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Firm Heterogeneity and Weak Intellectual Property Rights

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Abstract

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In weak intellectual property rights (IPR) environments, the imitation of proprietary technology by domestic firms has become a deterrent for foreign investment. Different multinationals may view this deterrent differently. This paper develops a model where firms with more technology are less likely to invest in weak IPR environments. If imitation is costly, the model predicts that multinationals with the lowest level and highest level of technology will invest in weak IPR environments, and multinationals with a moderate level of technology will invest only in strong IPR environments. Empirical analysis with firm level data is consistent with this non-monotonicity result.

JEL Classification Numbers: F10, F12, F23

Keywords: Firm Heterogeneity, Intellectual Property Rights, Foreign Direct Investment,

Table of Contents

I. INTRODUCTION

Over the last few decades, multinational activity has exploded. Multinationals have not only expanded the number of their subsidiaries, but increasingly more firms are also choosing to become multinational and are investing abroad. Concurrently, intellectual property rights (IPR) have become an important issue both for countries that are home to investing multinationals and for countries that are potential hosts for new affiliates.

Countries in the Middle East are no exception as foreign direct investment (FDI) has poured into the region over the last few years and as recent trade negotiations with the US and EU have focused on the enforcement of IPR. Recently, Middle Eastern countries like Egypt, Kuwait, Lebanon, Saudi Arabia and central Asian countries like Azerbaijan, Kazakhstan, and Pakistan have found themselves on the US special 301 watch list as countries with inadequate intellectual property protection.

Anecdotal evidence both from the press and private businessmen illustrate how FDI from multinationals and IPR can be closely related. Multinationals with plants in countries with weak intellectual property rights often complain of domestic firms illegally pirating proprietary designs and technologies and using these same technologies to compete directly. In the Middle East some countries have cracked down on copyright abuse at the request of foreign multinationals. To the extent that FDI renders multinationals more susceptible to technology stealing than exporting, weak IPR can be a deterrent to FDI.

Weak IPR may not only deter FDI but also have differential impacts on different types of multinationals. The literature on firm heterogeneity (Melitz, 2003; Helpman, Melitz, and Yeaple, 2004) has already shown how individual firm characteristics affect a variety of firm decisions in international trade. Unfortunately, the existing theoretical and empirical literature on IPR and FDI assume firm homogeneity and cannot predict nor describe how individual firm characteristics affect a firm's decision to outsource to weak IPR environments. This paper attempts to fill this gap.[1]

This paper develops a simple model to show how weak IPR can create a sorting across heterogenous firms where the least advanced firms build plants in weak IPR regions (the south) and more advanced firms stay in the strong IPR region (the north).[2] By assuming that locating in the south makes a firm's technology susceptible to imitation, a firm's willingness to move to the south decreases as its technology increases. Technology in the model makes firms more

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[1]See Helpman (1993), Lai (1998), Glass and Saggi (2002), Glass (2004), and Fosfuri (2004) for theoretical discussions assuming firm homogeneity. Lee and Mansfield (1996), Javorcik (2004), Yang and Masksus (2001), and Smith (2001) empirically measure whether countries with stronger FDI receive more FDI, again assuming firm homogeneity. Branstetter, Fisman, and Foley (2006) and Branstetter, Fisman, Foley, and Saggi (2005) exploit changes in IPR policy but again mostly rely on the firm homogeneity assumption.

[2]This designation is unfortunate but standard in the trade literature.

productive. Imitation, therefore, by making competitors more productive, reduces profits for the firm, and firms with more technology who are copied make competitors even more productive.

Although imitation also imposes an added cost to moving to the south and although this cost increases with a firm's technology, this intuition is not what drives the model. Assume that there are two firms considering moving to the south, one with more technology than the other. The technology of southern firms may be such that the imitation cost for the firm with less technology is sufficiently small so that this firm will locate to the south. However, once southern firms have imitated this new technology, the technology gap between southern firms and the remaining northern firm may now be sufficiently small such that the northern firm will locate to the south. Thus, with this intuition an unravelling can occur where all northern firms locate to the south. The sorting result where firms with more technology locate in the north in the model is achieved through the fact that imitation makes southern firms more competitive and not through the fact that firms with more technology suffer higher imitation costs.

If one assumes that the process of stealing and imitating technology is costly and increasing in the level of the technology, there can exist a set of northern firms that are immune to imitation. The model then predicts a non-monotonic result where the least advanced firms outsource to the south, the moderately advanced firms stay in the north, and the most advanced who are immune to imitation again outsource to the south.

Using the Bureau of Economic Analysis's (BEA) 1999 Benchmark Survey on Direct Foreign Investment Abroad, this paper also empirically tests the general implications of the firm heterogeneity model. An extensive margin analysis tests whether firms with more technology, measured as research and development expenditures (R&D) as a percentage of sales, are less likely to have affiliates in weak IPR environments. An intensive margin analysis tests whether firms with more technology have a smaller presence, measured in relative affiliate sales and employment, in weak IPR environments. Empirical results are consistent with the non-monotonicity result. Both the least and most technologically advanced multinationals invest in the south and firms in the middle only invest in the north.

By considering firm heterogeneity, the results have implications on government policies that specifically target multinationals. Many governments create tailored policies (i.e., tax incentives or structural improvements) to attract foreign multinationals to their borders. Even in the United States, different states compete with one another to attract multinational plants as in the recent cases of Honda and Toyota. By predicting which multinationals are most likely to move to weak intellectual property rights environments, the paper suggests that developing countries with weak IPR need not bother targeting low technology or extremely advanced firms, since they have natural incentives to locate there. Instead, weak IPR countries should spend resources targeting firms with moderate technology, as these firms are exactly those that would not have located there otherwise.

Section II introduces the model. Section III describes the data in detail. Section IV describes the empirical results and finds evidence of this non-monotonic relationship in a sample of US multinationals. Robustness checks in section V suggest that IPR is important in deriving these

results, although identification questions may still exist. Section VI concludes.

II. MODEL

A. Setup

The world is assumed to be divided into two countries, the north where IPR are protected and the south where they are not. Consumers are identical in all countries and abide by the following Cobb-Douglas utility function:

$$U = x_0^{\nu_0} * \prod_{j=1}^{J} X_j^{\nu_j}$$

where x_0 is a homogenous good and X_j is an aggregate consumption index in industry j and $\sum_{j=0}^{J} \nu_j = 1$. The aggregate index is defined as a function of the individual varieties:

$$X_j = \left(\int_0^{n_j} x_i^{\sigma} di \right)^{\frac{1}{\sigma}}, 0 < \sigma < 1$$

where x_i is consumption of the individual good and n_j is the number of varieties in the sector.

Each variety is produced by a separate firm, and firms have monopoly power over the variety they produce. Northern firms are heterogenous over technological advancement, k, where higher levels of k correspond to higher advancement, and advancement is distributed over a distribution $\mu(k)$ with support $[\underline{k}, \infty)$. Southern firms are homogenous and all have the lowest level of technological advancement, $\underline{k}$.

A higher level of technological advancement allows a firm to produce its good at lower marginal cost. Labor is the only factor of production, and each worker can produce k units of the final good. Labor is assumed to be immobile. Although technological advancement in this model is very similar to a general productivity term, it is important to note that k captures only that element of productivity that is imitable and protected in the north but not in the south. IPR should not affect more general concepts of productivity like firm organization or firm culture which can be imitated anywhere regardless of IPR laws.

Wages in the north are fixed at $w > 1$ and normalized to one in the south. This assumption of fixed wages can be derived from a general equilibrium framework by assuming that w is the productivity of workers in the north relative to workers in the south at producing one unit of the homogenous good and that the labor supply is large enough such that the homogenous good is produced in both countries.

Iceberg type transport costs are assumed between the north and the south where final delivery of one unit of the good requires $\tau > 1$ initial units. Southern firms produce goods in the south. Northern firms can choose whether to establish one plant either in the north or the south.[3] As will

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[3]In this model, a northern firm can only have either a plant in the north or a plant in the south. It

be clear later, to prevent all firms from moving to the south, $\tau > w$ is also assumed. The total expenditure of northern consumers in the industry, Y_N, and of southern consumers, Y_S, are taken to be exogenous.

If a northern firm establishes a plant (outsources) in the south, its technology is instantly and always imitated. Outsourcing to the south is assumed to render technology more vulnerable to imitation than simply exporting. This may occur because outsourcing firms presumably hire native workers who can transfer technology elsewhere or because industrial espionage can more easily occur in firms with a physical presence in the south. Khan (2003) makes a similar assumption and motivates it by assuming that existing technology in the north cannot be used in the south without paying an adaptation cost. However, once one firm pays the adaptation cost, all southern firms can free ride and adapt at no extra cost.

Imitation implies that all southern firms instantly produce at the technological advancement of the outsourcing northern firm. If multiple northern firms outsource, productivity of all southern firms is at the level of the most productive outsourcing northern firm. Following Chaudhuri, Goldberg, and Jia (2006) who find that northern drug companies violate each others' patent rights in India, outsourcing northern firms are assumed to also imitate and produce at the productivity of the most productive outsourcing northern firm. In accordance with TRIPS agreements, imitated technology can only be used for sale in the south, and goods in the north must be produced with non-imitated technologies. [4]

B.   Firm Decision

A northern firm will establish manufacturing plants in the south if profits from locating in the south exceed profits from locating in the north. The equilibrium will be found when all firms make an optimal location decision given the decisions of all other firms.

We first examine the decision of the firm whose entire set of less advanced competitors has located to the south and then show that, given this firm's decision, the entire set of less advanced competitors would, indeed, prefer to be in the south. Proposition 1 in this section will also show

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cannot have a plant in both markets. A three country model can be written where northern firms have a home market and an away northern and southern market. In this model, northern firms will have a plant in the home northern country and a plant either in the away northern country or the south. Theoretical predictions are identical with this alternative model. This alternative model is given in Appendix D.

[4]This model of imitation is different from many existing theories. Existing theories assume perfect substitution between the original and imitated good. (See Lai, 1998; Glass and Saggi, 2002; Branstetter, Fisman, Foley, and Saggi, 2005) This model allows for imperfect substitution. Imperfect substitution may be important as Caves, Whinston, and Hurwitz (1991) find that in the US pharmaceutical industry prices only fall by around 0.8% for the entry of each generic substitute. For an example from a developing country, Chaudhauri, Goldberg, and Jia (2006) find empirical evidence of imperfect substitutability in the Indian drug industry.

that this equilibrium is unique.

