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Intellectual Property Rights and Multinational Firms Modes of Entry

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Abstract

This paper studies the relationship between intellectual property rights (IPR) of a country and the modes of entry to the country by multinational firms. A model is developed that allows firms with new technologies to choose among three modes of entry: exporting, foreign direct investment (FDI), and licensing. Firms in the recipient country may imitate the technology under any of these entry modes, and their abilities to do so depend both on the nature of each entry mode and on the level of IPR protections in that country. Empirical analysis is conducted for entries by U.S. firms on the 1995 disaggregated data of 135 industries in 62 countries. Using a multinomial logit regression model, it is shown that while stronger IPR increases total entries by multinational firms, it especially enhances the location advantage of FDI and licensing. Unlike the findings in the literature, however, strong IPR impacts positively on FDI more than on licensing. This internalization incentive is reduced in high R&D industries where imitation may become more difficult.

1. Introduction

The issue of intellectual property rights, IPR, has attracted significant interest in trade negotiations and attention among trade economists. This growing interest in IPR is partly driven by two motivations. First, inadequate protection of intellectual property generates losses to firms conducting innovations. According to a study by USITC(1988), worldwide losses due to infringement of property rights are estimated to be around $23.8 billion per year. Second, the IPR system of a country might influence the mode of technology transfers by foreign firms, which in turn could affect growth of the recipient country[1].

It is widely believed that technology diffusion is more likely to occur when arm's length agreements are chosen for the commercialization of a new technology. From a survey, US multinational firms find it more secure to transfer their state-of-the-art technology to a wholly-owned subsidiary rather than to a licensee (Lee and Mansfield, 1996). Therefore, a weak IPR system may provide an internalization motive for a multinational firm to enter through foreign direct investment, FDI, by establishing a wholly owned subsidiary in the recipient market, which is considered to preclude imitation. The argument also applies to exporting, which might also be used as a strategy against imitation and technology diffusion.

The literature studying the entry mode of a firm endowed with new technology into a foreign market has focused on comparing the costs entailed in the different alternatives[2]. The theoretical literature has investigated the effect of IPR enforcement on technology transfer and FDI in several endogenous growth models[3]. Helpman (1993) and Lai (1998) show that innovation is promoted along with FDI when IPR enforcement increases. Vishwasrao (1994) argues that the lack of adequate enforcement of technology transfer agreements may encourage FDI relative to licensing. Glass and Saggi (1999), on

[1] Gould and Gruben(1996), for instance, find a positive relationship between IPR and growth rate using cross-country data.
[2] See Markusen(1995) for a survey.
[3] Several of the papers are linked via their use of the two models used intensively by Grossman and Helpman(1991).

the other hand, finds that FDI actually decreases with stronger IPR protection. Yang and Maskus (2001) find that both innovation and licensing increase with stronger IPR protection. However, as Ferrantino (1993) noted, all the preceding models suffer from a fundamental problem: it is assumed that multinational firms are allowed to transfer their technology to other countries only through one channel, either FDI or licensing. A more complete study requires that innovating firms be given the option of transacting in technology via market. A recent paper by Fosfuri (2000) allows for three modes of entry: exporting, FDI and licensing. She finds that the degree of patent protection in the South plays an important role for multinational firms (MNEs) to choose mode of entry and/or vintage of technology to be transferred. However, she allows imitation to occur only under licensing.

Existing empirical studies mostly only consider separate effects of IPR on a single mode of entry[4]. Smith(2001) is the only existing empirical study that takes account for the simultaneous effects of IPR on all three entry modes.[5] She finds that strong IPR promotes FDI and licensing activity and has no impact on export activity. Moreover, the effect of IPR on licensing is larger than those on both export and FDI. Since her data set is relatively small, an aggregate data set for 50 countries in 1989, the strength of her results might be diminished due to the lack of cross-industry variability.

Therefore, an interesting and important research question that largely remains to be answered is: ***What are the consequences of strengthening IPR protection in the recipient country on modes of entry by multinational firms if the latter can choose between licensing, FDI and export?*** The answer to this question can provide insights to the implications of recent international agreements on IPR. Moreover, this information could be important for the recipient countries in formulating their intellectual property protection policies.

In this paper, I answer the research question posted above by examining the impact of IPR of a country on US firms' mode of entry decision to that country, allowing

[4] For example, Maskus and Penubarti(1995) and Smith(1999) study the impact of IPRs on trade alone; Lee and Mansfield(1996) analyze the impact of IPRs on FDI alone; Yang(1998) links IPRs with licensing alone; Nicholson(2001) links IPRs with FDI and licensing but studies effects of IPRs on each mode of entry separately.

[5] Maskus (1998) and Ferrantino (1993) have also considered the simultaneous decisions of entry modes, but they allow only two modes of entry: export and FDI.

the firms to choose among (1) establish an affiliate abroad (FDI) or (2) to license knowledge assets to an unaffiliated foreign firm or (3) to export. To conduct the empirical analysis, I first develop a theoretical framework in which a firm's relative profitability from different entry modes can be evaluated. The simple theoretical model departs from the literature in several aspects. It not only allows MNEs to choose from all three mode of entry, but also allows imitation to occur in all three modes[6]. Furthermore, it allows for different degrees of imitation when MNEs decide to serve the foreign market in different modes.

Based on the theoretical formulation, I then develop the empirical analysis that adds to the literature in several aspects. First, the analysis accounts for the simultaneous effects of IPR on exports, FDI, and licensing. It therefore enables me to answer the question of what the consequences of strengthening IPR in the recipient country are if multinational firms can choose their modes of entry, while the existing literature, with the exception of Smith (2001), does not address this question by considering the effects of IPR on each mode of entry separately. Second, in addition to Smith (2001), a new data set that I obtained from the Bureau of Economic Analysis (BEA) is not only larger and more recent (1995), it is also disaggregated into industry level (135 industries in 62 countries). This allows me to analyze the impact of IPR on mode of entry in different R&D intensity industries. In other words, the disaggregated data set allows me to investigate the effects of industry specific differences on entry mode decision by MNE. Third, since the exports, FDI, and licensing data are in the form of number of firms engaging in these activities, it allows me to study effects of country characteristics and/or IPRs on the change in the ***probability*** of each entry mode by MNEs. Therefore, I can analyze what encourages MNEs to switch their mode of entry, while the use of volume of each mode of entry cannot[7].

We find that strong IPR in a country encourages MNEs' entry to the country. However, when a firm can choose between the three modes of entry, strong IPR actually reduces the use of exporting while increasing both FDI and licensing. Contrary to the

[6]Helpman(1993), Lai(1998), Glass and Saggi(1999), and Yang and Maskus(2001) allow only one mode of technology transfer in their model. Vishwasrao(1994), Ethier and Markusen(1996), and Fosfuri(2000) allow imitation to occur in one mode only.

[7] Ferrantino (1993), Maskus (1998) and Smith (2001) all use volumes of trade, FDI and licensing fees in their studies.

finding in the literature, an increase in IPR results in a high probability of FDI than of licensing. This suggests that the incentive for internalization remains strong with high IPR. This incentive, however, does become lower in industries with high R&D, perhaps due to reduced threat of imitation in these industries.

The rest of the paper is organized as follows. Section 2 develops a simple model that forms hypotheses to be tested empirically. Section 3 describes the econometric specification and data set. Section 4 provides the core empirical analyses. Concluding remarks are contained in Section 5.

2. Model

In this section, I develop a model that analyzes the effect of IPR on modes of entry by MNEs[8]. The theoretical literature that relates IPR to MNEs mostly focus on how IPR affect technology transfer and innovation, not on the entry modes of MNEs. Also, most of the literature, intensively using the model by Grossman and Helpman(1991), allow imitation to occur in only one mode.

