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

Lee G. Branstetter
Columbia Business School and NBER

Raymond Fisman
Columbia Business School and NBER

C. Fritz Foley
University of Michigan

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Abstract

This paper examines the response of U.S. multinational firms to a series of multilateral reforms of intellectual property rights regimes undertaken by 12 countries over the 1982-1999 period. The results indicate that the IPR regime changes result in 8.5 percent increases in royalty payment flows to parent firms on average and in 22.8 percent increases for firms that hold more patents than the median firm prior to the reforms. The sample of affiliates of parent companies that have a large number of U.S. patents before reforms also experience larger increases in employment, sales, and profitability than other firms around the time of policy changes. Since there is no evidence of an increase in royalties paid by unaffiliated foreigners, multinationals seem to respond to the IPR regime changes by exploiting their technologies inside the firm. An examination of data on international patent filings suggests that some component of the increased royalty flows represents the transfer of new technologies to the host country and that the increased flows do not merely reflect an increase in the price of the flows or greater rent extraction. These findings have crucial implications for the welfare impact of recent moves to strengthen intellectual property rights in developing countries, including, notably, the TRIPs agreement.

Lee G. Branstetter
Columbia Business School and NBER
Uris 815
3022 Broadway
New York, NY 10027
TEL 212-854-2722
lgb2001@columbia.edu

Raymond Fisman
Columbia Business School and NBER
Uris 815
3022 Broadway
New York, NY 10027
TEL
rf250@columbia.edu

Fritz Foley
University of Michigan
Graduate School of Business
701 Tappan St.
Ann Arbor, MI 48109
TEL (734) 763-1436
ffoley@umich.edu

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 large 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 decision to offer further protections to intellectual property 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.

In spite of the practical and theoretical importance of this issue, the international impact of IPR remains an understudied area within international economics. One barrier to empirical work has been the difficulties in measuring the level of intellectual property rights across countries. Another feature of the existing empirical work is the tendency to work with aggregate trade and investment flows (or data broken down into aggregated industry clusters), even when it is known that there are important differences in the

[2] Implementation of the terms of this agreement is ongoing. Some developing countries have until 2006 to fully comply.

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

impact of IPR and changes in IPR across and within industries.[4] Recent attempts to simulate the likely impact of TRIPs on global welfare have rested on largely untested assumptions about the responsiveness of either domestic innovation or international technology transfer to patent strengthening abroad.[5]

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 diplomatic pressure from the United States or other major trading partners.[6] Analysis of firm-level data from the Bureau of Economic Analysis's survey of U.S. multinational activity reveals robust evidence of an increase in royalty payments for the use or sale of intangible assets from affiliates to parent firms in the wake of strengthened IPR regimes. Furthermore, this increase is concentrated among the affiliates of firms that have larger patent portfolios before the reforms occur. In contrast, there is no evidence of an increase in technology licensing to unaffiliated parties. There is also evidence that the affiliates of firms that have large patent portfolios experience larger increases in employment, sales, and profitability than other firms around the time of reforms. These findings suggest that a component of the increased licensing flows probably stems from the increased ability of multinationals to extract rent from customers in the wake of these reforms. Examination of international trends in patent applications indicates that at least one component of the observable

[4] Keith Maskus, one of the pioneers in the literature on the international economic impact of IPR, has summarized much of the recent literature in his book, *Intellectual Property Rights in the Global Economy*.
[5] See, for instance, McCalman (2001).
[6] For an account of the diplomacy behind these changes, see Ryan (1998) and Uphoff (1990).

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. Thus, our results may be tentatively interpreted as being consistent with an increase in both real flows of technology and greater rent extraction by multinationals.

The rest of this paper will be organized as follows. Section 2 reviews the prior literature on the impact of IPR on technological innovation, technology transfer, and international economic activity. Section 3 presents a model that guides subsequent empirical analysis. Section 4 describes the data, Section 5 explains the empirical approach, and Section 6 provides the results. Section 7 concludes.

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 world on global welfare, and studies of the responsiveness of international economic activity (such as trade or FDI) to IPR.[7]

One stream of research in industrial organization 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

[7] 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.

(2000); Sakakibara and Branstetter (2001)). One strength of this literature is that empirical work is generally informed by the rich theoretical literature in IO on patent design.[8] However, the typical study focuses on a detailed empirical analysis of a single patent regime change, leading to concerns about whether the results can be generalized beyond their immediate context. Nevertheless, a large number of these studies find that a strengthening of IPR results in little or no measured increase in domestic innovation.[9]

Lerner (2001, 2002) avoids criticisms related to generality 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 do respond to these changes by increasing their patenting after reform. This paper does not consider the effects of reforms on technology transfer, *per se*.

A second stream of research has sought to examine the welfare implications of patent reform in developing countries. Theoretical work by Helpman (1993) and Grossman and Lai (2002) predict that harmonization of IPR standards reduces welfare in developing countries in many circumstances and is neither necessary nor sufficient for global efficiency.[10] Building on the work of Eaton 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

[8] For a recent review of this literature, see Gallini (2002).

[9] 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.

[10] Yang and Maskus (2000a) present a theoretical model, related to that of Helpman, which explicitly incorporates technology licensing.

U.S. As he acknowledges, this study does not include any accounting of the benefits that might accrue from a higher rate of innovation.

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. More recently, Smith (1999) has furthered this research agenda, still within the context of cross-country regressions, but providing more structure for her analyses, guided by theory. In particular, she looks at the interaction of market size and IPR regime in predicting exports and again reports results that are consistent with a role for IPR in encouraging trade.

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.[11] Another way of dealing with the simultaneity of entry decisions is to use a more direct measure of knowledge transfers, rather than measures of overall flows of investment and exports.[12] One recent paper does use a closer proxy for knowledge flows: Yang and Maskus (2000b) examine the effect of

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

[12] Note that we distinguish here between deliberate technology transfers by multinationals and technology "spillovers." For recent work on the latter, see Keller (2002) and Branstetter (2000).

improved IPR regimes on licensing by U.S. MNE's, and report a strong positive relationship.[13]

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 composition of investment.[14]

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 in the models described above. 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

[13] 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.

