Intellectual Property Rights, Imitation, and Foreign Direct Investment: Theory and Evidence*

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Abstract

What is the effect of a strengthening of intellectual property rights (IPR) protection by developing countries on local imitation and inflows of foreign direct investment (FDI)? We address this question both theoretically and empirically. On the theoretical side, we develop a North-South product cycle model in which Northern innovation, Southern imitation, and FDI are all endogenous. This model predicts that IPR reform in the South leads to increased FDI from the North, as Northern firms shift production to Southern affiliates. We confront the theoretical model with evidence on the response of U.S. multinationals to a series of well-documented IPR reforms by developing countries in the 1980s and 1990s. Our results indicate that U.S.-based

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MNCs expand the scale of their activities in reforming countries after IPR reform, and this effect is disproportionately strong for affiliates whose parents rely strongly on patented intellectual property as part of their global business strategy. Evidence from highly disaggregated trade data suggests that this expansion of multinational activity leads to a higher net level of production shifting to developing countries, more than offsetting any possible decline in the imitative activity of indigenous firms.

1 Introduction

The effective enforcement of intellectual property rights (IPR) confers monopoly power on the creators of intellectual property, generating a static welfare loss. The intellectual argument for IPR is predicated on the notion that the profit incentives generated by effectively enforced IPR will raise the rate of innovation, generating dynamic welfare gains. However, for economies that have limited capacity to innovate, the case for stronger IPR protection must rest largely on the *global* response to *local* IPR reforms. In fact, this is one of the main arguments in favor of the Agreement on Trade Related Intellectual Property Rights (TRIPS) ratified by the members of the World Trade Organization (WTO) in 1995.[1] Proponents of TRIPS argue that an improvement in enforcement of IPR by developing countries will encourage foreign firms to expand their local activities as well as invest more in research and development (R&D).[2] Mansfield's (1994) survey of executives of U.S. firms is often cited as evidence in support of this position because a large percentage of surveyed executives indicated that their firms would be likely to expand

[1] The TRIPS agreement has been controversial since it requires many developing countries with little or no innovative capacity to adopt standards for IPR protection that prevail among industrialized countries. In a recent paper, Grossman and Lai (2005) argue that such harmonization of IPR regimes is neither necessary nor sufficient for achieving global efficiency. However, this paper does not consider technology transfer or production shifting within multinational firms, which is the mechanism at the heart of our paper.

[2] An analytical demonstration of a more general version of this argument is provided by Taylor (1994) who investigates the effects of IPR protection in a two country set-up that embeds the quality ladders model of Grossman and Helpman (1991a) within the continuum Ricardian framework of Dornbusch, Fischer, and Samuelson (1977). He compares two scenarios: one where each country offers IPR protection to only local innovators and another where each grants national treatment to foreign innovators and shows that the second regime leads to higher growth and more multinational activity.

their production and R&D activities in countries that strengthened their IPR regimes. However, this survey is one of intentions and it does not provide us with any evidence regarding the *actual* responses of U.S. firms to changes in IPR regimes of other countries.

In an influential paper, using a two region (North-South) general equilibrium framework, Helpman (1993) showed that even if a strengthening of Southern IPR protection increases Northern innovation in the short run, such a policy change harms the South because it allocates production in favor of Northern firms whose prices tend to be higher than those of Southern ones. Furthermore, Helpman (1993) also showed that stronger IPR protection in the South could actually slow down the rate of innovation in the North in the long run. This can occur because stronger IPR in the South slows down the rate at which Northern products are imitated by Southern producers. This, in turn, increases the steady-state share of products manufactured in the North which then lowers the sales of a typical Northern firm. Due to reduced sales, the profitability of innovation declines and this dominates the reduction in risk faced by Northern innovators so that the overall effect of a reduction in Southern imitation is to lower Northern innovation. In principle, the decline in Northern innovation could lead to *welfare losses for the global economy as a whole*.

Helpman's analysis forcefully drove home the point that the North-South allocation of production is a crucial determinant of the welfare impact of an IPR policy change in the South. Accordingly, in this paper, we seek to investigate both theoretically and empirically the effects of increased Southern IPR protection on the international allocation of production in a North-South environment where the location of production is optimally chosen by Northern firms.

We do so by using a theoretical model that extends Helpman's (1993) analysis in two critical ways. First, we allow the level of FDI in the South to respond endogenously to changes in the strength of Southern IPR protection. As Lai (1998) has shown, allowing for this kind of endogenous response can lead to a reversal of the prediction that stronger IPR in the South slows the rate of innovation in the North.[3] Instead, Northern MNCs respond to stronger IPR in the South by pro-actively shifting production to their Southern affiliates, allowing for a reallocation of Northern labor away from production and toward R&D. Although Southern imitation declines, this is more than com-

[3]Helpman (1993) noted the absence of this feature was a shortcoming of his paper.

pensated by the increased shifting of production within multinational firms. This outcome, in turn, can increase the global rate of innovation and new product introduction, generating global welfare gains. Second, we treat imitation as a costly activity and allow the level of imitative effort by Southern firms to be endogenously determined.[4] These extensions increase the complexity of the model, but allow us to remedy a shortcoming of theoretical work in the Helpman-Lai tradition.[5] Numerical analysis confirms that, even in this augmented model, an increase in the strength of IPR in the South will lead to an acceleration in the shifting of production from South to North.

We confront our model with empirical evidence on the response of U.S. multinationals to a series of well-documented IPR reforms by sixteen countries in the 1980s and 1990s. Drawing upon U.S. BEA annual surveys of U.S. multinational activity, we conduct analysis of firm level data on several thousand multinationals operating in reforming countries before and after the IPR reform's inception. As per the prediction of our theoretical model, the results suggest that U.S.-based multinationals expand the scale of their activities in reforming countries after IPR reform. Local affiliate output, employment levels, and capital stocks expand significantly after reform, and this effect is disproportionately strong for affiliates whose parents rely strongly on patented intellectual property as part of their global business strategy. Finally, we review firm-level evidence from Branstetter, Fisman, and Foley (2005) demonstrating that the technological intensity of affiliates of patent-intensive parent firms rises dramatically after IPR reform. This is consistent with U.S. multinationals shifting production of more technologically intensive goods to affiliates in reforming countries after IPR reform.

While certain dimensions of the multinational response to IPR reform are relatively easy to quantify, it is much more difficult to assess changes in the rate of imitation by indigenous firms. For obvious reasons, firms do not report imitation and the ability of traditional industry-level data to

[4] Helpman (1993) encouraged the incorporation of this feature into models like his own. He noted that "...imitation is an economic activity much the same as innovation; it requires resources and it responds to economic incentives..." and that "...in order to take account of these considerations there is need for considerable extension of the models employed in this paper."

[5] Glass and Saggi (2002a) and Sener (2005) incorporate endogenous imitation into a North-South growth and trade model with intellectual property rights, but they take a different approach to the modeling of the innovation process than that employed by Helpman (1993) or Lai (1998).

capture this phenomenon is sharply limited. The theory calls for a measure of the transfer of production of individual goods to the South, and such a measure might not be strongly correlated with fluctuations in conventionally measured industrial output at the aggregate or industry level. To obtain indirect evidence on the rate at which production of goods is transferred to reforming countries, we exploit the high degree of disaggregation available in U.S. import statistics. Inspired by Feenstra and Rose (2000), we construct for each reforming country an annual count of "initial export episodes" – the number of 10-digit commodities for which recorded U.S. imports from a given country exceed zero for the first time. This is used as a rough indicator of the Poisson arrival rate at which production of goods shifts to the reforming countries, through a combination of multinational production and indigenous imitation. Controlling for trade and FDI openness, per capita GDP, exchange rates, and time and country effects, we find that this rate of production transfer increases sharply after IPR reform. This suggests that any decline in indigenous innovation is more than offset by an expanded range of goods being produced through multinational affiliates.

Recent empirical attempts to assess the welfare impact of stronger IPR in developing countries, such as Chaudhuri and Goldberg (2004), Fink (2000), McCalman (2001) have tended to focus on the short-run effects of higher patent-protected product prices on consumers, while ignoring or heavily discounting the possible effects of such reform on the global allocation of production, and, by extension, longer-run trends in innovation and growth. To the best of our knowledge, there have been no previous empirical attempts to seriously confront models in the "Helpman tradition." We seek to address this gap in the literature.