The model here allows imitation to occur in all three modes of entry, and, with the use of a profit dissipation rate parameter in a partial equilibrium model, it also allows us to take a much simpler approach in modeling how IPR affects all three entry modes by MNEs.

A multinational firm has three modes of entry to choose from when deciding to serve a foreign market: export, foreign direct investment, and licensing. Assuming that the technology that a multinational firm owns is unique so that when it serves a new market, it can achieve a monopoly profit. This view follows the idea of ownership advantage which arises when firms have assets, including intangible asset such as knowledge, that grant a cost advantage in servicing a market. From finance theory, Mirus(1980), the management will compare the cash flows from these three alternatives and choose the one with the highest positive net present value. Therefore, by comparing

[8] Ethier and Markusen(1996) model the role of knowledge assets in simultaneous servicing decisions accounting for interaction between ownership, location, and internalization; and model patent policies explicitly as the ability to enforce contracts in licensing only. Other literature that studies the impact of IPRs on servicing decisions include Helpman(1993), Markusen(1998), and Fosfuri(2000).

profit from each mode of entry, a multinational firm is able to choose the mode that awards the highest profit. In other words, a multinational firm will choose the entry mode *i* in country *n* if and only if

$$\Pi_n^i > \Pi_n^j \text{ , } \forall i \neq j$$

where Π_n^i is the total profit from mode *i* in country *n*[9].

Assuming that a multinational firm's product has a life of T period, the total profit of a firm when exports, FDI and licenses in country *n* are:

$$\Pi^E = \int_0^T \pi^E e^{-(\beta^E + r)t} dt \tag{1}$$

$$\Pi^F = \left(\int_0^T \pi^F e^{-(\beta^F + r)t} dt \right) - F \tag{2}$$

$$\Pi^L = \int_0^T \pi^L e^{-(\beta^L + r)t} dt \tag{3}$$

where π^E , π^F , and π^L are the instantaneous monopoly profit when a firm exports, FDI, and licenses, respectively. r is a discount rate in the US. F is a fixed cost of setting up a plant in country *n*[10]. β^E, β^F and β^L represent the profit dissipation rate due to imitation in country *n* when a multinational firm serves market *n* by export, FDI and licensing, respectively. β^i are not assumed to be equal in all three modes of technology transfer. Profit in one mode might dissipate faster than in the others due to the nature of each mode. I assume that these β^i are functions of IPR protection in country *n*. When IPR protection in country *n* is stronger, MNE profit should dissipate less, which results in a decrease in β^i. In other words, $\beta^{i'}(\alpha) < 0$, and I assume that $\beta^{i''}(\alpha) \geq 0$ where α is IPR protection in a country.

The difference in the size of the effect of IPR on profit of each mode can be explained by the location and internalization of MNEs. IPR not only affects the decision of whether to serve a foreign market, but it also affects the decision of how to serve a foreign market. Firms engaging in exports hold their knowledge both within the source

[9] Since it is a by-country analysis, I will drop subscript *n* for convenience.
[10] The fixed cost of setting up a plant in country *n* is followed from Markusen and Venables(1998).

country and the firms. If a firm chooses FDI, it transfers the knowledge outside the source country but holds the knowledge within the firm. However, when a firm licenses its knowledge asset to an unaffiliated foreign firm, it transfers knowledge both outside the source country and the firm. Location decision concerns whether or not to transfer knowledge outside the source country, to serve the foreign market through FDI and licensing rather than exports. The location advantages occur when there is a cost advantage of locating production in the foreign country rather than exporting. Examples of this cost advantage are transportation and lower labor costs[11]. Alternatively, cost disadvantages of operating outside the source country reduce location advantages. Imitation of knowledge by foreign firms can also be an example of location disadvantage.

Another decision concerning modes of knowledge transfer is an internalization decision. This decision concerns whether or not to transfer knowledge assets outside the source firm, through licensing, rather than exporting or FDI. Internalization of knowledge occurs when there is a cost advantage from holding assets inside the source firm[12]. Strong IPR decreases the need to internalize knowledge assets within the source firm as a way of inhibiting profit dissipation through imitation. Strong IPR imposes a penalty on foreign firms that defect from their licensing agreements and decreases the odds of defection. Thus, we might expect licensing to be highly responsive to IPR relative to exporting and FDI. Therefore, one might hypothesize that: $\beta^L > \beta^F \geq \beta^E$. Profits of MNEs might dissipate faster when licensing comparing to other modes. We can also think that high β^L is also a result of the incentive rent that a multinational firm has to give up to licensee in order to protect licensee from defecting and starting a new rival firm[13]. Moreover, the profit dissipation rate for both exports and FDI might be the same when the goods are low-tech because it is easy to reverse engineer the product. Profits might dissipate faster under FDI compared to under export when the good is of hi-tech because it may require more exposure to the process to be able to imitate. In other words, it is possible that in a low-tech industry, $\beta^F = \beta^E$, and in a hi-tech industry, $\beta^F > \beta^E$.

[11] See Brainard(1993), Horstmann and Markusen(1987, 1992) and Markusen and Venables(1998).
[12] See Barbosa and Louri(2002)
[13] Yang and Maskus(2001) find a negative relationship between IPR protection and the minimum incentive rent that licensor has to give up to licensee.

The instantaneous monopoly profit from exporting, FDI and licensing[14] is summarized below, respectively:

$$\pi^E = p(A, q^E) * q^E - c(w^{US}, t) * q^E \quad (4)$$

$$\pi^F = p(A, q^F) * q^F - c(w^n) * q^F \quad (5)$$

$$\pi^L = p(A, q^L) * q^L - c(w^n) * q^L \quad (6)$$

where $p(A,q)$ represents demand function with A denotes market size of a country *n*, q^E, q^F, q^L denote monopoly quantity that MNE produce when exporting, FDI, and licensing, respectively. $c(w,t)$ represents marginal cost function with w^{US} and w^n denote effective wage rate per worker in US and in country *n*, respectively. The effective wage rate per one unit of production in country *n* can be calculated from multiplying the real wage rate per worker to number of workers needed to produce one unit of good. t is a unit transportation cost from US to country *n*. Based on the literature of MNEs, the lower marginal cost, lower wage rate and the elimination of transportation cost, is the important reason that MNEs decide to FDI or license in the first place, therefore, I will assume that $c^E(w,t) > c^F(w) = c^L(w)$. With this assumption, we have that the instantaneous profits from FDI and licensing are equal and they are greater than that from exporting, as stated in Lemma 1.

<u>Lemma 1</u> : Assume that $c^E(w,t) > c^F(w) = c^L(w)$. Then, $\pi^{F*} = \pi^{L*} > \pi^{E*}$.

Proof: See Appendix A.

From Lemma 1, we can compare total profit of each mode to analyze when a multinational firm would choose to export, FDI or license.

[14] I assume that there are unlimited amount of local firms; therefore, MNEs can extract all the rents from the licensee.

Proposition 1 : Given a level of β^i, there exists $\overline{F}$ such that $\Pi^{E*} = \Pi^{F*}$. When F < $\overline{F}$, $\Pi^{E*} < \Pi^{F*}$; and when F > $\overline{F}$, $\Pi^{E*} > \Pi^{F*}$. At the fixed cost level $\overline{F}$, total profit in both FDI and export modes are the same.

