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Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Panel Data[1]

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Abstract

Over the past twenty years, there has been a global movement to strengthen intellectual property rights (IPR). This movement has been extremely controversial, with developing country leaders arguing that it will lead to increased rent extraction by multinational corporate patent holders, and advocates of stronger IPR arguing that it will lead to an acceleration of technology transfer from the developed world.

This paper examines the response of U.S. multinational firms to a series of reforms of intellectual property rights regimes undertaken by 12 countries over the 1982-1999 period. Using detailed data at the level of the transacting firm, we find evidence that multinationals respond to stronger IPR regimes by increasing their technology transfer to the reforming countries. This increase is reflected in intrafirm technology licensing, affiliate R&D spending, and patenting trends in the reforming countries.

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Section 1: Introduction

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), which was approved as part of the Final Act of the Uruguay Round, requires a number of developing countries to strengthen their patent and other intellectual property rights (IPR) systems.[2] Even though policy makers have committed to significant reforms, the implementation of this agreement remains contentious. On one side, many policymakers in developing nations believe that this mandated policy change will work against their national economic interests, transferring rents to multinational corporate patent holders headquartered in the world's most advanced countries, especially the United States.[3] Advocates for strong IPR counter that strengthening IPR in developing countries will induce more innovation, both in the developing world and in the developed world, fostering more rapid economic growth. These advocates also believe that a strengthening of IPR will accelerate the transfer of technology from the developed world to the developing world, ensuring a relatively equal distribution of gains from this policy change.

Despite this heated policy debate, the international impact of IPR remains an understudied area within international economics. In order to shed light on the impact of changing IPR regimes, this paper examines the responses of individual U.S.-based multinational enterprises to a series of recent unilateral reforms and studies trends in patent applications around these reforms. Beginning in the 1980s, a number of countries have undertaken reforms of their intellectual property systems, often in response to

[2] Implementation of the terms of this agreement is ongoing. Some developing countries have until 2016 to fully comply.

[3] For a more academic treatment of some of these claims in the context of India, see Lanjouw (1997).

diplomatic pressure from the United States or other major trading partners.[4] Analysis of firm-level data from the Bureau of Economic Analysis's survey of U.S. multinational activity reveals evidence of an increase in technology transfer form parent firms to affiliates located in IPR-reforming countries. More precisely, royalty payments for the use or sale of intangible assets from affiliates to parent firms increases in the wake of strengthened IPR regimes. This increase is concentrated among the affiliates of firms that have larger patent portfolios before the reforms occur. In contrast, the evidence of an increase in technology licensing to unaffiliated parties is weaker, and tends to be confined to those firms that did not possess affiliates in the reforming countries prior to the implementation of IPR reform.

The view that IPR reform results in an increase in technology transfer is strengthened by evidence that R&D spending by affiliates of U.S.-based multinationals – traditionally viewed as a *complement* to technology imports from the parent – increases after IPR reform. Examination of international trends in patent applications also suggest that at least one component of the observable increase in licensing flows is associated with the introduction of new technology in the wake of patent reform. Both the level and rate of change of nonresident patenting increase in the post-reform period. Consistent with earlier work, we find no corresponding reaction in resident patent filings.

Section 2. The Impact of Intellectual Property Rights on International Economic Activity: A Literature Review

Previous work on the role of IPR in promoting innovation and growth in the global economy falls into three main categories: studies of the responsiveness of domestic innovation to IPR, studies of the impact of changing IPR in the developing

[4] For an account of the diplomacy behind these changes, see Ryan (1998) and Uphoff (1990).

world on global welfare, and studies of the responsiveness of international economic activity (such as trade or FDI) to IPR.[5]

The first stream of research, based largely in the industrial organization literature, looks in a focused way at the role of IPR in promoting innovation. This work generally considers reactions to specific changes in IPR regimes, examining the resulting changes in measures of innovation, such as patent filings (see, for example, Scherer and Weisburst (1995); Bessen and Maskin (2000); Sakakibara and Branstetter (2001)). A large number of these studies find that a strengthening of IPR results in little or no measured increase in domestic innovation.[6]

Lerner (2001, 2002) avoids criticisms related to the generality of the econometric "case studies" cited above by studying the impact of *all* significant patent reforms over the last 150 years, using a window of time around each significant patent reform in each of 60 countries as the unit of analysis. His findings confirm that reforms have few positive effects on patent applications by entities in the country undertaking the policy change. On the other hand, he finds that *foreign* applicants respond to these changes by increasing their patenting after reform. This paper does not consider the effects of reforms on technology transfer, *per se*.[7]

A second stream of research, most of it theoretical, has sought to examine the global welfare implications of patent reform in developing countries. The pioneering

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[5] Space constraints prevent us from providing a complete and exhaustive literature review. Our limited review here necessarily omits some important related work in order to focus on the research most closely connected to the current paper.

[6] Cockburn and Lanjouw (2001) attempt to discern the impact of TRIPs on the composition of pharmaceutical research and find, at best, mixed evidence of a modest impact.

[7] Related recent theoretical work by Grossman and Lai (2002) emphasizes that, in a global economy, the strengthening of a domestic patent system may have little impact. This is particularly true if the world's largest economies already have strong patent systems under which firms based in developing countries can apply for patent protection. Going further, Grossman and Lai demonstrate that international harmonization of patent protection is neither necessary nor sufficient for global efficiency.

work of Helpman (1993) demonstrated that strengthening IPR in the "South" could actually lower global welfare. In Helpman's framework, human resources in the North are divided between generating new products (innovation) and the manufacture of existing products (production). Over time, the production of mature products is transferred to Southern firms through a process of imitation of Northern products. By raising the costs of Southern imitation, stronger IPR in the South slows down this process of transfer of production to the South. Because goods continue to be produced in the North, the wage of Northern labor is bid up – and this raises the cost of R&D, slowing the rate at which new products are generated. Because the pace of innovation is reduced, global welfare declines.

Lai (1998) introduced the possibility of foreign direct investment into a model similar to that of Helpman (1993).[8] Lai showed that, in a model with FDI, stronger IPR could actually accelerate the transfer of production to the South – but the means of this transfer would be through FDI rather than imitation by "indigenous" Southern firms. Glass and Saggi (2002) showed that Lai's result would not necessarily obtain, but in their model, the global welfare impact of IPR strengthening in the South also depends on its impact on FDI. They show a range of conditions and parameter values under which stronger IPR in the South reduces FDI, and conclude that the global welfare impact of stronger IPR could still be negative.