2 Theory

In what follows, we present our North-South product cycle model. Our model borrows from the work of Grossman and Helpman (1991b), Helpman (1993), and Lai (1998), but it also builds on this theoretical foundation in substantive ways.[6] The primary goal of our theoretical exercise is to derive the effect of

[6]Following Helpman (1993) and Lai (1998), our model focuses on the transfer of production within multinational firms. For analyses of the tradeoff between FDI and arm's length technology licensing in a product cycle framework, see Antràs (2005), Glass and Saggi (2002b), Yang and Maskus (2001). For models that focus on strategic and contrac-

an increase in Southern IPR protection on the international allocation of production when innovation, FDI, and imitation are all endogenous. We are able to demonstrate that an increase in Southern IPR protection leads to a decrease in Southern imitation but an increase in the degree to which Northern multinationals shift production to their Southern affiliates. Under a wide range of plausible parameter values, we can show that the second effect dominates; on net, stronger IPR accelerates the rate at which goods shift to the South. The model thus generates a clear, empirically testable hypothesis that can then be taken to the data. Readers who are primarily interested in our empirical results may wish to move to section 3.

2.1 A North-South Model with FDI

There are two regions (North and South). Labor is the only factor of production and region i's labor endowment equals L^i, $i = N, S$. As in Grossman and Helpman (1991a), preferences are identical in the two regions and a representative consumer chooses instantaneous expenditure $E(\tau)$ to maximize utility at time t:

$$U = \int_t^\infty e^{-\rho(\tau-t)} \log D(\tau) d\tau \tag{1}$$

subject to the intertemporal budget constraint

$$\int_t^\infty e^{-r(\tau-t)} E(\tau) d\tau = \int_t^\infty e^{-r(\tau-t)} I(\tau) d\tau + A(t) \text{ for all } t$$

where ρ denotes the rate of time preference; r the nominal interest rate; $I(\tau)$ instantaneous income; and $A(t)$ the current value of assets. The instantaneous utility $D(\tau)$ is given by

$$D = \left[\int_0^n x(j)^\alpha dj \right]^{\frac{1}{\alpha}} \tag{2}$$

where $x(j)$ denotes the consumption of good j; n the number of goods available and $0 < \alpha < 1$.

As is well known, under the above assumptions, the consumer's optimization problem can be broken down into two stages. First, it chooses how to

tual elements underlying the choice between licensing and FDI see Ethier (1986), Ethier and Markusen (1996) and Markusen (2001).

allocate a given spending level across all available goods. Second, it chooses the optimal time path of spending. Equation (2) implies that the elasticity of substitution between any two goods is constant and equals $\varepsilon = \frac{1}{1-\alpha}$ and demand for good j (given expenditure E) is given by

$$x(j) = \frac{Ep(j)^{-\varepsilon}}{P^{1-\varepsilon}} \tag{3}$$

where $p(j)$ denotes the price of good j and P a price index such that

$$P = \left[\int_0^n p(j)^{1-\varepsilon} dj\right]^{\frac{1}{1-\varepsilon}} \tag{4}$$

Furthermore, under the two-stage procedure, the optimal spending rule is given by

$$\frac{\dot{E}}{E} = r - \rho \tag{5}$$

Following Grossman and Helpman (1991b), if we normalize by $E(t) = 1$ for all t then in steady state we have $r(t) = \rho$.

2.1.1 Product Market

Three types of firms produce goods: Northern firms (N), Northern multinationals (M), and Southern imitators (S). Denote firms by J where $J = N$, M, or S. Northern firms can either produce in the North or the South. They need one worker to produce a unit of output in the North whereas $\theta \geq 1$ workers per unit of output are needed in the South. This assumption is based on the theory of the multinational firm which argues that such firms need advantages based on superior technology and management to offset the fact that they have to coordinate decisions over large distances and operate in an environment with which they are less familiar relative to local firms (see Markusen, 1995).

Given the demand function in (3), it is straightforward to show that prices of Northern firms are mark-ups over their marginal costs:

$$p^N = \frac{w^N}{\alpha} \text{ and } p^M = \frac{\theta w^S}{\alpha} \tag{6}$$

Southern firms can produce only those goods that they have successfully imitated and they need one worker to produce one unit of output. Let μ

denote the rate of imitation (defined in equation 15) and as in Helpman (1993) and Lai (1998) assume that imitation targets only Northern multinationals.[7] As is well known from the work of Mansfield (1994) and Maskus (2000), multinational firms internalize the risk of imitation that they face due to weak IPR protection in host countries.[8] Of course, in the real world, Northern firms that do not undertake FDI can also have their technologies imitated but its likely that they face a risk of imitation that is lower than that faced by multinational firms that produce in the South. In our model, the risk faced by Northern firms that do not produce in the South has been normalized to zero.[9]

If successful in imitating a multinational, a Southern firm engages in price competition with the Northern multinational whose good it has copied so that in equilibrium we have:

$$p^S = \theta w^S \tag{7}$$

Note that limit pricing is optimal for a Southern imitator iff its unconstrained monopoly price $\frac{w^S}{\alpha}$ exceeds the multinational's marginal cost θw^S:

$$\theta w^S < \frac{w^S}{\alpha} \Leftrightarrow \theta < \frac{1}{\alpha}.$$

When $\theta\alpha > 1$, a Southern imitator charges the unconstrained monopoly price $\frac{w^S}{\alpha}$. In what follows, we focus on the case where $\theta\alpha < 1$.

Let x^J denote the output level of firm J where $J = N, M$, or S. We know from the demand equation (3) that

$$\frac{x(i)}{x(j)} = \frac{p_i^{-\varepsilon}}{p_j^{-\varepsilon}} \tag{8}$$

Using the pricing equations for the three types of products, we have

$$\frac{x^S}{x^M} = \alpha^{-\varepsilon} \tag{9}$$

[7] Findlay's (1978) model showed that the 'contagion' effect of FDI could be an important determinant of growth in the South.

[8] See also Maskus (2000).

[9] This assumption is made for modeling convenience. We can relax this assumption, allowing for a positive, fixed risk of imitation of Northern firms, and our theoretical results will still obtain.

and

$$\frac{x^M}{x^N} = \left[\frac{\theta w^S/\alpha}{w^N/\alpha}\right]^{-\varepsilon} = \left[\frac{\theta w^S}{w^N}\right]^{-\varepsilon} \tag{10}$$

Flow profit of a Northern producer are given by

$$\pi^N = (p^N - w^N)x^N = \frac{(1-\alpha)w^N x^N}{\alpha} \tag{11}$$

Similarly, a multinational's flow profit equals

$$\pi^M = (p^M - w^S)x^M = \frac{\theta(1-\alpha)w^S x^M}{\alpha} \tag{12}$$

while that of a Southern firm equals

$$\pi^S = (\theta w^S - w^S)x^S = (\theta - 1)w^S x^S \tag{13}$$

2.1.2 Innovation, Imitation, and FDI

Of the n goods that exist, n_N are produced in the North, n_M are produced in the South by Northern multinationals, and n_I are produced by Southern imitators. Let $n_S \equiv n_I + n_M$ denote all goods produced in the South and let the rate of FDI be defined by

$$\phi \equiv \frac{\dot{n_M}}{n_N} \tag{14}$$

where n_N denotes the number of goods produced in the North. In other words, the stock of goods produced by multinational increases by ϕn_N at each instant. Let the rate of imitation μ be defined by

$$\mu \equiv \frac{\dot{n_I}}{n_M} \tag{15}$$

i.e. μ denotes the rate of increase of imitated goods relative to the total number of goods produced by Northern multinationals. Like Lai (1998), we study a steady state equilibrium in which all product categories grow at the same rate g:

$$g \equiv \frac{\dot{n}}{n} = \frac{\dot{n_N}}{n_N} = \frac{\dot{n_I}}{n_I} = \frac{\dot{n_M}}{n_M} = \frac{\dot{n_S}}{n_S} \tag{16}$$

Using equations (14) through (16), we have

$$\frac{n_M}{n_N} = \frac{\phi}{g} \text{ and } \frac{n_S}{n_N} = \frac{\phi}{g}\left[1 + \frac{\mu}{g}\right] \tag{17}$$

Similarly,

$$\frac{n}{n_N} = 1 + \frac{\phi}{g}\left[1 + \frac{\mu}{g}\right] \text{ and } \frac{n_I}{n_M} = \frac{\mu}{g} \tag{18}$$