Figure 1: Relationship between total profit and fixed cost

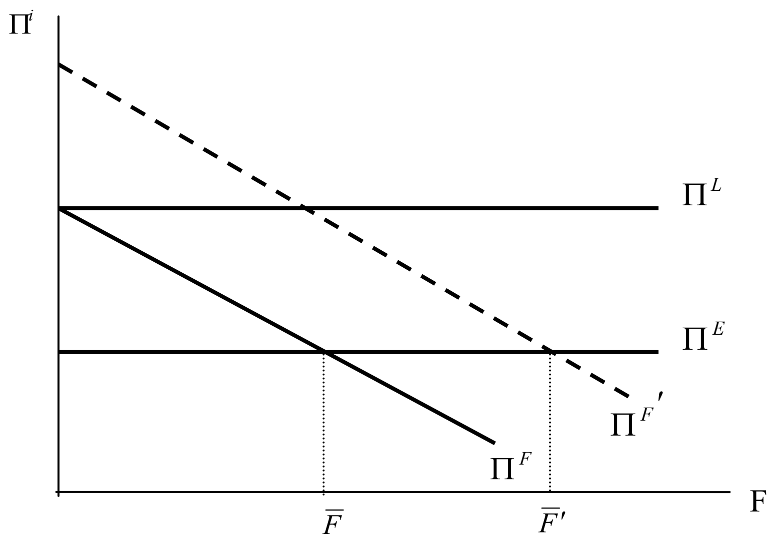


Figure 1 illustrates Lemma 2. The case when assuming that all β^i are equal is presented by solid lines. We can see that at the level of $\overline{F}$, profit in both export and FDI modes are the same. When I let β^F be the smallest while keeping $\beta^L = \beta^E$, we can see that the level of $\overline{F}$ increases to $\overline{F}'$.

Next, we will analyze how each variable affects a multinational firm's profit of each mode of entry. We have:

Proposition 2 :

i) $\frac{\partial \Pi^E}{\partial \alpha} > 0$, $\frac{\partial \Pi^F}{\partial \alpha} > 0$, $\frac{\partial \Pi^L}{\partial \alpha} > 0$.

ii) $\frac{\partial \Pi^E}{\partial A} > 0$, $\frac{\partial \Pi^F}{\partial A} > 0$, $\frac{\partial \Pi^L}{\partial A} > 0$.

iii) $\frac{\partial \Pi^E}{\partial t} < 0.$

iv) $\frac{\partial \Pi^F}{\partial F} < 0.$

v) $\frac{\partial \Pi^E}{\partial w^{US}} < 0$, $\frac{\partial \Pi^F}{\partial w^n} < 0$, $\frac{\partial \Pi^L}{\partial w^n} < 0$.

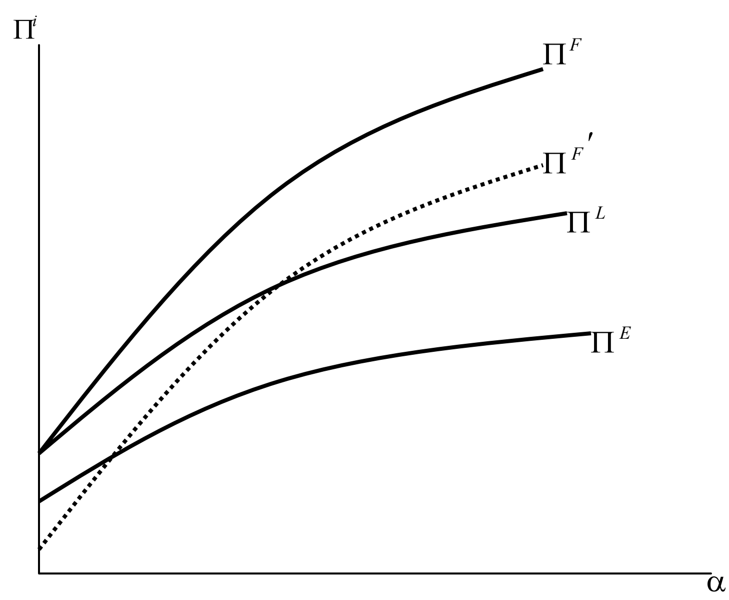
Proof: See Appendix B and C.

That is while profits under all modes increase in IPR, and market size in country *n*, they decrease in the effective wage. Moreover, profits under export decrease in the transportation cost and profits under FDI decrease in the set up cost of a plant in another market (fixed cost).

Strong IPR augments the ownership advantage of the MNEs in the foreign market by providing legal protection against imitation of their assets. Consequently, the protection of MNEs' knowledge assets enhances MNEs' control over and returns to its knowledge assets. This effect can be interpreted in terms of market expansion. The market expansion concept states that strong IPR expands foreign markets available for servicing by ensuring exclusive rights over knowledge that flows to the foreign country. Such knowledge is embodied in exports, FDI, or licensing. In the absence of strong IPR, firms reduce their bilateral exchange to countries where they expect imitation of their knowledge. Thus, under market expansion concept, there is a positive relationship between strong IPR and bilateral exchange, and we should expect this positive relationship when imitative abilities are strong.

It can also be noted that the size of $\frac{\partial \Pi^i}{\partial \alpha}$ depends on β^i and $\beta^{i\prime}(\alpha)$. That is, the size of the effect of IPR protection on the MNEs' profit of each mode depends on profit dissipation rate of each mode and how sensitive these rates are to a change in IPR protection. Therefore, there are many possible cases. For example: If $\beta^L > \beta^F$ and $\left|\beta^{L\prime}(\alpha)\right| \le \left|\beta^{F\prime}(\alpha)\right|$, then $\frac{\partial \Pi^L}{\partial \alpha} < \frac{\partial \Pi^F}{\partial \alpha}$. This condition can be translated to: an increase in IPR affects FDI profit more than it affects licensing profit if the profit dissipation rate when licensing is higher than when FDI but this profit dissipation rate is more sensitive to a change in IPR when FDI than when licensing. (For more cases, see Appendix C). Thus, the argument here is that the effect of IPR on modes of entry might not be as what traditional belief suggests. The internalization theory states that strong IPR reduces the MNEs' internalization incentive. MNE will license their technology rather than FDI or export when IPR protection is strong. In other words, internalization theory suggests that licensing mode should be more responsive to IPR than any other modes. However, as we can see here that this statement might not be true. The responsiveness to IPR depends on both profit dissipation rate in each mode and the sensitivity of these rates to IPR. To illustrate proposition 2 better, figure 2 shows the relationship between IPR and profit in each mode when assuming that $\beta^L > \beta^F$ and $\left|\beta^{L'}(\alpha)\right| < \left|\beta^{F'}(\alpha)\right|$.

Figure 2 : Relationship between total profit and IPR



The case where F = 0 is shown with solid profit lines. When allowing fixed cost to be positive, profit for FDI falls and is shown with the dotted line. We can see that when $\beta^L > \beta^F$ and $\left|\beta^{L'}(\alpha)\right| < \left|\beta^{F'}(\alpha)\right|$, an increase in IPR has stronger positive impact on FDI profit than those on licensing profit. Therefore, we will see more FDI with a stronger IPR protection compare to other modes. However, there are many other possibilities for sizes of β^i and $\beta^{i'}(\alpha)$, therefore, we need an empirical study to understand the effect of IPR on the MNEs' profit.

In sum, we expect positive impacts of IPR protection and market size on profits of all three modes of entry, a negative impact of transportation cost on exporting profit, a negative impact of fixed cost on FDI profit, a negative impact of effective wage rate in country *n* on FDI, and licensing profit and a negative impact of effective wage rate in US on export profit. However, the theory does not determine the relative sizes of these impacts on profit by the three entry modes.

3. Econometric Methods and Data

3.1 Econometric Methods

The econometric methods I will use involve two parts. First, to test the signs of the comparative static results and to replicate results from previous studies, I use fixed-effect negative binomial regression to study the direction of the impact of relevant variables on each mode of entry separately. Second, to test the size of the comparative static results, multinomial logit model is used to further analyze the effect of strengthening IPR protection, including changes in other variables, on the probability of choosing an entry mode by MNEs.

