Firm Level, MNC activity in 16 Countries, 1982-1999	BFF	+	n/a	n/a
FDI	Mayer and Pfister (2001)	Panel, Firm Level, French MNC location in 36 Countries, 1981-1992	GP	−	Inverted-U	0
FDI	Javocik (2004)	Cross-Section, Firm Level, MNC activity in Eastern Europe, 1989-1994	GP	+, 0 for low tech sectors	n/a	n/a
FDI	Belderbos et al. (2006)	Cross-Section, Firm Level, Japanese MNC R&D location, 42 Countries, 1996	GP	+	n/a	n/a
Licensing	Branstetter et al. (2006)	Panel, Firm Level, US Affiliated Licensing in 16 Countries, 1982-1999	BFF	+	n/a	n/a
Licensing	Yang and Maskus (2001)	Panel, US Unaffiliated and Affiliated Licensing in 23 Countries, 1985-1995	GP	U-shaped, 0 for affiliated licen.	n/a	n/a
Licensing	Wakasugi and Ito (2005)	Panel, Firm Level, Japanese Affiliated Licensing in 37 Countries, 1995-2001	GP	+	n/a	n/a
Licensing	Nagoaka (2004)	Cross-Section, Japanese Unaffiliated Licensing Contracts, 1999	GP	+	n/a	n/a
Trade, FDI, Licensing	Smith (2001)	Cross-Section, US Exports, Affiliate Sales, Unaffiliated Licensing in 50 Countries, 1989	RR	Licensing & Sales $\succ$ exports (for high IMIT)	n/a	n/a
Trade, FDI, Licensing	Nicholson (2003)	Cross-Section, US MNC activity in 62 Countries, 1995	GP	Licensing $\succ$ FDI & exports (for high K)	Licensing $\succ$ FDI &exports (for high K)	0
Trade, FDI, Licensing	Maskus et al. (2005)	Cross-Section, US MNC activity in 62 Countries, 1995	GP	Licensing $\succ$ FDI & exports (for high ι)	n/a	n/a
Trade, FDI, Licensing	Fosfuri (2003)	Panel, Global Chemical MNC activity in 75 Countries, 1981-1996	GP	0 for volume & composition	n/a	n/a

Trade, FDI, Licensing	Park and Lippoldt (2003, 2005)	Global FDI & Trade, and US Firm Level MNC Activity in 91 – 111 Countries, 1990 – 2000.	GP, P	FDI $\succ$ Exports, Licen $\succ$ FDI	FDI $\succ$ Export, Licen $\succ$ FDI, Unaffiliated $\succ$ Affil. licen	FDI $\succ$ Exports, Licen $\succ$ FDI
Nonresident patenting	Lerner (2002)	Cross-Section, 177 Reform Episodes in 60 Countries, 1852-1998	Dummy Variables	Inverted-U	n/a	n/a
Nonresident patenting	Branstetter et al. (2006)	Panel, Firm Level, US Affiliated Licensing in 16 Countries, 1982-1999	BFF	+	n/a	n/a
Nonresident patenting	Allred and Park (2007)	Panel, 100 Countries, 1965-2000	GP	+	Inverted-U	0

Notes: Under General Findings, + (positive), − (negative), inverted U (positive, then negative), U-shape (negative, then positive), $\succ$ (preferred to), and 0 (insignificant) refer to the effects of stronger patent rights on innovation or technology transfer. n/a indicates not available. Indexes refer to the measures of patent rights, where BFF denotes Branstetter et al. (2006), GP Ginarte and Park (1997), M Mansfield (1994), P Park (2005), RR Rapp and Rozek (1990), and WEF World Economic Forum (2000). Other notation include: MNC multinational corporations, IMIT imitative capacity, K capital costs, and ι innovation rates.