From profit maximization in this imperfect competition framework, by locating in the north a northern firm with technological advancement k whose entire set of less advanced competitors has moved to the south will earn profits of $\pi = \pi^N + \pi^S$ where

$$\pi^N = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_N}{\left(\frac{w}{k}\right)^\epsilon P^N(k)} \tag{1}$$

$$\pi^S = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_S}{\left(\frac{\tau w}{k}\right)^\epsilon P^S(k)}$$

$$P^N(k) = N_S\left(\frac{k}{\tau}\right)^\epsilon + N_N \int_0^k \left(\frac{i}{\tau}\right)^\epsilon \mu(i)di + N_N \int_k^\infty \left(\frac{i}{w}\right)^\epsilon \mu(i)di$$

$$P^S(k) = N_S k^\epsilon + N_N \int_0^k k^\epsilon \mu(i)di + N_N \int_k^\infty \left(\frac{i}{\tau w}\right)^\epsilon \mu(i)di$$

Y_N and Y_S are the total expenditures in the industry of the northern consumers and southern consumers, respectively. N_N and N_S are the number of northern and southern firms respectively, and $\epsilon = \frac{\sigma}{1-\sigma}$. All these parameters are taken to be exogenous.

Locating to the south gives profits of $\pi' = \pi'^N + \pi'^S$ to the same northern firm where:[5]

$$\pi'^N = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_N}{\left(\frac{\tau}{k}\right)^\epsilon P^N(k)} \tag{2}$$

$$\pi'^S = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_S}{\left(\frac{1}{k}\right)^\epsilon P^S(k)}$$

The northern firm will move to the south if $\pi \leq \pi'$. This will be true as long as $k \leq \overline{k}$ where $\overline{k}$ is defined implicitly by the following equation:

$$\frac{A}{Y_S}\left[N_S\overline{k}^\epsilon + N_N\left(\overline{k}^\epsilon F(\overline{k}) - \frac{G(\overline{k})}{(\tau w)^\epsilon}\right)\right] + \frac{ABG(\overline{k})N_N}{Y_N} = \tag{3}$$

$$\frac{B}{Y_N}\left[\frac{N_S k^\epsilon}{\tau^\epsilon} + \frac{N_N G(\overline{a})}{w^\epsilon}\right] - \frac{AN_N G(\overline{a})}{Y_S(\tau w)^\epsilon}$$

$$A = \frac{1}{w^\epsilon} - \frac{1}{\tau^\epsilon}; B = 1 - \frac{1}{(\tau w)^\epsilon}$$

$$F(k) = \int_0^k \mu(i)di; G(k) = \int_0^k i^\epsilon \mu(i)di; G(\overline{a}) = \int_0^\infty i^\epsilon \mu(i)di$$

The left hand side of equation 3 is an unbounded function of k (where $k = \overline{k}$) while the right hand side is a constant.

For expositional convenience, I define the following assumptions as assumption 1.

Assumption 1 .

(1) $\tau > w > 1$.

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(2) $B > \frac{Y_N A}{\tau^\epsilon Y_S}$.

(3) $\underline{k}$ is sufficiently small.

(4) $G(\overline{a})$ is bounded.

Proposition 1 *If Assumption 1 holds, $\overline{k} > \underline{k}$ exists and is unique.*

The proof is given in Appendix C.

The inequality $\tau > w$ guarantees that not all northern firms will locate in the south. The assumption that $B > \frac{AY_N}{\tau^\epsilon Y_S}$ guarantees that the relative size of the southern market is not too small. Because of transport costs, locating to the south increases profits from the south but reduces profits from the north. If the market size of the south is too small, northern firms will never have incentive to sacrifice sales from the north for increased sales to the south.

Requiring $\underline{k}$ to be sufficiently small ensures that the southern market is not already so competitive such that no northern firm wants to go to the south. Finally, $G(\overline{a})$ being bounded is a technical assumption to ensure that P^N and P^S exist.

Proposition 2 *All northern firms with technological advancement less than that of the most advanced outsourcing northern firm, $\overline{k}$, will locate to the south.*

The proof is given in Appendix C.

By locating to the south any individual firm with technology less than $\overline{k}$ will not change the technology of southern firms. However, by locating to the south this same northern firm will experience a technology gain by copying northern firms with better technology. This extra technology gain ensures that firms with technology below $\overline{k}$ prefer to locate in the south.

Northern firms weigh the effects of cheaper labor, transportation costs, and technology imitation in deciding to outsource. Northern firms that are only a little more advanced than the most advanced outsourcing firms always choose to outsource since the cost of technology imitation is small. In this way the equilibrium can unravel. Once one northern firm outsources and southern firms learn new technology, the next most advanced northern firm outsources which triggers the next most advanced firm to outsource, and so on. In this way, either all northern firms outsource or none do.

This unravelling is avoided in this model by assuming transport costs. Because of transport costs, firms have an extra cost advantage in selling to the market in which they produce. For example, a northern firm which locates its manufacturing facilities in the north saves on transport costs when selling products in the north. If the northern firm switches its production facilities to the south, it pays transport costs when selling products in the north but saves on transport costs when selling goods to the south.

Firms will locate to the south if the gains to the south exceed the costs to the north. The gains of moving to the south decline as the technology of southern firms increase. The technology of southern firms increase as northern firms with more and more technology locate in the south. Thus, a threshold exists where firms with less technology than the threshold locate to the south, and firms with more do not. Very advanced firms do not outsource because by outsourcing and letting southern firms imitate their technology, the gains of moving to the south become too small.

It is important to note that as more advanced firms move to the south, the gains to relocating decline for all northern firms since all competing southern firms suddenly become more competitive. Imitation creates an externality. One northern firm's decision to relocate affects the decision of all other firms by changing the technology of competitors. In fact, in equilibrium all northern firms who stay in the north are actually indifferent between staying in the north or relocating if they could effectively prevent imitation. However, these northern firms stay in the north because they know that, if they move to the south and are imitated, southern firms will become so advanced that outsourcing will be unprofitable for all northern firms including their own.

Mathematically, the firm moves to the south if

$$\frac{Y_N}{P^N}\left(\frac{1}{w^\epsilon} - \frac{1}{\tau^\epsilon}\right) \le \frac{Y_S}{P^S}\left(1 - \frac{1}{(\tau w)^\epsilon}\right) \tag{4}$$

If equation 4 holds when all northern firms are located in the north, some northern firms will move to the south. As northern firms move to the south and southern firms imitate technology, P^S will increase. Eventually, P^S will increase so much that equation 4 will hold with equality. At this point, all northern firms are indifferent between locating in the north or the south. However, because by moving to the south, an advanced northern firm will increase P^S and reverse the inequality in equation 4, firms with technology above $\overline{k}$ will prefer not to locate in the south. Figure 1 gives a visual depiction of $\overline{k}$.

C.   Cost to Imitating

This subsection introduces a very simple model of imitation cost. Including imitation cost can generate non-monotonicity in terms of technology advancement and the decision to move to the south. Each firm that seeks to imitate a technology must pay a marginal cost $c(k)$ where k is the level of technology being imitated. The marginal cost $c(k)$ is presumably much smaller than the original research cost, but no imitating firm can free ride off the imitation efforts of another. Intuitively, stealing a technology requires managers to learn technology or to hire workers who can understand the new technology. This cost must be paid by all imitators (Teece 1977).

Assume that the marginal cost of imitating new technology is $c(k) = \frac{k^\epsilon}{C}$ where C is a constant, and k is the level of technology being imitated.

The marginal benefit of stealing a technology is:

$$\frac{\partial \pi^S}{\partial k} = \frac{\epsilon k^{\epsilon-1} \sigma \left(\frac{1}{\sigma} - 1\right) Y_S}{P^S(k)} \tag{5}$$

As long as the cost of imitating increases faster in k than the gains to imitating, some northern firms will be immune to imitation. For this to be the case, any cost function $c(k)$ that is more convex than $\frac{\partial \pi^S}{\partial k}$ will suffice.

Because the marginal cost is more convex than the marginal benefit, there will exist a threshold k^* such that the marginal cost to imitating will exceed the marginal benefit. No technology beyond k^* will be imitated, and northern firms with technology higher than k^* will be immune to imitation. In this framework, the level of k^* is increasing in C, and k^* can be defined implicitly in C i.e. $k^*(C)$.[6]

Again, for expositional convenience, I define the following as assumption 2.

Assumption 2 .

(1) $\tau > w > 1$.

(2) $N_S \underline{k}^\epsilon \left[\frac{A}{Y_S} - \frac{B}{Y_N}\right] < ABN_N G(k^*(C)) \left[\frac{1}{Y_N} + \frac{1}{Y_S}\right] + N_N G(\overline{a}) \left[\frac{B}{Y_N \tau^\epsilon} - \frac{A}{Y_S}\right].$

(3) C is sufficiently high.

(4) $G(\overline{a})$ is bounded.

Proposition 3 *If Assumption 2 holds, then all northern firms with technology less than $\overline{k}$ locate in the south, northern firms with technology $\subseteq (\overline{k}, k^*)$ locate in the north, and northern firms with technology greater than or equal to k^* locate in the south.*

The proof is given in Appendix C.

Thus, with a simple model of imitation cost, it is possible to generate a non-monotonic result where northern firms with technology less than or equal to $\overline{k}$ locate in the south, firms with technology $\subseteq (\overline{k}, k^*)$ locate in the north, and firms with very high technology greater than or equal k^* locate in the south. Figure 2 gives a visual depiction of both $\overline{k}$ and k^*.

III. DATA DESCRIPTION

Data for this paper comes primarily from the BEA's confidential annual survey on US direct

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[6]One could imagine alternative models of imitation costs, perhaps, where costs depend also on the difference between a firm's technology and the technology being imitated. As long as the cost structure implies that some northern firms will be immune to imitation, the results of this section will apply.

investment abroad. By legal requirement US multinational firms report selected financial data separately for their own US operations and operations of each foreign affiliate subject to reporting requirements depending on size.

This dataset only includes American firms with multinationals abroad. Parent firms with operations only in the United States are not required to report. Thus, with this dataset, one can only test the theory conditional on a firm already having decided to conduct FDI. Although the theory does not make this distinction, in practice, this distinction may actually be important. Helpman, Melitz, and Yeaple (2004) show that only certain types of firms undergo FDI. Thus, a dataset which includes firms not doing any FDI could confound the effects that are being estimated with the firm's decision to do FDI, at all.[7]

This paper uses the 1999 "benchmark" survey.[8] Benchmark surveys are given every five years and include more extensive financial information. The 1999 benchmark survey was chosen because it was the most recent one available at the time of writing and because all foreign affiliates were required to report regardless of size.[9] In addition, Hanson, Mataloni, and Slaughter (2001) document that the pattern of US FDI shifted in the 1990s. During that decade, US FDI greatly expanded outside of the OECD where it was concentrated before. Because countries with weak IPR tend to be outside the OECD, data from the late 1990s is particularly relevant.