The first empirical model studies directions or signs of each independent variable on each entry mode. Since the data on exports, FDI, and licensing activity are in the form of count of firms that engage in a certain activity in each industry in each country, the fixed-effect negative binomial regression[15] is used in the analysis. This regression method follows the approach of Hausman, Hall, and Griliches(1984). Based on the model in section 2, the structural model to be estimated can be expressed as follow:

[15] See Long (1997) for more detailed explanation on negative binomial regression model.

$$EX = f(\alpha_n, A_n, t_n)$$

$$FDI = f(\alpha_n, A_n, F_n, w_n)$$

$$LIC = f(\alpha_n, A_n, w_n)$$

Where α_n represents IPR protection, A_n denotes market size, t_n represents transportation cost variable, F_n denotes fixed cost, and w_n denotes effective wage rate in destination country as mentioned in the last section.

The second empirical analysis involves the study of the effect of changes in independent variables on probability of choosing an entry mode. The appropriate econometric model to be used here is a multinomial logit model with three choices : exports, FDI and licensing. I will assume that a firm will choose to engage in only one mode of entry. Our dependent variable assumes only three possible values: 0 for a firm engaging in export, 1 for a firm engaging in FDI, and 2 for a firm engaging in licensing. With this multinomial logit model, we will be able to draw conclusion about the relative size of the impact of each variable on entry modes.

From section 2, when a firm chooses to enter a market by mode *i* in country *n*, its profit is:

$$\Pi^i = \frac{\pi^{i*}}{\left(\beta^i + r\right)}\left[1 - e^{-\left(\beta^i + r\right)T}\right] \text{ or}$$

$$\ln \Pi^i = \ln \pi^{i*} + \ln\left[1 - e^{-\left(\beta^i + r\right)T}\right] - \ln\left(\beta^i + r\right)$$

This firm will choose to enter a market with mode *i* if and only if

$$\ln \Pi^i > \ln \Pi^j \quad , \forall i \neq j$$

Since the instantaneous profit from each mode and the profit dissipation rate due to imitation are not observable, country characteristics or country conditions can be used to approximate them. Let the profit a firm *m* can expect from choosing the alternative *i* in country *n* be,

$$\pi^{i*}_{nm} = e^{\delta_i^{'} x_n + \varepsilon_{mi}} \tag{7}$$

and let the discount rate $\left(\beta^i + r\right)$ when a firm chooses the alternative *i* be,

$$\left(\beta^i + r\right) = e^{\gamma' z_n} \tag{8}$$

where the vector x_n and z_n contain the observed country characteristics, δ and γ are the compatible vectors of unknown parameters to be estimated, and ε_{mi} is the stochastic term associated with each choice and firm. The introduction of the stochastic term aims to capture unobserved firm-specific characteristics, and unobserved choice-specific attributes.

Given the stochastic nature of the profit function, the probability that mode *i* is selected by any firm *m* can be written as

$$P_{mi} = \text{Prob}(\ln \Pi_{mi} > \ln \Pi_{mj} \quad \forall i \neq j) \tag{9}$$

To specify a particular discrete choice model, a particular joint distribution of the stochastic term should be selected. The common specification is the multinomial logit model, which assumes that ε_{mi} values are drawn from independent and identical extreme value distribution. The estimated results in the next section that are based on this multinomial logit model provide a set of probabilities for the choices of a firm facing country characteristics x_n. These probabilities[16] are

$$P_{mi} = \frac{\exp(\delta_i' x_n + \gamma_i' z_n)}{1 + \sum_{i=0}^{2} \exp(\delta_i' x_n + \gamma_i' z_n)}, \qquad \text{for } i = 1, 2 \tag{10}$$

and

$$P_{mo} = \frac{1}{1 + \sum_{i=0}^{2} \exp(\delta_i' x_n + \gamma_i' z_n)} \tag{11}$$

This means that the coefficient estimates give the marginal effects of x_n and z_n on the estimated log-odd ratios, which can be computed as

$$\ln\left[\frac{P_{mi}}{P_{m0}}\right] = \hat{\delta}_i' x_n + \hat{\gamma}_i' z_n \tag{12}$$

That is, the estimated coefficients, $\hat{\delta}_i$ and $\hat{\gamma}_i$, give the effects on the odds of choosing the *i* mode over the base choice, say *i* = 0, of changes in the explanatory variables. To obtain

[16] I assume that $T = \infty$ for simplicity. This assumption will be dropped in the future research.

the estimated marginal effects of the regressors (x_n) on the probabilities, one should compute

$$\frac{\partial \hat{P}_i}{\partial x_n} = \hat{P}_i \left[\hat{\delta}_i - \sum_{i=0}^{2} \hat{P}_i \hat{\delta}_i \right] \tag{13}$$

which differs from (11) in its magnitude and interpretation. Since our main objective is to identify the determinants of firms' preferences with respect to the entry mode choice, we will base the discussion of the results on the estimated marginal effects on the probabilities.

The vector of country characteristics x_n includes the market size of country *n*, A_n; the transportation costs from US to country *n*, t_n; the fixed cost of setting up a plant in country *n*, F_n; and the effective wage rate in country *n*, w_n. The vector of country characteristics z_n includes a measure of IPR protection in country *n*, α_n.

3.2 Data

As mentioned earlier, the data on dependent variables-FDI, licensing and exporting-used in this paper possess interesting features that allow us to study the change in probability of each mode being chosen rather than the change in volume of each mode. This data set is obtained from the Bureau of Economic Analysis's survey reports through the Bureau of Census[17]. They are in the form of count variables for the number of U.S. multinational firms engaging in FDI or licensing in the year 1995 and exporting in the year 1994. This data is disaggregated to 3-digit BEA industry code[18]. After the process of cleaning the data set, 135 industries in 62 countries are used.

The choice of independent variables is driven by the theoretical issues and data availability.

To measure IPR protection, I use the GP index in the year 1990, a common measurement of intellectual property rights protection developed by Juan C. Ginarte and Walter G. Park(1997). They examined the patent laws of a comprehensive number of countries, considering five components of the laws: duration of protection, extent of

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[17] This data is kindly provided by Raymond Mataloni, Bureau of Economic Analysis.
[18] A table listed BEA 3-digit industry codes and names are provided in the Appendix D.

coverage, membership in international patent agreements, provisions for loss of protection, and enforcement measures. This index ranges from 0 to 5, with higher numbers reflecting stronger levels of protection. I chose to use the 1990 Ginarte and Park index because it allows for a time lag between the IPR measure (1990) and data on modes of entry (1995). This lag ensures that IPR are exogenous with respect to the modes of entry.

I use GDP of the recipient country as a measure of country *n*'s market size. This data is collected from the World Development Statistics CD-ROM. For data on effective wage rate of country *n*, I use wage rate, collected from Occupational Wages Around the World Database[19] by Freeman and Oostendorp, which is downloaded from NBER website, along with labor productivity or unit labor input requirement, which is calculated by dividing real GDP with labor force data that are collected from the World Development Statistics CD-ROM as well. Distance from country *n* to the US is a good measure to use as a proxy for transportation costs. Therefore, the distance in kilometers from each country's national capital to Washington D.C., obtained from http://www.indo.com/distance/index.html, is used. In fact, one might think that distance variable might be translated to capture the fixed cost variable when MNEs engaging in FDI. Distance can be used to portray the difference in culture, the custom of doing business or even language barrier. The further the countries are, the more differences they might have, and therefore, the higher the fixed cost of setting up a plant there. Another variable that might well captures the fixed cost variable is an economic freedom index. This data is collected from the Economic Freedom of the World 1997, Annual Report (Gwartney and Robert, 1997). The economic freedom index ranges from 0 to 10 with a higher index indicating a higher level of economic freedom. The central elements of this index are personal choice, freedom of exchange and protection of private property, and provision of a stable infrastructure. Therefore, the higher the economic freedom index should relate to a lower fixed cost variable. Another possible measure for fixed cost is the investment cost index developed by Carr, Markusen, and Maskus(2001). This index is an average of ten indices of perceived impediments to investment, reported in the World

[19] For more detail about this data set, see Freeman and Oostendorp(2000).