[14] 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.[15] If the firm chooses to produce through a local affiliate, then it competes directly in the market.[16] 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 $q=q(s)$.

[15] 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.

[16] 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) $$p_a + mx = p_o + m(s - x))$$

Hence,

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

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:

$$(4) \qquad \begin{aligned} p_a &= \frac{1}{2}\left(p_o + sm + c\right) \\ q_a &= \frac{1}{4m}\left(p_o + sm - 2c\right) \end{aligned}$$

Under these conditions, it is straightforward that:

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

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

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

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.[17]

BEA collects identifiers linking affiliates through time, thereby permitting the creation of a panel. By checking the status of all affiliates that filed forms in the previous year and are expected to fall within reporting requirements, BEA identifies which enterprises leave the sample. By monitoring news services for information on mergers,

[17] 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.

acquisitions, and other activities of U.S. companies, BEA identifies which new enterprises should be included in the sample.

The survey forms concerning MNE activity capture information not only on output, employment, and trade, but also on the value of intangible property transferred from parent companies to affiliates.[18] American tax law requires that foreign 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

[18] 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 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.

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 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%. In each of the benchmark years, the median affiliate does not make a royalty payment to its parent. However, 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 median value of these flows was $128 thousand in 1999, and the mean value 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.[19] 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.

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.

[19] 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.

More detailed patent data may give us further insight into the nature of technology being transferred. It is possible to obtain counts of patent applications by American inventors in the reforming countries broken down into finely disaggregated classes of technology. By tracking the changing distribution of patents across technology classes, we may be able to make inference concerning the ways in which IPR reform affects the nature and sophistication of technology being transferred, as well as the volume of technology transfer. Statistical analysis of such detailed patent data is the focus of ongoing research.[20]

Data on individual technology licensing agreements between U.S. firms and foreign parties can be obtained from the SDC strategic alliance database.[21] This data source has shortcomings documented in the literature, but it provides some details on the nature of the technology being transferred at the level of the individual licensing agreement. These data can be supplemented with the more comprehensive CATI (Cooperative Agreements and Technology Indicators) database developed by Geert Duysters and John Hagedoorn. Analysis of these databases is a focus of ongoing research.

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

[20] We obtained the necessary patent data from INPADOC via the STN-Online Database and utilize the OECD Technology Concordance developed by Daniel Johnson of Wellesley College.
[21] This data set is available to the authors through institutional subscription. For an empirical analysis of licensing based on these data, see Anand and Khanna (2001).

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.[22]

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:

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

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 – either in levels, or scaled by measures of affiliate size. 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

[22] 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.

payments.[23] 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 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.[24] Finally, A_{ilt} is a vector of time-varying characteristics of individual affiliates, including measures of affiliate size.[25]

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 grants in each year before reform when compared to the parents of other affiliates in the host country are assigned a high 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

[23] 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.

[24] 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.

[25] 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.

zero. This dummy variable is interacted with the post reform dummy variable and included in the following specification:

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

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

$$(10) \quad Operations_{ilt} = \alpha_0 + \alpha_{il} + \alpha_t + \beta_0 y_{jt} + \beta_1 P_{it} + \beta_2 H_{jt} + \beta_3 A_{ilt} + \beta_4 R_{jt} + \varepsilon_{ilt}$$

Affiliate employment, sales, costs, and return on assets are the measures of affiliate operations considered. This analysis also tests if changes in affiliate behavior are largest for affiliates that have access to large portfolios of patents by allowing the coefficient on the post reform dummy to differ for these affiliates through the inclusion of the post reform dummy interacted with the high patent portfolio dummy.

The 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:

$$(11) \quad License_{ijt} = \alpha_0 + \alpha_{ij} + \beta_0 y_{jt} + \beta_1 H_{jt} + \beta_2 P_{it} + \beta_4 R_{jt} + \varepsilon_{ijt}$$

In this analysis, a parent firm is designated as having a large portfolio of patents if that firm more cumulative patent grants than the median firm receiving royalties from unaffiliated foreigners in a particular country in all years prior to reform.

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:

$$(12) \quad Patent_{jt} = \alpha_0 + \alpha_j + \alpha_t + \beta_0 y_{jt} + \beta_1 H_{jt} + \beta_2 R_{jt} + \beta_3 R_{jt} * y_t + \varepsilon_{jt}$$

We estimate (12) 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

Transfers to Affiliates

To give the reader a general sense of trends in the data, Figures 1-3 trace out changes in licensing and affiliate performance measures. Figure 1 examines differential movements in total licensing revenues received from affiliates based in Japan versus Germany. Clearly, there is an increase in licensing revenues from Japanese affiliates roughly coincident with Japanese patent reform – particularly the procedural reforms of 1995.[26] This relative increase in licensing to Japan is particularly striking given the particularly poor performance of the Japanese economy after 1995.

Figures 2 and 3 trace out the movement of licensing/sales ratios and affiliate profitability, respectively, in the periods 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.

[26] There was also a change in the Japanese patent law in 1988, studied in detail in Sakakibara and Branstetter (2001), that brought the structure of Japanese patent design into line with Western European and American norms. For a variety of reasons, however, the procedural reforms of 1995 are likely to have a stronger effect on technology licensing.

Figure 4 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. Three different approaches are used to measure the dependent variable of interest. Columns (1)-(3) of Table III present results obtained from a straightforward linear regression of a dummy variable indicating whether a particular subsidiary remits royalty payments of any level to its parent. The standard econometric problems arise from this use of the linear probability model, but the linear probability specification allows for the straightforward introduction of affiliate and year fixed effects, which are included in all regressions, and a clear interpretation of coefficients. In the specification reported in column (1) the post reform dummy is positive and insignificant, but it becomes significant when country specific time trends are included as controls, as indicated in column (2). As additional regressors, both of these specifications, and all other 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 restrictions, and the log of host country GDP per capita. The specification in column (3) also includes additional controls, such as 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.[27] The post reform dummy remains positive and moderately significant here.

