

Intellectual Property Rights, International Joint Ventures and FDI: An Empirical Study*

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Abstract: Two types of foreign direct investments (FDI), joint ventures (JVs) and wholly owned affiliates, should be treated separately when studying the influence of intellectual property rights (IPRs) on FDI. Failure to distinguish between types of FDI may explain previously mixed results regarding the effects of IPRs on FDI. Using U.S. affiliates data, we find that JVs and wholly owned affiliates react to a change in IPRs regime differently. In particular, there exists an education threshold level above which IPRs have opposite effects on JVs and on wholly owned affiliates.

Keywords: joint ventures, foreign direct investment, intellectual property rights
JEL Codes: F1, F2, L1

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*We would like to thank Keith Maskus, Murat Iyigun and Robert McNown for helpful suggestions and discussions. Financial support from a CIBER Faculty Grant (Spring 2005) is gratefully acknowledged.

1. Introduction

Foreign direct investment (FDI) can be divided into two types, based on the amount of control over the firm: wholly owned affiliates, which give a multinational firm (MNE) 100% control over the firm and joint ventures (JVs), which give only partial control¹. In recent decades, JVs seem to continue to have been a reliable channel for MNEs to transfer their production and technology to other countries. BEA statistics show that U.S. JV sales increased about 58% over the period 1989-2001, while wholly owned affiliate sales increased by about 136% over the same period, as shown in Figure 1. The reason that JV activities do not show such significant increase as it once was in the past² might be the Tax Reform Act of 1986³ and the fact that, from the 1980s to the present, restrictions on foreign ownership of domestic firms were significantly reduced. This allowed the formation of wholly owned and/or majority-owned affiliates in some developing countries, such as China and India, where they were not allowed before⁴. Nonetheless, international joint ventures and wholly owned affiliates are important means by which MNEs transfer their production and technology to other countries⁵.

One of the most important reasons for the formation of a JV is a sharing incentive. Forming JVs with local partners can bring great benefits such as sharing of risks, skills, technology, production inputs, experience in local markets, and MNE familiarity with local political issues. Asieudu and Esfahani (2001) show that MNEs prefer JVs as a technology transfer

¹ Control of the firm refers to the right to make important decisions on issues such as management, production process, pricing, product standards, hiring and training of workers, sources of inputs, sales, and use of intangible assets.

² Franko (1989) finds evidence of a move toward minority owned affiliates of U.S. MNEs in the manufacturing sector in developing countries during the 1970s.

³ Desai and Hines, Jr. (1999) use aggregate sales data from U.S. minority owned affiliates in 1982 and 1989 and find that the Tax Reform Act of 1986 reduced the attractiveness of JVs to U.S. MNEs, particularly in low-tax host countries.

⁴ Contractor (1990) finds that global liberalization in government restriction of foreign equity in the 1980s reduced the share of U.S. 50-50 and majority owned affiliates.

⁵ According to Maskus (2000), there are three important means of production and technology transfer: FDI, licensing, and joint ventures.

medium when the partners' assets such as technologies complementary to those of the MNE are of high productivity, or when a host country has weak physical infrastructure, or negative institutional settings such as black markets, weak rule of law⁶, and high risk of expropriation. In addition, if the host countries have less educated workers, an MNE is likely to find investment costly and is therefore more likely to form JVs. However, sharing information with partners could create problems such as a non-proprietary use of intangible assets and various other conflicts⁷. Therefore, the protection of IPRs is crucial to the formation of JVs. In contrast, establishing a wholly owned affiliate, even though it does not provide the sharing benefits, gives the MNE the benefits of internalization, which allow the MNE to have more control over the firm compared to JVs. The MNE may protect itself against possible opportunistic behavior by keeping assets or knowledge within the source firm where the protection of IPRs is not as crucial as it is for JVs⁸. Desai, Foley, and Hines, Jr. (2004), show that apart from factors such as host country ownership restriction, tax incentives and trade with parent companies or related affiliates, MNEs are less likely to form JVs in situations where their intangible assets could be exploited. Moreover,

⁶ The rule of law index is obtained from International Country Risk Guide (ICRG) data set. It is an indicator of the degree to which citizens of a country are willing to accept the established institutions that make and implement laws and adjudicate disputes. Higher scores indicate sound political institutions, a strong court system, and provisions for an orderly succession of power. Lower scores indicate a tradition of depending on physical force or illegal means to settle claims. The index ranges from 0 to 6.

⁷ Other conflicts include problems over integration process and delegation of decision making, and disagreement between partners over policies, strategies, and tactics.

⁸ The literature does not show whether the imitation risk is greater or lesser when knowledge or assets are outside the source firm. In other words, it is not established that wholly owned affiliates are less exposed to imitation compared to JVs.

Henisz (2000) shows that majority-owned affiliates become more favored when high political hazard is accompanied by high contractual hazard⁹.

Therefore, based on the above reasoning and the evidence from existing studies, IPRs should have an effect on the ownership structure of FDI. Moreover, different ownership structure (JVs or wholly owned affiliates) should react to the change in IPRs differently. Hence, the analyses of the effect of IPRs on JVs and wholly owned affiliates should be done separately. Ignoring differences in the nature of JVs and wholly owned affiliates could mask the true effect of IPRs on FDI.

Therefore, this paper studies the effect of IPRs on JVs and wholly owned affiliates separately, using empirical data on U.S. MNE. Our empirical analysis departs from the literature in several respects. First, unlike existing papers on ownership structure such as Beamish and Bank (1987), Gatignon and Anderson (1988), Contractor and Lorange (1998), Gomes-Casseres (1989), Franko (1989), and Gomes-Casseres (1990), we will focus on the effect of IPRs on ownership structure. Second, this paper applies a widely used IPRs index developed by Ginarte and Park (1997) to capture directly the level of IPRs in the host countries, which differs from the approach of authors such as Asiedu and Esfahani (2001), Henisz (2000), and Desai, Foley and Hines, Jr. (2004) that consider the IPRs in the context of the overall institutional reliability of a country. Third, differing from papers that study the effect of IPRs on aggregate FDI such as Ferrantino (1993), Maskus and Konan (1994)¹⁰, Lee and Mansfield (1996), Smith (2001),

⁹ Henisz (2000) defines political hazard as the likelihood of political changes in the host country's government which either directly or indirectly affect MNEs' expected return on assets. Contractual hazard is defined as expropriation hazard from potential JV partners.