Competitiveness Report of the World Economic Forum. This index is computed on a scale from 0 to 100, with a higher number indicating higher investment costs.

To study how technology level difference affects entry mode decisions, I use the R&D expenditure to separate data into two groups: high technology group and low technology group. This R&D index is measured by using all costs related to the development of new products and services and it is collected from Nicholson (2001).

Descriptive Statistics of the data set are summarized in Table 1. More detailed Statistics on means and standard deviations of independent variables separated in each mode are summarized in Table 2.

Table 1: Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Export	8370	1.560	3.954	0	59
FDI	8370	1.910	5.719	0	117
License	8370	0.449	1.518	0	22
IPR	62	3.049	0.938	0.33	4.24
Econ Freedom	62	5.885	1.315	1.7	9.3
GDP	62	8.22e+11	1.19e+12	1.85e+09	5.10e+12
Effective Wage	62	0.036	0.016	0.014	0.214
Distance	62	7670.957	4219.557	732	16355
R&D	135	0.032	0.041	0	0.484
Investment Cost	35	40.360	8.502	27.13	61.44

Table 2: Mean and Standard Deviation in each mode

Variable	Export	FDI	License
IPR	2.873 (1.002)	3.188 (0.850)	3.068 (0.965)
Econ Freedom	5.758 (1.395)	6.031 (1.228)	5.705 (1.316)
GDP	7.30e+11 (1.19e+12)	8.76e+11 (1.13e+12)	9.13e+11 (1.42e+12)
Effective Wage	0.036 (0.019)	0.035 (0.012)	0.036 (0.014)
Distance	8058.001 (4356.043)	7216.121 (4097.315)	8261.518 (4039.932)
Investment Cost	41.856 (9.136)	38.960 (7.714)	41.544 (8.583)
Observations	62	60	59

Note: Means are shown together with standard deviations in parentheses.

Table 2 contains some interesting statistics that are worth noting. We can see that out of all three modes, the average value of IPR are higher in FDI and licensing compare to that of the export mode. Economic freedom index is the highest in FDI mode. Moreover, investment cost in FDI mode is the lowest. However, more can be said with the regression analysis in section 4.

4. Empirical Analysis

I start the empirical analysis with the negative binomial regression model to both test the signs of the comparative static results in section 2 and to replicate previous studies' results. Table 3 reports results of the specific effect negative binomial regression model on all three modes separately[20]. The second, third and forth column show the

[20] The investment cost variable is dropped in Table 3 since it is highly insignificant and by including it, the sample size will drop by almost half. There are 62 countries in the data set, while there are only 35 countries that have investment cost data.

coefficients along with the standard errors in parentheses of exports, FDI, and licensing channel, respectively.

Table 3
Negative Binomial Regression Model

Variable	Export (FE)†	FDI (FE)†	License (FE)†
Constant	-0.125 (0.072)	-2.283* (0.137)	0.638* (0.151)
IPR	0.170* (0.019)	0.380* (0.021)	0.240* (0.029)
EF	-	0.397* (0.017)	-
DIST	-3.08e-05* (4.72e-06)	-1.15e-04* (1.28e-14)	-
GDP	3.31e-13* (1.19e-14)	1.64e-13* (1.28e-14)	3.17e-13* (1.46e-14)
W	-	-7.672* (1.068)	-12.198* (1.225)
N	6042	5453	3526
Log-likelihood	-8284.3178	-7246.4238	-2857.9888

Note : Estimated coefficients are shown together with the standard error in parentheses. * denotes significance of variable at 1% level of significance. †: I use fixed effect negative binomial regression in export, FDI, and licensing equations. The results from random effect negative binomial regression are qualitatively similar.

IPR does enhance ownership advantage; therefore, it increases exports, FDI, and licensing activities. Market size, captured by GDP variable, confirms the size effect theory. Distance negatively affects export activity as expected. Distance negatively affects FDI along with economic freedom index positively affects FDI activity, which confirms that an increase in fixed cost reduced the FDI profitability and therefore, decreases FDI activity. Wage negatively affects both FDI and licensing activity due to an increase in the cost structures of both modes. The results from Table 3 confirm the theory prediction from section 2. Moreover, it also replicates the results of previous studies. One interesting point to make here is that, based on the results in Table 3, IPR has the highest impact on FDI then licensing and export. However, the analysis in Table 3 considers the impacts of independent variables on each entry mode separately and therefore; it might be misleading to compare the size of the coefficients from it.

The best way to compare the size of the effects on each mode of entry is to use the multinomial logit model as explained earlier. Table 4 reports the results with export mode being a based category[21]. The second column shows estimated coefficients, $\hat{\delta}_i$ and $\hat{\gamma}_i$, along with standard errors in parentheses for FDI mode, while the third column shows estimated coefficients with standard errors in parentheses for licensing mode. To aid interpretation, the marginal effects of the covariates on the predicted probability of each entry mode are also presented in column 4, 5, and 6[22].

From the second and third column, some results can be drawn. First, the odds of choosing FDI (licensing) mode instead of exports mode will be increased by 1.467 (1.240) times with a one-unit increase in IPR index. Also, a unit increase in economic freedom index will increase the odds of choosing FDI over exports by 1.186 times, but will decrease the odds of choosing licensing over exports by a factor of 0.928.

To make the interpretation easier, we use an average value of all dependent variables to calculate the probability of each mode being chosen. It turns out that at the mean of all variables, the probability of a firm choosing an FDI mode is the highest, with the probability of 0.481, which is slightly higher than the probability of choosing the exports mode with a probability of 0.404. Licensing mode will be chosen with only a probability of 0.115.

[21] The investment cost variable is dropped for the same reasons as in regression analysis in Table 3.
[22] The probabilities at the mean of all independent variables are used in calculating these values.

Table 4
Multinomial Logit Model

(Based Category : Export)

	Model estimates[1]		Marginal effect on probabilities[2]		
Variable	**FDI**	**License**	**Export**	**FDI**	**License**
			Predicted Probabilities		
Constant	-1.453* (0.185)	-1.621* (0.334)	0.404	0.481	0.115
			Marginal Effect		
IPR	0.383* (0.044)	0.215* (0.038)	-0.0844	0.0837	0.0007
Economic Freedom	0.171* (0.021)	-0.075* (0.018)	-0.0297	0.0468	-0.0171
Distance	-5.92e-05* (4.41e-06)	1.09e-05* (4.36e-06)	1.10e-05	-1.54e-05	4.38e-06
GDP	-7.12e-14* (1.73e-14)	7.86e-14* (3.03e-14)	1.02e-14	-2.21e-14	1.19e-14
Effective Wage	-0.959 (1.119)	-0.023 (0.985)	0.1874	-0.2381	0.0507
N	24624				
Log-likelihood	-23115.656				

Note : 1. Estimate coefficients are shown together with the standard error in parentheses. * denotes significance of variable at 5% level of significance.
2. Predicted probabilities and marginal effects are based on the values at mean of all independent variables.