Only US parent firms whose main line of business are in manufacturing, computer services, telecommunications, and research and design services are included in the dataset. In addition, parent firms whose main line of business constitute less than 70% of total sales are dropped.[10] Only majority-owned affiliates who have the same main line of business as their parents are

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[7]In addition, the model can be written as a three country model with two northern countries and a southern country. Northern firms have a home market, an away northern market, and a southern market. Northern firms service the home market with a home plant and must decide whether to service the foreign markets with a plant in the other northern country or the south. All results follow as in the two country model. Firms with the least and most technology place their foreign plant in the south, and firms with moderate technology place their foreign plant in the north. This model is given in Appendix D. With the model written in this way, this dataset which only includes firms with foreign affiliates is naturally suited to test the predictions of the theory.

[8]Data from the 1994 benchmark survey was used as a robustness test. Results are not as strong from this dataset although it is noted that the volume of foreign direct investment increased tremendously between 1994 and 1999, especially to weak IPR countries.

[9]For affiliates whose sales, assets, and net income were smaller than US$7 million, very minimal information was provided on supplement A forms.

[10]This is done because parent firms' financial data are reported on a consolidated basis. Parents who have many US subsidiaries in varying lines of business report financials for the entire US conglomerate. Therefore, data from a manufacturing company which owns a US subsidiary doing hotel management will include operations from all its affiliates including those pertaining to hotel management. This restriction is imposed to ensure that the data reported correspond primarily to the industry of interest.

considered.[11]

Countries are classified as having weak IPR or strong IPR according to Zhao (2004). A list of countries and their classification are given in Appendices A and B. Zhao (2004) investigated the extent to which multinationals conduct research in weak IPR countries. Because her application is similar to the one here, her classification seems to be a natural one to use. In addition, by combining the analyses of six different IPR indices, Zhao (2004) captures a more accurate picture of IPR environments and is able to classify a greater sample of important countries including China and several Eastern European countries. Most other indices omit these countries from their analyses and also overemphasize one aspect of IPR over all others such as legal statutes over practical enforcement in the case of Ginarte and Park (1997), the most often cited IPR index.[12] Finally, Zhao (2004) requires that a country have some type of imitative and innovative potential in the form of human capital capacity.[13] This is particularly appealing as even in weak IPR environments the act of imitation is not automatic and requires intellectual ability.

Zhao (2004) fails to classify several countries primarily in sub-Saharan Africa. Since it is not clear whether these countries should be considered as having weak or strong IPR, these are not considered in the analysis. Less than 7% of US affiliates operate in these omitted countries. Any parent who reports having an affiliate in these omitted countries is dropped from the analysis. This results in 96 parents being dropped from the final sample.[14]

With these criteria the dataset includes 2,674 foreign affiliates in 50 different countries belonging to 830 US parent firms. The measure of technological advancement of the firm chosen is parent R&D expenses as a percentage of parent firm sales. These R&D expenses only include expenses incurred at the parent firm and do not include R&D at any of the parent's subsidiaries. This choice is particularly important since the theory predicts that only that component of technological advancement that can be imitated and is protected in the north but not protected in the south matters.[15] Unfortunately, R&D expenses are subject to a parent firm size requirement. Parent firms with less than US$100 million in assets, sales, or absolute value of net income are not required to report this figure. This restriction eliminates close to 50% of the parents in the dataset. Although this requirement is unfortunate, size requirements are common when using firm level data. This

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[11]Affiliates that report having sales, assets, and employees less than or equal to zero are not considered.

[12]The Ginarte and Park (1997) index is used as a robustness check and results do not change.

[13]This is done with population and education minimums.

[14]The main regressions were also run including some of these parents if the parent also reported having an affiliate in a weak IPR country. This returned 76 of the 96 parents that were dropped. The main results of the analysis were unchanged.

[15]R&D expenses as a percentage of parent firm sales is a flow rather than a stock variable. Parent level patent data would be the ideal measure for technological advancement. Unfortunately, the use of patent level data requires matching done on firm names which has not been completed.

dataset is advantageous in the sense that the extent of the missing data is known.[16]

With this collection of parents and affiliates, the dataset is then collapsed such that each parent only appears once. If the parent has an affiliate in at least one weak IPR country, the variable entitled $weak$ will be assigned one. Parents with no affiliates in a weak IPR country have variable $weak = 0$. With this framework country level explanatory variables cannot be included.

An alternative empirical framework that has been used elsewhere in the literature is to expand the dataset so that each parent appears multiple times. If there are 50 countries in the world, each parent will appear 50 times, and the parent's choice of investing in each country is analyzed. This specification allows for country level explanatory variables to be included. However, this specification also requires that a parent's choice of investing in one country be independent of its choice in investing in any another country. Clustering standard errors may partially alleviate the independence concern but may still not be sufficient as the decision to invest in one country could directly influence the decision to invest in another. Because of these difficulties, this specification is not pursued.

Although taxes are a country level variable, tax rates are important at the firm level as through transfer pricing they may confound parent R&D expenses, the main explanatory variable of interest. Parents who have affiliates in countries with low tax rates may funnel some of their sales through the affiliate to take advantage of lower taxes. Analogously, affiliates in countries with high tax rates may funnel their sales through the parent to avoid higher taxes. Since the measure of technological advancement, R&D expenses as a percentage of sales, includes parent level sales, transfer pricing will affect the main independent variable of interest. To correct for this, regressions include a sales weighted average tax rate over countries in which the parent has affiliates. When R&D expenses as a percentage of sales appears as a square, this mean tax rate variable will also appear as a square. Country tax rates are taken as the top corporate tax rate from the University of Michigan World Tax Database.

Another problem related to transfer pricing is that parent firms may intentionally establish affiliates in countries with low tax rates just to take advantage of tax incentives. If weak IPR countries tend to have low tax rates, parents may establish affiliates in weak IPR countries for reasons not related to IPR. To control for this, regressions will include a minimum tax variable which is defined as the minimum tax rate in all strong IPR countries the parent operates in. This variable is capped at 35% which is the tax rate of the US Parents with affiliates only in weak IPR countries also have this variable assigned as 35%.

Finally, because parents with affiliates in weak IPR countries tend to have more affiliates overall, regressions include a firm's total number of affiliates to control for this observable difference.

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[16]Data is extremely limited for parent firms with less than US$100 million in assets, sales, or absolute value of net income. The total sum of royalties, licenses, and other fees for the use of intangible property for a parent would be a possible alternative measure for technology. However, a very large fraction of parent firms report a zero value for this figure.

It may seem obvious that parents with many affiliates are more likely to have affiliates in weak IPR countries. A finding that R&D has explanatory power even with the inclusion of number of affiliates implies that R&D is important even beyond this obvious fact. Finally, industry dummies at the North American Industry Classification System (NAICS) four digit level are included in all regressions.

IV. EMPIRICAL RESULTS

A.   Extensive Margin

The main empirical specification is a probit regression with *weak* as the dependent variable and R&D as a percentage of sales as the main independent variable of interest. Tax variables are included to control for transfer pricing effects, and the total number of affiliates is also included. The first column of Table 1 tests the linear specification to see if increases in technological advancement decrease the likelihood of a parent firm investing in a weak IPR country.[17] Because different firms in the same industry may experience common shocks, all standard errors are clustered at an industry level that is classified by the BEA.[18] Although the sign on technological advancement is as predicted, it is hardly significant. Column 2 eliminates those parents whose measure of technological advancement are in the largest 1% of the sample. Their exclusion does not change the results.

Column 3 of Table 1 tests whether the relationship is non-monotonic. It appears that, at low levels of technological advancement, increases in R&D as a percentage of sales decrease the likelihood of investing in a weak IPR country, while, at high levels of technological advancement, further increases in R&D spending increase the likelihood of investing in weak IPR countries. These relationships are highly significant and robust to the exclusion of outliers (column 4). Turning point in Table 1 gives the level of R&D as a percentage of sales such that increases in R&D no longer reduce but increase the probability of investing in a weak IPR country. CI gives the confidence interval associated with the turning point calculated by the delta method, and percentage gives the percentage of firms with R&D below this point.

Although these results are consistent with the theory, there are concerns with identification. Identification problems can be separated into two categories. On one hand, R&D expenses as a percentage of sales may be proxying for other firm characteristics that are important in determining location choice like capital intensity or general productivity levels. On the other hand, the classification of weak and strong IPR countries may be closely correlated with a classification based on country economic development or country market size. Therefore, the results outlined above do not describe the relationship between technological advancement and IPR but between

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[17]Regressions do not include one obvious outlier. One parent in the dataset has R&D expenses as a percentage of sales larger than 1. This is more than twice as large as that of the next largest value.

[18]All results in Table 1 are robust to standard errors simply corrected by White's correction for heteroskedasticity.

technological advancement and another factor like economic development. The first of these issues is considered in the rest of this section. The second of these issues is explored in the Robustness section.

If R&D expenses as a percentage of sales is proxying for other firm characteristics, an easy way to address this problem is to include these firm characteristics in the regression directly. One possibility is that technologically advanced firms are also capital intensive, and that this capital intensity is what is driving the results.

To address this concern, column 5 of Table 1 includes the capital intensity of the parent firm directly. Capital intensity is defined as the log of the value of property, plant, and equipment at the parent subtracted by the log of its total number of employees. The non-monotonic relationship of R&D as a percentage of sales remains, and the coefficient on capital intensity is insignificant.

The argument about capital intensity can be extended to human capital. Technologically advanced firms may more heavily rely on skilled labor. To proxy for the extent of skilled labor at the parent firm, column 6 of Table 1 includes the log of the average employee wage at the parent firm. The employee wage is defined as the total amount of employee compensation divided by the total number of employees. Again the non-monotonic relationship of R&D as a percentage of sales remains, and the coefficient on the log of wages is insignificant.