Empirical work that directly addresses the welfare impact of changes in IPR has lagged behind theory. Perhaps the best-known empirical work to date that explicitly seeks to measure welfare impact is that of McCalman. Building on the work of Eaton

[8] In Helpman's original formulation, the only way production of a good was transferred to the South was through imitation by indigenous Southern firms.

and Kortum (1996), McCalman (2001) estimates a structural model of innovation and technology transfer to infer the implications of the TRIPs agreement. His calculations suggest that patent harmonization would result in large transfers between countries and in particularly large benefits for the U.S. As he acknowledges, this study does not include any accounting of the benefits that might accrue from a higher rate of innovation, nor does it factor in the potential for an acceleration of technology transfer in response to a strengthening of IPR.

There is also a literature that analyzes the cross-sectional relationship between IPR and measures of international trade and investment. In particular, in looking at bilateral trade patterns, Maskus and Penubarti (1995) found a strong positive effect of IPR on imports. Smith (1999) reports results that are consistent with a role for IPR in encouraging U.S. exports.

The evidence of the effect of IPR on FDI is less clear. Maskus and Eby-Konan (1994) find no effect of IPR measures on FDI. Maskus (1998), however, claims that this 'non-result' may be due to the fact that these studies consider FDI in isolation, whereas investment is only one part of the broader set of decisions that a multinational firm makes in entering a market. He reports regressions that are consistent with a positive effect of IPR on FDI, but only for more developed countries.[9] Of course, multinationals can, in principle, transfer technology to developing countries even without undertaking FDI. In work somewhat related to the current paper, Yang and Maskus (2000b) examine the

[9] Lee and Mansfield (1996) also study the impact of IPR on FDI.

effect of improved IPR regimes on licensing by U.S. MNE's, and report a strong positive relationship.[10]

While these papers are suggestive of some interesting patterns, they all suffer from the usual problems that affect cross-country regressions. The measures of IPR utilized do not generally take into account the effectiveness of enforcement and are largely time-invariant, thereby precluding the use of country fixed-effects. Finally, since FDI data are typically not disaggregated, even by industry, it has not been possible to look at the impact of IPR reform on the composition of investment.[11]

Section 3. A Simple Model of IPR and Firm-Level Technology Transfers

Our goal here is to generate a relatively simple structure to guide our firm-level estimation. Hence, rather than building on a general equilibrium model of innovation, we focus on a firm-level (partial equilibrium) model of responses to IPR to generate a set of predictions that may ultimately be useful in estimating the parameters that are crucial to estimating the effects of IPR reform. Furthermore, since we are looking at reactions to discrete IPR regime shifts in individual markets that may not loom large in a firm's overall level of sales, we may safely take the firm's stock of innovations as being held constant, and may therefore ignore (at least for now) the induced effect of IPR reform on future innovation.

Our model is similar to that of Green and Scotchmer (1995), in that we consider the sequential choice of introduction of technology to a new market (whereas Green and

[10] Smith (2001) also examines the impact of IPR on licensing and FDI, obtaining results with the licensing variable that are consistent with those of Yang and Maskus.

[11] One recent exception is Smarzynska (2000), who examines the composition of FDI in Eastern Europe in the 1990s and relates this composition to differences across countries in IPR regimes. Because this study focuses on a small number of countries in a single region of the developing world, natural questions arise about the extent to which these findings can be generalized outside their regional context.

Scotchmer examine an initial innovation) followed by a decision of whether to license to other producers. However, in transforming their model to the context of technology transfers (as opposed to original innovation), we make a number of changes, including the incorporation of a second-stage model of spatial competition.

We model a multinational firm that is considering a transfer of technology that will generate additional profits. The cost of transferring this technology is given by t. We may think of this as an innovation that improves an existing good, or an entirely new product, and normalize the 'no transfer' case to yielding a zero payoff for the multinational. Below, we will allow this transfer cost to depend on whether the technology is being licensed (t_l) or used by a multinational affiliate (t_a). This differential may arise, for example, because of the greater difficulties in transacting across firm boundaries.

Conditional on deciding to enter the market, the firm must decide whether to transfer the technology through a local affiliate, or by licensing the technology to an unrelated party. If the technology is licensed to an outside party, a licensing fee, L, is paid by the licensee.[12] If the firm chooses to produce through a local affiliate, then it competes directly in the market.[13] If entry occurs through licensing, there is some probability that the licensee fails to pay the licensing fee (q), and this depends on the extent of IPR enforcement, s, so that $q=q(s)$.

[12] We assume a lump sum licensing fee (independent of sales). This is optimal in the context of the simple model described here, since it avoids problems of double marginalization.

[13] For simplicity, we do not consider the case where profit may be maximized by entering through an affiliate *and* licensing. For this to make sense, it would have to be necessary for the multinational to either control downstream prices, or for a duopoly to generate greater profits that a monopoly. Furthermore, empirically, we largely see firms either licensing *or* transferring technology to affiliates, but not both.

The structure of competition, conditional on entry, also depends on the extent of IPR protection. We model this as a simple "linear city" model of product differentiation on the interval [0,1], with a uniform distribution of customers who face transport costs mx, where x is the distance from the firm that makes the sale (see, for example, Tirole, 1993, for details). The multinational occupies the point at zero, and we assume that the closest competitor is given by s, so that improved IPR broadens the firm's monopoly power. On [s,1], we assume free entry, so that the price charged by this 'fringe' group will be unaffected by s (let this price be p_o) . For the multinational affiliate, the marginal cost of production is c_a, a constant. If entry takes place through licensing, we assume that the licensee faces an exactly parallel set of circumstances, except possibly with a different marginal cost of production (c_l).

The timing of the game is therefore as follows:

1. Decide whether to provide the technology to the market.
2. Choose mode of transfer (licensing versus affiliate).
3. If entry through licensing, technology is stolen with probability $q(s)$
4. Licensee/Affiliate competes in spatial differentiation game.

To determine the equilibrium entry decisions of the multinationals, as a function of the model's parameters, we work backwards. In the final stage, the position of the marginal consumer, x, is determined by:

$$(1) \qquad p_a + mx = p_o + m(s - x))$$

Hence,

$$(2) \qquad x = \frac{p_o + sm - p_a}{2m}$$

It is then straightforward to calculate the profit maximizing levels of output, price, and profitability as a function of the model's parameters, in particular, s. Profits are given by:

$$(3) \qquad \pi = \frac{p_o + sm - p_a}{2m}(p_a - c)$$

First order conditions therefore yield:

$$(4) \qquad p_a = \frac{1}{2}(p_o + sm + c)$$
$$q_a = \frac{1}{4m}(p_o + sm - 2c)$$

Under these conditions, it is straightforward that:

$$(5) \qquad \frac{dp_a}{ds}, \frac{dq_a}{ds}, \frac{d\pi}{ds} \geq 0$$

The intuition is clear: greater IPR expands the product space over which the firm enjoys monopoly power. As a result, profits and price increase. While the firm's sales also increase, aggregate sales remain unchanged, by construction.