Columns (4)-(6) present results of similar specifications where the dependent variable is the log of one plus the value of intrafirm royalty payments. This transformation is necessary so that the large numbers of affiliates that pay zero royalties are included in the sample. Again, the estimated impact of patent reform is positive and statistically significant when country time trends are included. The implied increase in annual royalty flow is on the order of 9%. Columns (7)-(9) recast the dependent variable as the log of royalty payments to sales, essentially imposing the constraint that the coefficient on the log sales variable in the previous specifications be equal to 1. The post reform dummy is positive and statistically significant in all of the specifications presented in these columns. Taken together, the results in Table III indicate that transfers of technology from parents to their affiliates increase after reforms, but the size of the increase is modest.

[27] 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.

However, the effects of IPR regime changes are quite different for firms with a significant amount of intellectual property. Table IV reports results of regression specifications similar to those examined in Table III, but here we include an interaction term estimating the separate impact of regime change on U.S. multinationals that possessed a large patent portfolio, as in specification (9). Again, columns (1)-(3) measure royalty payments to parents as a simple dummy variable, columns (4)-(6) measure the log of royalty payment levels in U.S. dollars, and columns (7)-(9) measure the royalty payments to sales ratios. The sample of affiliates used in the analysis only includes affiliates that have parents that can be linked to the NBER patent database. As a result, the sample is smaller that the sample used in the analysis presented in Table III and includes only publicly traded firms.

Columns (1), (4), and (7) re-estimate specifications shown in Table III on the new sample. In each of these specifications, the coefficient on the post reform dummy is positive and significant, indicating that intrafirm royalty payments increase for affiliates of the parent firms in the sample. The magnitude of this coefficient is larger than in similar specification in Table III. These differences could be due to the fact that the firms included are large, publicly traded, or have patents. To identify the importance of having a large patent portfolio, the other specifications presented in Table IV allow the coefficient on the post reform dummy to differ for affiliates in the high and low patent samples.

The results in columns (2)-(3) suggest that affiliates in the high patent sample are no more likely to switch from zero royalty payments to a positive level after reform than are affiliates in the low patent sample. However, the results in columns (5)-(6) indicate

that the level of annual royalty payments increased by about 17% more for the high patent sample than the low patent sample. The results in columns (8)-(9) also confirm the existence of a differential effect on high patent sample affiliates when the licensing variable is measured as a licensing to affiliate sales ratio. These findings provide important insight about the nature of the estimated effects. The impact of IPR regime changes is concentrated in that subset of firms that would *a priori* be expected to respond relatively strongly.

Table V seeks to shed further light on the nature of the impact of IPR reform on multinational affiliates by examining how various measures of affiliate operating activities evolve around an IPR regime change, as in specification (10). The specifications presented in columns (1) and (2) indicate that affiliate employment does not change in a statistically significant way when IPR regime changes take place. The results in columns (3)-(6) find evidence that levels of both sales and costs do increase around reforms, although the change in sales is only marginally significant. The final two specifications suggest that an affiliate's return on assets, measured as net income divided by assets, also does not change when reforms occur.

The results of this table are meant to be viewed in comparison to the results presented in Table VI. The analysis here focuses on only the affiliates of those firms that can be linked to the NBER patent database. Columns (1), (3), (5), and (7) repeat specifications displayed in the same columns in the previous table using the reduced sample. The results indicate large, robust increases in employment, sales, costs, and return on assets for affiliates of publicly traded parent firms that are patent holders. To identify the differential impact of IPR reform on holders of large patent portfolios, the

specifications in columns (2), (4), (6), and (8) allow the post reform effects to differ for affiliates classified in the high patent group. The results confirm that these affiliates experience disproportionately large increases in employment, sales, costs, and return on assets in the wake of reforms. These changes are all statistically and economically significant. Affiliates of firms with large patent portfolios experience employment increases of 9%, sales increases of 34%, cost increases of 21% and increases in return on assets of 1.8 percentage points.

There are at least two main potential interpretations of the results on intrafirm royalty payments and affiliate operating activities. It is important to note that the value of royalty payments for the transfer of intangibles equals the price of these assets times the quantity of the assets transferred. Increased royalty payments after reform are consistent with parents supplying more technology to their affiliates after reform but also with parents charging higher prices for the same level of technology provision. Likewise, the boost in sales and profitability recorded by affiliates is consistent with the view that the provision by the parents of superior technology has raised their productivity, and it is also consistent with the view that expanded IPR provides the affiliates with a greater ability to exclude rivals and imitators from entering the market. The welfare impact of the change depends very much on which of these observationally equivalent interpretations is correct. These two alternative explanations are discussed further after the analysis considers the impact of IPR reforms on arm's length licensing.

Arm's length licensing

U.S. firms do not only receive royalty payments for the sale or use of intangibles from their affiliates but also from unaffiliated foreigners. Table VII displays results of

tests of how these types of royalty payments respond to changes in IPR regimes. Columns (1)-(3) present specifications that are similar to the specifications that examine intrafirm royalty payments in Table III. Arm's length royalty data are collected for each firm by country, and the analysis therefore includes a fixed effect for each firm and country pair instead of a fixed effect for each affiliate-parent pair. The post reform dummy in these first three specifications are indistinguishable from zero, indicating that IPR regime changes do not change royalties from unaffiliated foreigners for the average firm. The specifications presented in columns (4)-(6) repeat this analysis for the sample of firms that can be linked to the NBER patent database, and the post reform dummy remains insignificant in these specifications. The final three columns display results of analysis that allows the coefficient on the post reform dummy to differ for firms that have large patent portfolios prior to reforms. The results illustrate that reforms do not affect arm's length royalty of firms regardless of their access to patent portfolios. These results suggest that any increased provision of new technology to host countries after reform takes place through affiliates rather than through licensing of technology to unaffiliated parties.