Most studies of heterogeneous firms on affiliate location choice focus on general productivity as the main determinant of location choice (Melitz, 2003; Helpman, Melitz, and Yeaple, 2004; and Yeaple, 2005). R&D expenses may be a proxy for general levels of productivity. To control for this, the log of sales in the main line of business[19] is included in the specification. The coefficient on this variable is positive and significant. However, the non-monotonic relationship of technological advancement survives. This suggests that productivity may have an effect on where a multinational decides to outsource. However, technological advancement or that element of productivity that is able to be imitated and protected in the north but not in the south still has a separate and important effect as described in the preceding model.[20]

B. Intensive Margin

A second empirical specification attempts to take advantage of the intensive margin of firms. The dependent variable of the previous specification was binary and measured the extensive margin of a firm's decision to locate. The following specification considers the extent of a firm's presence in weak IPR countries measured as affiliate sales or employment in weak IPR environments.

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[19]This is the common proxy for productivity in this literature. The results of Table 1 are robust to using the log of sales minus the log of the number of employees as a proxy for general levels of productivity.

[20]All results are robust to including the square of capital intensity, log of average employee wage, and log of sales in the main line of business.

Affiliate sales and employment in weak IPR countries are measured relative to total affiliate sales and employment around the world. The dependent variable of column 10 in Table 1 is the total sum of affiliate sales in weak IPR countries for a given parent divided by total affiliate sales around the world. The non-monotonic relationship appears and significantly so.[21] Note that controls for parent level capital intensity, skilled labor, and the general level of productivity are included.[22]

A concern with using affiliate sales may be that many parents export to the affiliate a large percentage of the affiliate's sales. Thus, affiliate sales may not be a good proxy for the amount of value added done by the affiliate. To address this concern, column 11 in Table 1 uses affiliate employment as the dependent variable. Results are similar.

Finally, the theory suggests that the relationship between technological advancement and affiliate location choice should be more pertinent in industries where technology is particularly important. The theory may not hold as well for industries like textiles or food and beverage manufacturing. Table 2 repeats the analysis in Table 1 but separates the sample into industries that are more technologically sensitive and industries that are not. Technologically sensitive industries are defined to be machinery manufacturing, computers and electronic products, electrical equipment, transportation equipment, and medical equipment and supplies.[23] Although the square of R&D is significant across both types of industry groups, the negative linear R&D term is significant only for the technologically sensitive industries.[24] In the theory, the predicted negative linear term on R&D comes from the northern firm's fear of imitation and the positive prediction on the squared term comes from firms that are immune to southern imitation. The results of this analysis suggest that the fear of imitation is more prevalent in the technologically sensitive industries, although very advanced firms in both types of industry are willing to invest in the south.

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[21] Because tax mean is a sales weighted average of the tax rate, there could be concerns that a mechanical relationship exists between the tax mean variable and the dependent variable. When the average tax rate is weighted by employment, all results are still the same.

[22] Affiliate sales in levels is not analyzed as idiosyncratic firm effects could highly influence sales. Some firms simply have affiliates with high levels of sales across the board. Relative sales, which normalizes for these effects, is a better measure of affiliate activity (See Brainard, 1997).

[23] These industries appear most often in the National Bureau of Economic Research (NBER) patent database. They exclude the chemicals and pharmaceutical industries because imitation in these industries can occur anywhere and not just in places where firms have affiliates.

[24] For regressions separated between technologically sensitive and non-sensitive industries, standard errors are not estimated with clustering across general industry categories. Standard errors are simply corrected with White's correction for heteroskedasticity. For asymptotic properties, clustering requires a large number of cluster groups. This analysis divides the sample so that each regression contains very few cluster groups. When doing the analysis with clustering, the estimated non-monotonicity is generally stronger for the technology group, although the distinction is not as sharp. All results in Table 1 are robust to not including clustered standard errors.

C. Within Industry

Although the results of the extensive margin and the intensive margin with relative sales and employment are consistent with the theory, it is important to note that the theory predicts a non-monotonic relationship within industries. Pooling all the industries together even with industry fixed effects does not fully test the theory since different industries may have different turning points.

To address this concern, the specifications on the extensive margin and the intensive margin are run with R&D as a percentage of sales interacted with a general industry dummy for each general industry.[25] General industry dummies are interacted with the square of R&D as a percentage of sales in the same way. The log of wages, capital intensity, the log of sales in the main line of business, and NAICS 4 digit industry dummies are included as explanatory variables although their coefficients are not reported.[26] The results are given in Table 3.

Across the twelve general industry groups with a large enough sample size such that coefficients and standard errors can be estimated, eight general industry groups have negative R&D linear terms and positive squared terms as the theory suggests across both the extensive and intensive margin specifications. Of the four general industries that do not have the predicted signs, only furniture manufacturing has the inconsistent signs across all three estimations.

Because the coefficients on the interactions are estimated within general industry groups, the fact that many of these general industry groups have small sample sizes makes inference difficult. Regardless, the estimated non-monotonic relationship is significant at the 10% level a total of thirteen times in these three regressions. The relationship is especially apparent for food and beverage manufacturing and electronic components manufacturing. Only in two of these thirteen cases does the significant relationship not follow the predicted theory, once for furniture manufacturing and once for transportation equipment.

Although it is puzzling why the theory seems to fail in the extensive margin case for transportation equipment, it should be noted that this reverse relationship is not found in the intensive margin analysis. Regardless, in other industries where one would expect the theory to most apply like

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[25]General industries are industry classifications that are more aggregated than at the NAICS four digit level. They are classified by the BEA, and the dataset includes 15 general industries. They are food, beverage, and tobacco manufacturing; textiles, apparel, and leather products; wood products and paper; printing and related support activities; petroleum and coal products; chemicals, plastics and rubber products, and non-metallic mineral products; primary and fabricated metals; machinery; computers and electronic products; electrical equipment, appliances, and components; transportation equipment; furniture and related products; miscellaneous manufacturing; telecommunications and information services and data processing; and professional, scientific, and technical services.

[26]Clustering techniques are not used since the coefficients on the interactions are estimated only within cluster groups. Clustering with general industry groups makes the results even sharper.

machinery, computers, and electronic components, the data seems to be supportive.

Because small sample sizes in each of the general industries makes interpretation difficult, it is important not to overanalyze these results. This analysis is useful in that it clearly indicates that the relationship estimated in the pooled regressions also exists at the general industry level.

V. ROBUSTNESS

A. Identification

The second identification problem is that the classification of countries as having weak or strong IPR may be highly correlated with other country characteristics that may be affecting affiliate choice. It is definitely true that countries with strong IPR tend to be more developed, to be larger, and to have more educated workforces. However, if the weak IPR classification is proxying for other country characteristics like economic development, an objection to the identification in the main regression requires an alternative story that explains the non-monotonicity.

A determinant of affiliate location choice often cited in the literature is market size. To differentiate between the effects of IPR and market size, this analysis takes the sample of the main analysis and reclassifies the countries according to market size. About 1/3 of the countries in the original sample are classified as being large and the rest of the countries in the original sample are classified as being small.[27] The ratio 1/3 for large countries is chosen because 1/3 of the countries in the sample are considered to have strong IPR. The correlation between having a large market size and strong IPR is quite strong. The dependent variable $small$ will be one if the parent has an affiliate in a country with small market size. Table 4 indicates that despite the strong similarity, when the countries are reclassified by market size, the results of the main section do not appear.

A second determinant of affiliate location choice often cited is economic development. Again, the original sample of countries is reclassified according to whether the country belongs in the OECD in 1999. The Czech Republic, Greece, Hungary, Korea, Mexico, Poland, Portugal, Spain, and Turkey are the 9 weak IPR countries in the OECD. Singapore, Sri Lanka, and Uzbekistan are strong IPR countries not in the OECD. Unfortunately, very few firms have affiliates in these strong IPR non OECD countries. Because of the even stronger level of similarity between both categories, with this new classification 75% of parents remain identically the same.

The dependent variable, $NOECD$ will be one if the parent owns an affiliate operating in a country that is not part of the OECD in 1999. In Table 5 the results of the extensive margin analysis are much weaker with this new classification. The results of the main section seem to reappear in the intensive margin analysis.

The correlation between weak IPR and being economically developed is quite strong, so it is not

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[27]GDP data is 1999 GDP in current US dollars taken from the World Bank's World Development Indicators (WDI).

entirely surprising that an attempt to parse between these factors is not entirely clean. However, a classification based on economic development certainly does not work better and may even be worse as results do not appear in the extensive margin.

The same exercise is considered with country education levels to examine the effect of human capital.[28] Table 6 shows that under this classification ($leduc$) the non-monotonic results go away in both the intensive and extensive analysis.

This exercise is repeated again for distance from the United States. Transport costs are often cited as a major factor in FDI decisions.[29] Table 7 (dependent variable far) indicates that this classification does not deliver the same results as the main section.

Finally, Yeaple's (2005) empirical analysis of affiliate location choice uses the social infrastructure variable from Hall and Jones (1999). This social infrastructure variable considers the government's role in protecting against diversion and the country's openness to free trade. Trade barriers are again an oft cited determinant of FDI choice. Repeating the exercise for the set of countries whose social infrastructure is worse than 2/3 of the original sample gives the results in Table 8. The results of the extensive margin fall away. For the intensive margin, the IPR results are not replicated as the coefficient on the linear term of R&D is not significant.

Although market size, economic development, human capital, physical distance, and social infrastructure were all analyzed as possible alternatives to the IPR story, it is important to note that many of these alternative stories would not necessarily give the prediction that parents at low levels of technological development would be less likely to invest and then at higher levels of technology be more likely to invest independent of firm characteristics like capital intensity, wages, and general productivity.

Regardless, when the original sample is parsed into different categorizations, the non-monotonic results of the main section consistently seem to weaken. Even a reclassification by economic development only returns the results for the intensive margin. Therefore, it does not appear that any one of these alternatives is primarily driving the results of the main section. One objection, however, is that parent firms make location choices with all these factors in mind. Although each factor taken individually may not be able to replicate the results of the main section, a thorough investigation would consider all these factors simultaneously. This simultaneous analysis is impossible under the current framework.

B. Alternative Estimation

A large drawback associated with the empirical analysis, thus far, is that it does not allow for the inclusion of country level explanatory variables. Currently, the dataset is constructed so that each firm appears only once and the dependent variable is one if the firm has an affiliate in a weak IPR

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[28]The data on education levels is the "tyr" variable in the Barro and Lee (2000) dataset.

[29]Data on country distance from the US was gratefully taken from Andrew Rose's website.

country. The dataset could be expanded so that each firm appears once for every country in the dataset. The dependent variable will be one if the firm has an affiliate in that country.