Note that the above description assumes that the multinational's monopoly price is low enough such that all customers are served. However, if we consider the possibility that consumers have a reservation utility, u^*, then a purchase will only be made if $u^* > p_a + mx$. If price were already high enough that some customers were not served by any firm, then the extent of IPR would be irrelevant for the firm's pricing decisions, as it would already effectively have an effective monopoly over the relevant range. In this case, increasing IPR does not affect the multinational, but decreases the overall level of output, due to the further crowding out of the competitive fringe.

Entry through licensing versus affiliate

We model the licensing process to an unrelated party transaction as essentially the sale of the right to the product space, [0,s], that the multinational enjoys in the previously described model of spatial competition. If this is the case, then the profit earned by the licensee may be calculated in exactly the same manner as above, with the total level of profits dependent upon s, as well as the firm's marginal cost of production. Once we add in the cost of transferring technology, which we expect to differ between arm's length and internal transfers, and the probability of no-license payment, we generate two obvious conditions on the subsidiary versus licensing choice:

$$(6) \quad (1-q(s))L - t_l > \pi(s,c_a) - t_a$$

$$(7) \quad \pi(s,c_l) - q(s)L > 0$$

Equation (7) reflects the domestic firm's participation constraint, while (6) represents the multinational's trade-off between licensing and direct investment. Once again, it is straightforward that the choice is dependent on the level of s, and in particular, how this affects the probability of expropriation, $q(s)$, as s increases. Furthermore, to the extent that domestic or foreign firms are more effective in serving a particular market, this will manifest itself in the form of differential values of c_L versus c_f. Overall, it will not be possible to sign the licensing-affiliate choice as a function of s, as this will depend on transfer and production costs, as well as the shape of $q(s)$.

Working back to the final stage, it is again straightforward that, since both π_l and π_a will increase with s, technology transfers will increase with stronger property rights enforcement; as a result, profits are pushed toward the threshold at which they offset transfer costs.

We may now summarize the characteristics of our model that will be relevant for the empirical estimation below:

1. An increase in IPR leads to an increase in technology transfers by multinationals
2. The extent to which these transfers take place through licensing to third parties relative to affiliates will depend on the relative expertise of the multinational relative to domestic producers (c_a versus c_l), the relative costs of transferring technology (t_a versus t_l), and the shape of the 'expropriation function', $q(s)$.
3. IPR improvements will increase firm profitability, output, and price.

Section 4. Data Sources

Data from BEA Surveys

Responses to various surveys conducted by the U.S. Bureau of Economic Analysis (BEA) are the source of firm level panel data covering the value of transfers of intangibles from the U.S. to other countries and the operating and financial characteristics of U.S. firms operating abroad. The International Investment and Trade in Services Survey Act governs the collection of these data and the Act ensures that "use of an individual company's data for tax, investigative, or regulatory purposes is prohibited." Willful noncompliance with the Act can result in penalties of up to $10,000 or a prison term of one year. As a result of these assurances and penalties, BEA believes that coverage is close to complete and levels of accuracy are high.

Data on U.S. multinational firms comes from the annual Survey of U.S. Direct Investment Abroad and the quarterly Balance of Payments Survey. U.S. direct investment abroad is defined as the direct or indirect ownership or control by a single U.S. legal entity of at least ten percent of the voting securities of an incorporated foreign

business enterprise or the equivalent interest in an unincorporated foreign business enterprise. A U.S. multinational entity is the combination of a single U.S. legal entity that has made the direct investment, called the U.S. parent, and at least one foreign business enterprise, called the foreign affiliate. In order to be considered as a legitimate foreign affiliate, the foreign business enterprise should be paying foreign income taxes, have a substantial physical presence abroad, have separate financial records, and should take title to the goods it sells and receive revenue from the sale.

The foreign affiliate survey forms that U.S. multinational firms are required to complete vary depending on the year, the size of the affiliate, and the U.S. parent's percentage of ownership of the affiliate. The most extensive annual data are available for 1982, 1989, 1994, and 1999 when BEA conducted Benchmark Surveys. In the first three of these years, all affiliates with sales, assets, or net income in excess of $3 million in absolute value and their parents were required to file extensive reports, and in 1999 the threshold was increased to $7 million. In non-benchmark years between 1982 and 1999, exemption levels were higher and less information is collected.[14]

The survey forms concerning MNE activity capture information not only on capital stock, output, R&D, and trade, but also on the value of intangible property transferred from parent companies to affiliates.[15] American tax law requires that foreign

[14] From 1983-1988, all affiliates with an absolute value of sales, assets, or net income less than $10 million were exempt, and this cutoff increased to $15 million from 1990-1993 and $20 million from 1995-1999. BEA uses reported data to estimate universe totals when surveys cover only larger affiliates or when only certain affiliates provide information on particular survey forms. Estimated data is unlikely to have a significant impact on the BEA's published data at the industry or country level as data based on actual reports exceeds 90 percent of the estimated totals of assets and sales in each of the years between 1982 and 1999. To avoid working with estimated data, only affiliates required to provide all the information associated with a particular analysis are considered.

[15] The figures on licensing of "intangible property" include an amalgam of technology licensing fees, franchise fees, fees for the use of trademarks, etc. However, in nearly all industries, the aggregate data suggest that licensing data are *overwhelmingly* dominated by technology licensing. In all industries except

affiliates pay royalties to their parent firms for the fair market value of the technologies and other intangibles transferred from the parent firm. The quarterly Balance of Payment Survey requires firms to report these transfer payments. It is difficult to establish the market value of intangibles that are transferred within a firm since these goods do not have a market price. In addition, depending on the particular circumstances, firms may have an incentive to misrepresent the value of a technology transfer to avoid taxes. Although governments are aware of these incentives and try to use their enforcement powers to ensure that royalties do not deviate from reasonable values, Hines (1995) and Grubert (1998) do find evidence of tax effects on reporting. Fortunately, these papers indicate variables that can be used to control for the effects of tax incentives on reported intrafirm royalties. BEA also collects data on royalty payments made by arm's length foreigners to U.S. firms on the Annual Survey of Royalties, License Fees, and Other Receipts and Payments for Intangible Rights Between U.S. and Unaffiliated Foreign Persons. A sample covering 1987 forward is drawn from the results of this survey. Since these payments are between unrelated parties, they are not subject to concerns about manipulation for tax purposes. A large fraction of firms that file responses in this survey are also multinational firms that respond to the Survey of U.S. Direct Investment Abroad, thus providing firm level coverage of technology transfers to both affiliated and unaffiliated parties in individual countries through time.