Resident versus Non-Resident Patenting

Table VIII shifts the focus from royalty payments and affiliate operating measures 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 additional controls, the log of host country GDP per capita and the log of host country net inward FDI, and 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 after controlling 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 some evidence that MNEs do not merely increase rent extraction around the time of reforms but also increase the quantity of technology transferred. 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. 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 filing that would eventually fall off as firms completed protecting the portfolio of technologies currently being used in the country in question.

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 VIII 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.

More detailed and disaggregated patent data could help us to refine our inference about the nature, volume, and technological sophistication of underlying technology transfer. Thoughts along these lines are laid out in the next section.

Section 7: Preliminary Conclusions and Next Steps

U.S. multinationals do respond to changes in IPR regimes abroad. In the wake of legal reforms that strengthen patent rights and other kinds of intellectual property 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. Affiliates that can access large amounts of technology developed and patented by their parent firm also experience larger increases in employment, sales, costs, and return on assets than affiliates than do not have access to these intangible resources. Multinationals appear to leverage their technology inside the firm as there is no evidence of an increase in arm's length licensing. These findings are 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.

Evidence from international patent filings suggests that the trajectory of foreigners' patent applications in the countries undergoing reform undergoes both a level shift up and an increase in the rate of growth over time. This pattern in the data suggests that at least some component of the recorded increase in licensing payments reflects the provision to the reforming countries of new technologies that had not previously been deployed in that jurisdiction. In other words, the data do not tell a simple story of either pure rent extraction or only an increase in the volume and sophistication of technology being transferred. Rather, the data suggest that both are taking place in the aftermath of patent reform. Signing the welfare impact of IPR reform would require us, at the very least, to be able to make some more precise statements about the relative magnitude of

these two effects. In the paragraphs below, we lay out a research strategy for moving in that direction.

Using Disaggregated Patent Filing Data

Basing inference about the underlying technological content of the technology being transferred into a particular country on aggregated patent statistics is problematic. Fortunately, more disaggregated patent data are available which could allow us, in principle, to get a much better view of the effect of IPR reform on patent *composition*. The European Patent Office maintains a comprehensive data base on international patent filings which is available through an on-line subscription. Using these data, it is possible to obtain counts of patent applications broken down by the nationality of the applicant and the nature of the technology being protected. The international patent classification (IPC) system provides us with a quite disaggregated classification of technologies of varying degrees of sophistication. At the seven digit level, there are over one thousand categories of technology in which we can track patenting over time. We propose to examine not only the *changing volume* of patent applications generated by American applicants but also the *changing distribution of these patent applications across technological categories*.

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 patent data, 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.

Who Responds to IPR Regime Changes?

Although the previous section indicates that, on average, strengthened IPR systems lead to increases in technology licensing payments to parents, it would obviously be of interest to determine the characteristics of parent firms that are most strongly associated with an active response to the regime change. For instance, it is possible that nearly all of the measured response to IPR strengthening is generated by a small number of industries in which IPR is critical to commercial success, such as chemicals and pharmaceuticals. To test this hypothesis, we could interact our measures of patent reform with industry-level variables that measure reliance on patenting, as suggested in Maskus (2000), and in the spirit of Rajan and Zingales (1998).

Alternatively, it is possible that sensitivity to IPR regime changes varies substantially by firm size. Large multinationals may be able to appropriate the returns to their technology by engaging in limit pricing, vertical foreclosure, or some other exercise of monopoly power, and may thus be relatively insensitive to all but the most substantial IPR regime changes. We can explore these and related hypotheses by allowing the measured impact of the IPR regime changes to vary with the characteristics of the parent firms, all the while controlling for the characteristics of the host countries and various aspects of the IPR regime changes.

What Countries Benefit from IPR Regime Changes?

In addition to identifying the types of parent firms that respond most actively to IPR regime changes, it will also be of interest to identify what kind of host country characteristics are most strongly associated with a strong response to a strengthening of IPR. For instance, it is possible (and prior research suggests) that host countries must be at a certain level of economic development before they can benefit from strengthened IPR. It will be relatively straightforward for us to break our data set down by characteristics of the host country, such as per capita GDP, educational attainment, R&D intensity, and per capita counts of patent applications by domestic residents across a range of technologies and industries. Controlling for the characteristics of parent firms, their affiliates, and key characteristics of the IPR regime changes, we can estimate how the impact of a strengthening of IPR on measured technology transfer varies as we vary these key characteristics of the host country.

Licensing, FDI, and Exports

As already noted, 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 is focused on the impact of 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 therefore be to embed our study of the impact of IPR regime changes on technology licensing 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. Recent contributions to

the theory of the multinational firm provide us with a useful foundation on which to build.[28]

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

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Figure 1 Royalty Payments from Related Parties