A successful Northern innovator has the option of producing either in the North or in the South. While it is cheaper to produce in the South (as we show below, the Southern relative wage is lower in equilibrium), shifting production to the South invites the risk of imitation. The lifetime value of a successful innovator who chooses to produce in the North equals:

$$v^N = \frac{\pi^N}{\rho + g} \tag{19}$$

while that of one that chooses to become a multinational equals

$$v^M = \frac{\pi^M}{\rho + \mu + g} \tag{20}$$

Since all Northern firms are free to become multinationals we must have

$$v^N = v^M \tag{21}$$

Similarly, the lifetime value of a Southern producer (i.e. the reward earned by a successful imitator) equals

$$v^S = \frac{\pi^S}{\rho + g} \tag{22}$$

2.1.3 Relative Wage

Since $v^N = v^M$, we have

$$\frac{\pi^M}{\pi^N} = 1 + \frac{\mu}{\rho + g} \tag{23}$$

But from the definition of profit we have

$$\frac{\pi^M}{\pi^N} = \frac{\theta w^S x^M}{w^N x^N} = \left[\frac{\theta w^S}{w^N}\right]^{1-\varepsilon} \tag{24}$$

The last two equations define the Northern relative wage as a function of the rate of innovation and imitation as well as the other exogenous parameters of the model:

$$\frac{w^N}{w^S} = \theta \left[1 + \frac{\mu}{\rho + g}\right]^{\frac{1}{\varepsilon - 1}} \tag{25}$$

As is clear, the relative wage in the North increases with the production disadvantage faced by Northern multinationals (θ) as well as with the Southern rate of imitation (μ) since both these factors encourage Northern firms to produce in the North as opposed to the South (thereby increasing the relative demand for Northern labor). The relative wage can also be written as

$$\frac{w^N}{w^S} = \theta \left[\frac{n_S}{n_M}\right]^{\frac{1}{\varepsilon - 1}}$$

i.e. the larger the share of Southern production that is done by multinationals, the lower the relative wage in the North. This endogenous adjustment of relative wage implies that as the extent of Northern FDI increases, the incentive for further FDI is reduced.

2.1.4 Free Entry

Free entry into innovation implies that the value of Northern firm must exactly equal the cost of innovation:

$$v^N = \frac{w^N a_N}{n} \Leftrightarrow \frac{\pi^N}{\rho + g} = \frac{w^N a_N}{n} \tag{26}$$

where a_N is the unit labor requirement in innovation. The above formulation assumes that the cost of innovation falls with the number of products (n) that have been invented. In other words, knowledge spillovers from innovation sustain further innovation. This assumption is standard in the literature (see Grossman and Helpman, 1991a and b, and Romer, 1990) and in its absence growth cannot be sustained in the variety expansion model. The flow profit of a successful innovator declines with the number of products invented. Substituting from equation (19) into (26) gives

$$x^N = \frac{a_N \alpha(\rho + g)}{n(1 - \alpha)} \tag{27}$$

Let the unit labor requirement in imitation be a_I and the cost function for imitation be given by

$$c_I = \frac{w^S a_I}{n_S} \tag{28}$$

where $n_S = n_I + n_M$ denotes the number of products produced in the South. The above cost function for imitation assumes that the cost of imitation declines with the number of goods produced in the South – i.e. both imitation and FDI generate knowledge spillovers for the South. The cost of imitation must decline over time in order to sustain imitation in the long run because as the number of products in the world economy expand, the flow profit of a successful imitator falls.

Free entry into imitation implies

$$v^S = \frac{w^S a_I}{n_S} \Leftrightarrow \frac{\pi^S}{\rho + g} = \frac{w^S a_I}{n_S} \tag{29}$$

Substituting from (22) into the above equation gives

$$x^S = \frac{a_I(\rho + g)}{n_S(\theta - 1)} \tag{30}$$

Using (9) gives

$$x^M = \frac{a_I(\rho + g)}{n_S(\theta - 1)\alpha^{-\varepsilon}} \tag{31}$$

Finally, from equations (26) and (29) we have

$$\frac{n}{n_S}\frac{a_I}{a_N}\frac{v^N}{v^S} = \frac{w^N}{w^S} \tag{32}$$

Substituting from (11) and (12) gives

$$\frac{n}{n_S}\frac{a_I}{a_N}\frac{\frac{(1-\alpha)w^N x^N}{\alpha}}{(\theta - 1)w^S x^S} = \frac{w^N}{w^S} \Leftrightarrow \frac{n}{n_S}\frac{a_I}{a_N \alpha}\frac{(1-\alpha)x^N}{(\theta - 1)x^S} = 1 \tag{33}$$

Using equations (25), (27), and (30) allows us to rewrite the above equation as

$$\frac{n_S}{n_N}\frac{n_N}{n}\frac{a_N}{a_I}\frac{\alpha^{1-\varepsilon}(\theta - 1)}{(1-\alpha)}\left[\frac{\rho + g + \mu}{\rho + g}\right]^{\frac{\varepsilon}{\varepsilon - 1}} = 1$$

Substituting from (17) and (18) gives us our **first equilibrium condition** in terms of three endogenous variables g, ϕ, and μ and exogenous parameters of the model:

$$\frac{\frac{\phi}{g}\left[1+\frac{\mu}{g}\right]}{1+\frac{\phi}{g}\left[1+\frac{\mu}{g}\right]}\frac{a_N}{a_I}\frac{\alpha^{1-\varepsilon}(\theta-1)}{(1-\alpha)}\left[\frac{\rho+g+\mu}{\rho+g}\right]^{\frac{\varepsilon}{\varepsilon-1}}=1 \qquad (34)$$

2.1.5 Resource Constraints

The other two equilibrium conditions are derived from the resource constraints in the two regions. In the North, labor is allocated to innovation and production:

$$\frac{a_N}{n}\dot{n}+n_N x^N=L^N \qquad (35)$$

Substituting into the above resource constraint from equations (17), (18), and (27) yields the **second equilibrium condition**:

$$a_N g+\frac{g}{g+\phi\left[1+\frac{\mu}{g}\right]}\frac{a_N\alpha(\rho+g)}{(1-\alpha)}=L^N \qquad (36)$$

Southern labor is allocated to imitation and production by multinationals and local firms:

$$a_I\frac{\dot{n}_I}{n_S}+\theta n_M x_M+n_I x^S=L^S$$

Substituting into the above resource constraint from equations (17), (18), (30), and (31), gives the **third equilibrium condition**:

$$a_I\frac{g\mu}{g+\mu}+\theta\frac{g}{(g+\mu)}\frac{a_I\rho}{(\theta-1)\alpha^{-\varepsilon}}+\frac{\mu}{g+\mu}\frac{a_I(\rho+g)}{(\theta-1)}=L^S \qquad (37)$$

2.1.6 Effects of Southern IPR reform

Equations (34), (36) and (37) define the steady state equilibrium of the model in terms of the three endogenous variables: the rate of innovation g, the rate of imitation μ, and the rate of FDI ϕ. An important objective of this paper is to understand how a strengthening of IPR protection in the South (as measured by an increase in the cost of imitation a_I) alters the distribution of production across the two regions as well as between Northern multinationals and Southern imitators.

Using sections 2.1.1 and 2.1.2 it is straightforward to show that the total value of multinational sales relative to those of Southern imitators has the following simple expression:

$$\frac{n_M p^M x^M}{n_S p^S x^S} = \alpha^{1-\varepsilon} \frac{g}{\mu}$$

Thus, *all else equal, factors that lower the Southern rate of imitation (μ) or those that increase the Northern rate of innovation (g) will lead to an increase in sales of multinationals relative to those of Southern firms.* Similarly, we have

$$\frac{n_M p^M x^M}{n_N p^N x^N} = \frac{\phi}{g} \left[\frac{\theta w^S}{w^N}\right]^{1-\varepsilon} = \frac{\phi}{g} \left[\frac{\rho + g}{\rho + g + \mu}\right]$$

In other words, *all else equal, factors that increase the flow of FDI (ϕ) or the Northern rate of innovation (g) as well as those that lower the Southern rate of imitation (μ) will increase the value of multinational sales relative to those of Northern firms.*

Assuming the rate of imitation μ is exogenously given, Lai (1998) has shown that *a strengthening of Southern IPR protection (i.e. a decline in μ) increases Northern innovation (g) and the rate of production shifting to the South.*[10] The question, of course, is whether the above result holds when imitation is endogenous and the underlying exogenous variable is the cost of imitation a_I. To address this question, we first solve equation (34) for FDI flow ϕ in terms of the other two endogenous variables (g and μ) and then use the two resource constraints to derive a system of two equations in two unknowns which can be illustrated graphically. From equation (34) we have

$$\phi(\mu, g) = \frac{A(\mu, g)\,[1-\alpha]\,a_I g^2}{(\mu + g)\,[B(\alpha) a_N (\theta - 1) - A(\mu, g) a_I (1-\alpha)]} \tag{38}$$

where

$$A(\mu, g) = \left[\frac{\rho + g}{\rho + g + \mu}\right]^{\frac{1}{\alpha}} < \ 1 < B(\alpha) = \alpha^{\frac{\alpha}{\alpha - 1}} \tag{39}$$