¹⁰ Ferrantino (1993) and Maskus and Konan (1994) find no significant relationship between FDI and IPRs. Ferrantino (1993) uses international patent and copyrights convention membership as a measure of IPRs, while Rapp and Rozek's (1990) IPRs indices are used in Maskus and Konan (1994).

Smarzynska Javorcik (2004), Nunnenkamp and Spatz (2004)¹¹, this paper distinguishes two types of FDI, JVs and wholly owned affiliates. In addition, we examine the effect of IPRs on two aspects of JVs and wholly owned affiliate activities: sales and the number of firms.

The paper consists of two analyses. The first analysis is of the effect of IPRs on the sales of JVs and wholly owned affiliates. We find evidence supporting the internalization incentive. The effect of IPRs on JVs is generally larger than that on wholly owned affiliates and is dependent on the education level. The second analysis of the paper is of the effect of IPRs on the count of JVs and wholly owned affiliates. Specifically, we find a threshold level of education that IPRs generate different effects on JVs and wholly owned affiliates. Above this threshold level, stronger IPRs increase the number of JVs but decrease the number of wholly owned affiliates and vice-versa below the threshold level. This finding can be explained by a trade-off between a sharing incentive and an internalization incentive.

The structure of this paper is as follows: Section 2 explains the theoretical background. Section 3 describes the data set. Sections 4 and 5 analyze the effect of IPRs on FDI sales and on the number of firms engaging in FDI, respectively. Discussion and concluding remarks are given in Section 6.

2. Theoretical Background

Several theoretical papers study the effect of a host country's IPRs on FDI. These papers vary in their assumptions of innovation. Therefore, their results are mixed. Lai (1998) models

¹¹ Lee and Mansfield (1996) used a perceived IPR survey of 100 major U.S. firms and found positive effects of IPRs on FDI. Smith (2001) used Rapp and Rozek (1990) index to find the same results. Smarzynska Javorcik (2004) uses GP index to find that weak IPRs not only deters positive FDI effects but also encourages distribution of FDI rather than local production. Nunnenkamp and Spatz (2004) also used GP index to study the industry-level FDI data and found that IPRs is less likely to attract FDI than expected. Strengthening of the IPRs requires other ingredients such as the size of the host country and industry characteristics to successfully attract more FDI.

innovation as an introduction of new product variety and finds that stronger IPRs encourages FDI¹². Glass and Saggi (2002) model innovation as quality improvement and find that stronger IPRs decreases the FDI flows because an increase in imitation cost crowds out FDI through resource scarcity. Glass and Wu (2005) show that the difference in the above results may be driven by how innovation is modeled. They show that when the model is kept identical to Lai except that the type of innovation is quality improvement, the results are similar to Glass and Saggi (2002). Moreover, Glass and Wu (2005) distinguish between FDI flows (sales) and the extent of FDI defined as a fraction of the products produced by multinational firms. They find that the impact of IPRs on FDI flows and extent of FDI can differ depending on the assumption of innovation. In their model, only Northern firms have the ability to innovate (through quality improvement) and innovators are separated into two groups, leaders and followers. Leaders are firms who developed the most recent quality and have a cost advantage in designing the next-highest quality level; followers are all other firms. In a model where the labor requirement in innovation for followers is sufficiently large relative to the leaders that innovation is undertaken only by leaders, an increase in IPRs raises both FDI flows and the extent of FDI. However, when the authors allow followers to be efficient and to have the same innovation cost as leaders, an increase in IPRs will decrease the FDI flows¹³ but will increase the extent of FDI. More details can be found in Glass and Wu (2005).

However, the above models focus their attention on the wholly owned affiliates side of the FDI. As mentioned above, the incentives to engage in wholly owned affiliates or in JVs might be different. Therefore, we should also look at the model of JV. Panpiemras (2005) studies the

¹² Similarly, Yang and Maskus (2001, 2002) study the effect of IPRs on licensing and find that stronger IPRs encourages licensing.

¹³ Glass and Wu (2005) found that increase in IPR decreases the aggregate expenditure. If we assume that the prices of wholly owned affiliates' products are constant, an increase in aggregate expenditure implies an increase in wholly owned affiliates sales.

effect of IPRs on JV and considers three types of JV contract: a preventing contract, a compensating contract, and a self-enforcing contract. Different types of JV contracts yield different results for the effect of IPRs on the aggregate expenditure¹⁴ and the extent of joint ventures, which is defined as the fraction of all products produced by JVs. With an assumption that only Northern firms can innovate and only Southern partners of the JV can imitate the product, the incentive for the Northern firm to engage in JV is to exploit the cost advantage of producing in the South. The conclusions of the Panpiemras (2005) models are as follows:

First, in the preventing contract, Northern profit share is a decreasing function of imitation. When the imitation risk is high, the Northern partner sacrifices more profit share to discourage the Southern partner from imitation. (However, it cannot completely prohibit imitation.) An increase in IPRs which reduces the risk of imitation in the South will initially increase the incentive to engage in JV and therefore increase the demand for labor in the South while decreasing the demand for labor in the North. The relative wage rate in the North decreases which will lower the incentive to engage in JV and therefore lower both JV flows and the extent of JV. Second, in the compensating contract, the Northern partner requires a higher profit share when imitation risk is higher; therefore, the Northern profit share is an increasing function of imitation. An increase in IPRs reduces the imitation risk and lowers the compensation, which, in turn, will initially decrease the incentive to engage in JV. The demand for labor decreases in the South and increases in the North. An increase in relative wage rates in the North increase the incentive to engage in JV. Therefore JV sales and the extent of JV increase¹⁵.