With this expanded dataset, a logit or probit regression could be run. The main drawback with this type of analysis is that this implictly assumes that a firm's decision to invest in one country is independent of its decision to invest in another. This assumption is most likely counterfactual. Clustering standard errors may not be sufficient as the decision to invest in one country could directly affect the decision to invest in another in a manner that is beyond a simple correlation in error terms.

It may be slightly better to run a firm level conditional logit. This would find estimates after conditioning on the total number of countries in which the firm has affiliates. Unfortunately, even after conditioning on the number of countries the firm has affiliates in, this analysis still assumes that the decision to invest in one country does not directly influence its decision to invest in another.

This subsection proposes a slight variant of this conditional logit regression which allows an investment decision in one country to influence the decision to invest in another country. This method allows the inclusion of country level characteristics and utilizes each parent's entire location decision.[30] To describe the estimation technique, take as an example a firm that has affiliates in three countries called A, B, and C. This analysis assumes that the firm can order the three countries according to a preference. One might suppose that it prefers locating in country A the most, country B the second most, and country C the least. If this is the case, a likelihood function can be written.

If the firm most prefers establishing an affiliate in country A, using a Heckman selection model, the probability of this occurring is:

$$Pr(\text{1st choice} = A) = \frac{e^{X'_A \beta}}{\sum_i e^{X'_i \beta}} \tag{6}$$

where the subscript i indexes countries. Recall that in the Heckman selection model, the explanatory variables X vary across choices (countries in this case).

If the firm perceives establishing an affiliate in country B as second most desirable, then conditional on having preferred A over B the probability that B is preferred over all remaining possibilities is:

$$Pr(\text{2nd choice} = B \mid \text{1st choice} = A) = \frac{e^{X'_B \beta + Z'_B \gamma_A}}{\sum_{i \neq A} e^{X'_i \beta + Z'_i \gamma_A}} \tag{7}$$

where Z_i is a subset of the country characteristics X_i. The term $Z'_B \gamma_A$ is included to reflect the fact that after a firm has preferred country A and established an affiliate there, the characteristics

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[30]I thank Eric Sun for suggesting this approach.

of country B may have different effects. For example, assume that low tax rates in a country increase the probability of a firm creating an affiliate there. If country A already has low tax rates, the value of tax rates may not be as important to the firm when it chooses its second most preferred country. Thus, Z_i are country characteristics that may have effects on the decision to locate a subsidiary but whose effects may change after an affiliate has already been established in another country.

Similarly, the probability of the firm perceiving country C as the third most desirable is:

$$Pr(\text{3rd choice = C} \mid \text{2nd choice = B, 1st choice = A}) \tag{8}$$

$$= \frac{e^{X_C'\beta + Z_C'(\gamma_A + \gamma_B)}}{\sum_{i \neq A,B} e^{X_i'\beta + Z_i'(\gamma_A + \gamma_B)}}$$

.

The logic is similar as above.

Finally, the fact that the firm only chose to have affiliates in these three countries implies that the firm preferred to have no affiliates than having affiliates in any other country. This probability is given by:

$$Pr(\text{4th choice = no choice} \mid \tag{9}$$

$$\text{3rd choice = C, 2nd choice = B, 1st choice = A})$$

$$= \frac{e^{X_0'\beta + Z_0'(\gamma_A + \gamma_B + \gamma_C)}}{\sum_{i \neq A,B,C} e^{X_i'\beta + Z_i'(\gamma_A + \gamma_B + \gamma_C)}}$$

.

The variable X_0 are the explanatory variables associated with choosing to have no other affiliates. The values of these explanatory variables are all set to zero. The variable X_i also includes an indicator variable that is one when $i = 0$. This is the only non zero entry in X_0. It is important to note that the decision to not have any more affiliates is considered a separate choice. At every stage, the firm can decide to not establish any more affiliates. Therefore, X_0 is included in the summation in each of the denominators above.

Thus, if a firm has affiliates in all three countries and if it prefers country A to country B to country C, the likelihood of this occurring is :

$$Pr(\text{4th choice = no choice, 3rd choice = C,} \tag{10}$$

$$\text{2nd choice = B, 1st choice = A})$$

$$= Pr(\text{4th choice = no choice} \mid \text{3rd choice = C, 2nd choice = B, 1st choice = A})$$

$$* Pr(\text{3rd choice = C} \mid \text{2nd choice = B, 1st choice = A})$$

$$* Pr(\text{2nd choice = B} \mid \text{1st choice = A}) * Pr(\text{1st choice = A})$$

Since one does not actually know the firms' preferences, the probability of observing the firm

having affiliates in country A, B, and C is:

$$Pr(\text{4th choice = no choice, 3rd choice = C, 2nd choice = B, 1st choice = A}) \quad (11)$$
$$+Pr(\text{4th choice = no choice, 3rd choice = C, 2nd choice = A, 1st choice = B})$$
$$+Pr(\text{4th choice = no choice, 3rd choice = B, 2nd choice = C, 1st choice = A})$$
$$+Pr(\text{4th choice = no choice, 3rd choice = B, 2nd choice = A, 1st choice = C})$$
$$+\ldots$$

This methodology can be generalized to any number of countries in which a firm has affiliates, although the number of terms in equation 18 is equal to $n!$ where n is the number of countries in which the firm has affiliates. Given this likelihood function, maximum likelihood estimation can be done.

The results of this estimation technique are given in Table 9. The main results seem robust to this alternative estimation. The main variables of interest are R&D intensity and R&D intensity squared both interacted with the weak IPR dummy. The interaction is necessary because, just as in the conditional logit framework, this technique does not allow for the inclusion of firm (individual) specific characteristics, only country (choice) specific characteristics. The coefficients on these interaction variables should describe how R&D intensity affects the probability of establishing an affiliate only in weak IPR countries. Firm specific characteristics like capital intensity, the log of wages, and the log of sales are included in the same way. The log of GDP per capita, log of population, log of distance, tax rates, educational attainment and social infrastructure are included as country level explanatory variables. These variables are also included in Z_i where Z_i are the country level variables that may affect the probability of investing depending on where else the firm has already invested.

Finally, because the terms in equation 18 increase according to the factorial of the choices, computational limitations prevent the use of the full sample. In the results presented, only firms that invest in four or fewer countries are included. In addition, in order to estimate the γ's given above, only countries in which more than six firms invest are included. Unfortunately, this drops 31% of the sample. This is regrettable but unavoidable given computational challenges.[31]

VI. POLICY IMPLICATIONS AND CONCLUSION

Firm heterogeneity has proved to be empirically important in many contexts. It appears that firm heterogeneity may also be contributing to FDI decisions in weak IPR environments. Although identification issues are still a legitimate concern, empirical results seem to indicate that a non-monotonicity exists such that firms at low levels of technology outsource to the south, firms with moderate amounts of technology locate in the north, and firms with very high technology

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[31]The coefficients estimated with this analysis should be interpreted with caution. The likelihood function is very flat at the maximum, and, so, estimates from the optimization program may be imprecise. The results of this section should be interpreted as a check against the main regressions.

again outsource to the south.

If one takes these results seriously, both developing and developed countries should reconsider policies targeting multinationals. If low technology and high technology firms are likely to locate in weak IPR environments, governments in such countries should expend resources targeting multinationals with moderate technology. Analogously, developed countries that worry about the extent of outsourcing should focus their attentions on policies that target the most advanced multinationals since these are most at risk for locating abroad.

In terms of technology transfer, the results of this paper suggest that lowering the cost of imitation by only enforcing weak IPR laws could have ambiguous effects on technology transfer to the south. On one hand, weak IPR laws render it easier for domestic firms to learn the technology of multinationals invested in the host country. However, if weak IPR laws select less advanced multinationals to invest, overall technology transfer could be lower under a weak IPR regime. Whether weak IPR fosters or hinders overall technology transfer will depend on the sensitivity of IPR laws on multinational investment and the sensitivity of IPR laws on domestic technology learning. The precise magnitudes of these sensitivities could be considered for future research.

APPENDIX A: LIST OF COUNTRIES WITH WEAK IPR

Argentina	Belarus	Brazil	Bulgaria	Chile	China
Costa Rica	Czech Rep.	Egypt	Greece	HKSAR, China	Hungary
India	Indonesia	Israel	Korea, Rep.	Lithuania	Malaysia
Mexico	Pakistan	Peru	Philippines	Poland	Portugal
Romania	Russia	Slovak Rep.	South Africa	Spain	Taiwan, China
Thailand	Turkey	Ukraine	Venezuela		

APPENDIX B: LIST OF COUNTRIES WITH STRONG IPR

Australia	Austria	Belgium	Canada	Denmark	France
Germany	Ireland	Italy	Japan	Netherlands	New Zealand
Norway	Singapore	Sri Lanka	Sweden	United Kingdom	United States
Uzbekistan					

APPENDIX C: PROOFS OF PROPOSITIONS

Proof of Proposition 1: The derivative of the left hand side of equation 3 with respect to k is

$$\frac{A}{Y_S}\left[\epsilon N_S k^{\epsilon-1} + N_N\left(\epsilon k^{\epsilon-1}F(k) + k^\epsilon \mu(k) - \frac{k^\epsilon \mu(k)}{(\tau w)^\epsilon}\right)\right] + \frac{ABk^\epsilon \mu(k)N_N}{Y_N}. \qquad (12)$$

This is always positive since $\tau > 1$, $w > 1$, and $\tau > w$. Thus, the left hand side of equation 3 is monotonically increasing in k.

Since the left hand side of equation 3 is monotonically increasing in k and the right hand side is a constant, existence and uniqueness of $\overline{k}$ only requires that at $k = \underline{k}$, the left hand side is less than the right hand side of equation 3. This is guaranteed by assuming $B > \frac{Y_N A}{\tau^\epsilon Y_S}$ and $\underline{k}$ is sufficiently small.●

Proof of Proposition 2: The northern firm with technological advancement $k < \overline{k}$ will move to the south if profits from moving to the south are larger than profits from locating in the north, that is, if:

$$\frac{Y_N}{\left(\frac{w}{k}\right)^\epsilon P^N(\overline{k})} + \frac{Y_S}{\left(\frac{\tau w}{k}\right)^\epsilon P^S(\overline{k})} \leq \frac{Y_N}{\left(\frac{\tau}{k}\right)^\epsilon P^N(\overline{k})} + \frac{Y_S}{\left(\frac{1}{k}\right)^\epsilon P^S(\overline{k})} \qquad (13)$$

This condition can be rewritten:

$$\frac{Y_N}{w^\epsilon P^N(\overline{k})} + \frac{Y_S}{(\tau w)^\epsilon P^S(\overline{k})} \leq \frac{Y_N}{\tau^\epsilon P^N(\overline{k})} + \left(\frac{\overline{k}}{k}\right)^\epsilon \frac{Y_S}{P^S(\overline{k})} \qquad (14)$$

Rewriting equation 3 gives:

$$\frac{Y_N}{w^\epsilon P^N(\overline{k})} + \frac{Y_S}{(\tau w)^\epsilon P^S(\overline{k})} = \frac{Y_N}{\tau^\epsilon P^N(\overline{k})} + \frac{Y_S}{P^S(\overline{k})}. \tag{15}$$

The left hand side of equation 14 is the same as the left hand side of equation 15. Since $k < \overline{k}$, we know that equation 14 must hold. ●

Proof of Proposition 3: For the sake of the proof, I first assume that all firms with technology greater than k^* locate in the south and then check that this is true later.