Next, note that the Southern labor market constraint is independent of $\phi(\mu, g)$. Substituting for $\phi(\mu, g)$ into the Northern labor market constraint

[10] In the appendix, we show how our model can be reduced to that of Lai (1998).

gives us two equations in two unknowns. Let $L^S(\mu, g) = L^S$ denote the Southern labor market constraint where $L^S(\mu, g)$ is the left hand side of equation (37) and it measures the total demand for labor in the South. We have

$$\frac{\partial L^S(\mu, g)}{\partial \mu} = -\frac{a_I g \left[g\theta(B(\alpha) - 1) + \rho(B(\alpha) - \theta)\right]}{(\mu + g)^2 B(\alpha)(\theta - 1)} < 0$$

where we have assumed that $B(\alpha) > \theta$. Similarly,

$$\frac{\partial L^S(\mu, g)}{\partial g} = -\frac{a_I \left[(B(\alpha)\mu(\mu\theta - \rho) + \theta(\rho\mu + 2g\mu + g^2)\right]}{(\mu + g)^2 B(\alpha)(\theta - 1)} < 0$$

where we have assumed that $\mu\theta > \rho$. Thus, the Southern labor market constraint is downward sloping in the (g, μ) space:

$$\left.\frac{d\mu}{dg}\right|_{L^S(\mu,g)=L^S} = -\frac{\frac{\partial L^S(\mu,g)}{\partial g}}{\frac{\partial L^S(\mu,g)}{\partial g}} < 0$$

Also,

$$\frac{\partial L^N(\mu, g)}{\partial \mu} = -\frac{a_I(\rho + g)A(\mu, g)}{(\rho + \mu + g)B(\alpha)(\theta - 1)} < 0$$

While the expression for $\frac{\partial L^N(\mu,g)}{\partial g}$ is rather complicated, it has a negative sign for most reasonable parameter values. Thus, the Northern labor market constraint is also downward sloping in the (g, μ) space.

Now consider how an increase in the cost of imitation impacts both of these constraints. From equation (37) it is immediate that an increase in a_I causes the Southern labor market constraint to shift downward – holding constant the rate of imitation and growth, an increase in the labor requirement in imitation increases labor demand thereby creating a resource crunch in the South.

From equation (36) we note that holding constant g and m, an increase in a_I effects the Northern labor market constraint via its effect on the rate of FDI ϕ. From equation (38) we have that the flow of FDI to the South increases with the cost of imitation:

$$\frac{\partial \phi(\mu, g)}{\partial a_I} = \frac{A(\mu, g)B(\alpha)(1 - \alpha)a_N g^2(\theta - 1)}{(\mu + g)\left[B(\alpha)a_N(\theta - 1) - A(\mu, g)a_I(1 - \alpha)\right]^2} > 0$$

Given the effect of an increase in a_I on ϕ, it follows that labor demand in the North $L^N(\mu, g)$ (i.e. the left hand side of equation (36)) decreases with an

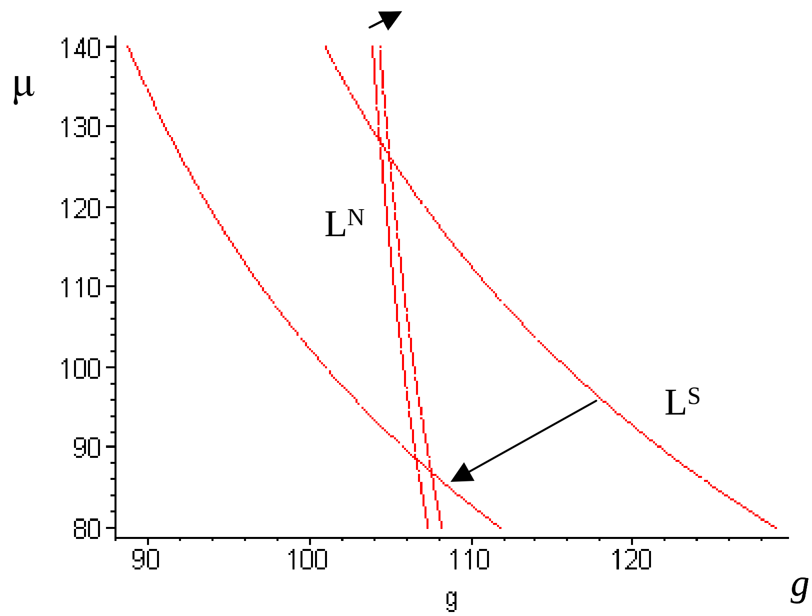

Figure 1: Effects of an increase in Southern IPR protection

increase in a_I. This is equivalent to an outward shifts in the Northern labor market constraint.

The effect of a strengthening of IPR protection in the South on equilibrium rates of imitation and innovation is shown in Figure 1. With an increase in the cost of imitation in the South, the Southern labor market constraint shifts down while the Northern constraint shifts up. As a result, the rate of innovation increases while the rate of imitation decreases.[11]

To see how a change in Southern IPR protection affects the allocation of production across the two regions as well as the relative wage, we conducted numerical simulations. Consistent with Figure 1, these simulations show that as IPR protection in the South is strengthened, the rate of imitation goes down whereas the rate of innovation and FDI both increase. As a result, the measure of goods produced by Northern multinationals (n_M) increases, the measure of imitated products (n_I) decreases, while the total measure (n_S) of Southern products increases. Table 1 below reports the results of one

[11] The following parameters were used to generate Figure 1: $L^S = 150$, $L^N = 200$, $a_N = 1$, $\rho = 1/100$, $\theta = 1.3$, and $\alpha = 1/2$. The cost of imitation a_I parameter is increased from 0.5 to 0.55.

such typical simulation (assuming the following parameter values: $L^S = 150$, $L^N = 200$, $a_N = 1$, $\rho = 1/100$, $\theta = 1.3$, and $\alpha = 1/2$).

Table 1: Effects of increased IPR protection in the South

a_I	$\frac{n_S}{n}$	$\frac{n_M}{n_S}$	$\frac{w^N}{w^S}$
0.5	8%	45%	2.90
0.55	14%	55%	2.35
0.60	21%	64%	2.02
0.65	28%	72%	1.79
0.70	37%	80%	1.63

The intuition underlying the results shown in Table 1 (as well as those in Figure 1) is clear. A strengthening of Southern IPR protection makes imitation less attractive, thereby lowering the rate of imitation μ. A lower risk of imitation makes FDI in the South more attractive to Northern firms who respond by increasing the rate of FDI (ϕ) which translates into a higher share of FDI in Southern production ($\frac{n_M}{n_S}$).[12] Also, note that as Southern IPR are strengthened, the South ends up producing a greater percentage of the world's basket of goods ($\frac{n_S}{n}$) despite the fact that the share of imitated goods as a percentage of total Southern production shrinks because the increase in FDI offsets the decline in imitation.

3 Empirical Analysis with BEA Data on Multinationals

Having derived a relationship between the strength of IPR in the South and the scale of multinational activity in the ideal world of theory, we must now move to the decidedly imperfect world of measurement. If the model is to be useful, then it should be true that an increase in the strength of IPR in developing countries induces an expansion of multinational activity. This immediately raises the question of how one can effectively measure the relative

[12] A slight subtle point to note here is that the decline in Northern relative wage counteracts the lower risk of imitation in the South – lower relative wage in the North means there is weaker incentive to produce in the South whereas a lower imitation risk implies that there is a stronger incentive to do so. The effects of Southern IPR protection captured in Figure 1 and Table 1 apply so long as the relative wage effect is dominated by the imitation risk effect.

strength of IPR regimes across countries and over time. The index generated by Ginarte and Park (1997) is probably the most serious effort yet made to measure this attribute across a large number of countries. Unfortunately, the shortcomings of this index are also well-known. In constructing it, Ginarte and Park rely on observable features of the patent statute and related laws. They are unable to account for the degree to which such provisions are enforced. Finally, the index is updated at five year intervals, making it difficult to precisely date discrete changes in the IPR regime of a specific country and examine the multinational response to this in the years immediately following the regime change.