Last, a self-enforcing contract is a preventing contract that completely prevents imitation. The Northern partner is perfectly informed about the Southern partner's imitating ability and

¹⁴ Assuming that the price of a JV's product is constant, an increase in the aggregate expenditure implies an increase in JV sales.

¹⁵ This result is based on the assumption that the elasticity of the Northern profit share of a JV with respect to imitation is sufficiently high.

imitation cost and can therefore set the reward of imitation to be lower than the total cost of imitation, to prevent imitation completely. In this model, Northern followers are also assumed to be efficient and can undertake innovation (similar to Glass and Wu (2005)). When IPRs increases, just as with the preventing contract, JV sales decrease. However, the extent of JV increases because of the resource crowd-out effect in the North when Northern firms are competing in innovating. Therefore, more products must be produced in the South via JV. We summarize the effect of stronger IPRs on sales and the extent of JV from Panpiemras (2005) in Table 1¹⁶.

We can see from the above summary that the effect of strengthening IPR on wholly owned affiliates and JVs can vary depending on the assumptions of the model. Therefore empirical analysis is needed. Based on the above models, we can write the reduced form of the extent of JVs, JV sales, the extent of wholly owned affiliates, and wholly owned affiliate sales as functions of the Northern labor supply, the Southern labor supply, the cost of innovation, and the cost of imitation. The empirical models are constructed based on the reduced forms using the characteristics of host countries to reflect the variables of interest in order to verify empirically the results of imitation on wholly owned affiliates and JVs.

Since actual data on imitation does not exist, we use an education variable¹⁷ (EDU) along with an index of the strength of IPRs in the host country (IPR) to capture imitation. The strength of IPRs reflects an imitation cost. A high IPRs index reflects a higher imitation cost, which should result in an increase in FDI (both JVs and wholly owned affiliates) activities (both sales and the extent of FDI). The EDU variable reflects an imitating ability in the host country. We believe that a country having a larger portion of population with higher education should have a higher imitating ability than a country with a smaller portion. However, a high-EDU country is

¹⁶ For thorough explanation and proofs, see Panpiemras (2005).

¹⁷ We use the percentage of the population over 25 years old having a higher than secondary level of education as a measure of education level in the host country.

usually capable of adopting an MNE's technology to the local environment faster and has a lower set-up cost for MNEs, which should result in higher FDI activities. Thus, high EDU may have an ambiguous effect on FDI activities.

In addition to IPR and EDU, we add real GDP per capita (GDPC), labor force adjusted by country size¹⁸ (LABOR), and the interaction term between IPR and EDU to the empirical specification. The GDPC can capture not only the level of development of the host country, but also the size of the local demand in host countries. A high-GDPC country can adopt the MNEs' technology to the local environment faster and provide necessary facilities for the FDI and should thus attract more FDI activities. The size effect implies that a larger-demand country should attract more FDI. Therefore, we expect GDPC to have a positive impact on FDI activities (both sales and number of firms). Due to friction in the labor market, a labor force variable (LABOR) can be used as an instrument variable for the wage rate in the host country. A larger labor force per GDP (the inverse of labor productivity) implies a lower wage rate which should increase FDI activities. The interaction variable between IPR and EDU (IPR*EDU) captures how the combination of IPR and EDU affects FDI activities. Adding the interaction term helps us explore differences in the nature of JVs and wholly owned affiliates, as we will discuss later.

In addition to the theoretical models mentioned above, the concepts of market expansion and market power effect introduced in Smith (2001) can be helpful. The market expansion concept predicts that strong IPRs increase sales of JVs and wholly owned affiliates by ensuring exclusive rights over knowledge that flows to foreign countries. This effect is strengthened when a host country has a high ability to imitate. Thus we expect the total effect of IPRs on sales to be positive when EDU is high. In contrast, the market power concept predicts that strong IPRs reduce sales of JVs and wholly owned affiliates since it ensures a temporary monopoly over the protected knowledge. This effect is strengthened when a host country has a low ability to imitate. Thus, we expect the total effect of IPRs on sales to be negative when EDU is low. In addition,

¹⁸ LABORGDP=labor force/GDP

according to Panpiemras (2005) and Glass and Wu (2002), we should expect the extent of JVs and wholly owned affiliates to change in the opposite direction of the change in sales of joint ventures and wholly owned affiliates, respectively.

3. Affiliate Sales

Since our focus is on both sales and the extent of FDI, we use two data sets to perform our analysis. For the analysis of sales, we use data on U.S. affiliate sales in 49 countries¹⁹ in 1989 and in the period 1993-2001. The countries in the study include both developed and developing ones. The data set was obtained from the Bureau of Economic Analysis's survey reports²⁰. BEA data differentiate sales of majority-owned U.S. affiliates from sales of affiliates for which the combined ownership of all U.S. parents is equal to or is greater than 10% but less than 50%. We will refer to the latter group as JVs. The data on U.S. majority-owned affiliates are ready to be used. In addition, the terms majority-owned affiliate sales and wholly owned affiliate sales can be used interchangeably since the BEA reports that over 90% of the majority-owned foreign affiliates of U.S. firms are wholly owned. Subtracting sales of majority-owned affiliates from sales of all affiliates, we obtain sales of minority affiliates or JV sales.

For the analysis of the effect of IPRs on the extent of joint ventures and wholly owned affiliates, we use counts of U.S. firms having wholly owned affiliates and counts of U.S. firms having joint ownership affiliates to reflect the extent of wholly owned affiliates and the extent of joint ventures, respectively²¹. These data comprise a BEA data set of counts of U.S. firms that have JVs or wholly owned affiliates in 55 industries in 43 countries²².

¹⁹ A list of countries in the analysis is provided in the Appendix.