Table I displays descriptive statistics for the benchmark years on 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

food manufacturing, technology licensing accounts for between 80% and 99% of total "intangible" royalty payments from affiliates to parents. Even in food manufacturing, technology licensing accounts for more than 50% of the total.

1,000 parent companies. These affiliates are substantial operations. In 1999, the mean affiliate employed 548 workers, had sales of $110 million, and reported a return on assets of 3.56%. Mean intrafirm royalty payments increase substantially over the period from $182 thousand in 1982 to $1.1 million in 1999.

There is no information on the arm's length royalty payments received by U.S. firms in 1982 since the collection of these data did not begin until 1986. In 1989, 1994, and 1999, about 1,000 U.S. firms reported the receipt of royalty payments from unaffiliated foreigners in the countries undergoing reforms. The mean value of these flows in 1999 was $2.5 million. The bottom panel of Table I provides descriptive statistics on other variables that are used in the regression analysis that follows.

Data from Other Sources

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 firm R&D expenditures in years in which this item was not captured in BEA surveys, the BEA data on publicly traded parent firms is linked to COMPUSTAT using parent firm employee identification numbers. Parent firm data is also linked to data on patenting activity captured in the NBER patent citation database.[16] 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 with large portfolios of patents prior to the reforms.

[16] This comprehensive data set on U.S. patents is documented in Hall et. al. (2001). Linking these data to BEA data requires the use of a mapping between the assignee codes used by the U.S. PTO to identify patent applicants and the CUSIP identifier codes used by the COMPUSTAT database created for all firms in the 1989 COMPUSTAT data.

Data on flows of licensing payments for technology tell us little about the nature and sophistication of technology being transferred. For more information on these factors, we turn to data on patent filings in the countries that underwent patent reform. Data on patent applications, broken down by nationality of applicant (foreign vs. domestic) but aggregated across technology classes, are available from the WIPO. If patents provide little or no protection in a country, there is little incentive to patent. If multinationals respond to an IPR reform that substantially strengthens patent rights by increasing the *volume* of technology being transferred (rather than merely increasing the *price* of technology that has already been introduced to the market in question), then this may be reflected in an increase in both the level and the growth rate of total patent applications by foreign entities. In this paper, we track trends in domestic and foreign patent applications over the 1980-1999 period – and find evidence of a pronounced increase in patenting by foreign applicants in the wake of reform.

Finally, information on the timing and content of IPR regime changes come from a number of sources including Maskus (2000), Uphoff (1990), and Sakakibara and Branstetter (2001). Table II displays the list of patent reforms considered in the analysis that follows. 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. Other examples include the introduction of intellectual property protection for semiconductor chip designs and plant varieties and steps to establish or strengthen laws governing "trade secrets." In future

research, we plan to expand our coverage of IPR regime changes to include these and other reforms.[17]

Section 5. Empirical Approach

The preceding theoretical section, as well as 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 shifts. This prediction is examined with regressions of the following form:

$$(8) \quad Transfer_{ilt} = \alpha_0 + \alpha_{il} + \alpha_t + \beta_0 y_{jt} + \beta_1 P_{it} + \beta_2 H_{jt} + \beta_3 A_{ilt} + \beta_4 R_{jt} + \beta_5 R_{jt} * Pat_{il} + \varepsilon_{ilt}$$

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 volume of intrafirm royalty payments for intangible assets – our proxy for technology transfer. The key variable of interest is R_{jt}, the post reform dummy variable, equal to one in the year of patent reform (and subsequent years) in country j. The specification includes time-invariant fixed effects for the affiliate (α_{il}), year fixed effects for the entire sample (α_t), and country-specific time trends in royalty payments.[18] P_{it} is a vector of time-varying characteristics of the parent firm, including measures of size and R&D investment. These variables control for the natural tendency for technology transfers from this parent to change as these state variables change over time. H_{jt} is a set of time-varying characteristics of the host country, including measures of GDP per capita, an indicator of whether the host

[17] An additional complication is that some countries undertook a series of patent reforms in different years. Our current analysis focuses on the particular change to the patent system judged most likely to impact technology licensing by foreign firms, but we plan to expand our focus to look at the separate impact of the entire sequence of reforms.

[18] To be precise, we include dummy variables for each affiliate-parent pair. Some affiliates are sold to other multinationals over our sample period. When an affiliate is acquired by a new parent, we effectively treat it as a different firm. This treatment of the data precludes the need for separate parent firm fixed effects.

country imposes restrictions on inward FDI, the withholding tax rate charged on royalty payments by the host country, and the difference between the host country corporate income tax rate and the U.S. corporate income tax rate.[19] Finally, A_{ilt} is a vector of time-varying characteristics of individual affiliates, including measures of affiliate size.[20]

The increase in the value of technology flows from parent firms to affiliates should 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 size of the patent portfolio of the affiliate's parent prior to the reform. Those affiliates whose parents have above the median number of cumulative patent applications in the years immediately preceding IPR reform are assigned a patent portfolio 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.

To shed further light on how affiliates respond to changes in IPR regimes, regressions analyzing affiliate R&D are run on a similar set of controls and the post IPR reform dummy. These specifications take the form:

$$(9) \qquad R\&D_{ilt} = \alpha_0 + \alpha_{il} + \alpha_t + \beta_0 y_{jt} + \beta_1 P_{it} + \beta_2 H_{jt} + \beta_3 A_{ilt} + \beta_4 R_{jt} + \beta_5 R_{jt} * Pat_{il} + \varepsilon_{ilt}$$

[19] Measures of international economic activity generally find that "distance" is an important factor in explaining the distribution of trade and investment across countries, but geographic distance between the United States and each host country will be absorbed into the host country dummy variable. Inclusion of variables on tax rates would enable us to control, at least in part, for the potential impact of "transfer pricing" on our measures of technology transfer.

[20] We recognize that some of the regressors are potentially endogenous, but our aim here is not to estimate "structural coefficients" but rather to obtain a general sense of how measures of affiliate performance are conditionally correlated with IPR reform. As we noted earlier, our simple model implies that affiliate profitability will be positively correlated with the additional technology transfers induced by IPR reform – we want to see if these predictions are broadly consistent with the data.