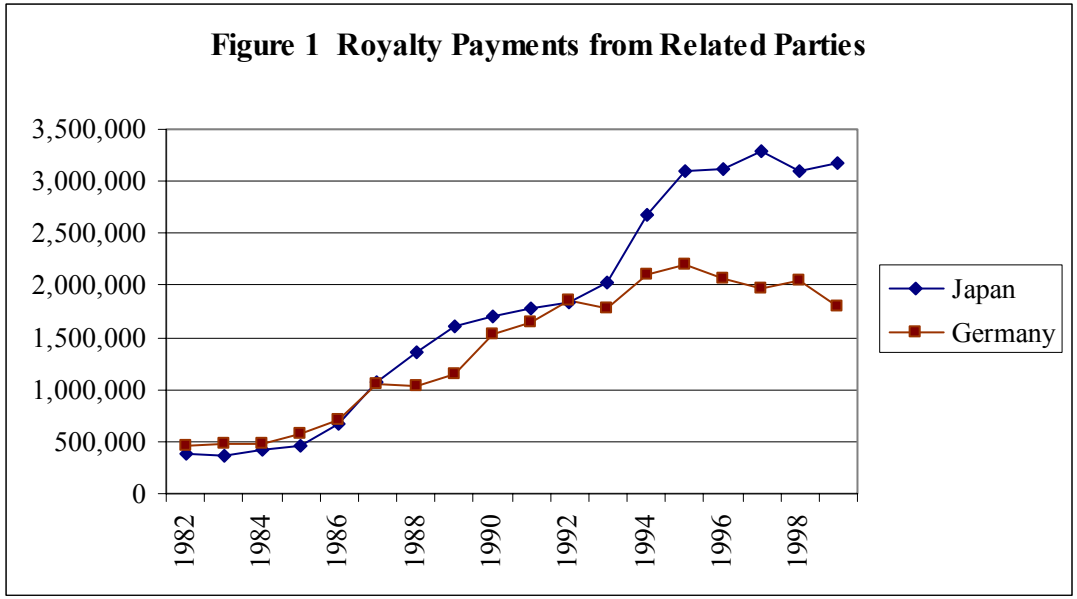
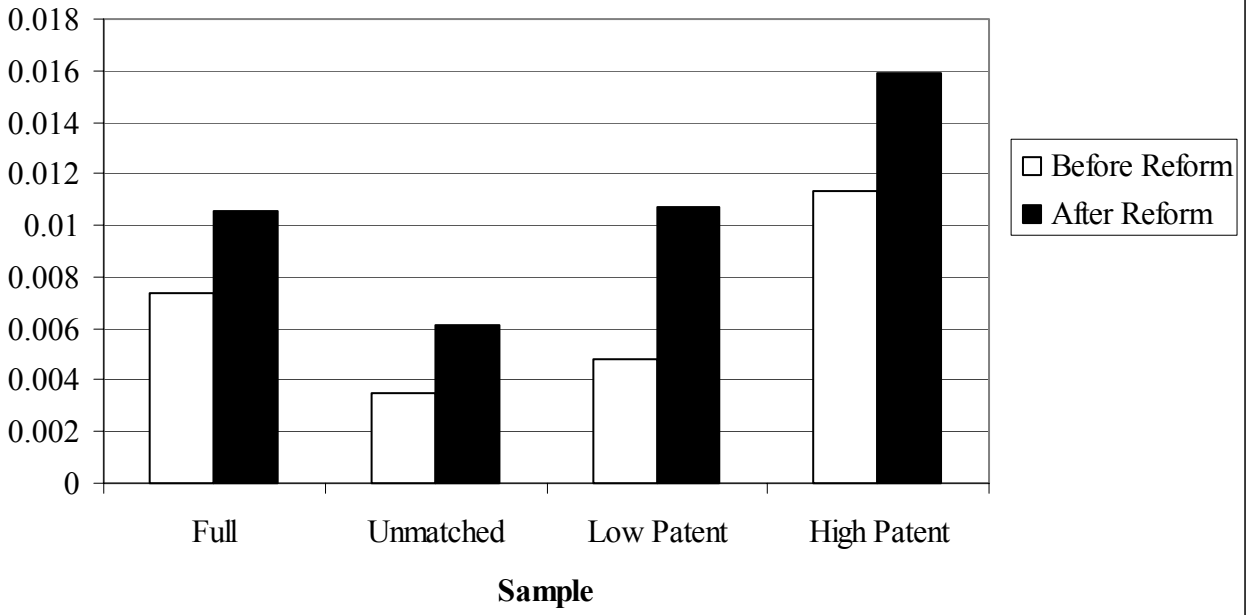


Figure 2 Aggregate Royalty Payments/Aggregate Sales



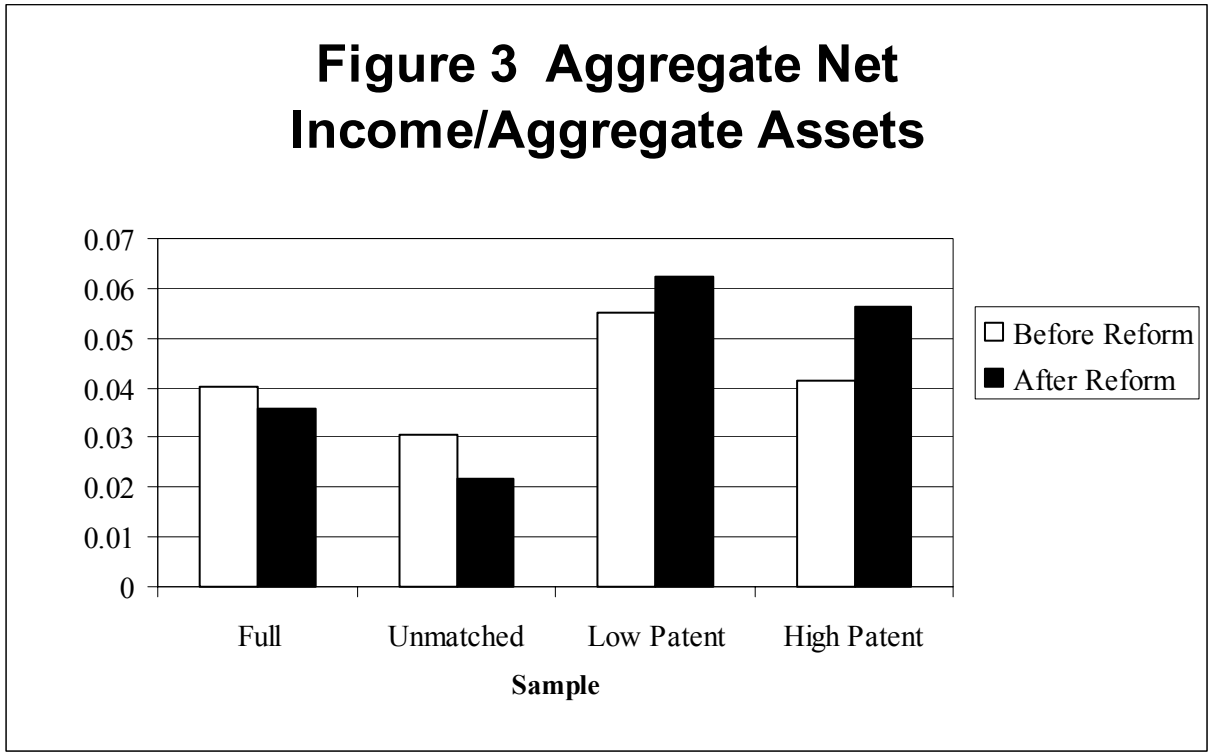


Figure 3 Aggregate Net Income/Aggregate Assets
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Full
Unmatched
Low Patent
High Patent
Sample
Before Reform
After Reform