²⁰ Details on JVs data are available on the BEA website (www.bea.gov/bea).

²¹ We thank Raymond J. Mataloni, Jr. for his help in obtaining this data set.

²² The lists of industries classified by the BEA and the lists of countries are provided in the Appendix.

To measure intellectual property rights protection (IPR), we use the GP index, a common measure of such protection developed by Juan C. Ginarte and Walter G. Park (1997)²³. They examine the patent laws of a comprehensive number of countries, considering five components of the laws: duration of protection, extent of 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. We chose to use the 1985 GP index for the year 1989, the 1990 index for 1990-94, 1995 for 1995-1999, and 2000 for 2000-2001.

The GDPC data in millions of dollars were drawn from the Penn World data set. Data on labor force in millions of people were drawn from the World Development Indicators available on the World Bank CD-ROM. The education variable is the percentage of population aged 25 and over who achieve a post-secondary level of education and were drawn from Barro and Lee data set. Descriptive statistics and the correlation matrix of the variables in the analysis of sales are summarized in Table 2 and Table 3, respectively. All of the variables are in log format.

3.1 IPR and JV Sales

To make our analysis more concrete, we added another dependent variable, the ratio of JV sales to GDP, to control for some size measures. All variables in the following equations are in log form.

$$LJV_{it} = \alpha + \beta_1 LIPR_{it} + \beta_2 LGDPC_{it} + \beta_3 LLABOR_{it} + \beta_4 LEDU_{it} + \beta_5 (LIPR * LEDU)_{it} + u_{it} \quad (1)$$

$$L(JV / GDP)_{it} = \alpha + \beta_1 LIPR_{it} + \beta_2 LGDPC_{it} + \beta_3 LLABOR_{it} + \beta_4 LEDU_{it} + \beta_5 (LIPR * LEDU)_{it} + u_{it} \quad (2)$$

where LJV_{it} is the log of U.S. JV sales in country i in year t ; $L(JV / GDP)_{it}$ is the log of the ratio of U.S. JV sales in country i to GDP of country i in year t ; $LIPR_{it}$ is the log of the IPRs

²³Another widely used IPRs index in the literature was developed by Rapp and Rozek (1990). However, these data were developed in the mid-1980s and are available for only one year.

index of country i in year t ; $LGDP_{it}$ is the log of the real GDP per capita of country i in year t ; $LLABOR_{it}$ is the log of the labor force adjusted by GDP of country i in year t ; $LEDU_{it}$ is the log of the percentage of population over 25 years old having post secondary level of education of country i in year t ; and $(LIPR*LEDU)_{it}$ is the interaction term between IPR and the education variable of country i in year t .

We first run the OLS regression on equations 1 and 2. However, due to the nature of the panel data of 49 countries over 10 years, we suspect that there might be a country-specific effect in both equations. Results from an F-test and an LM test suggest that either fixed or random effects should be used for this data set, as they are more appropriate than the classical OLS regression in both equations.

We then use the Hausman test to see whether fixed or random effects models are more appropriate for each equation. For both equations, we reject the null hypothesis that estimates from fixed and random effects models are not systematically different at a 1% level of significance. Therefore, the fixed effects model will be used in both equations for consistent estimates even though the results from both models are quite similar. The results of both models are reported in Table 4²⁴.

For LJV , results from the fixed effects model are such that $LIPR$, $LGDP$, and $LEDU$ all have positive and significant impacts on JV sales. The interaction between IPR and education is negative but not significant. Thus, the total effect of $LIPR$ on LJV is based solely on the sign of the coefficient of $LIPR$. An increase in $LIPR$ increases JV sales since it increases the level of protection over JV products²⁵. The positive effect of per capita GDP confirms the size effect.

²⁴ OLS estimates are available from the authors upon request.

²⁵ Unfortunately, the data set does not allow us to explore directly the link between imitation and the Northern share of a JV .

For $L(JV / GDP)$, results from the fixed effect model are similar to those of LJV except that $LLABOR$ becomes significant at the 1% level. As we expected, an increase in $LLABOR$ lowers the wage rate in the host country, resulting in higher JV activities and sales. Moreover, we can conclude that for both regressions, the market power effect, where an increase in IPR reduces the JV activities, could only be achieved at an extremely high education level. However, it does not have a significant effect in the model.

3.2 IPR and Wholly Owned Affiliate Sales

Next, we extend our analysis to another type of FDI, wholly owned affiliates. Even though the BEA does not provide data on sales specific to wholly owned affiliates, based on the 1995 BEA survey, about 90% of U.S. majority-owned affiliates are wholly owned affiliates. Therefore, it is sensible to use the term interchangeably. Therefore, we use the data set of sales of U.S. majority-owned affiliates over the same period as the analysis of JVs as a proxy for sales of U.S. wholly owned affiliates. As in the previous section, for a robustness check, we also use sales of the U.S. majority-owned affiliates per host country GDP as an additional dependent variable.

$$LMAJOR_{it} = \alpha + \beta_1 LIPR_{it} + \beta_2 LGDPC_{it} + \beta_3 LLABOR_{it} + \beta_4 LEDU_{it} + \beta_5 (LIPR * LEDU)_{it} + u_{it} \quad (3)$$

$$L(MAJOR / GDP)_{it} = \alpha + \beta_1 LIPR_{it} + \beta_2 LGDPC_{it} + \beta_3 LLABOR_{it} + \beta_4 LEDU_{it} + \beta_5 (LIPR * LEDU)_{it} + u_{it} \quad (4)$$

where $LMAJOR_{it}$ is the log of U.S. majority-owned affiliate sales in country i in year t ; $L(MAJOR / GDP)_{it}$ is the log of the ratio of U.S. majority-owned affiliate sales in country i to the GDP of country i in year t .