Affiliate R&D spending has traditionally been focused on modification of the parent firm's technology to meet local market conditions. Affiliate R&D is thus a *complement* to technology imports from the parent. If IPR reform stimulates an increase in the deployment of new technology from the parent to its affiliates in IPR-reforming countries, then one might expect to see an increase in affiliate R&D spending in the aftermath of that reform. Evidence of an increase in affiliate R&D spending could be useful in distinguishing between a real increase in deployment of new technology and a simple increase in the price multinationals charge for the use of technology already deployed.

Our model also predicts a potential increase in arm's length licensing, particularly if the function q(s) is sensitive to the strength of the IPR regime, s. Equation (8) above can be slightly altered to study these flows:

$$(10) \quad License_{ijt} = \alpha_0 + \alpha_{ij} + \beta_0 y_{jt} + \beta_1 H_{jt} + \beta_2 P_{it} + \beta_4 R_{jt} + \varepsilon_{ijt}$$

Here, the dependent variable measures royalty payments received by parent firms from unaffiliated parties. Unfortunately, BEA surveys do not record detailed information on the characteristics of licensee firms, but we do have detailed information on the characteristics of the licensor parents.

Finally, international patent data is used to examine the response of both domestic and foreign inventors to changes in IPR regimes. Here, specifications take the form:

$$(11) \quad Patent_{jt} = \alpha_0 + \alpha_j + \alpha_t + \beta_0 y_{jt} + \beta_1 H_{jt} + \beta_2 R_{jt} + \beta_3 R_{jt} * y_t + \varepsilon_{jt}$$

We estimate (11) separately for domestic and foreign patenting in the countries that underwent IPR reform. Patent applications in year *t* are a function of country and (calendar) time fixed effects and host country characteristics. We allow patent reform to

affect not only the level of patenting, but also its growth rate over time – note the interaction term with the reform dummy and the time trend.

Section 6: Results

Technology Transfer to Affiliates

To give the reader a general sense of trends in the data, Figures 1-2 trace out changes in licensing and patenting measures. Figure1 traces out the movement of the licensing/sales ratio in the period before and after IPR reform. Here, averages across the entire pre-reform and post-reform period are taken for all affiliates in countries that eventually undergo IPR reform. These are simple unconditional averages, but they do suggest broad trends in the data consistent with the view that IPR reform has affected U.S. multinational behavior.

Figure 2 presents a first look at how, on average, patent filings by foreigners and domestic residents change after IPR reform. Here, we present ratios of patent filings relative to the level recorded in the year immediately preceding patent reform for both residents and nonresidents. This figure suggests that, relative to the pre-reform period, patenting grows for nonresidents after reform – while, on average, patenting by domestic residents is flat. This pattern is broadly consistent with the findings of Lerner (2001, 2002). It also suggests that at least one component of the observed increase in licensing payments may be connected to an increase in the volume of technology transferred.

Of course, it is necessary to move beyond these simple data plots to estimation of regressions that control for other factors influencing technology transfer and affiliate performance. Results of regression analysis of royalty payments made by affiliates to their parents based on specification (8) are reported in Table III. Columns (1)-(3) report

the impact of IPR reform on log levels of recorded licensing payments to the parent firm. As can be directly seen, in all specifications, IPR reform increases measured technology transfer, and this impact is substantially stronger for affiliates of more patent-intensive parents. If one takes the regression coefficients at face value, they imply that affiliates of patent-intensive parents experience a roughly 24%-28% increase in annual levels of technology transfer after IPR reform. Cumulated over several years, the coefficients imply a substantial change in technology deployment.

As additional regressors, all specifications in the table include the difference between the corporate income tax in the host country and the U.S., the host country withholding tax rate, an indicator of host country FDI restrictions, measures of host country openness to trade, and the log of host country GDP per capita. The specification in column (3) also includes the log of affiliate sales, the log of parent R&D expenditures and the log of parent system sales. The first of these is meant to control for the naturally expanding "technology demand" of an affiliate as it grows, while the second two variables are meant to control for the natural tendency of potential "technology supply" for a parent to increase as it invests in R&D and grows in size. As already noted, we recognize the potential endogeneity of these control variables.[21] The interaction term of the reform dummy with the patent-intensive parent dummy remains positive and significant here.[22]

Affiliate R&D Spending

[21] However, we also note that the coefficients on the reform dummy do not qualitatively change regardless of whether we incorporate these potentially endogenous controls or not.

[22] As a robustness check, the licensing/sales ratio was used as the dependent variable in a set of regression specifications that paralleled columns (1)-(3). The impact of IPR reform on licensing remains positive and statistically significant in these alternative specifications.

Increased royalty payments after reform are consistent with parents supplying more technology to their affiliates after reform, but this could also be consistent with parents charging higher prices for the same level of technology provision. In an attempt to distinguish between these two views, we present results on the impact of IPR reform on affiliate R&D activity in Table IV. The structure of the columns in this table and the set of control variables employed are parallel to that of Table III. As columns (1)-(3) demonstrate, the impact of IPR reform on the level of affiliate R&D spending is positive and statistically significant for the affiliates of patent-intensive parents. The results of column 3, for instance, suggest that IPR reform leads to a 28% increase in affiliate R&D spending. Because R&D represents a cost born by the parent system, the coincidence of the measured increase in R&D spending with the measured increase in licensing payments suggests that at least some component of the latter represents a real increase in the deployment of new technology to affiliates.[23]

Arm's length licensing

U.S. firms not only receive royalty payments for the sale or use of intangibles from their affiliates but also from unaffiliated foreigners. Table V displays results of tests of how these types of royalty payments respond to changes in IPR regimes. As is apparent from this table, the only subset of multinationals for which IPR regime change has a measurably positive impact are multinationals which lack affiliates in the reforming countries prior to reform. These results are highlighted in column (3) of Table V. Taken

[23] Alternative specifications were run with R&D spending scaled by affiliate sales. In these regressions, IPR reform had a positive, statistically significant impact on R&D spending.

together, the evidence of an impact of IPR regime change on licensing to unaffiliated parties is considerably weaker and less robust than for intra-firm technology transfer.[24]

This is consistent with the predictions of our model, provided it is less expensive to transfer technology within firms rather than across firm boundaries. To the extent to that indigenous enterprises lack either the technical skill or access to the capital necessary to fully exploit U.S. multinational parent firm technology, it may make economic sense to deploy technology through foreign affiliates. The inability of foreign legal regimes to perfectly enforce complicated contracts may influence the shape of the "expropriation function" in a way that favors deployment within affiliates.