Figure 4 Trends in Patenting

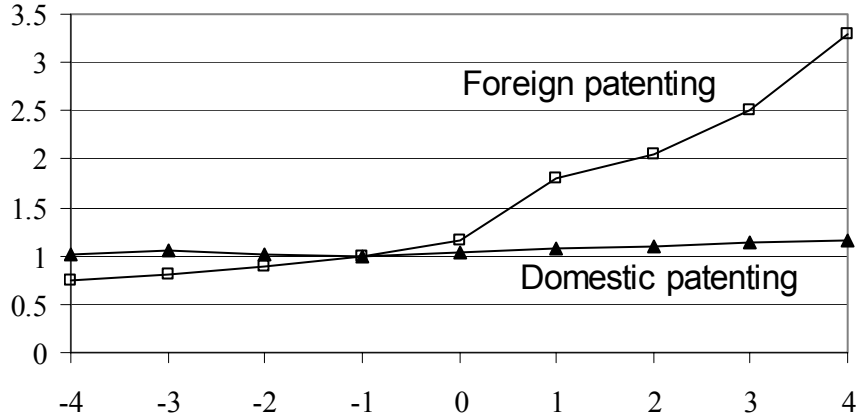


Table I

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
Median	158	120	105	108
Standard Deviation	1,489	1,936	2,057	2,059
Sales				
Mean	63,383	87,034	98,460	110,777
Median	12,193	15,088	15,934	22,007
Standard Deviation	328,242	497,225	555,079	491,625
Costs				
Mean	62,002	84,126	95,982	111,385
Median	12,289	15,058	16,036	23,666
Standard Deviation	321,861	489,993	546,561	484,555
Return on Assets				
Mean	0.0116	0.0633	0.0327	0.0356
Median	0.0271	0.0557	0.0349	0.0317
Standard Deviation	0.2153	0.1686	0.1836	0.1721
Intrafirm Royalty Payments				
Mean	182	631	1,036	1,087
Median	0	0	0	0
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
Median	na	143	182	128
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 and IPR Regime Changes

Dependent Variable:	Intrafirm Royalty Payment Dummy			Log of Intrafirm Royalty Payments			Log of Intrafirm Royalty Payments/Affiliate Sales		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	-0.8617	0.8772	5.2038	-5.5649	-31.0985	-2.1909	-0.0182	-0.0331	-0.0366
	(0.1535)	(3.4349)	(3.9902)	(1.0040)	(21.8486)	(25.5063)	(0.0065)	(0.1272)	(0.1488)
Post Reform Dummy	0.0026	0.0116	0.0106	0.0442	0.0898	0.0824	0.0006	0.0007	0.0007
	(0.0059)	(0.0060)	(0.0064)	(0.0400)	(0.0410)	(0.0435)	(0.0003)	(0.0003)	(0.0003)
Difference of Host Country Tax Rate and US Tax Rate	0.0081	-0.0127	-0.0074	0.1523	-0.2027	-0.1852	-0.0008	-0.0020	-0.0024
	(0.0338)	(0.0369)	(0.0395)	(0.2203)	(0.2436)	(0.2627)	(0.0013)	(0.0015)	(0.0016)
Host Country Withholding Tax Rate	0.0010	-0.0123	0.0160	0.3014	-0.1063	0.0874	-0.0031	-0.0034	-0.0039
	(0.0493)	(0.0511)	(0.0594)	(0.3165)	(0.3302)	(0.3844)	(0.0020)	(0.0020)	(0.0023)
Host Country Inward FDI Restrictions	-0.0211	-0.0166	-0.0157	-0.1455	-0.1498	-0.1376	-0.0002	-0.0002	-0.0003
	(0.0097)	(0.0098)	(0.0100)	(0.0666)	(0.0672)	(0.0682)	(0.0005)	(0.0005)	(0.0005)
Log of Host Country GDP per Capita	0.1165	0.1362	0.1479	0.7208	1.0936	1.1344	0.0024	0.0034	0.0043
	(0.0178)	(0.0299)	(0.0339)	(0.1163)	(0.1921)	(0.2184)	(0.0008)	(0.0012)	(0.0013)
Log of Affiliate Sales			0.0124			0.0936			
			(0.0012)			(0.0081)			
Log of Parent R&D Expenditures			0.0013			0.0144			0.0000
			(0.0009)			(0.0063)			(0.0000)
Log of Parent System Sales			0.0136			0.1760			0.0006
			(0.0054)			(0.0384)			(0.0003)
Affiliate and Year Fixed Effects?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country Specific Time Trends?	N	Y	Y	N	Y	Y	N	Y	Y
No. of Obs.	44,375	44,375	40,055	44,375	44,375	40,055	42,597	42,597	38,827
R-Squared	0.7193	0.7204	0.7286	0.7458	0.7467	0.7547	0.6834	0.6837	0.6911