Given these shortcomings, we take a very different approach. Following Branstetter, Fisman, and Foley (2005), we measure the reaction of U.S.-based multinational firms to well-documented discrete changes in patent regimes over the 1980s and 1990s in sixteen countries. The list of regime changes examined in this paper and the dates assigned to these regime changes are provided in Table 2.[13] Because we observe the operations of U.S. multinationals in multiple countries, we can take a "difference-in-differences" approach to the estimation of the multinationals' response to these regime changes. If one is willing to assume that the precise timing of the regime change is exogenous to the activities of the individual firms, then one can identify the impact of a strengthening of the local patent system on the scale and nature of multinational activity based on differences in the timing of reform in different countries.[14]

This approach allows us to sidestep the difficulties generated by the Ginarte-Park index and other rival indices of IPR strength. It has been widely observed that the level of the Ginarte-Park index tends to be highly correlated with other features of the business environment in a country that tend to make it a desirable host for foreign direct investment and that are themselves difficult to measure with accuracy. Our approach allows us to hold many of these factors constant, tracing out the short-run multinational response to variation in the IPR environment. Because we can do this for

[13] These are the only countries for which sufficient firm-level U.S. FDI exists to accurately estimate the impact of changes in the IPR regime on affiliate activity. A detailed discussion of the particulars of these sixteen reform episodes is provided by Branstetter, Fisman, and Foley (2005) and their accompanying Data Appendix.

[14] Branstetter, Fisman, and Foley (2005) provide detailed historical and econometric evidence suggesting that the exact timing of patent reform is likely to be plausibly exogenous to the activities of our sample firms.

a set of well-documented discrete regime changes, we need not create our own measure of the level of IPR strength in a set of countries, nor do we even have to specify in what units such an index would be measured. The highly disaggregated nature of our data allow us to control for country, parent firm, and affiliate characteristics that might impact the behavioral variables of interest, allowing us to get conceptually close to the measurement of the marginal impact of an IPR regime shift on these variables.

The next empirical challenge concerns measurement of the scale of multinational activity in the "South." In the theory section, this concept is unambiguously defined, and it corresponds to the number of distinct products for which production has shifted to the South. Our data on multinational activity are available at the affiliate level, but data are not available on the sales of individual products. While some affiliates are indeed focused on production of a single product, many are not. Some foreign affiliates operate multiple production facilities whose output spans multiple industry categories. Limited data are available classifying affiliate sales by aggregate industry category of output, but we have no measure of changes in output *within* industry categories. Effectively, our measures of the "scale of multinational activity" are likely to reflect both an expansion of the range of products produced and an expansion of the scale of production for individual products. Given this inexact correspondence between theory and data, we will measure the "expansion of multinational activity" in reforming countries along a number of dimensions. We consider three: total affiliate sales, as an output measure, and capital stock and employment, as input measures. A measurable expansion in all three, in the wake of local patent reform, is likely to reflect a considerable expansion in multinational activity. Drawing on the results of Branstetter, Fisman, and Foley (2005), we will also show that the technological intensity of affiliate activity expands sharply after patent reform, which is strongly consistent with a shift of the production of more technology intensive products to these affiliates.[15]

Our discussion above suggests regressions of the form:

$$S_{ilt} = \alpha_0 + \alpha_{il} + \alpha_t + \beta_0 y_{jt} + \beta_1 P_{it} + \beta_2 H_{jt} + \beta_3 R_{jt} + \beta_4 R_{jt} * Pat_{il} + \varepsilon_{it} \quad (40)$$

where l indexes the individual affiliate, i the affiliate's parent firm, j the affiliate's host country, and t the year. The dependent variable measures the total sales of affiliate l in U.S. dollars – our first proxy for the scale of

[15] These results are taken from a related working paper that is currently under review.

multinational activity. This measure includes sales to the domestic market and export sales, both valued in a common currency. The key variable of interest is R_{jt}, the post reform dummy variable, equal to one in the year of and years following patent reform in country j. The specification includes a number of controls: Time-invariant fixed effects for the affiliate (α_{il}), year fixed effects for the entire sample (α_t), and country-specific time trends; P_{it} and H_{jt} are vectors of time-varying parent and host country characteristics respectively. We control for the total sales of the parent system as well as the level of parent firm R&D spending. Host country characteristics include per capita GDP, measures of trade and FDI openness, corporate tax rates relative to the U.S.

If an improvement in the IPR regime actually leads to an expansion of the scale of multinational activity, then the effect should presumably be largest for firms that value patent protection the most. In order to study the differential effects of patent reforms across firms, affiliates are split into two groups according to the extent to which parents of affiliates use U.S. patents prior to the reform. Those affiliates of parents that, over the four years prior to a particular reform, average at least as many U.S. patent applications as the parent of the median affiliate in the reforming country over the same period are assigned a high patent use dummy, Pat_{il}, equal to one. For other affiliates that have parents that can be matched to the NBER patent database, Pat_{il} equals zero. This dummy variable is interacted with the post reform dummy variable.

Changes in the volume of affiliate sales will reflect both changes in output and changes in the price of output. In the context of a strengthening of the patent system, this could lead to inference problems. Stronger patent laws will confer a higher degree of monopoly power on the incumbent patent holder, possibly leading to higher prices for patent-protected goods. Given this, it would be useful to separate out the expansion in sales that is wholly attributable to higher prices. Unfortunately, affiliate-product specific price indices are not available. However, it is possible to examine the expansion of inputs into the production process. If these both expand substantially in the wake of patent reform, then it is likely that the expansion in the volume of sales is not wholly due to higher prices being charged for the same level of output. In this spirit we also present a regression with labor input as the dependent variable:

$$L_{ilt} = \alpha_0 + \alpha_{il} + \alpha_t + \beta_0 y_{jt} + \beta_1 P_{it} + \beta_2 H_{jt} + \beta_3 A_{ilt} + \beta_4 R_{jt} + \beta_5 R_{jt} * Pat_{il} + \varepsilon_{it} \tag{41}$$

where the dependent variable of interest is the log of the number of employees in affiliate l of parent system i in year t. The other variables remain as defined in equation (40). In addition to the controls we have already used, we add affiliate sales as an additional control. An examination of the impact of IPR regime change on employment is of particular interest, given the emphasis placed by the theoretical literature on labor – it is typically modelled as the only factor of production. In a similar vein, one could estimate a similar equation with the level of the (book value) capital stock of the affiliate as the dependent variable:

$$C_{ilt} = \alpha_0 + \alpha_{il} + \alpha_t + \beta_0 y_{jt} + \beta_1 P_{it} + \beta_2 H_{jt} + \beta_3 A_{ilt} + \beta_4 R_{jt} + \beta_5 R_{jt} * Pat_{il} + \varepsilon_{it} \tag{42}$$

We do not view this as a structural investment equation in any sense, and we do not impute structural interpretations to any of the regression parameters generated by such a specification. Instead, our sole purpose is to investigate the ceteris paribus impact of a strengthening of patent rights on the capital stock of the firm. If we find that sales, labor input, and capital input all expand significantly in the wake of patent reform, that would be consistent with, if not necessarily proof of, an expansion of multinational activity along the dimensions stressed in our theoretical model. As the reader will see, we find strong evidence of such expansion, and the expansion is disproportionately concentrated in firms for which intellectual property appears to be an especially strong element of corporate strategy.

As noted before, the above measures of "scale of multinational activity" probably reflect an expansion in the scale of production of previously produced products as well as the introduction of new products. One would like to have assurance that expansion along the latter dimension – the dimension stressed by our theoretical framework – is more than trivial. While the limitations in our affiliate data preclude us from identifying new product introductions *per se*, we can track variables that are arguably highly correlated with the introduction of new products, requiring new technology. As our model and the policy discussion has stressed, one of the potential benefits of stronger intellectual property rights is that such protections may induce foreign firms to produce and sell more technologically advanced goods in the host country – goods whose production they might not have been willing to shift to the host country under the prior, weaker IPR regime. Basic intuition suggests that if IPR regime shifts have a material impact on true intellectual property protection, then there should be an increase in the value of technology flows from parents to affiliates following regime changes. Following Branstetter, Foley, and Fisman (2005), this suggests regressions of the form:

$$T_{ilt} = \alpha_0 + \alpha_{il} + \alpha_t + \beta_0 y_{jt} + \beta_1 P_{it} + \beta_2 H_{jt} + \beta_3 A_{ilt} + \beta_4 R_{jt} + \beta_5 R_{jt} * Pat_{il} + \varepsilon_{it} \tag{43}$$

where the dependent variable measures the volume of intrafirm royalty payments for intangible assets – our proxy for technology transfer. The other variables remain as before. If the increase in the value of technology flows from parent firms to affiliates is actually from improved IPR protection (and not, for example, from correlated reforms), the effect should be largest for firms that value patent protection the most. Hence, it is important for us to include our interaction term.