At the mean level, an increase in economic freedom index increases the probability of choosing FDI, while decreases the probability of choosing both exporting and licensing. Economic freedom captures political stability and governmental control. When economic freedom is low, a firm might be less willing to handle these problems by themselves and would either export to that particular market or let a local agent who knows more about the market and how to deal with the government, handles these problems. Once a country becomes more politically stabilize or once a firm knows more about a country, they will be willing to invest and do the business themselves. This confirms the idea that the lack of knowledge of a foreign market conspires against FDI. An example of this (Contractor(1985)) is the experience of Boots, a British pharmaceutical company, choosing to license the production of ibuprofen to Upjohn in the US because of the marketing and sales advantage enjoyed by Upjohn. Upjohn marketed ibuprofen very successfully under the brand Mortrin. When Boots eventually chose to enter the US market itself, and tried to compete with Upjohn, using its own brand Rufen, it could not gain a large market share in spite of lower prices.

Distance at the mean level decreases the probability of choosing FDI mode, while increases the probabilities of choosing both exporting and licensing. This result is surprising and somewhat contradicts to a widely believed thought that distance should negatively affect exports. However, as explained earlier, distance may also be used to capture the difference in culture, the custom of doing business or even language barrier, which can be translated to the fixed cost variable in engaging in FDI. Therefore, this result might be because the fixed cost effect outweighs the transportation cost effect. Then an increase in distance variable decreases probability of engaging in FDI activity and in turn increases the probabilities of both exporting and licensing.

At the mean level, an increase in market size, GDP, increases the probabilities of choosing both exporting and licensing but decreases the probability of FDI[23]. Moreover, the effect is larger in licensing mode than those in export mode, which implies that when a market gets larger, firms prefer licensing to exporting and/or FDI.

An increase in the effective wage rate decreases the probability of choosing FDI but increases the probabilities of choosing both licensing and exporting. This might be due to the fact that when a multinational firm engages in FDI activity, it faces the wage cost directly, while when the multinational firm licenses its technology to a local firm, it is the local firm who bares the wage cost. Therefore, when wage increases, MNEs would be less likely to FDI and switch to licensing or exporting instead.

An increase in IPR index increases the probability of FDI more than those of licensing while decreases the probability of choosing export. The results that an increase in IPR will increase the probability of choosing FDI more than licensing contradicts to

[23] An alternative choice of market size variable is population of the recipient country. The qualitative result in Table 4 remains when using population instead of GDP.

the results by Smith (2001) and to the traditional thought that licensing should be more responsive to IPR relative to FDI. The belief argues that by licensing, a firm locates their knowledge assets outside the source firm, which increases the likelihood of imitation while the firm can reduce this likelihood of imitation by internalizing their knowledge assets by doing FDI. Therefore, an increase in IPR, which reduces the imitation ability, should increase licensing probability by more than that of FDI. However, based on our comparative static analysis, the size of the effect of IPR on FDI and licensing depend on both β^i, profit dissipation rate due to imitation in each mode, and $\beta^{i'}(\alpha)$, how sensitive the dissipation rate in each mode to a change in IPR index. It could be the case that $\beta^L > \beta^F$, and $\left|\beta^{L'}(\alpha)\right| \leq \left|\beta^{F'}(\alpha)\right|$. In other words, licensing dissipation rate is larger than that of FDI but the dissipation rate of FDI mode is more sensitive to IPR than that of licensing, which make $\frac{\partial \Pi^L}{\partial \alpha} < \frac{\partial \Pi^F}{\partial \alpha}$ and leads to the result here. Moreover, as suggested by Smarzynska (1999), in general, different industry structures such as R&D intensities would react differently in terms of mode of entry by nature. Therefore, I next separate data set into two groups: high R&D group and low R&D group[24], and use the same multinomial logit model regression analysis to study whether the difference in each industry's technology level would affect the results of entry mode decisions.

To better understand the effect of IPR protection on the probability of choosing each entry mode, predicted probabilities of each mode at different values of IPR index are summarized in Table 5[25]. We can see that, when other variables are held at their mean level, an increase in IPR protection increases the probability of choosing FDI while decreases the probability of choosing export. This confirms the location advantage concept. IPR increases the probability of licensing up to some level of IPR, and then a further increase in IPR decreases the probability of licensing mode. In other words, we see an inverted U-shape relationship between IPR and the probability of licensing. Based on the results here, on average, firms prefer to engage in FDI more than licensing when

[24] The high R&D group consists of industries that have R&D ≥ 0.03 and the low R&D group consists of industries that have R&D < 0.03.
[25] This table is constructed using the regression results from table 4 and the mean values of all other variables.

they are confident in IPR protection. If IPR protection is really weak, they prefer exporting.

Table 5

Predicted Probabilities of Entry Modes by IPR Index Level

	Probabilities		
IPR	**Export**	**FDI**	**License**
0	0.659	0.244	0.097
1	0.580	0.315	0.106
2	0.494	0.394	0.112
3	0.408	0.477	0.115
4	0.327	0.560	0.114
5	0.254	0.637	0.109

Note : Predicted Probabilities are calculated by holding other independent variables at their mean levels.

Next, to study how R&D intensity affects the entry mode decision, I separate data according to their R&D intensities and do the same analysis. Table 6 and 7 report the regression results of low R&D group and high R&D group, respectively.

Table 6
Low R&D Group

(Based Category : Export)

	Model estimates[1]		Marginal effect on probabilities[2]		
Variable	**FDI**	**License**	**Export**	**FDI**	**License**
			Predicted Probabilities		
Constant	-1.420* (0.250)	-1.895* (0.333)	0.366	0.548	0.086
			Marginal Effect		
IPR	0.440* (0.050)	0.219* (0.053)	-0.095	0.099	-0.004
Economic Freedom	0.169* (0.029)	-0.078* (0.026)	-0.031	0.046	-0.014
Distance	-5.62e-05* (5.53e-06)	2.50e-05* (6.10e-06)	1.05e-05	-1.51e-05	4.61e-06
GDP	-8.97e-14* (1.73e-14)	8.20e-14* (2.52e-14)	1.54e-14	-2.61e-14	1.07e-14
Effective Wage	-0.233 (1.390)	-0.676 (1.668)	0.068	-0.026	-0.042
N	14350				
Log-likelihood	-12613.345				

Note : 1. Estimate coefficients are shown together with the standard error in parentheses. * denotes significance of variable at 5% level of significance.
2. Predicted probabilities and marginal effects are based on the values at mean of all independent variables.

Table 7
High R&D Group

(Based Category : Export)

	Model estimates[1]		Marginal effect on probabilities[2]		
Variable	**FDI**	**License**	**Export**	**FDI**	**License**
			Predicted Probabilities		
Constant	-1.419* (0.263)	-1.372* (0.540)	0.515	0.311	0.174
			Marginal Effect		
IPR	0.315* (0.074)	0.195* (0.061)	-0.068	0.057	0.011
Economic Freedom	0.157* (0.029)	-0.064* (0.023)	-0.019	0.037	-0.018
Distance	-5.96e-05* (8.38e-06)	-3.22e-06 (5.68e-06)	9.83e-06	-1.26e-05	2.76e-06
GDP	-4.73e-14 (3.45e-14)	7.97e-14 (5.06e-14)	4.34e-16	-1.44e-14	1.40e-14
Effective Wage	-3.425* (1.739)	0.882 (1.106)	0.470	-0.782	0.312
N	10274				
Log-likelihood	-10182.181				

Note : 1. Estimate coefficients are shown together with the standard error in parentheses. * denotes significance of variable at 5% level of significance.
2. Predicted probabilities and marginal effects are based on the values at mean of all independent variables.