Table IV

Intrafirm Royalty Payments, Patent Portfolios, and IPR Regime Changes

Dependent Variable:	Intrafirm Royalty Payment Dummy			Log of Intrafirm Royalty Payments			Log of Intrafirm Royalty Payments/Affiliate Sales		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	10.0387	10.0361	13.9768	24.9006	24.8673	58.0741	-0.0149	-0.0113	-0.0954
	(4.1313)	(4.1308)	(4.4442)	(26.8534)	(26.8411)	(28.7424)	(0.1523)	(0.1520)	(0.1678)
Post Reform Dummy	0.0240	0.0171	0.0130	0.1660	0.0749	0.0582	0.0009	-0.0001	0.0000
	(0.0081)	(0.0094)	(0.0097)	(0.0567)	(0.0638)	(0.0657)	(0.0003)	(0.0003)	(0.0003)
Post Reform Dummy * High Patent Portfolio Dummy		0.0143	0.0154		0.1889	0.1760		0.0019	0.0018
		(0.0104)	(0.0106)		(0.0728)	(0.0744)		(0.0004)	(0.0004)
Difference of Host Country Tax Rate and US Tax Rate	-0.0458	-0.0450	-0.0461	-0.3552	-0.3446	-0.3972	-0.0026	-0.0025	-0.0029
	(0.0499)	(0.0499)	(0.0516)	(0.3335)	(0.3332)	(0.3466)	(0.0018)	(0.0018)	(0.0019)
Host Country Withholding Tax Rate	-0.0482	-0.0472	-0.0386	-0.2272	-0.2130	-0.1512	-0.0049	-0.0048	-0.0051
	(0.0664)	(0.0664)	(0.0711)	(0.4300)	(0.4301)	(0.4608)	(0.0023)	(0.0023)	(0.0024)
Host Country Inward FDI Restrictions	-0.0077	-0.0076	-0.0058	-0.1369	-0.1359	-0.1214	-0.0001	-0.0001	-0.0001
	(0.0157)	(0.0157)	(0.0157)	(0.1102)	(0.1101)	(0.1102)	(0.0006)	(0.0006)	(0.0006)
Log of Host Country GDP per Capita	0.1483	0.1486	0.1518	1.1870	1.1911	1.1861	0.0028	0.0029	0.0031
	(0.0394)	(0.0394)	(0.0416)	(0.2565)	(0.2564)	(0.2702)	(0.0014)	(0.0014)	(0.0015)
Log of Affiliate Sales			0.0113			0.0882			
			(0.0017)			(0.0117)			
Log of Parent R&D Expenditures			0.0017			0.0170			0.0001
			(0.0016)			(0.0098)			(0.0000)
Log of Parent System Sales			0.0252			0.2781			0.0002
			(0.0087)			(0.0608)			(0.0004)
Affiliate and Year Fixed Effects?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country Specific Time Trends?	Y	Y	Y	Y	Y	Y	Y	Y	Y
No. of Obs.	20,500	20,500	19,462	20,500	20,500	19,462	19,868	19,868	19,039
R-Squared	0.6964	0.6964	0.6982	0.7282	0.7283	0.7297	0.6746	0.6752	0.6738

Table V

Affiliate Operating Performance and IPR Regime Changes

Dependent Variable:	Log of Affiliate Employment		Log of Affiliate Sales		Log of Affiliate Costs		Affiliate Return on Assets	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	16.2202	40.3381	-7.6270	40.4226	-25.1148	13.3831	7.6975	7.9382
	(8.7118)	(9.7181)	(17.0078)	(19.8046)	(11.2259)	(13.1336)	(2.2165)	(2.4352)
Post Reform Dummy	-0.0074	-0.0107	0.0917	0.0549	0.0766	0.0586	0.0016	-0.0014
	(0.0141)	(0.0144)	(0.0295)	(0.0299)	(0.0210)	(0.0212)	(0.0030)	(0.0032)
Difference of Host Country Tax Rate and US Tax Rate	-0.1968	-0.1763	-0.1923	-0.1237	-0.1767	-0.1396	-0.1561	-0.1346
	(0.1026)	(0.1065)	(0.2352)	(0.2440)	(0.1561)	(0.1582)	(0.0253)	(0.0262)
Host Country Withholding Tax Rate	-0.8251	-0.8509	0.0515	0.0700	-0.1934	-0.3020	-0.1845	-0.1476
	(0.1463)	(0.1593)	(0.3148)	(0.3386)	(0.1943)	(0.2018)	(0.0342)	(0.0376)
Host Country Inward FDI Restrictions	-0.0122	-0.0093	-0.1871	-0.1680	-0.1701	-0.1577	-0.0033	-0.0033
	(0.0247)	(0.0241)	(0.0499)	(0.0503)	(0.0374)	(0.0369)	(0.0056)	(0.0056)
Log of Host Country GDP per Capita	0.4879	0.4764	1.5637	1.6300	1.2573	1.2818	0.0828	0.0877
	(0.0735)	(0.0790)	(0.1504)	(0.1632)	(0.1009)	(0.1051)	(0.0183)	(0.0199)
Log of Parent R&D Expenditures		0.0016		-0.0056		-0.0024		-0.0006
		(0.0029)		(0.0073)		(0.0041)		(0.0007)
Log of Parent System Sales		0.2363		0.6361		0.4696		0.0082
		(0.0218)		(0.0411)		(0.0330)		(0.0029)
Affiliate 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.	40,974	37,179	43,953	40,055	42,934	39,128	43,380	39,407
R-Squared	0.9112	0.9185	0.8402	0.8461	0.8378	0.8473	0.5246	0.5402