In JVs, sharing information between different firms often leads to a violation of the protection of proprietary assets and even to imitation. Therefore, IPR is a crucial factor which partners should take into account before forming JVs. In wholly owned affiliates, firms internalize their technology in order to have more control over their proprietary assets. As a

result, IPR should not be as crucial to the majority-owned affiliates as to the JVs, unless the imitating capacity in the recipient country is very high. Therefore, we expect IPR to affect JVs more than it affects the wholly owned affiliates. In other words, JV sales should be more responsive to a change in IPR than wholly owned affiliate sales.

Following the same process as in the analysis of JV sales, the Hausman test confirms that the fixed-effect model is more appropriate for this data set, as it gives consistent estimates. The results of both fixed effect and random effect models for equations 3 and 4 are reported in Table 5²⁶.

As we expected, results from the fixed-effect models show that the real GDP per capita and labor force per GDP have significantly positive effects on both wholly owned affiliate sales and wholly owned affiliate sales per GDP. IPR alone negatively affects both dependent variables; however, the interaction term between IPR and the education variable is positive. The total effects of IPR on both dependent variables will be positive if the education level is sufficiently high. The positive total effect implies the market expansion effect. That is, when the education level is high, stronger IPR increases sales and sales per GDP of the wholly owned affiliates. From our calculation, IPR has a positive effect on sales and sales per GDP if *LEDU* is higher than 0.549 and 0.727, respectively. In our data set, around 96% of the sample has an *LEDU* level higher than 0.727 (more than 2.1% of the population over 25 years old have more than a secondary level of education). Therefore, stronger IPRs increases wholly owned affiliate sales and sales per GDP in most of our sample. Moreover, education positively affects both sales and sales per GDP. Thus, the total effect of *LEDU* on sales and sales per GDP is positive unless *LIPR* is less than zero. Less than 1% of our sample indicates such a low level for the IPRs index. Thus, on average, an increase in education increases both sales and sales per GDP of wholly owned affiliates.

²⁶ OLS estimates are available from the authors upon request.

3.3 Comparison of the effect of IPRs on JV sales and wholly owned affiliate sales

Regarding the concern over the heteroskedasticity problem, we apply the White test to equations 1-4. Based on this test, we reject the null hypothesis of homoskedasticity at a 1% level of significance in all equations. There exist heteroskedasticity problems in all equations. We correct the problems by using the robust covariance estimators. Results similar to those in the previous subsections are shown in Table 6.

As shown in Table 6, the real GDP per capita and labor force per GDP have positive effects on all equations. $LIPR$ is positively significant at 1% for both LJV and $L(JV/GDP)$ while the interaction term $LIPR*LEDU$ is negative but not significant. Education is positive and significant at a 1% level for both LJV and $L(JV/GDP)$. The results for wholly owned affiliate equations show that IPR has a significant negative impact on $LMAJOR$ and $L(MAJOR/GDP)$. The total effect of $LIPR$ on $LMAJOR$ and $L(MAJOR/GDP)$ is positive if $LEDU$ is greater than 0.549 and 0.727, respectively. Education has a positive effect on both overall sales and sales per GDP of wholly owned affiliates even though it is not significant in the sales per GDP equation. The total effect of $LEDU$ is positive if $LIPR$ is positive. 98.54% of our sample has an IPR index greater than 1. Thus, it is very likely that an increase in education level will lead to an increase in sales and sales per GDP of the wholly owned affiliates.

It is surprising that the education level required to produce a positive total effect of IPR on wholly owned affiliate sales is very low compared to the sample mean. Despite the low level of the $LEDU$, our results support the findings on Smith (2001) that we see a market expansion effect when the ability to imitate is high and a market power effect when the ability to imitate is low. In addition, it is interesting that while $LIPR$ only has a positive effect on sales of JVs, it could have either a positive or a negative effect on sales of wholly owned affiliates, depending on the education level of the host country. In other words, we find evidence of both a market expansion effect and a market power effect on wholly owned affiliate sales-but not in JV sales.

To explore this result further, we use the maximum and minimum level of *LEDU* to obtain the range of magnitude of the total effect of *LIPR* on *LMAJOR*, which is [-0.482,0.660], while the total effect on *LJV* is 0.443. We can see that when looking at only the positive effect of *LIPR*, it has a greater effect on *LJV* than on *LMAJOR* when *LEDU* is larger than 2.16 (representing 56% of our data set). Our inference is that IPR is more crucial to JVs compared to wholly owned affiliates. However, when the imitation ability is strong (a high level of *LEDU*), the MNE would prefer to internalize its knowledge by establishing the wholly owned affiliates.

We are aware of other variables that might be included in the regression models. Therefore, additional variables, including total trade as a percentage of real GDP which explains the openness of the host country, investment as a share of real GDP, and the growth rate of real GDP, are considered²⁷. For all equations, adding these variables does not change the signs of the previously included variables, but only reduces the significance level of variables such as *LEDU* and *LLABOR*. Moreover, following Smith (2001), we also add other measures of imitation ability of the host countries such as R&D expenditure share of real GDP and researchers in R&D per million people²⁸ as a robustness check. In all equations, an increase in R&D expenditure attracts more investment to the host country in both forms while the number of researchers in the host country does not have a significant impact on any type of investment. Results showing robust from adding these additional variables are available from the authors upon request²⁹.

²⁷ These data were drawn from Penn World Table 6.1.

²⁸ These data are drawn from the Statistical Yearbook of UNESCO.

²⁹ The OLS results are robust from using the Rapp and Rozek (1990) IPRs measure with the exception that this measure is not significant in JV equations. The reason could be that RR index data were available for only one year and therefore did not show enough variation to pick up the effect of IPRs on volume of JV sales. Moreover, since these are country-specific data that do not change over time, the RR index is dropped in the fixed and random effect models.

4. IPRs and Number of Affiliates

Apart from the effect of the IPRs on the sales of JVs and wholly owned affiliates, it is interesting to see how IPRs affects the number of JVs and wholly owned affiliates which represent the extent of FDI. To analyze this issue, we use a BEA data set of counts of U.S. firms that had JV or wholly owned affiliate activities in 1995. These data give the numbers of U.S. firms that have wholly owned affiliates or the joint ownership affiliates across 55 industries in 43 countries, both developed and developing³⁰.