Comparing the results from table 4, 6 and 7, the effects of economic freedom index, distance, GDP, and effective wage qualitatively do not change much. The main contrast between table 6 and 7 is in the effect of IPR on entry mode decisions. While it is still the case that an increase in IPR increases the probability of choosing FDI and decreases the probability of exporting in both high and low R&D groups, there is an interesting result worth mentioning. In industries with low R&D index, it turns out that an increase in IPR decreases the probability of licensing, while in industries with high R&D index, it increases the probability of licensing. Moreover, an increase in the probability of

FDI is larger than an increase in the probability of licensing in the pooled data of all R&D intensities; while in industries with high R&D index, this difference is pretty small. It could be concluded that overall when IPR increases, firms still internalize their knowledge through FDI mode. However, this happens more in the low R&D industries where technology is easier to be imitated. In other words, when it is harder to imitate the technology (in high R&D industries), firms are more willing to license their technology to the licensee.

In sum, we find that an increase in IPR index increases all three activities. Moreover, at the mean value, IPR increases the probability of choosing FDI more than an increase in the probability of choosing licensing mode, and it decreases the probability of choosing exports. This implies that the size of the impact of IPR on profit of FDI is the highest, then licensing and then exporting. $\frac{\partial \Pi^F}{\partial \alpha} > \frac{\partial \Pi^L}{\partial \alpha} > \frac{\partial \Pi^E}{\partial \alpha}$ on average. An increase in fixed cost (a decrease in economic freedom index and/or an increase in distance) decreases the probability of choosing FDI and increases the probabilities of choosing exporting and licensing. An increase in market size increases the probabilities of choosing exporting and licensing (with a larger effect on licensing), but decreases the probability of choosing FDI.

5. Conclusion

This paper has studied the effects of intellectual property rights protection of a country on the modes of entry of US multinational firms into the country. A key feature of our analysis, one that departs from the existing literature, is to allow the simultaneous consideration of exporting, FDI, and licensing and to allow imitation to occur under each of these three modes. The empirical analysis utilizes a count data set of US firms disaggregated into 3-digit industry level, which allows us to investigate not only the effects of IPR on entry modes in aggregate levels, but also the possible differences of these effects across industries. We find that strong IPR enhances location advantage, in the sense that there are more FDI and licensing with stronger IPR. Surprisingly, however, the probability of licensing does not increase as much as that of FDI, suggesting that the relationship between IPR and the incentive for internalization is more complicated than what is thought of in the literature. One possible explanation for this result is that the profit dissipation rate under FDI is more sensitive to changes in IPR than that under licensing, and that the profit dissipation rate is larger under licensing than under FDI. When we divide the data set into a high-tech group and a low-tech group, this result holds for the low-tech group but becomes insignificant for the high-tech group. It appears that MNEs internalize their knowledge assets more in the low R&D group where imitation is easy; this internalization incentive is reduced in the high R&D industries where imitation may become more difficult.

Appendix A

Proof for Lemma 1

From the assumption that $c^{E}(w,t) > c^{F}(w) = c^{L}(w)$ we can show that

$$\pi^{F*} = p(q^{F*}) \cdot q^{F*} - c^{F}(w) \cdot q^{F*}$$
$$\geq p(q^{E*}) \cdot q^{E*} - c^{F}(w) \cdot q^{E*}$$
$$> p(q^{E*}) \cdot q^{E*} - c^{E}(w,t) \cdot q^{E*} = \pi^{E*}$$
$$\pi^{F*} > \pi^{E*}$$

$$\pi^{F*} = p(q^{F*}) \cdot q^{F*} - c^{F}(w) \cdot q^{F*}$$
$$\geq p(q^{L*}) \cdot q^{L*} - c^{F}(w) \cdot q^{L*}$$
$$= p(q^{L*}) \cdot q^{L*} - c^{L}(w) \cdot q^{L*} = \pi^{L*}$$
$$\pi^{F*} \geq \pi^{L*}$$

$$\pi^{L*} = p(q^{L*}) \cdot q^{L*} - c^{L}(w) \cdot q^{L*}$$
$$\geq p(q^{F*}) \cdot q^{F*} - c^{L}(w) \cdot q^{F*}$$
$$= p(q^{F*}) \cdot q^{F*} - c^{F}(w) \cdot q^{F*} = \pi^{F*}$$
$$\pi^{L*} \geq \pi^{F*}$$

Therefore, $\pi^{F*} = \pi^{L*} > \pi^{E*}$.

Appendix B

Comparative Static Analysis

Total profit function of each mode of entry:

$$\Pi^E = \frac{\pi^{E*}}{(\beta^E + r)}\left[1 - e^{-(\beta^E + r)T}\right]$$

$$\Pi^F = \frac{\pi^{F*}}{(\beta^F + r)}\left[1 - e^{-(\beta^F + r)T}\right] - F$$

$$\Pi^L = \frac{\pi^{L*}}{(\beta^L + r)}\left[1 - e^{-(\beta^L + r)T}\right]$$

Proof for Proposition 2

IPR protection (α)

$$\frac{\partial \Pi^E}{\partial \alpha} = \frac{\pi^{E*}}{(\beta^E + r)^2}\left\{\beta^{E'}(\alpha)\left[e^{-(\beta^E + r)T}\left(1 + (\beta^E + r)T\right) - 1\right]\right\} > \mathbf{0}$$

$$\frac{\partial \Pi^F}{\partial \alpha} = \frac{\pi_j^{F*}}{(\beta^F + r)^2}\left\{\beta^{F'}(\alpha)\left[e^{-(\beta^F + r)T}\left(1 + (\beta^F + r)T\right) - 1\right]\right\} > \mathbf{0}$$

$$\frac{\partial \Pi^L}{\partial \alpha} = \frac{\pi^{L*}}{(\beta^L + r)^2}\left\{\beta^{L'}(\alpha)\left[e^{-(\beta^L + r)T}\left(1 + (\beta^L + r)T\right) - 1\right]\right\} > \mathbf{0}$$

Market size (A)

$$\frac{\partial \Pi^E}{\partial A} = \frac{\left[1 - e^{-(\beta^E + r)T}\right]}{(\beta^E + r)}\frac{\partial p^*(q^{E*})}{\partial A}q^{E*} > 0$$

$$\frac{\partial \Pi^F}{\partial A} = \frac{\left[1 - e^{-(\beta^F + r)T}\right]}{(\beta^F + r)}\frac{\partial p^*(q^{F*})}{\partial A}q^{F*} > 0$$

$$\frac{\partial \Pi^L}{\partial A} = \frac{\left[1 - e^{-(\beta^L + r)T}\right]}{(\beta^L + r)}\frac{\partial p^*(q^{L*})}{\partial A}q^{L*} > 0$$

Discount rate (r)

$$\frac{\partial \Pi^E}{\partial r} = \frac{\pi^{E*}}{\left(\beta^E + r\right)^2}\left[e^{-\left(\beta^E + r\right)T}\left(1 + \left(\beta^E + r\right)T\right) - 1\right] < 0$$

$$\frac{\partial \Pi^F}{\partial r} = \frac{\pi^{F*}}{\left(\beta^F + r\right)^2}\left[e^{-\left(\beta^F + r\right)T}\left(1 + \left(\beta^F + r\right)T\right) - 1\right] < 0$$

$$\frac{\partial \Pi^L}{\partial r} = \frac{\pi^{L*}}{\left(\beta^L + r\right)^2}\left[e^{-\left(\beta^L + r\right)T}\left(1 + \left(\beta^L + r\right)T\right) - 1\right] < 0$$