Resident versus Non-Resident Patenting

Table VI shifts the focus from royalty payments and measures of R&D spending recorded by the BEA to counts of patent filings recorded by the World Intellectual Property Organization (WIPO). The analysis measures the impact of IPR reform, if any, on patent filings by both domestic and foreign innovators. The unit of observation here is aggregate patent filings in a country in a given year by nationality of the applicant. The log of the count of patent filings is regressed on the post reform dummy, an interaction term between the post reform dummy and an overall time trend, the host country withholding tax rate, an indicator of the presence of host country restrictions on inward FDI, country and year fixed effects, country specific time trends, and some additional controls. Columns (1)-(4) present specifications explaining the log of resident patent filings. In column (1), the post reform dummy is indistinguishable from zero, indicating that resident patent filings do not increase after reforms occur. Column (2) includes two

[24] Other specifications not shown in table found no differential response of patent-intensive parents in terms of licensing to unaffiliated parties.

additional controls: the log of host country GDP per capita and the log of host country net inward FDI. The post reform dummy remains insignificant. As the results in the next two columns show, the post reform dummy interacted with a time trend is also insignificant, indicating that resident patent filings also do not increase through time after reforms when one controls for overall time trends in each country. These findings are consistent with Lerner (2002).

Columns (5)-(8) present similar specifications for non-resident patent filings. There is robust evidence that these filings experience large increases and that these filings grow at an increased rate after reforms. The coefficient on the post reform dummy in columns (5) and (6) imply 35% increases in non-resident filings, and the positive and statistically significant coefficient on the post reform dummy interacted with the time trend points out the increased growth in the level of non-resident filings after reforms.

These findings provide us with additional evidence that MNEs increase the quantity of technology transferred after IPR reform. In the absence of a truly international patent system, firms have to seek patent grants in each country in which they operate. Obtaining these patent grants is not costless. One could view obtaining a patent grant as equivalent to purchasing an option to deploy a particular technology with local legal protection. A foreign multinational has little incentive to go through the time and trouble of preparing and filing patent applications in a jurisdiction where patent rights are weak.[25] When IPR reform occurs and patent laws are strengthened, the multinational may have the incentive to file patents for all of the technologies currently employed in the jurisdiction. This would imply a temporary increase in foreign patent

[25] Interviews with multinational managers confirmed the historically selective nature of U.S. firms' foreign patenting.

filing that would eventually fall off as firms completed protecting the portfolio of technologies currently being used in the country in question.[26]

However, multinationals may be induced by the patent regime changes to transfer into the jurisdiction new technologies not previously used there. The argument made by advocates of strong global IPR is precisely this – that higher levels of protection will induce additional technology transfer. If this actually happens, then one would expect to see not only a one-time shift in the level of patent filings, but also increased growth in foreign patenting over time in the reformed jurisdictions after reforms. As multinationals generated useful new "frontier" technology, they would be expected to exploit some of these inventions in the reformed jurisdictions. The results in Table VI are consistent with the latter story. The level of patent filings increases in the years after reform, but the rate of growth also shifts up.

Section 7: Preliminary Conclusions and Next Steps

U.S. multinationals respond to changes in IPR regimes abroad. In the wake of legal reforms that strengthen patent rights, intrafirm royalty payments received by U.S. parents with large patent portfolios from their overseas affiliates increase substantially, even controlling for increases in the sales of U.S. affiliates. These findings are, of course, consistent with either an increase in the volume of technology being transferred or an increase in the degree to which U.S. multinationals are able to extract higher levels of rent from technologies that have already been deployed in these countries. However,

[26] Most countries require inventors to seek local patent protection for their inventions within one year of filing a patent in any country – otherwise, the inventor forfeits the possibility of patent protection in that country. In theory, firms could circumvent this restriction by slightly altering the technical contents of their patent applications, effectively presenting applications for "old" technology as if it were new. Conversations with multinational IPR managers suggested that, while this sometimes happens, it is difficult to do this in practice when the local patent system is competently and professionally managed.

subsidiary evidence on affiliate R&D spending and foreign patenting in the reforming countries considerably strengthens the interpretation that at least a component of the measured increase in technology licensing reflects a "real" increase in the deployment of new technology to foreign affiliates in IPR-reforming countries.

There are several directions in which this research project could be extended. One promising direction would be to use patent data broken down by narrowly defined technology class and the nationality of the inventor. In the absence of strong IPR protection, multinationals may limit the deployment of certain critical technologies – typically, more advanced technologies -- for fear that they will be imitated by local rivals. The existence of stronger IPR could induce multinationals to deploy these technologies because they now have a legal remedy against imitation. Using highly disaggregated data international patenting available from the European Patent Office, we can actually track the filing of patent applications in sensitive, highly advanced technological areas. While data on royalty payments provide us, at least in principle, with measures of the economic value of technology deployed by affiliates, highly disaggregated patent data allow us, in principle, to track the technological content of the underlying technology flows.

While our results to date seem to establish that IPR reform leads to an increase in intrafirm technology transfer on average, it would be of interest to investigate how this impact varies depending on the characteristics of the host country, the characteristics of the parent firms, and the characteristics of individual IPR regime changes. What countries benefit most from IPR regime changes? What kinds of firms respond most strongly to IPR regime changes? What aspects of a country's IPR system seem to be most closely associated with post-reform increases in technology transfer and

investment? Given the detailed, disaggregated data at our disposal, these are all questions we may be able to answer.

Finally, having taken an essentially descriptive approach in the present paper, we intend to move forward in a manner that is more explicitly linked to and guided by theoretical work. The international economics literature has established that changes in the IPR environment will affect the trade-off between licensing, local production, and exports. While this paper has focused primarily on the impact of IPR reform on technology licensing, both to affiliates and unaffiliated parties, it is important to place this effect within the larger context of the firm's overall strategy for seeking to maximize profits in a given country. The next step in our research agenda will be to embed our study of the impact of IPR regime changes within a larger model in which the level of investment in a country and exports from production facilities located outside the country are also endogenously determined. The imposition of more structure, along these lines, holds out the promise of enabling us to come to more definitive conclusions about the global welfare impact of recent changes in IPR systems. Recent contributions to the theory of the multinational firm provide us with a useful foundation on which to build.[27]

[27] See Markusen (2000) and, for a treatment that combines empirics and theory, Carr, Markusen, and Maskus (2001).