Beyond the country characteristic variables used in the previous sections, we also add industry characteristic variables. These include R&D expenditure as a fraction of total sales by industry of U.S. parents measured in U.S. dollars, and employees of U.S. parents by industry measured in thousands³¹. These data are collected by the BEA. R&D expenditure as a fraction of sales (*R&D/SALES*) can be used to reflect the level of technological intensity of each industry. Firms with higher R&D intensity should be likely to take advantage of incentives provided by foreign countries in order to retrieve more profits overseas to offset the money they invest in R&D. The measure of employees of U.S. parents by industry (*EMPLOYEE*) reflects the size of an industry in the U.S. U.S. firms in a large industry are more likely to take advantage of opportunities to engage in FDI than firms in a small industry. Therefore, we expect both *R&D/SALES* and *EMPLOYEE* to have positive relationships with the number of U.S. affiliates, both JVs and wholly owned. Summary statistics and a correlation matrix of variables used in this section are provided in Tables 7 and 8.

³⁰ This total count of U.S. firms is 9498. Of this number, 2252 firms are considered JVs (24% of the total count), which leaves 7242 firms to be considered as wholly owned affiliates.

³¹ A U.S. parent is a person, resident in the U.S., who owns or controls 10% or more of the voting securities, or the equivalent, of a foreign business enterprise.

4.1 Model Selection

To analyze this count data set, we chose the most appropriate model from three candidates: Poisson regression, negative binomial model, and zero-inflated negative binomial model. The Poisson regression has been widely used in analyzing count data. However, it relies on a strong assumption that the conditional mean of the dependent variable equals its conditional variance. From the goodness of fit test of our data set, we find that we can reject the hypothesis that the data are Poisson distributed at a 1% level of significance in both the JVs and the wholly owned affiliates model³².

An overdispersion of the data could be attributed to an unobserved heterogeneity or to excess zeroes in the count (the nature of the process generating zero). If the overdispersion arises from the unobserved heterogeneity in the data, a negative binomial model which introduces an individual unobserved effect into the conditional mean would be appropriate. We use the Likelihood Ratio test (LR test) to check whether the negative binomial regression has a conditional mean equal to the conditional variance, and can conclude that the negative binomial mode is more appropriate to our data than the Poisson in both the *JV* and the wholly-owned (*WO*) equations³³.

However, our data set contains many zeroes, which could also lead to an overdispersion problem. To tackle these excess zeroes, we use the zero-inflated negative binomial that uses a logit model to account for them. This model provides a treatment of zero counts separate from strictly positive counts. The zero outcomes can arise in one of two regimes. In one the outcome is always zero, and in the other the negative binomial can produce zero counts or positive counts. Using the Vuong test, we find that the zero-inflated negative binomial models are more

³² The chi-square for the JV model is 4775.599 and 11958.75 for the wholly owned affiliates model.

³³ The chi-square values for the JV and WO models are 1169.41 and 6731.72, respectively, allowing us to reject the null hypotheses in both models.

appropriate to both equations than are the negative binomial models³⁴. Nevertheless, we report results for all three models in Tables 9 and 10. The marginal effects of each independent variable are included to aid interpretation. All results are corrected for the heteroskedasticity problem using the robust covariance estimators. Even though we interpret the results for just the zero-inflated negative binomial models, it should be pointed out as a robustness check that results from all three models are similar in terms of the signs of all coefficients.

4.2 IPR and the number of JVs

The results of the zero-inflated negative binomial regression on the *JV* model are shown in Table 9. The signs of *GDPC*, *R&D/SALES*, and *EMPLOYEE* are positive and significant. As we expected, firms in technologically intensive industries choose *JV* more than firms in industries that have lower *R&D/SALES*. Firms in large industries engage in *JV* more than firms in small industries. *LABOR/GDP* is negatively significant. Normally, an increase in *LABOR/GDP* (a lower productivity of labor) would imply a lower wage, providing a cost-saving incentive for MNEs. The negative sign of *LABOR/GDP* could reflect the need for high-productivity labor for *JVs* rather than cheap but low-productivity labor. Moreover, our results highlight the role played by IPRs and education on the number of *JVs*. IPR has a negative and significant effect on *JV*. However, the interaction term (*IPR*EDU*) has a positive and significant effect on *JV*. The total effect of IPR on *JV* will be positive if *EDU* is higher than 7.5306 (more than 7.5306% of the population over 25 years old achieves a higher than secondary level of education)³⁵. Therefore, as IPRs gets stronger, we experience the market expansion effect in terms of the number of *JV* at a sufficiently high *EDU*. *EDU* has a significant negative impact on *JV*; its total effect on *JV* is

³⁴ Young statistics for the *JV* and *WO* models are 7.71 and 4.70, respectively. These statistics are large enough to confirm that the negative binomial models are not appropriate for the data sets at a 1% level of significance.

³⁵ Approximately 37% of our sample has a lower number.

positive if the IPRs index is higher than 3.061³⁶. Therefore, a higher *EDU* fails to increase the number of JVs at a sufficiently weak IPRs level³⁷.

4.3 IPR and the number of wholly owned affiliates

The results of the zero-inflated negative binomial *WO* model are shown in Table 10. As we expected, the signs of *RGDPCAP*, *R&D/SALES*, and *EMPLOYEE* are significantly positive. *IPR* has a positively significant effect on *WO*. However, the interaction term between *IPR* and *EDU* has a negatively significant impact on *WO*. The total effect of *IPR* on *WO* is positive if *EDU* is lower than 7.367³⁸. *EDU* has a positively significant effect on *WO*. The total effect of *EDU* is positive if the IPRs index is lower than 3.067³⁹. Therefore, stronger IPRs fails to increase *WO* if *EDU* is sufficiently high, and higher *EDU* fails to increase *WO* if IPRs is too strong.