Effective wage rate (w^{US}, w^n)

$$\frac{\partial \Pi^E}{\partial w^{US}} = -\frac{\left\lfloor 1 - e^{-\left(\beta^E + r\right)T}\right\rfloor}{\left(\beta^E + r\right)}\frac{\partial c^E}{\partial w^{US}} q^{E*} < 0$$

$$\frac{\partial \Pi^F}{\partial w^n} = -\frac{\left\lfloor 1 - e^{-\left(\beta^F + r\right)T}\right\rfloor}{\left(\beta^F + r\right)}\frac{\partial c^F}{\partial w^n} q^{F*} < 0$$

$$\frac{\partial \Pi^L}{\partial w^n} = -\frac{\left\lfloor 1 - e^{-\left(\beta^L + r\right)T}\right\rfloor}{\left(\beta^L + r\right)}\frac{\partial c^L}{\partial w^n} q^{L*} < 0$$

Transportation cost (t)

$$\frac{\partial \Pi^E}{\partial t} = -\frac{\left\lfloor 1 - e^{-\left(\beta^E + r\right)T}\right\rfloor}{\left(\beta^E + r\right)}\frac{\partial c^E}{\partial t} q^{E*} < 0$$

All of the analyses above assume $\pi^{i^*} > 0$ and $q^{i^*} > 0$. The foreign market is large enough to allow for positive profit.

Appendix C

Comparative Static Analysis (cont'd)

Cases on $\frac{\partial \Pi^i}{\partial \alpha}$:

1. If $\beta^E = \beta^F$ and $\beta^{E'}(\alpha) = \beta^{F'}(\alpha)$, then $\frac{\partial \Pi^E}{\partial \alpha} < \frac{\partial \Pi^F}{\partial \alpha}$.
2. If $\beta^F > \beta^E$ and $\beta^{E'}(\alpha) = \beta^{F'}(\alpha)$, then it is ambiguous to determine which effect is larger.
3. If $\beta^L > \beta^E$, then it is ambiguous to determine which effect is larger.
4. If $\beta^L > \beta^F$ and $\left|\beta^{L'}(\alpha)\right| > \left|\beta^{F'}(\alpha)\right|$, then it is ambiguous.

Appendix D

BEA 3-digit Industry Code

10 Agricultural production--crops	384 Medical instruments & supplies and ophthalmic Mfg..
20 Agricultural production--livestock and animal......	386 Photographic equipment and supplies Mfg............
70 Agricultural services	390 Miscellaneous manufacturing industries ....
80 Forestry	401 Railroads ....
90 Fishing, hunting, and trapping	441 Petroleum tanker operations ....
101 Iron ores mining..................................	449 Water transportation ....
102 Copper, lead, zinc, gold, and silver ores mining...	450 Transportation by air ....
107 Other metallic ores mining.........................	461 Pipelines, petroleum and natural gas ....
108 Metal mining services	462 Pipelines, except petroleum and natural gas ....
120 Coal mining	470 Petroleum storage for hire ....
124 Coal mining services	472 Passenger transportation arrangement ....
133 Crude petroleum (no refining) and natural gas......	477 Transportation, nec, and related services ....
138 Oil and gas field services	481 Telephone and telegraph communications ....
140 Nonmetallic minerals mining, except fuels	483 Other communications services ....
148 Nonmetallic minerals services, except fuels........	490 Electric, gas, and sanitary services ....
150 Construction	501 Motor vehicles and equipment Wholesale.............
201 Meat products Mfg.................................	503 Lumber and other construction materials Wholesale..
202 Dairy products Mfg................................	504 Professional & commerical eq. & supplies Wholesale.
203 Preserved fruits and vegetables Mfg................	505 Metals and minerals, except petroleum Wholesale....
204 Grain mill products Mfg...........................	506 Electrical goods Wholesale.........................
205 Bakery products Mfg...............................	507 Hardware, & plumbing & heating equipment Wholesale.
208 Beverages Mfg.....................................	508 Machinery, equipment, and supplies Wholesale.......
209 Other food and kindred products Mfg................	509 Durable goods, nec Wholesale.......................
210 Tobacco products Mfg..............................	511 Paper and paper products Wholesale.................
220 Textile mill products Mfg..........................	512 Drugs, proprietaries, & sundries Wholesale.........
230 Apparel and other textile products Mfg.............	513 Apparel, piece goods, & notions Wholesale..........
240 Lumber and wood products Mfg.......................	514 Groceries and related products Wholesale...........
250 Furniture and fixtures Mfg.........................	515 Farm product raw materials Wholesale..............
262 Pulp, paper, and board mills Mfg...................	517 Petroleum wholesale trade ....
265 Other paper and allied products Mfg................	519 Nondurable goods, nec Wholesale....................
271 Newspapers Mfg....................................	530 General merchandise retail stores ....
272 Miscellaneous publishing Mfg.......................	540 Food retail stores ....
275 Commercial printing and services Mfg...............	554 Gasoline service stations ....
281 Industrial chemicals and synthetics Mfg............	560 Apparel and accessory retail stores ....
283 Drugs Mfg...	580 Eating and drinking places ....
284 Soap, cleaners, and toilet goods Mfg...............	590 Retail, nec ....
287 Agricultural chemicals Mfg.........................	600 Depository Institutions
289 Chemical products, nec Mfg.........................	603 Savings instutions and credit unions ....
291 Integrated petroleum refining and extraction	612 Other finance, including security and commodity br.
292 Petroleum refining without extraction	631 Life insurance ....
299 Petroleum and coal products, nec	632 Accident and health insurance ....
305 Rubber products Mfg...............................	639 Other insurance ....
308 Miscellaneous plastics products Mfg................	650 Real estate ....

310 Leather and leather products Mfg..................	671 Holding companies ....
321 Glass products Mfg................................	679 Franchising, business -- selling or licensing .....
329 Stone, clay, concrete, gypsum, etc. Mfg............	700 Hotels and other lodging places ....
331 Ferrous Metals Mfg................................	731 Advertising ....
335 Nonferrous Metals Mfg.............................	734 Services to buildings ....
341 Metal cans, forgings, and stampings Mfg............	735 Equipment rental and leasing, exc. automobiles.....
342 Cutlery, hardware, and screw products Mfg..........	736 Personnel supply services ....
343 Heating equipment, plumbing fixtures, etc Mfg......	741 Computer processing and data preparation services .
349 Metal services, ordnance, & fabricated metal Mfg...	742 Information retrieval services ....
351 Engines and turbines Mfg	743 Computer related services, nec ....
352 Farm and garden machinery Mfg......................	749 Business sevices, nec ....
353 Construction, mining, & materials handling Mfg.....	751 Automotive rental and leasing, without drivers ....
354 Metalworking machinery Mfg.........................	752 Automotive parking, repair, and other services ....
355 Special industry machinery Mfg.....................	760 Miscellaneous repair services ....
356 General industrial machinery Mfg...................	780 Motion pictures, including television tape and film
357 Computer and office equipment Mfg..................	790 Amusement and recreation services ....
358 Refrigeration and service industry machinery Mfg...	800 Health services ....
359 Industrial machinery and equipment, nec Mfg........	810 Legal services ....
363 Household appliances Mfg...........................	820 Educational services ....
366 Household audio & video, & communications Mfg......	871 Engineering, architectural, and surveying services.
367 Electronic components and accessories Mfg..........	872 Accounting, auditing, and bookkeeping services ....
369 Electronic and other electric equipment, nec Mfg...	873 Research, development, and testing services........
371 Motor vehicles and equipment Mfg...................	874 Management and public relations services ....
379 Other transportation equipment, nec Mfg............	890 Other services provided on a commercial basis .....
381 Measuring, scientific, & optical instruments Mfg...	905 Nonbusines entities, except Government ....

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