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Figure 1 Aggregate Royalty Payments/Aggregate Sales

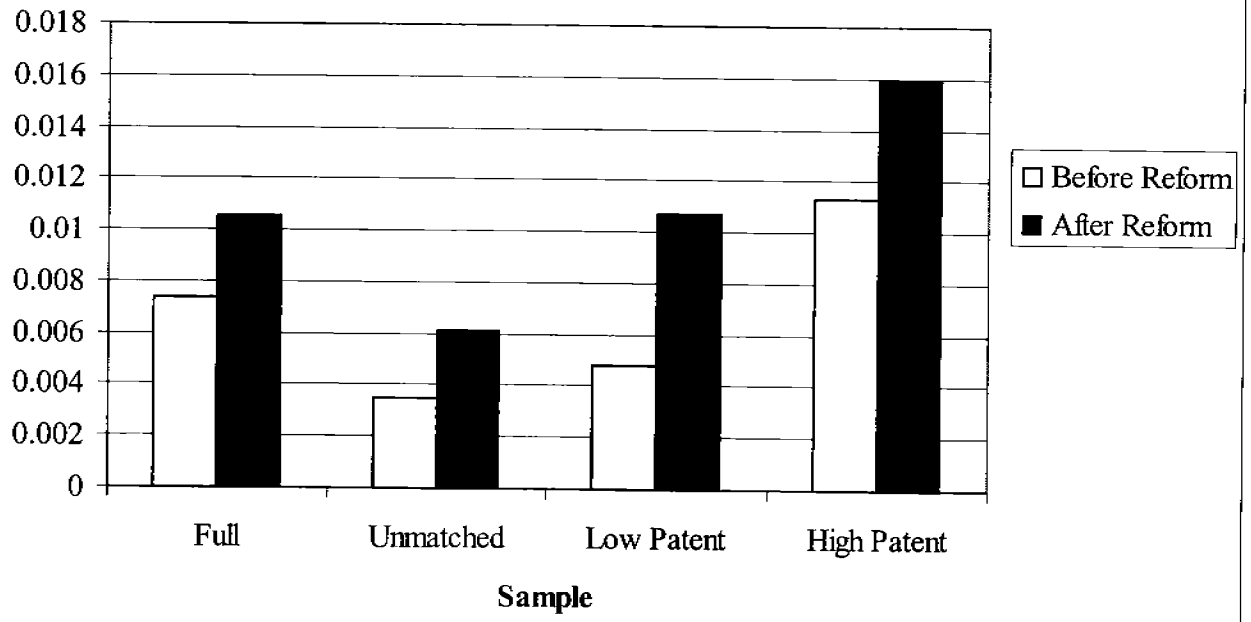

Figure 2 Trends in Patenting

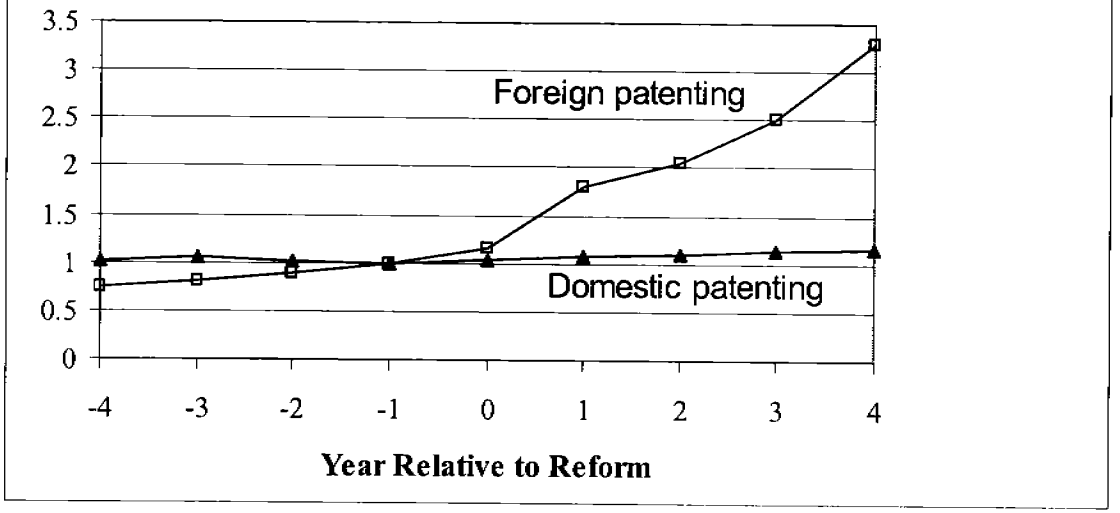

Table I

Descriptive Statistics for U.S. Multinational Activity in Reforming Countries

	Benchmark Years			
	1982	1989	1994	1999
Number of Affiliates	3,275	3,524	4,235	5,026
Number of Parents	803	875	1,069	1,090
Employment				
Mean	542	561	525	548
Standard Deviation	1,489	1,936	2,057	2,059
Sales				
Mean	63,383	87,034	98,460	110,777
Standard Deviation	328,242	497,225	555,079	491,625
Costs				
Mean	62,002	84,126	95,982	111,385
Standard Deviation	321,861	489,993	546,561	484,555
Return on Assets				
Mean	0.0116	0.0633	0.0327	0.0356
Standard Deviation	0.2153	0.1686	0.1836	0.1721
Intrafirm Royalty Payments				
Mean	182	631	1,036	1,087
Standard Deviation	2,567	14,986	16,092	15,938
Arms Length Royalty Payments				
Number of Payments Reported		899	1,015	1,348
Number of Firms Reporting Payments		355	396	457
Mean	na	1,341	2,083	2,552
Standard Deviation	na	7,861	13,008	21,405

Descriptive Statistics for all Affiliate Years

	Mean	Median	St. Dev
Difference of Host Country Tax Rate and US Tax Rate	-0.0268	-0.0428	0.1328
Log of Host Country GDP per Capita	9.0343	8.9336	0.7038
Log of Parent R&D Expenditures	9.8489	11.1512	4.5269
Log of Parent System Sales	15.6057	15.6603	1.7822
Number of Non-Resident Patent Filings	22,144	6,636	30,793
Number of Resident Patent Filings	35,991	951	95,759
Log of Host Country FDI	21.2053	21.2971	1.7117

Table II

Timing of Major Patent Reforms

Country	Year of Reform	Number of Affiliates in BEA database	
		1982	*1999*
Argentina	1996	206	388
Brazil	1997	601	596
China	1993	11	522
Indonesia	1991	143	169
Japan	1995	704	928
South Korea	1987	93	241
Mexico	1991	702	927
The Philippines	1997	186	163
Spain	1986	362	569
Taiwan	1993	118	235
Thailand	1992	87	225
Turkey	1995	27	116