4.4 IPR, Education and the number of affiliates: Evidence of substitution between JVs and Wholly owned affiliates

The results from the previous sections show the substitution between JVs and wholly-owned affiliates. Stronger IPRs has different effects on JVs and wholly owned affiliates depending on the level of *EDU*. The threshold level of *EDU* is about 7.4488 (the average of 7.5306 and 7.367 from the last two sections). If *EDU* is greater than the threshold level, a stronger IPRs increases the number of JV and decrease the number of wholly owned affiliates. Thus, stronger IPRs could attract the exercise of either JVs or wholly owned affiliates depending on the education level of the host country. We also find the substitution between JV and wholly

³⁶ Approximately 44% of our sample has a weaker IPR.

³⁷ The results are robust to using an alternative IPR measure (Rapp and Rozek index).

³⁸ Approximately, 35% of the sample has a lower *EDU*.

³⁹ Approximately 44% of our sample has a weaker IPR level.

owned affiliates with an IPRs threshold level when the education level changes. The IPRs threshold is about 3.064; above this level, an increase in *EDU* increases the number of JVs and decreases the number of wholly owned affiliates. If the IPRs index in the host country is below this threshold, an increase in education level will increase the number of wholly owned affiliates and decrease the number of JVs. Therefore, a higher *EDU* could attract either JVs or wholly owned affiliates, depending on the strength of IPR in the host country.

The switching between *JV* and *WO* when there is a change in either *IPR* or *EDU* is a result of the trade-off between two incentives, a sharing information incentive and an internalization incentive. *JV* formation brings benefits mostly from sharing information, knowledge, skills, and resources among partners. The sharing incentive would be most beneficial when both partners acquire knowledge specific to the production of *JV*, and IPRs protection is strong in order to protect partners from opportunistic behavior. When *EDU* is low, implying that a host partner could not provide an MNE with specific skills or knowledge, even stronger IPR could not induce more *JV* formation. An MNE would rather control the whole entity themselves, which leads to an increase in wholly owned affiliates. Moreover, if IPRs is too weak, making it risky to share information through a *JV*, an increase in *EDU* might suggest an increasing ability to imitate among the local partners. This decreases the *JVs* and increases the wholly owned affiliates instead. On the other hand, wholly owned affiliates benefit most from internalization by keeping knowledge, skills, and assets within the controlling firm. The internalization incentive would be most beneficial when weak IPRs protection prevails in the host country, the set up cost is low, or both. Therefore it is not surprising that our results show that stronger IPRs would increase the number of *JVs* but decrease the number of wholly owned affiliates when *EDU* is sufficiently high. The inference is as follows: As IPRs gets stronger, the sharing incentive starts to overshadow the internalization incentive when *EDU* exceeds the threshold level. Moreover, an increase in *EDU* increases the number of *JVs* but decreases the number of wholly owned

affiliates when IPR is sufficiently strong. This is because as *EDU* increases, the sharing incentive begins to dominate the internalization incentive when the IPRs index exceeds the threshold level.

5. Discussion and Conclusion

FDI adopts two types of ownership structures: JVs and wholly owned affiliates. The choice is based on the juxtaposition of the sharing and the internalization incentives. Consequently, JVs and wholly owned affiliates would react to changes in IPR differently. Thus, instead of studying aggregate FDI, we should look at JVs and affiliates separately. In this paper, we examine empirically the effect of IPR on two aspects of FDI: sales and the number of firms. We find that stronger IPR increases sales of JVs and wholly owned affiliates even in a host country that has a modest ability to imitate. We also find evidence of a market expansion effect on sales of wholly owned affiliates.

When analyzing the effect of IPRs on the number of JVs and wholly owned affiliates, stronger IPRs generally provides an incentive for U.S. MNEs to form either JVs and wholly owned affiliates, depending on the education level of the host country. We find a threshold level of education where IPRs has different effects on JVs and wholly owned affiliates. At a level above the threshold, stronger IPRs increases the number of JVs and decreases the number of wholly owned affiliates, and vice-versa below the threshold level. These threshold levels can be explained by the trade-off between the sharing information incentive and the internalization incentive for the MNEs. The sharing incentive works best when local partners are able to share information, knowledge, and assets without concern over opportunistic behaviors by partners. As IPRs gets stronger, the internalization incentive dominates the sharing incentive because partners in the host country are not able to provide adequate knowledge and technology, as reflected by a low level of education. However, the sharing incentive becomes dominant if partners in the host country are capable of providing sufficient knowledge and technology to MNEs. From a policy

perspective, IPRs policy could be used effectively to target both types of FDI, depending on the education level of the host country.

Combining the results in both analyses, we can outline the effect of IPR on FDI. IPRs can generate a complicated and profound effects on FDI. Stronger IPRs affects sales and the number of firms differently.

Our results show that stronger IPRs increases JV sales, but could decrease the number of JVs if the education level of the host country is sufficiently low. Moreover, stronger IPRs could increase sales of wholly owned affiliates if the education level is sufficiently high, and could decrease the number of wholly owned affiliates if the education level of the host country is sufficiently low. As IPRs becomes stronger, we could experience a simultaneous increase in sales and decrease in the number of firms. Our results also show that not all firms benefit from stronger IPR. We conjecture that large and/or technology-intensive firms should benefit from stronger IPR, for several reasons. First, large MNEs usually acquire advance and specific technology that generates more profits. Therefore, the protection of their technology is crucial. In addition, a large MNE is able to take advantage of an increasing returns to scale as sales increase. As larger firms gain more sales, small firms shrink further and are eventually forced to leave the market. Moreover, an increase in sales for large MNEs uses more resources, resulting in less resources' being available to other firms. Consequently, some small MNEs are pushed out of the market. As shown in our analysis, it is possible that stronger IPRs benefits large MNEs by increasing their sales, but hurts small firms and drives them out of the market, which results in a reduction in the number of firms.