Changes in the value of licensing payments could reflect changes in the volume of technology transferred or merely changes in the price charged for that technology. Analyzing changes in the R&D expenditures of affiliates is helpful in distinguishing between these two possibilities. There is a considerable body of work that details the relationship between affiliate and parent-firm R&D. It is clear that U.S.-based multinationals undertake basic and applied research abroad, as well as product development. However, to the extent that it is done outside the United States, true research tends to be concentrated in other developed countries where the local scientific and engineering community is highly accomplished and the infrastructure for frontier research is well-developed. R&D conducted by affiliates in developing countries, which account for most of the countries in our sample, tends to be focused on the modification of parent firm technology for local markets. The literature review presented in Kuemmerle (1999) makes the point that a number of studies suggest that the co-location of R&D with foreign manufacturing facilitates the "transfer of knowledge and prototypes from the firm's home location to actual manufacturing." Viewed in this light, affiliate R&D and technology transfers from the parent can be considered complements. Given this complementary relationship, IPR reform should also prompt an increase in R&D spending.

To test if this is the case, variations of the basic specification are used to analyze affiliate R&D. These specifications take the form:

$$R_{ilt} = \alpha_0 + \alpha_{il} + \alpha_t + \beta_0 y_{jt} + \beta_1 P_{it} + \beta_2 H_{jt} + \beta_3 A_{ilt} + \beta_4 R_{jt} + \beta_5 R_{jt} * Pat_{il} + \varepsilon_{it} \tag{44}$$

The dependent variable measures the level of R&D spending conducted by affiliate l of parent i in year t. The right hand side variables remain as they were in specification (40).

Data on U.S. multinational firms comes from the U.S. Bureau of Economic Analysis (BEA) annual Survey of U.S. Direct Investment Abroad and the quarterly Balance of Payments Survey. The survey forms concerning MNE activity capture extensive information on measures of parent and affiliate operating activity like levels of sales, employment, affiliate exports, and R&D expenditures. MNEs must also report the value of royalties paid by affiliates to parents for the sale or use of intangible property. American tax law requires that foreign affiliates make these payments. The reported figures on the value of intangible property transferred include an amalgam of technology licensing fees, franchise fees, fees for the use of trademarks, etc. However, the aggregate data indicate that intangible property transfers are overwhelmingly dominated by licensing of industrial products and processes.

Table 3 displays descriptive statistics for the benchmark years in which BEA collected the most extensive data on U.S. foreign affiliates. The sample includes firms that were active in countries that undertook the IPR regime changes described below. In the most recent benchmark year, 1999, the sample includes more than 5,000 affiliates of more than 1,000 parent companies.

A number of other databases are used to augment the information on U.S. firms in the BEA data. In order to obtain information on parent firm R&D expenditures in years in which this item was not captured in BEA surveys, the BEA data on publicly traded parents is linked to COMPUSTAT using employee identification numbers. Parent firm data is also linked to data on patenting activity captured in the NBER patent citation database. This comprehensive database covers all patents granted by the U.S. Patent and Trademark Office (U.S. PTO) throughout the 1982-1999 sample period. These data provide a rich picture of the evolving technological trajectories of parent firms and are used to test if patent reforms have larger effects for firms that make more extensive use of the U.S. patent system prior to the reforms.

Finally, information on the timing and content of IPR regime changes come from a number of sources. Our starting point was the complete set of significant patent reforms identified by Maskus (2000). Information on the details of individual reforms was obtained from Ryan (1998), Uphoff (1990), and Sakakibara and Branstetter (2001), and various reports published by the patent agencies. We also undertook a series of interviews with multinational managers, legal experts on intellectual property rights based in some of the reforming countries, and international IPR consultants, in order to understand better the substance of the reforms and to confirm their timing. This is not a complete or exhaustive list of IPR regime changes that occurred over our sample period. For instance, some countries undertook reforms of their copyright laws in ways that impacted the computer software and entertainment industries – these are not studied in the current paper.

4 Empirical Analysis using U.S. Import Data

If stronger IPR did not result in a marginal increase in affiliate output, capital stock, labor input, technology transfer from the parent, and R&D spending, it would be difficult to argue that a stronger IPR regime had the impact on production shifting forecast by our model. As the reader will see, we find strong evidence of an expansion in the "scale of multinational activity" along all five of these dimensions. Nevertheless, these results alone do not necessarily prove our point. None of our measures of affiliate activity really capture the introduction of new goods per se. Most of these findings could result from expanded production of previously produced goods. Furthermore, it could be the case that the increase in production transfer through affiliates, even if it is happening, is more than offset by a decrease in production transfer through imitation.

The best way of capturing the "production shifting" of individual goods is likely to come through use of the U.S. trade data base created by Feenstra, Romalis, and Schott (2001). Annual data on U.S. imports from nearly all the world's countries are available at a very disaggregated level. The data do not quite go down to the level of individual products, but they are available at the 10-digit level of disaggregation – and this is as close to the product level as we are likely to get. Furthermore, because the U.S. is the world's single biggest market for many commodities, looking at the date at which country i starts exporting good j to the U.S. is probably a reasonable indicator of "production shifting" for that good. This is likely to be particularly true for countries in Latin America and Asia for which the United States has historically been either the most important single trading partner or one of the top 3-5 trading partners over the past 3 decades. Domestic production may precede exports by several years, but in the Helpman framework and its descendents, it is the export of this good by the South that promotes welfare.

The variable of interest suggested by this reasoning will thus be a count variable that measures, for a given country in a given year, the number of 10-digit commodities this country exported to the U.S. for the first time. One could think of this as a proxy for a Poisson "arrival rate" of production-shifting. This count would be regressed on "country-year" variables that control for a country's changing export capabilities. A simple empirical specification suggested by this approach would be:

$$P_{jt} = \alpha_0 + \alpha_j + \alpha_t + \beta_0 H_{jt} + \beta_1 R_{jt} + \varepsilon_{it} \tag{45}$$

where P measures the number of 10-digit "initial export episodes" coming from country j in year t. This is regressed on an overall constant term, country dummy variables, time dummy variables, a vector of time-varying characteristics of country j, and the reform dummy variable. Country characteristics included in vector H include measures of per capita income, changes in trade and FDI regimes, and the log of the real exchange rate of country j vis-a-vis the U.S. dollar, as in the earlier regressions.

A positive coefficient on the reform dummy would suggest that the expansion of multinational activity along the five dimensions mentioned above also leads to an acceleration in the rate at which products are shifted from North to South. Furthermore, even if imitation by Southern producers decelerates, the acceleration of production shifting through multinational affiliates more than offsets that, resulting in a net acceleration in the rate at which products get transferred to the South. Following the logic traced out by Helpman (1993) and Lai (1998), this would imply that additional resources get freed up in the North to be focused on R&D, allowing for an acceleration in the rate of Northern innovation. This allows the range of goods available to consumers in all countries to expand more quickly. If the discount rate is low enough and the preference for variety strong enough, this could raise the welfare of both the North and the South.

One major issue with these data is that the 10-digit commodity classification system was extensively revised in 1989. As a consequence, data before and after the revision are not really comparable at the most disaggregated level. The data do come with a "correspondence" that allows one to link the

1970s-era classification to the later "harmonized system," but this mapping is neither unique nor exact. Most attempts to link the pre- and post-revision data are done at a much higher level of aggregation – but going up to the 5-digit or 4-digit level would extinguish many of the "new product introductions" that we are trying to measure. This caveat needs to be kept in mind in our discussion of the results based on these data.

5 Results of Empirical Analyses

Table 4 summarizes the results of regressions run using the BEA micro-data for firms with operations in one or more of the reforming countries listed in Table 2. Column 1 provides results in which the dependent variable is the log of the level of affiliate sales, as in equation (40). The estimated coefficients are reported in the table; robust standard errors are provided in parentheses below the coefficients. Of particular interest are the coefficients on the patent reform dummy variable and the interaction term of this dummy variable with the dummy variable for patent intensity of the parent firm. Both coefficients are positive, statistically significant at the conventional levels, and of reasonably large magnitudes. Because the dependent variable is measured in logs, the coefficients have a semi-elasticity interpretation. Taken at face value, the coefficients imply that all firms experience a roughly 9% level increase in the volume of sales, and the affiliates of patent intensive firms experience an additional 11% increase over and above that level, resulting in a nearly 20% expansion of the volume of sales in post-reform years.