Table III

Intrafirm Royalty Payments, Patent Portfolios, and IPR Regime Changes

Dependent Variable:	Log of Intrafirm Royalty Payments		
	(1)	(2)	(3)
Constant	21.9439	22.1481	62.5752
	(30.2516)	(30.2057)	(31.7866)
Post Reform Dummy	0.1561	0.0199	0.0247
	(0.0563)	(0.0647)	(0.0664)
Post Reform Dummy * High Patent Portfolio Dummy		0.2657	0.2130
		(0.0715)	(0.0732)
Difference of Host Country Tax Rate and US Tax Rate	-0.2055	-0.2144	-0.2924
	(0.3681)	(0.3675)	(0.3782)
Host Country Withholding Tax Rate	0.1157	0.1078	0.0699
	(0.4956)	(0.4950)	(0.5198)
Host Country Inward FDI Restrictions	-0.1074	-0.1108	-0.1038
	(0.1104)	(0.1103)	(0.1103)
Host Country Trade Openness	0.0050	0.0050	0.0038
	(0.0032)	(0.0031)	(0.0032)
Log of Host Country GDP per Capita	1.1060	1.1045	1.0772
	(0.2762)	(0.2758)	(0.2854)
Log of Affiliate Sales			0.0993
			(0.0130)
Log of Parent R&D Expenditures			0.0138
			(0.0103)
Log of Parent System Sales			0.3244
			(0.0678)
Affiliate and Year Fixed Effects?	Y	Y	Y
Country Specific Time Trends?	Y	Y	Y
No. of Obs.	16,998	16,998	16,418
R-Squared	0.7258	0.7261	0.7289

Table IV

Affiliate R&D Expenses, Patent Portfolios, and IPR Regime Changes

Dependent Variable:	Log of R&D Expenses		
	(1)	(2)	(3)
Constant	90.6370	92.9742	104.2398
	(51.8631)	(51.6872)	(52.9545)
Post Reform Dummy	0.1591	-0.0144	-0.0099
	(0.0836)	(0.0946)	(0.0949)
Post Reform Dummy * High Patent Portfolio Dummy		0.3353	0.2775
		(0.1020)	(0.1026)
Difference of Host Country Tax Rate and US Tax Rate	-0.1110	-0.1515	-0.2776
	(0.6088)	(0.6082)	(0.6097)
Log of Affiliate Sales			0.1472
			(0.0184)
Log of Parent R&D Expenditures			0.0285
			(0.0150)
Log of Parent System Sales			0.0779
			(0.1061)
Affiliate and Year Fixed Effects?	Y	Y	Y
Country Specific Time Trends?	Y	Y	Y
No. of Obs.	9,688	9,688	9,623
R-Squared	0.6957	0.6961	0.6983

Table V

Arm's Length Royalty Payments and IPR Regime Changes

Dependent Variable:	Arm's Length Technology Licensing		
	Full Sample	Have Affiliate	No Affiliate
	(1)	(2)	(3)
Constant	13.7093	97.0149	11.8042
	(25.7812)	(99.3360)	(31.4634)
Post Reform Dummy	0.0454	0.0904	0.0592
	(0.0261)	(0.1028)	(0.0292)
Difference of Host Country Tax Rate and US Tax Rate	-0.0389	-0.6281	0.1346
	(0.1670)	(0.6535)	(0.1978)
Host Country Withholding Tax Rate	-1.0048	-1.9413	-0.7489
	(0.5452)	(1.9997)	(0.6592)
Host Country Inward FDI Restrictions	-0.1451	-0.1782	-0.1405
	(0.0758)	(0.2386)	(0.0911)
Host Country Trade Openness	-0.0004	0.0056	-0.0019
	(0.0028)	(0.0134)	(0.0034)
Log of Host Country GDP per Capita	0.4540	0.5724	0.5373
	(0.2009)	(0.6856)	(0.2385)
Parent/Country and Year Fixed Effects?	Y	Y	Y
Country Specific Time Trend?	Y	Y	Y
No. of Obs.	46,460	4,871	28,914
R-Squared	0.7643	0.7642	0.7481

Table VI

Host Country Patenting Activity and IPR Regime Changes

Dependent Variable:	Log of Resident Patent Filings				Log of Non-Resident Patent Filiings			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	7.0197	20.7387	6.6135	19.7757	7.8368	-8.1660	6.8564	-4.1342
	(0.6487)	(10.2948)	(0.7204)	(9.7460)	(0.4270)	(6.8139)	(0.5344)	(6.4278)
Post Reform Dummy	0.0183	0.0800	0.0792	0.1605	0.3841	0.4257	0.5435	0.5881
	(0.2114)	(0.2203)	(0.2063)	(0.2163)	(0.1352)	(0.1329)	(0.1295)	(0.1255)
Post Reform Dummy * Time Trend			0.1065	0.1269			0.2706	0.2488
			(0.0962)	(0.1012)			(0.0690)	(0.0679)
Log of Host Country GDP per Capita		-1.3475		-1.6205		1.7457		1.1949
		(1.1136)		(1.1458)		(0.7324)		(0.6941)
Host Country Withholding Tax Rate	-0.2781	0.1048	0.5517	1.1393	1.0122	0.6577	3.1513	2.7043
	(1.4100)	(1.3565)	(1.4292)	(1.4784)	(0.8211)	(0.7593)	(0.9240)	(0.9864)
Host Country Inward FDI Restrictions	0.7600	0.8600	0.7804	0.9036	0.0231	-0.2307	0.0742	-0.1413
	(0.5375)	(0.5554)	(0.5331)	(0.5474)	(0.2130)	(0.1541)	(0.2233)	(0.1651)
Host Country Trade Openness	0.0036	0.0083	0.0080	0.0144	0.0214	0.0243	0.0307	0.0361
	(0.0153)	(0.0161)	(0.0160)	(0.0170)	(0.0120)	(0.0076)	(0.0126)	(0.0082)
Log of Host Country FDI		-0.0588		-0.0566		-0.0222		-0.0176
		(0.0565)		(0.0549)		(0.0404)		(0.0368)
Country and Year Fixed Effects?	Y	Y	Y	Y	Y	Y	Y	Y
Country Specific Time Trends?	Y	Y	Y	Y	Y	Y	Y	Y
No. of Obs.	160	157	160	157	163	158	163	158
R-Squared	0.9545	0.9511	0.9548	0.9516	0.9618	0.9715	0.9672	0.9759