Table VI

Affiliate Operating Performance, Patent Portfolios, and IPR Regime Changes

Dependent Variable:	Log of Affiliate Employment		Log of Affiliate Sales		Log of Affiliate Costs		Affiliate Return on Assets	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	43.8982	56.8727	30.4052	72.0554	-11.9770	25.6691	10.2512	13.3776
	(10.0187)	(11.2172)	(21.1236)	(22.8060)	(12.7206)	(14.3854)	(2.6067)	(2.7545)
Post Reform Dummy	0.0673	0.0310	0.2237	0.1056	0.1757	0.1408	0.0106	0.0039
	(0.0175)	(0.0204)	(0.0363)	(0.0437)	(0.0237)	(0.0297)	(0.0039)	(0.0046)
Post Reform Dummy * High Patent Portfolio Dummy		0.0583		0.2337		0.0735		0.0141
		(0.0248)		(0.0511)		(0.0327)		(0.0050)
Difference of Host Country Tax Rate and US Tax Rate	-0.1785	-0.2132	0.0094	0.0932	0.1674	0.1554	-0.1629	-0.1581
	(0.1232)	(0.1252)	(0.2850)	(0.2903)	(0.1840)	(0.1856)	(0.0324)	(0.0330)
Host Country Withholding Tax Rate	-0.4978	-0.5298	-0.1769	0.1339	-0.3187	-0.3041	-0.2267	-0.2278
	(0.1691)	(0.1753)	(0.3692)	(0.3790)	(0.2244)	(0.2276)	(0.0418)	(0.0435)
Host Country Inward FDI Restrictions	0.0085	0.0140	-0.1747	-0.1597	-0.1422	-0.1393	-0.0130	-0.0130
	(0.0343)	(0.0333)	(0.0659)	(0.0652)	(0.0449)	(0.0436)	(0.0075)	(0.0075)
Log of Host Country GDP per Capita	0.4832	0.4389	1.5543	1.4021	1.1340	1.0884	0.1067	0.1118
	(0.0916)	(0.0917)	(0.1883)	(0.1905)	(0.1144)	(0.1135)	(0.0225)	(0.0234)
Log of Parent R&D Expenditures		-0.0032		-0.0007		-0.0116		0.0003
		(0.0043)		(0.0138)		(0.0051)		(0.0010)
Log of Parent System Sales		0.2956		0.6256		0.4988		0.0059
		(0.0293)		(0.0626)		(0.0309)		(0.0043)
Affiliate 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.	19,404	18,546	20,322	19,462	19,921	19,079	20,172	19,289
R-Squared	0.9026	0.9078	0.8118	0.8131	0.8388	0.8425	0.4565	0.4630

Table VII

Arm's Length Royalty Payments, Patent Portfolios, and IPR Regime Changes

Dependent Variable:	Log of Arm's Length Royalty Payment								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	1.4509	3.2978	64.5987	3.3087	-37.1812	-0.7515	3.3986	-38.8184	0.6215
	(1.7353)	(37.9406)	(49.6997)	(2.8027)	(60.9661)	(55.6071)	(2.7979)	(60.9228)	(55.6973)
Post Reform Dummy	-0.0091	-0.0131	-0.0613	-0.0344	-0.0400	-0.0150	0.0184	-0.0036	-0.0391
	(0.0490)	(0.0497)	(0.0624)	(0.0777)	(0.0789)	(0.0754)	(0.0895)	(0.0902)	(0.0867)
Post Reform Dummy * High Patent Portfolio Dummy							-0.1307	-0.0909	0.0480
							(0.0977)	(0.0978)	(0.0977)
Difference of Host Country Tax Rate and US Tax Rate	-0.0242	0.2539	0.3666	-0.9020	-0.0392	0.5750	-0.8744	-0.0432	0.5781
	(0.3103)	(0.3355)	(0.4230)	(0.4682)	(0.5368)	(0.4925)	(0.4684)	(0.5372)	(0.4927)
Host Country Withholding Tax Rate	-2.0000	-1.5546	0.2651	-1.8903	-1.1135	1.5505	-1.8133	-1.0972	1.5407
	(0.6340)	(1.1623)	(1.4027)	(0.9224)	(1.9620)	(1.7758)	(0.9206)	(1.9624)	(1.7745)
Host Country Inward FDI Restrictions	-0.1408	-0.0791	-0.1548	-0.0679	0.0525	-0.0464	-0.0640	0.0524	-0.0459
	(0.0720)	(0.0748)	(0.1034)	(0.1232)	(0.1311)	(0.1375)	(0.1232)	(0.1312)	(0.1375)
Log of Host Country GDP per Capita	0.3686	1.0413	0.9700	0.2140	0.0995	0.5828	0.2052	0.0935	0.5788
	(0.1980)	(0.3306)	(0.4397)	(0.3023)	(0.5182)	(0.5094)	(0.3018)	(0.5178)	(0.5093)
Log of Parent R&D Expenditures			-0.0143			0.0322			0.0327
			(0.0183)			(0.0432)			(0.0431)
Log of Parent System Sales			0.6041			0.6303			0.6375
			(0.0819)			(0.1146)			(0.6375)
Parent/Country and Year Fixed Effects?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country Specific Time Trends?	N	Y	Y	N	Y	Y	N	Y	Y
No. of Obs.	13,650	13,650	6,702	4,386	4,386	3,529	4,386	4,386	3,529
R-Squared	0.8549	0.8566	0.8215	0.8203	0.8222	0.8183	0.8204	0.8222	0.8183

Table VIII

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	7.1104	19.1460	6.8559	19.7757	8.3325	-12.8342	7.7318	-11.5977
	(0.5128)	(9.6722)	(0.5384)	(9.7460)	(0.1904)	(6.6872)	(0.2447)	(6.4610)
Post Reform Dummy	0.0097	0.0544	0.0529	0.1015	0.3343	0.3504	0.4425	0.4383
	(0.2048)	(0.2088)	(0.1976)	(0.2006)	(0.1298)	(0.1249)	(0.1254)	(0.1217)
Post Reform Dummy * Time Trend			0.0912	0.0966			0.2125	0.1737
			(0.0910)	(0.0931)			(0.0661)	(0.0630)
Log of Host Country GDP per Capita		-1.1584		-1.2617		2.2998		2.1026
		(1.0394)		(1.0473)		(0.7155)		(0.6921)
Host Country Withholding Tax Rate	-0.2423	0.1485	0.5054	0.9597	1.2169	0.7827	2.9667	2.2537
	(1.3880)	(1.3272)	(1.4125)	(1.4299)	(0.8892)	(0.8157)	(1.0182)	(1.0281)
Host Country Inward FDI Restrictions	0.7713	0.8713	0.8005	0.9107	0.0928	-0.1982	0.1567	-0.1248
	(0.5363)	(0.5487)	(0.5265)	(0.5379)	(0.2623)	(0.1764)	(0.2980)	(0.2094)
Log of Host Country FDI		-0.0569		-0.0541		-0.0165		-0.0115
		(0.0559)		(0.0547)		(0.0400)		(0.0383)
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	0.9510	0.9547	0.9513	0.9598	0.9694	0.9634	0.9718