Column 2 provides results of estimates of equation (41), in which the dependent variable is the log of affiliate employment. The coefficient on the patent reform dummy variable is not statistically significant at conventional levels. However, the interaction term is positive and statistically significant, implying that patent-intensive affiliates respond to patent reform with a nearly 5% increase in the level of employment relative to other affiliates. These results suggest that the expansion in volume of sales estimated in column 1 is not wholly driven by price increases. Instead, firms are expanding their local production operations by hiring more workers. We note that these results are obtained in a specification in which we include affiliate sales as a control variable. Affiliates that are not patent intensive do not appear to increase employment, conditioning on sales. Patent-intensive affiliates do, and this may suggest that patent-intensive affiliates are expanding the scope of their activities by expanding employment.

Column 3 provides an additional perspective on multinational production expansion in the wake of patent reform by estimating the impact on affiliate capital stocks, along the lines of equation (41). Caution must be taken in interpreting these results, as they are based on the "book value" of capital stocks taken directly from the affiliate-level balance sheet information reported to the BEA. As has long been noted, these accounting data can deviate substantially from the economic concept of "capital stock" in a number of ways. Regression results indicate that the coefficient on the reform dummy is positive, but not statistically significant at conventional levels. However, the interaction term is positive and significant, suggesting a roughly 10% increase in the capital stock of patent-intensive affiliates. Taking these coefficients at face value, they imply that the affiliates of patent-intensive parents expand their capital stock in the wake of patent reform by roughly 11%. This suggests a substantial increase in inputs to the local production operation, reinforcing the message of column 2. If multinationals respond to patent reform by undertaking more sophisticated activities in reforming countries, we might expect the capital intensity of affiliate activity to increase. The results in the column show that, even after controlling for affiliate sales, patent-intensive affiliates increase their capital stock by an amount that is statistically and economically significant, whereas other affiliates do not.

While the results of the first three columns all suggest an expansion of the scale of multinational activity in the wake of patent reform, they do not necessarily imply an expansion in the scope of multinational activity – that is, an acceleration in the rate at which the production of new goods is transferred to the South. As we have already noted, our affiliate level data are not sufficiently disaggregated for us to identify the production of new goods. However, we can presume that the production of a new good is likely to require the provision of new technology by the parent firm. Under U.S. law, multinational firms are required to account for intra-firm technology transactions. Our affiliate-level data include information on technology licensing payments made by affiliates to their parents for the use of such technology. The results of column 4 suggest that there is a pronounced increase in these licensing payments after IPR reform. The effect appears to be highly concentrated within the affiliates of patent-intensive multinationals, as might be expected. The coefficient on the patent reform dummy is small and statistically insignificant. The coefficient on the interaction term, however, is positive, highly significant, and rather large in magnitude. Taken together, the results imply a marginal increase in the level of annual licensing payments of about 30%. To the extent that technology transfer is proportional to licensing payments, such a large increase, cumulated over several years, would seem to suggest a substantial increase in the technological intensity of affiliate activity. The results of column 4 are consistent with a change in the focus of affiliate activity toward the production of new, more technology-intensive products. Alternative specifications using the affiliate-level ratio of royalties to affiliate sales yielded qualitatively similar results.

Finally, column 5 shows the results of a specification using affiliate R&D spending as the dependent variable, as in equation (44). Most R&D spending by U.S.-based multinational firms is concentrated in the U.S. However, some foreign affiliates of U.S. firms do spend on R&D. As noted by Branstetter, Fisman, and Foley (2005), the vast majority of this R&D spending is designed to modify the parent firm's technology to local circumstances and conditions. It can thus be seen as a complement to technology imports from the parent. If the post-reform increase in technology licensing payments identified in column 4 truly represents the deployment of new technology, then we might expect that increase to be mirrored by an increase in affiliate R&D spending. And, indeed, column 5 shows evidence of just such an increase, albeit one that is largely concentrated in the affiliates of patent-intensive parents. The coefficient on the patent reform dummy is statistically indistinguishable from zero, but the coefficient on the reform*patent intensity interaction term is large, positive, and statistically significant. At face value, the coefficient implies a roughly 30% increase in the level of patent-intensive affiliate R&D spending relative to other affiliates, which is comparable to the increase technology licensing payments estimated in column 4. Again, these results are consistent with an expansion of multinational activity that involves the use of new technology to produce new kinds of products.

Having examined the multinational response to patent reform at the affiliate level, we now examine the lessons of trade data at the country level. Table 5 provides results from regressions using various specifications of equation (45). Here, the dependent variable measures the count of initial export episodes at the 10-digit level. Given the count nature of the dependent variable, one might wish to use an econometric specification designed for count data. Column 1 provides results of the negative binomial fixed effects regression model derived by Hausman, Hall, and Griliches (1984). In this specification, we pool across the entire data set, effectively ignoring the fact that the thorough reclassification of trade statistics in 1989 means that the pre-1989 and 1989-2001 data are not directly comparable. We also include data for all the reform episodes identified in Table 2, even though serious doubts have been raised about the effectiveness of enforcement of the patent regime in China. Despite all these caveats, we see that the coefficient on the reform dummy variable is strongly positive, and statistically significant. The coefficient on the reform dummy implies an increase in the arrival rate of new goods on the order of 14%. At the margin, it seems that an increase in the strength of the IPR regime is associated with an acceleration of production shifting, as measured by the initial export episodes of 10-digit level commodity categories.

In column 2, we continue to employ a negative binomial fixed effects model, but we only measure initial export episodes in product classes that can be associated with R&D-intensive industries. If the post-reform acceleration in product-shifting is truly driven, at least in part, by the reaction of multinationals to stronger IPR, then we would expect to see even larger effects if we restricted our view to "technology-intensive" goods. In fact, when we run such a regression, we obtain a point estimate that is considerably larger in magnitude.

These basic patterns are confirmed in other specifications. In column 3, we use a fixed effects Poisson specification to estimate the impact of patent reform, noting that the negative binomial regression model imposes strong assumptions on the distribution of the error term that may not hold in reality. Econometric research has indicated that the point estimates of the Poisson model are more robust to misspecification of the error term. Recalling the doubts that have been expressed about patent reform in China, we drop this country from our sample. Again, the regression results suggest a positive, statistically significant impact of patent reform on production shifting. The coefficient in column 3 implies an acceleration of about 18% when we examine initial export episodes in all product categories. When we restrict our set of initial export episodes to those in technology-intensive industries (not shown for reasons of space), the point estimate suggests an acceleration of more than 33%.

While the dependent variable is a count variable, the number of zero observations – that is, country-year observations for which there were no initial export episodes at the 10-digit level, is relatively small. Because of the small number of zeros, we also use linear fixed effects models to assess the robustness of our results. In column 4, we take the log of the count of initial export episodes. Because there are a small number of zero observations, we first add "1" to all realizations of the dependent variable, then take the log of the transformed variable. Given concerns over the degree to which China's patent regime has been effectively enforced, we continue to omit China from our sample. Finally, we restrict ourselves to the consistent 1989-2001 data series, thereby sharply cutting the number of observations. Despite these sample restrictions, the estimated impact of patent reform suggests a roughly 16% acceleration in product-shifting, and this is statistically significant at conventional levels even when we use robust standard errors to allow for arbitrary heteroskedasticity in the data.

As a final test, we continue to employ all the sample restrictions used in column 4, but we also restrict our count of "initial export episodes" to technology-intensive goods. As in other specifications, we find that this increases the magnitude of the point estimate. The results of column 5 imply a 24% acceleration in product shifting. We note that the statistical signficance of this coefficient is at the borderline of the traditional threshold (p-value of .053) when we employ robust standard errors. Given the small number of observations, we are actually surprised by the relative robustness of our results.

6 Conclusion

In the 1990s, the international economic policy agenda shifted from its traditional postwar focus on the reduction of tariff and non-tariff barriers to international trade to the embrace of stronger intellectual property rights around the world. This shift occurred largely at the behest of the advanced industrial nations, particularly the United States. It has been – and remains – deeply controversial, even today, ten years after the incorporation of the TRIPs agreement into the WTO charter. Sharp disagreements persist over the impact of this shift on developing nations. Unfortunately, the economics literature to date has shed relatively little light on this debate, despite the best efforts of many talented researchers. One of the shortcomings of the empirical literature in this field has been its insufficient connection with recent theoretical work.

More than 10 years ago, Helpman (1993) introduced a theoretical framework that elegantly captured the basic trade-off generated by stronger intellectual property rights in the South. He showed that the positive effect of stronger IPR on incentives to innovate could be undermined (and global welfare reduced) in the long run by Northern resource constraints, as production gets reallocated from the inexpensive South to the high-cost North. The literature following Helpman (1993) and Grossman and Helpman (1991) has argued that stronger IPR in the South can slow the rate at which production is shifted to developing countries, tying up Northern labor resources in production rather than R&D. The centrality of this channel – that is, the impact of stronger IPR on production shifting – has been a feature of theoretical work in this area. In general, the literature based on Helpman's model has shown that, where stronger IPR in the South leads to an *acceleration* of production-shifting, it tends to lead to higher rates of innovation and, under a plausible range of key model parameters, generates higher global welfare. The theoretical model we present in this paper shows that this result holds under a fair degree of endogenity.