By locating in the north, a northern firm with technological advancement k whose entire set of less advanced competitors has moved to the south will earn profits of $\pi = \pi^N + \pi^S$ where

$$\pi^N = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_N}{\left(\frac{w}{k}\right)^\epsilon P^N(k)} \tag{16}$$

$$\pi^S = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_S}{\left(\frac{\tau w}{k}\right)^\epsilon P^S(k)}$$

$$P^N(k) = N_S \left(\frac{k}{\tau}\right)^\epsilon + N_N \int_0^k \left(\frac{i}{\tau}\right)^\epsilon \mu(i)di + N_N \int_k^{k^*} \left(\frac{i}{w}\right)^\epsilon \mu(i)di$$
$$+ N_N \int_{k^*}^\infty \left(\frac{i}{\tau}\right)^\epsilon \mu(i)di$$

$$P^S(k) = N_S k^\epsilon + N_N \int_0^k k^\epsilon \mu(i)di + N_N \int_k^{k^*} \left(\frac{i}{\tau w}\right)^\epsilon \mu(i)di$$
$$+ N_N \int_{k^*}^\infty i^\epsilon \mu(i)di$$

Profits from locating in the south are:

$$\pi'^N = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_N}{\left(\frac{\tau}{k}\right)^\epsilon P^N(k)} \tag{17}$$

$$\pi'^S = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_S}{\left(\frac{1}{k}\right)^\epsilon P^S(k)}$$

Repeating the analysis from before gives a new threshold $\overline{k}$ below which all firms will locate in the south. All firms with technology $\subseteq (\overline{k}, k^*)$ will locate in the north. $\overline{k}$ is defined implicitly by:

$$\frac{A}{Y_S}\left[N_S\overline{k}^\epsilon + N_N\left(\overline{k}^\epsilon F(\overline{k}) - \frac{G(\overline{k})}{(\tau w)^\epsilon}\right)\right] + \frac{ABG(\overline{k})N_N}{Y_N} = \tag{18}$$
$$\frac{B}{Y_N}\left[\frac{N_S k^\epsilon}{\tau^\epsilon} + \frac{N_N G(k^*)}{w^\epsilon} + \frac{D(k^*)}{\tau^\epsilon}\right] - \frac{A}{Y_S}\left[\frac{N_N G(k^*)}{(\tau w)^\epsilon} + D(k^*)\right]$$
$$D(k^*) = N_N\left(G(\overline{a}) - G(k^*)\right)$$

Again, the left hand side of equation 12 is an unbounded function of k (where $k = \overline{k}$), and the right hand side is a constant.

The existence and uniqueness of $\overline{k}$ follow from Assumption 2 and is proved exactly as before. Assumption 2 again guarantees that the left hand side of equation 12 is less than the right hand side at $\underline{k}$ and that the right hand side is monotonically increasing in k. The proof that all northern firms with technology less than $\overline{k}$ go to the south is exactly as in Proposition 2.

The assumption that all northern firms with technology greater than k^* locate in the south holds at equilibrium. At equilibrium, firms with technology greater than k^* are technically indifferent between locating in the north and the south. Recall that at equilibrium equation 4 holds as an equality so that a northern firm who will not change P^S by moving to the south is indifferent between locating in the north or the south. Since firms with technology higher than k^* cannot be imitated, they do not change P^S by locating in the south. They are indifferent between locating in the north and the south and can be assumed to go to the south.

This indifference breaks down, and very productive firms prefer moving to the south, the moment imitation is anything less than instantaneous. If imitation takes two periods to occur fully, very productive firms will enjoy rents from locating to the south for the one transition period (since P^S will not be at its long run high level) and be indifferent between locating in the north or south thereafter.[32]

A complication exists if $k^* < \overline{k}$. However, as long as C is sufficiently large, this will never be the case.●

APPENDIX D: THREE COUNTRY MODEL

This appendix presents the model where the world consists of three countries, two northern countries named the east and the west, and one southern country. For the sake of convenience , the two northern countries are assumed to be symmetric.

The northern firm now owns a plant in its home market (i.e. a western firm has a plant in the western market). Demand for its good in the home market is entirely serviced by the home plant. The western firm decides whether to build a plant in the east or the south to service the entire foreign market. It must be assumed that the firm cannot build a plant both in the east and the south.

Northern firms with technology beyond k^* are immune to imitation by the framework given before. Because conditions in the east and the west are symmetric, firm decision is the same for an eastern or western firm. Thus, a prototypical northern firm by locating its foreign plant in the

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[32]The model can be written with all the same results to include an extra fixed cost associated with locating to the south. With this fixed cost, the indifference again breaks down, and firms with technology greater than k^* prefer locating in the south.

north earns profit of $\pi = \pi^H + \pi^N + \pi^S$ where

$$\pi^H = \pi^N = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_N}{\left(\frac{w}{k}\right)^\epsilon P^N(k)} \tag{19}$$

$$\pi^S = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_S}{\left(\frac{\tau w}{k}\right)^\epsilon P^S(k)}$$

$$P^N(k) = N_S \left(\frac{k}{\tau}\right)^\epsilon + N_N \int_0^k \left(\frac{i}{\tau}\right)^\epsilon \mu(i)di + N_N \int_k^{k^*} \left(\frac{i}{w}\right)^\epsilon \mu(i)di +$$
$$N_N \int_{k^*}^\infty \left(\frac{i}{\tau}\right)^\epsilon \mu(i)di + N_N \int_0^\infty i^\epsilon \mu(i)di$$
$$P^S(k) = N_S k^\epsilon + 2N_N \int_0^k k^\epsilon \mu(i)di + 2N_N \int_k^{k^*} \left(\frac{i}{\tau w}\right)^\epsilon \mu(i)di$$
$$+2N_N \int_{k^*}^\infty i^\epsilon \mu(i)di$$

Profits from locating in the south are $\pi' = \pi^H + \pi'^N + \pi'^S$:

$$\pi'^N = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_N}{\left(\frac{\tau}{k}\right)^\epsilon P^N(k)} \tag{20}$$

$$\pi'^S = \frac{\sigma\left(\frac{1}{\sigma}-1\right)Y_S}{\left(\frac{1}{k}\right)^\epsilon P^S(k)}$$

Again, northern firms will locate in the south if $\pi \leq \pi'$. This will be true as long as k is less than $\overline{k}$ where $\overline{k}$ is defined implicitly by:

$$\frac{A}{Y_S}\left[N_S\overline{k}^\epsilon + 2N_N\left(\overline{k}^\epsilon F(\overline{k}) - \frac{G(\overline{k})}{(\tau w)^\epsilon}\right)\right] + \frac{ABG(\overline{k})N_N}{Y_N} = \tag{21}$$
$$\frac{B}{Y_N}\left[\frac{N_S k^\epsilon}{\tau^\epsilon} + \frac{N_N G(k^*)}{w^\epsilon} + \frac{D(k^*)}{\tau^\epsilon} + N_N G(\overline{a})\right]$$
$$-\frac{2A}{Y_S}\left[\frac{N_N G(k^*)}{(\tau w)^\epsilon} + D(k^*)\right]$$

With assumption 3, the proof that all firms with technology less than $\overline{k}$ locate in the south and that all firms with technology greater than k^* locate in the south are the same as in Proposition 3.

Assumption 3 .

(1) $\tau > w > 1$.

(2) $N_S \underline{k}^\epsilon \left[\frac{A}{Y_S} - \frac{B}{Y_N}\right] < ABN_N G(k^*(C)) \left[\frac{1}{Y_N} + \frac{2}{Y_S}\right] + N_N G(\overline{a}) \left[\frac{B}{Y_N\tau^\epsilon} - \frac{2A}{Y_S}\right] + \frac{BN_N G(\overline{a})}{Y_N}.$

(3) C is sufficiently high.

(4) $G(\overline{a})$ is bounded.
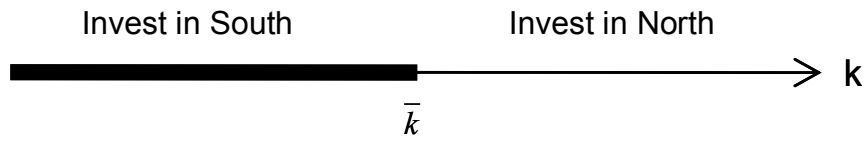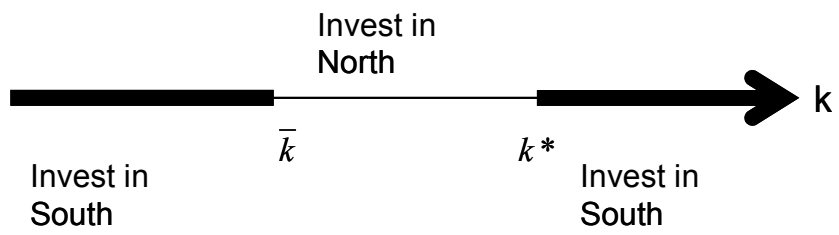
Invest in South　　　　　　　Invest in North