This theoretical result opens up an opportunity for empirical work to clarify the nature of the impact of stronger IPR in the South on production shifting. We present in this paper a mix of evidence drawn from U.S. affiliate-level data and U.S. import data. All of the evidence points in the direction of stronger IPR in the South *accelerating* the rate at which production of goods gets transferred to Southern countries. We find that discrete IPR regime changes in sixteen countries leads to an expansion of multinational activity in those countries along multiple dimensions. Affiliate sales, employment, and capital stock all increase, and the increase is disproportionately concentrated in the affiliates of patent-intensive parents, for whom patents and other kinds of intellectual property are likely to be an especially important component of corporate strategy. We also find that parent firms provide more technology to their affiliates, and affiliates increase their R&D spending in the wake of patent reform. As we argue in the paper, this is consistent with parent firms deploying new technology to their affiliates so that these affiliates can begin the manufacture of new, more sophisticated goods.

In principle, the increase in production-shifting through multinational firms could crowd out imitative activity by indigenous Southern producers, with ambiguous effects on the total net amount of production shifting. To address this concern, we provide evidence from highly disaggregated U.S. trade data strongly suggesting that this does not occur. Instead, data measuring the "initial export episodes" of tradable goods from our IPR reforming countries suggests that the increase in production -shifting through multinationals more than compensates for any deceleration in production-shifting through imitation. To the extent that the central channel stressed by the theoretical literature of the last decade is at all empirically relevant, our results strongly suggest that it is operating in a positive fashion. Stronger IPR in the South appears to lead to an acceleration of production-shifting. In the long run, this will free up Northern resources for investment in innovative activity.

In this paper, we do not attempt to estimate the precise magnitude or exact timing of these longer-run general equilibrium impacts. However, other researchers have noted a robust expansion of U.S. innovative activity in the 1990s, even as manufacturing jobs have continued to move offshore. Relative to inventors based in other countries, U.S.-based inventors appear to have increased their generation of new ideas.[16] Along with this surge in innovative outcomes has come an acceleration in total factor productivity growth – an acceleration which has persisted in recent years.[17] These are complex phenomena with multiple causes, and one would not want to make too much of the broad coincidence in time between the domestic downsizing and offshoring of American manufacturing and the acceleration of American innovative activity. But these recent developments are certainly consistent with the kind of general equilibrium resource reallocation stressed in Grossman-Helpman style product cycle models. Exploring the potential link between production shifting and the apparent acceleration of innovation in U.S. industry in a more systematic way at the industry and firm level is a focus of ongoing research.

7 Appendix

Our model differs from Lai's in two main ways. First, and most importantly, imitation is endogenous in our model whereas it is exogenous in his model. Second, unlike us, Lai (1998) interprets σ where

$$\sigma = \frac{\dot{n}_S}{n_N}$$

as the rate of multinationalization. However, σ measures an expansion in the Southern production base that results both from multinationals as well as local imitation. Strictly speaking, only products made by Northern multinationals ought to count as those that have been multinationalized. The other products made in the South are those that have been imitated by Southern

[16] See Kortum and Lerner (1999) for a discussion of evidence based on patent data.

[17] See Gordon (2003) and the studies cited therein.

firms and whose production can longer be controlled by Northern firms. In our terminology, only those goods that are produced by Northern multinationals are viewed as being multinationalized and the rate of FDI is measured by $\phi \equiv \frac{\dot{n}_M}{n_N}$.

Setting $\theta = 1$ and assuming μ is exogenous simplifies our model down to Lai's. In that case, the two endogenous variables (i.e. g and ϕ) must satisfy the following two equations:

$$\left[\frac{\sigma}{g}\left(\frac{\mu + \mu\alpha^{-\varepsilon}}{\mu + \mu}\right)\left(\frac{L_N - ag}{L_S}\right)\right]^{\alpha} = \frac{\rho}{\rho + \mu}$$

and

$$\left(\frac{1-\alpha}{\alpha}\right)(L_N - ag)(\frac{\sigma}{g} + 1) = a\rho$$

where

$$\sigma = \phi(1 + \frac{\mu}{g})$$

The following result is proved in Lai (1998): *a strengthening of Southern IPR protection (i.e. a decrease in the rate of imitation μ) increases the Northern rate of innovation g.* The proof proceeds in a straightforward fashion: the implicit function theorem is applied to the above equation to determine the sign of $\frac{dg}{d\mu}$.

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Table 2: Reform Episodes

Country	Date
Argentina	1996
Brazil	1997
Chile	1991
China	1993
Colombia	1994
Indonesia	1991
Japan	1987
Mexico	1991
Philippines	1997
Portugal	1992
South Korea	1987
Spain	1986
Taiwan	1986
Thailand	1992
Turkey	1995
Venezuela	1994

Table 3: Descriptive Statistics for U.S. Multinational Activity in Reforming Countries

Variable	Data from Benchmark Years			
	1982	1989	1994	1999
Number of Affiliates	3,970	4,115	4,888	5,785
Number of Parents	836	902	1,114	1,132
Sales				
Mean	57,129	77,604	90,229	106,866
St. Dev.	299,376	460,023	517,553	463,536
R&D				
Mean	117	407	482	570
St. Dev.	911	9,470	4,397	6,595
Tech. Transfer				
Mean	157	552	932	988
St. Dev.	2,335	13,873	14,989	14,870
Descriptive Statistics for all Affiliate Years				
	Mean		St. Dev.	
Host Country Tax Rate	0.3375		0.1309	
Host Country Withholding Tax Rate	0.0707		0.0889	
Host Country Inward FDI Restrictions	0.0661		0.2485	
Host Country Trade Openness	36.7459		22.8795	
Log of Host Country GDP per Capita	8.9843		0.6759	

Table 4: Results from BEA Data

Dependent Variable	Sales (1)	Employment (2)	Capital (3)	Tech Transfer (4)	R&D (5)
IPR Reform	.091	-.015	.014	-.053	-.120
	(.038)	(.019)	(.044)	(.069)	(.094)
IPR Reform*Patent Intensity	**.108**	**.048**	**.095**	**.306**	**.302**
	(.040)	**(.021)**	**(.045)**	**(.072)**	**(.104)**
Corporate Tax Rate	.292	-.051	.640	.004	.456
	(.239)	(.105)	(.248)	(.369)	(.565)
Trade Restrictions	.004	-.003	.004	-.019	.007
	(.004)	(.002)	(.004)	(.005)	(.008)
FDI Restrictions	.056	.049	-.142	-.037	.012
	(.064)	(.034)	(.079)	(.130)	(.163)
Host Country GDP	1.04	.078	.304	1.80	-.415
	(.231)	(.108)	(.245)	(.392)	(.625)
Real Exchange Rate	-.357	.074	-.223	-.252	-.008
	(.040)	(.022)	(.047)	(.076)	(.129)
Parent Sales	.154	.061	.095	.090	-.043
	(.037)	(.016)	(.036)	(.026)	(.044)
Parent R&D	-.015	.005	.030	.023	.034
	(.009)	(.004)	(.011)	(.009)	(.013)
Affiliate Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	17,393	16,892	14,632	17,393	10,010
R-squared	.8021	.9137	.8262	.7173	.6844

Table 5: Results from Trade Data

Specification	Neg. Bin. FE	Neg. Bin. FE	Poisson FE	Linear FE	Linear FE
Data Restriction	None	Tech Goods	China dropped	China dropped Post 1988	China dropped Post 1988 Tech Goods
	(1)	(2)	(3)	(4)	(5)
Reform	**.135**	**.205**	**.183**	**.155**	**.242**
	(.061)	**(.083)**	**(.009)**	**(.077)**	**(.124)**
GDP per Capita	-.352	.046	-.331	-.250	1.18
	(.106)	(.138)	(.027)	(.329)	(.601)
Trade Openness	.001	.010	.003	.001	.000
	(.003)	(.003)	(.001)	(.006)	(.010)
FDI Openness	.031	.105	-.007	-.067	-.084
	(.127)	(.143)	(.020)	(.077)	(.162)
Log Real ER	.025	-.025	.043	.034	.051
	(.015)	(.022)	(.002)	(.011)	(.014)
Observations	232	232	219	133	133
R-squared				.9021	.8264
Log Likelihood	-1381.4	-1080.8	-5249.5		