$$\longrightarrow k$$

$$\overline{k}$$

Figure 1

Invest in
North

$$\longrightarrow k$$

$$\overline{k}$$　　　　　$$k*$$

Invest in
South

Invest in
South

Figure 2

Table 1: Extensive Margin

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10) Relative Sales	(11) Relative Empl
	Full	No Out	Full	No Out	Full	Full	Full	Full	No Out		
R&D%	0.26	-2.26	-14.13	-18.12	-14.85	-14.55	-14.00	-14.44	-18.87	-1.68	-1.76
	(2.16)	(1.21)+	(3.65)**	(6.22)**	(4.02)**	(3.34)**	(3.60)**	(3.56)**	(6.54)**	(0.28)**	(0.29)**
R&D% sq			44.59	62.68	45.94	45.38	43.90	44.74	64.57	5.81	5.66
			(12.52)**	(21.50)**	(13.39)**	(11.81)**	(12.84)**	(12.72)**	(21.62)**	(0.58)**	(0.50)**
Tax Mean	-23.37	-32.37	21.39	33.80	25.03	22.39	22.51	24.19	38.73	2.81	6.52
	(9.48)*	(10.22)**	(102.41)	(105.65)	(85.75)	(97.87)	(93.58)	(85.78)	(78.42)	(4.01)	(4.80)
Tax Mean Sq			-79.87	-106.14	-85.33	-81.31	-80.75	-83.22	-112.97	-11.43	-17.13
			(161.57)	(161.89)	(138.15)	(155.38)	(148.91)	(138.02)	(123.49)	(7.11)	(8.54)+
Tax Min	36.34	46.16	43.06	47.85	42.86	43.14	42.86	42.69	47.68	6.84	7.24
	(11.63)**	(14.49)**	(12.85)**	(14.07)**	(12.96)**	(12.92)**	(12.77)**	(12.83)**	(14.23)**	(0.95)**	(1.10)**
Nmbr	0.67	0.74	0.73	0.77	0.72	0.73	0.72	0.71	0.75	0.02	0.03
	(0.16)**	(0.20)**	(0.17)**	(0.19)**	(0.17)**	(0.17)**	(0.17)**	(0.17)**	(0.19)**	(0.00)**	(0.00)**
Cap Intensity					0.15			0.08	0.10	0.01	0.02
					(0.09)+			(0.13)	(0.14)	(0.03)	(0.03)
ln wage						0.09		0.01	0.02	-0.01	0.01
						(0.25)		(0.30)	(0.29)	(0.04)	(0.04)
ln sales							0.19	0.17	0.18	0.03	0.03
							(0.08)*	(0.09)+	(0.10)+	(0.01)+	(0.01)*
Obs	334	331	334	331	334	334	334	334	331	387	387
Turning Point			0.16	0.14	0.16	0.16	0.16	0.16	0.15	0.14	0.16
CI			.12 - .20	.13 - .16	.12 - .20	.12 - .20	.12 - .20	.12 - .21	.13 - 16	.11 - .18	.11 - .20
Percentage			>90%	>90%	>90%	>90%	>90%	>90%	>90%	>90%	>90%

Notes:
Dependent variable is 1 if parent has affiliate in a weak IPR country.
Industry dummies at the 4 digit NAICS level included in all regressions.
Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.
Turning Point is the level of R&D% such that increases in R&D% have a positive effect.
CI is the confidence interval associated with the turning point.
Percentage gives the percentage of firms with R&D% less than the turning point.
No Out excludes firms whose R&D% is in the highest 1% of the sample.
Standard errors are clustered at a general industry level.
Standard errors are in parentheses.
+ indicates significance at the 10% level, * at the 5% level, and ** at the 1% level.
Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

Table 2: Technology Classifications

Dep Variable	(1) Weak	(2) Weak	(3) Relative Sales	(4) Relative Sales	(5) Relative Empl	(6) Relative Empl
Sample	Tech	No Tech	Tech	No Tech	Tech	No Tech
R&D %	-21.75	-11.05	-2.22	-1.29	-2.44	-1.35
	(6.71)**	(8.25)	(0.82)**	(0.79)	(0.90)**	(0.83)
R&D % Sq	49.01	53.67	6.80	5.54	6.52	5.55
	(22.07)*	(23.55)*	(2.26)**	(2.02)**	(2.37)**	(2.18)*
Tax Mean	-209.49	151.10	-5.97	8.52	-0.42	10.44
	(84.52)*	(42.89)**	-3.82	(5.07)+	-5.41	(5.13)*
Tax Mean Sq	277.21	-300.01	3.21	-20.61	-5.32	-23.57
	(128.07)*	(81.25)**	(6.92)	(8.63)*	(9.22)	(8.62)**
Tax Min	35.34	71.53	5.87	7.48	6.26	7.96
	(12.04)**	(16.57)**	(1.18)**	(1.42)**	(1.24)**	(1.43)**
Nmbr	0.61	1.03	0.02	0.02	0.03	0.03
	(0.20)**	(0.20)**	(0.01)*	(0.01)**	(0.01)**	(0.01)**
Cap Intensity	0.09	0.06	0.07	-0.01	0.06	0.01
	(0.27)	(0.16)	(0.05)	(0.03)	(0.05)	(0.03)
ln wage	0.75	-0.08	0.00	-0.04	0.09	-0.05
	(0.54)	(0.30)	(0.08)	(0.05)	(0.09)	(0.05)
ln sales	0.52	0.03	0.04	0.00	0.05	0.00
	(0.16)**	(0.13)	(0.02)	(0.02)	(0.03)+	(0.02)
Obs	146	188	157	230	157	230
Turning Point	0.22	0.10	0.16	0.12	0.19	0.12
CI	.14 -.30	.03 - .18	.10 - .22	0.04 - 0.19	.12 - .26	.10 - .19
Percentage	>90%	>90%	>75%	>90%	>90%	>90%

Notes:

Industry dummies at the 4 digit NAICS level included in all regressions.

Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.

Turning Point is the level of R&D% such that increases in R&D% have a positive effect.

CI is the confidence interval associated with the turning point.

Percentage gives the percentage of firms with R&D% less than the turning point.

No Out excludes firms whose R&D% is in the highest 1% of the sample.

Standard errors are corrected with White's correction for heteroskedasticity.

Standard errors are in parentheses.

+ indicates significance at 10% level, * at 5% level, and ** at 1% level.

Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

Table 3: Industy by Industry Regressions

	Extensive		Sales %		Empl %	
	Linear	Squared	Linear	Squared	Linear	Squared
Food, Beverage, and Tobacco	-1182.48 (531.42)*	64028.41 (24,213.81)**	-113.29 (47.24)*	5473.48 (2,068.08)**	-94.46 (47.07)*	5021.76 (2,055.90)*
Textiles, Apparel, and Leather	-226.54 (137.11)+	9033.71 (4,505.48)*	-17.23 (18.47)	369.83 (338.55)	-27.90 (20.47)	538.42 (378.09)
Wood Products and Paper	-342.28 (311.93)	7553.61 (13999.59)	-31.49 (29.12)	1407.93 (1269.63)	-25.23 (30.83)	1080.89 (1360.68)
Chemicals, Plastics and Rubber Products and Non-metallic Mineral Products	2.35 (22.17)	87.31 (86.79)	-3.76 (3.00)	20.35 (12.97)	-3.82 (3.50)	21.59 (14.08)
Primary and Fabricated Metals	-11834.08 (2,623.47)**	5593876.38 (1,729,554.14)**	-4.86 (15.04)	288.44 (345.11)	7.98 (14.49)	-203.65 (367.12)
Machinery	-45.86 (13.24)**	144.16 (50.95)**	-0.62 (1.48)	3.38 (4.57)	-1.41 (1.80)	4.46 (5.53)
Computers and Electronics	-7.92 (8.03)	13.66 (25.31)	-2.12 (1.16)+	6.37 (2.74)*	-2.10 (1.31)	5.95 (3.05)+
Electrical Equipment, Appliances and Components	-142.58 (57.03)*	1313.91 (559.86)*	-20.89 (9.13)*	135.23 (53.42)*	-20.67 (9.41)*	135.04 (55.94)*
Transportation Equipment	329.21 (74.54)**	-12546.20 (2,263.24)**	-6.78 (6.63)	36.83 (60.66)	-8.32 (6.92)	47.71 (63.11)
Furniture and Related Products	1901.64 (2365.66)	-212305.35 (323982.23)	61.68 (103.90)	-3593.90 (4557.29)	53.98 (104.19)	-3283.30 (4580.20)
Miscellaneous Manufacturing	-188.10 (47.13)**	715.09 (216.52)**	-4.49 (2.99)	22.28 (14.36)	-2.63 (5.71)	13.70 (28.76)
Professional, Scientific, and Technical Services	-14.23 (9.39)	61.51 (24.56)*	-1.71 (1.12)	5.92 (2.54)*	-1.55 (1.01)	5.40 (2.39)*
Observations		334		387		387

Notes:

Dependent variable is 1 if parent has affiliate in a weak IPR country.

Industry dummies at the 4 digit NAICS level included in all regressions.

Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.

Turning Point is the level of R&D% such that increases in R&D% have a positive effect.

CI is the confidence interval associated with the turning point.

Percentage gives the percentage of firms with R&D% less than the turning point.

Standard errors are corrected with White's correction for heteroskedasticity.

Standard errors are in parentheses.

+ indicates significance at the 10% level, * at the 5% level, and ** at the 1% level.

Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

Table 4: Market Size Classifications

Dep Variable	(1) NOECD	(2) NOECD	(3) NOECD	(4) NOECD	(5) Relative Sales	(6) Relative Empl
	Full	No Out	Full	No Out	Full	Full
R&D %	2.57	1.38	0.70	6.92	-0.06	-0.28
	(1.12)*	(1.40)	(4.07)	(5.82)	(0.60)	(0.51)
R&D % Sq			6.21	-22.88	1.27	1.80
			(11.34)	(20.13)	(1.36)	(1.34)
Tax Mean	-12.73	-12.77	13.42	11.54	-2.70	-2.66
	(2.76)**	(2.89)**	(21.23)	(20.62)	(4.14)	(4.68)
Tax Mean Sq			-44.56	-40.33	-0.36	-0.29
			(36.86)	(35.51)	(6.96)	(7.70)
Tax Min	5.70	5.58	5.58	5.75	1.29	1.30
	(2.73)*	(2.74)*	(2.45)*	(2.34)*	(0.70)+	(0.55)*
Nmbr	0.36	0.36	0.35	0.35	0.01	0.02
	(0.13)**	(0.13)**	(0.13)**	(0.13)**	(0.00)+	(0.01)**
Cap Intensity	-0.05	-0.06	-0.07	-0.12	0.01	0.01
	(0.11)	(0.11)	(0.12)	(0.12)	(0.02)	(0.02)
ln wage	0.10	0.15	0.11	0.17	-0.01	0.00
	(0.17)	(0.17)	(0.17)	(0.19)	(0.02)	(0.03)
ln sales	0.10	0.09	0.11	0.13	0.00	0.00
	(0.06)	(0.06)	(0.06)+	(0.06)*	(0.01)	(0.01)
Obs	291	288	291	288	371	371

Notes:

Industry dummies at the 4 digit NAICS level included in all regressions.

Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.

No Out excludes firms whose R&D% is in the highest 1% of the sample.

Standard errors are clustered at a general industry level.

Standard errors are in parentheses.

+ indicates significance at 10% level, * at 5% level, and ** at 1% level.

Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

Table 5: OECD Classifications

Dep Variable	(1) NOECD Full	(2) NOECD No Out	(3) NOECD Full	(4) NOECD No Out	(5) Relative Sales Full	(6) Relative Empl Full
R&D %	-0.65	-1.77	-5.80	-5.14	-1.01	-1.15
	(1.02)	(1.36)	(4.82)	(9.85)	(0.27)**	(0.33)**
R&D % Sq			14.39	12.31	3.73	4.04
			(11.87)	(35.52)	(1.19)**	(1.45)*
Tax Mean	-31.37	-32.08	-389.20	-385.48	-10.96	-7.82
	(8.30)**	(8.31)**	(74.15)**	(67.10)**	(3.06)**	(3.94)+
Tax Mean Sq			539.56	533.63	10.88	5.82
			(117.60)**	(107.53)**	(6.00)+	-7.01
Tax Min	19.51	18.44	16.54	16.04	2.63	2.56
	(9.58)*	(9.52)+	(9.43)+	(9.15)+	(1.43)+	(1.24)+
Nmbr	0.48	0.47	0.50	0.50	0.01	0.02
	(0.17)**	(0.17)**	(0.17)**	(0.17)**	(0.01)+	(0.01)**
Cap Intensity	0.33	0.32	0.26	0.25	0.02	0.03
	(0.17)+	(0.17)+	(0.19)	(0.17)	(0.02)	(0.02)+
ln wage	0.22	0.28	0.26	0.28	0.00	0.00
	(0.23)	(0.20)	(0.23)	(0.21)	(0.02)	(0.02)
ln sales	0.11	0.13	0.16	0.17	0.02	0.01
	(0.08)	(0.09)	(0.09)+	(0.09)*	(0.01)	(0.01)
Obs	328	325	328	325	387	387
Turning Point			0.2	0.21	0.13	0.14
CI			.14 - .26	-.21 - .63	.09 - .18	.09 - .20
Percentage			>90%	>90%	>90%	>90%

Notes:

Industry dummies at the 4 digit NAICS level included in all regressions.

Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.

Turning Point is the level of R&D% such that increases in R&D% have a positive effect.

CI is the confidence interval associated with the turning point.

Percentage gives the percentage of firms with R&D% less than the turning point.

No Out excludes firms whose R&D% is in the highest 1% of the sample.

Standard errors are clustered at a general industry level.

For technology and non-tech subsamples, standard errors are only corrected with White's correction for heteroskedasticity.

Standard errors are in parentheses.

+ indicates significance at 10% level, * at 5% level, and ** at 1% level.

Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

Table 6: Human Capital Classificatoins

Dep Variable	(1) LEDUC	(2) LEDUC	(3) LEDUC	(4) LEDUC	(5) Relative Sales	(6) Relative Empl
Sample	Full	No Out	Full	No Out	Full	Full
R&D %	0.59	1.97	3.72	-1.63	-0.08	-0.11
	(2.15)	(1.80)	(2.98)	(4.34)	(0.63)	(0.62)
R&D % Sq			-10.94	14.21	1.01	0.86
			(8.95)	(14.28)	(1.69)	(1.83)
Tax Mean	-24.89	-25.67	21.59	31.76	-1.61	1.45
	(6.18)**	(6.68)**	-37.33	-28.30	-4.00	-4.86
Tax Mean Sq			-69.80	-87.51	-1.34	-5.61
			(54.37)	(42.19)*	(6.78)	(8.03)
Tax Min	40.98	42.24	40.82	41.80	3.65	3.40
	(6.74)**	(7.36)**	(6.45)**	(6.85)**	(0.68)**	(0.80)**
Nmbr	1.27	1.29	1.27	1.28	0.02	0.03
	(0.20)**	(0.22)**	(0.22)**	(0.23)**	(0.01)+	(0.01)**
Cap Intensity	-0.08	-0.09	-0.08	-0.06	0.02	0.04
	(0.17)	(0.18)	(0.17)	(0.18)	(0.04)	(0.03)
ln wage	-0.24	-0.28	-0.26	-0.30	0.00	0.00
	(0.33)	(0.31)	(0.33)	(0.30)	(0.04)	(0.05)
ln sales	0.00	0.02	-0.01	-0.01	0.00	-0.01
	(0.15)	(0.15)	(0.15)	(0.15)	(0.02)	(0.02)
Obs	333	330	333	330	373	373

Notes:
Industry dummies at the 4 digit NAICS level included in all regressions.
Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.
No Out excludes firms whose R&D% is in the highest 1% of the sample.
Standard errors are clustered at a general industry level.
Standard errors are in parentheses.
+ indicates significance at 10% level, * at 5% level, and ** at 1% level.
Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

Table 7: Distance Classifications

Dep Variable	(1) Far	(2) Far	(3) Far	(4) Far	(5) Relative Sales	(6) Relative Empl
Sample	Full	No Out	Full	No Out	Full	Full
R&D %	0.27	0.66	-0.27	-2.67	0.92	0.74
	(1.54)	(2.06)	(3.95)	(4.81)	(0.49)+	(0.42)+
R&D % Sq			1.70	14.40	-0.09	0.80
			(8.43)	(12.84)	(1.10)	(0.97)
Tax Mean	-14.60	-14.56	-23.35	-21.14	2.68	-1.64
	(3.73)**	(3.76)**	-22.26	-21.68	-3.79	-4.13
Tax Mean Sq			14.74	10.45	-12.62	-5.78
			(36.93)	(35.98)	(6.34)+	(7.03)
Tax Min	11.38	11.16	11.52	11.31	2.62	2.55
	(4.05)**	(4.07)**	(4.00)**	(3.97)**	(0.52)**	(0.49)**
Nmbr	0.85	0.84	0.85	0.85	0.03	0.04
	(0.18)**	(0.18)**	(0.18)**	(0.18)**	(0.01)**	(0.01)**
Cap Intensity	0.13	0.13	0.14	0.14	0.04	0.04
	(0.14)	(0.14)	(0.14)	(0.14)	(0.03)	(0.02)+
ln wage	0.23	0.22	0.23	0.22	0.00	-0.02
	(0.26)	(0.27)	(0.26)	(0.28)	(0.04)	(0.04)
ln sales	0.12	0.13	0.11	0.12	0.04	0.02
	(0.16)	(0.16)	(0.15)	(0.15)	(0.02)+	(0.01)+
Obs	321	318	321	318	364	364

Notes:

Industry dummies at the 4 digit NAICS level included in all regressions.

Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.

No Out excludes firms whose R&D% is in the highest 1% of the sample.

Standard errors are clustered at a general industry level.

Standard errors are in parentheses.

+ indicates significance at 10% level, * at 5% level, and ** at 1% level.

Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

Table 8: Social Infrastructure Classifications

Dep Variable	(1) Weak	(2) Weak	(3) Weak	(4) Weak	(5) Relative Sales	(6) Relative Empl
Sample	Full	No Out	Full	No Out	Full	Full
R&D %	0.94	0.79	-2.62	-5.59	-1.03	-1.00
	(1.24)	(1.93)	(6.61)	(6.86)	(0.57)+	(0.62)
R&D % Sq			11.53	25.23	2.71	2.48
			(18.47)	(19.57)	(1.11)*	(1.11)*
Tax Mean	-10.57	-10.37	20.81	21.35	1.41	3.25
	(2.92)**	(3.08)**	-19.41	-19.53	-4.68	-4.96
Tax Mean Sq			-52.07	-53.23	-6.50	-8.70
			(34.64)	(35.03)	(8.68)	(9.06)
Tax Min	15.81	15.55	16.23	16.09	3.36	3.34
	(5.19)**	(5.29)**	(5.32)**	(5.42)**	(0.82)**	(0.82)**
Nmbr	0.44	0.44	0.44	0.44	0.01	0.03
	(0.13)**	(0.13)**	(0.13)**	(0.14)**	(0.01)	(0.01)*
Cap Intensity	0.11	0.11	0.12	0.14	0.02	0.04
	(0.10)	(0.10)	(0.10)	(0.10)	(0.03)	(0.03)
ln wage	-0.18	-0.18	-0.17	-0.19	-0.04	-0.04
	(0.26)	(0.28)	(0.28)	(0.28)	(0.05)	(0.06)
ln sales	0.06	0.06	0.07	0.06	0.01	0.01
	(0.07)	(0.07)	(0.06)	(0.06)	(0.02)	(0.02)
Obs	322	319	322	319	375	375
Turning Point			0.11	0.11	0.19	0.2
CI			-0.09 - 0.32	-.01 - .21	.09 - .29	.07 - .33
Percentage			>75%	>75%	>90%	>90%

Notes:

Industry dummies at the 4 digit NAICS level included in all regressions.

Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.

Turning Point is the level of R&D% such that increases in R&D% have a positive effect.
CI is the confidence interval associated with the turning point.
Percentage gives the percentage of firms with R&D% less than the turning point.
No Out excludes firms whose R&D% is in the highest 1% of the sample.
Standard errors are clustered at a general industry level.
For the technology and non-tech subsamples, standard errors only include White's correction for heteroskedasticity.
Standard errors are in parentheses.
+ indicates significance at 10% level, * at 5% level, and ** at 1% level.
Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

Table 9: Alternative Estimation

Weak * R&D%	-8.78	
	(4.43)	*
Weak * R&D% Sq	23.49	
	(11.12)	*
Weak * ln Sales	27.92	
	(9.58)	**
Weak * Cap Int	1.89	
	(1.27)	+
Weak * ln Wage	-4.77	
	(5.13)	
ln GDPPC	-3.57	
	(4.21)	
ln Pop	1.65	
	(0.78)	*
Tax Rate	-3.70	
	(1.49)	**
Ln Distance	-9.32	
	(1.26)	**
Education	1.04	
	(0.79)	
Social Infrastructure	0.74	
	(1.05)	+
Obs	274	

Notes:

Industry dummies at the 4 digit NAICS level included in all regressions.

Only parents with NAICS industries 3111 to 3399 or 5133 to 5142 or 5413 to 5419 are included.

Standard errors are in parentheses.

+ indicates significance at 10% level, * at 5% level, and ** at 1% level.

The log likelihood function is very flat at the optimum. These results should be interpreted with caution.

Regressions do not include one obvious outlier where R&D% > 1 and more than twice as large as next largest value.

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