Relating the effect of IPRs on sales to the effect IPRs on the number of firms seems intuitive. However, there are two important points that we must be careful with. First, the data on sales are not perfectly compatible with the data on the number of firms. While we use data on the sales of majority-owned affiliates, data on the number of firms belongs to wholly owned affiliates. We could assume that the sales of majority-owned affiliates are close enough to the

sales of wholly-owned affiliates, since over 90% of the majority-owned are wholly owned affiliates according to the BEA survey. Second, while the data of sales reflect a panel of countries over 10 years, the data of the number of firms reflect a panel of countries and industries over just one year (1995). Despite these points, the results from both data sets provide us with an interesting characterization of the effect of IPR on JV and wholly owned affiliate activities.

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Table 1: Summary of effects of stronger IPRs

Type of Contract	Sales	Extent of JVs
Preventing	decrease	decrease
Compensating	increase*	increase*
Self-Enforcing	decrease	increase

*denotes the effect of IPRs given that the elasticity of the Northern profit share of JV with respect to imitation is sufficiently high.

Table 2: Descriptive statistics of the variables in the sales analysis

Variable	Observations	Mean	Std. Dev.	Min	Max
LJV	473	7.45	1.88	0	11.52
L(JV/GDP)	359	-4.52	1.12	-8.31	-0.58
LMAJOR	475	9.41	1.54	5.55	12.94
L(MAJOR/GDP)	463	-16.39	1.04	-21.12	-14.00
LIPR	481	1.05	0.39	-1.11	1.55
LGDPC	480	9.22	0.85	-6.56	10.69
LLABOR	489	-9.69	1.33	-11.80	-6.37
LEDU	469	1.99	0.60	-1.20	2.95

Notes: LJV denotes log of JVs sales in millions of U.S. dollars. L(JV/GDP) denotes log of JV sales adjusted by real GDP in U.S. dollars. LMAJOR denotes log of majority-owned affiliates sales in millions of U.S. dollars. L(MAJOR/GDP) is log of majority-owned affiliates sales adjusted by real GDP in U.S. dollars. LIPR denotes the log of IPR index developed by Ginarte and Park (1997). LGDPC denotes log of real GDP per capita in U.S. dollars. LLABOR denotes log of labor force adjusted by real GDP. LEDU denotes log of the percentage of population over 25 year old having higher than secondary level of education.

Table 3: Correlation matrix of the variables in the sales analysis

	LIPR	LGDPC	LLABOR	LEDU
LIPR	1			
LGDPC	0.703	1		
LLABOR	-0.702	-0.977	1	
LEDU	0.521	0.392	-0.426	1

Table 4: JV models

Variable	LJV		L(JV/GDP)	
	Fixed	Random	Fixed	Random
constant	-4.523 (4.424)	-7.551*** (2.416)	-19.591*** (4.196)	-22.436*** (1.896)
LIPR	0.442*** (0.183)	0.456*** (0.180)	0.377** (0.174)	0.389** (0.167)
LGDP	3.047*** (0.958)	2.954*** (0.601)	2.225** (0.908)	1.329*** (0.480)
LLABOR	1.803 (1.114)	1.404*** (0.423)	2.108** (1.055)	0.983*** (0.306)
LEDU	0.484** (0.207)	0.407** (0.188)	0.488** (0.196)	0.510*** (0.162)
LIPR*LEDU	-0.033 (0.104)	-0.011 (0.102)	-0.071 (0.098)	-0.035 (0.094)
R2	0.257	0.285	0.044	0.199
Observations	416	416	414	414
F test	***		***	
LM test		***		***
Hausman test	Fixed		Fixed	

Estimated coefficients are shown together with the standard errors in parentheses. ***, **, and * denote 1%, 5%, and 10% levels of significance respectively. All variables are in log format.

Table 5: Wholly owned affiliate models

Variable	LJV		L(JV/GDP)	
	Fixed	Random	Fixed	Random
constant	-10.358*** (1.680)	-9.083*** (1.134)	-25.713*** (1.513)	-25.579*** (0.993)
LIPR	-0.151** (0.070)	-0.156** (0.069)	-0.179*** (0.063)	-0.175*** (0.063)
LGDP	3.038*** (0.362)	3.360*** (0.267)	2.441*** (0.326)	2.287*** (0.236)
LLABOR	0.938** (0.422)	1.373*** (0.233)	1.415*** (0.380)	1.283*** (0.198)
LEDU	0.174** (0.078)	0.173** (0.075)	0.075 (0.071)	0.088 (0.068)
LIPR*LEDU	0.275*** (0.039)	0.267*** (0.039)	0.246*** (0.035)	0.245*** (0.035)
R2	0.460	0.465	0.062	0.069
Observations	418	418	418	418
F test	***		***	
LM test		***		***
Hausman test	Fixed		Fixed	

Estimated coefficients are shown together with the standard errors in parentheses. ***, **, and * denote 1%, 5%, and 10% levels of significance respectively. All variables are in log format.

Table 6: Fixed effect models with robust covariance estimators

Variable	LJV	L(JV/GDP)	LMAJOR	L(MAJOR/GDP)
constant	-3.521 (5.256)	-4.898 (4.903)	-10.926*** (2.633)	-26.154*** (2.391)
LIPR	0.443*** (0.140)	0.378*** (0.134)	-0.151** (0.065)	-0.179*** (0.059)
LGDP	3.047*** (0.47)	2.251** (0.927)	3.035*** (0.464)	2.441*** (0.404)
LLABOR	1.803 (1.142)	2.111* (1.1290)	0.938* (0.500)	1.415*** (0.440)
LEDU	0.484*** (0.183)	0.481*** (0.166)	0.174** (0.084)	0.075 (0.074)
LIPR*LEDU	-0.033 (0.090)	-0.070 (0.090)	0.275*** (0.036)	0.246*** (0.032)
R2	0.916	0.778	0.982	0.961
Observations	416	414	418	418

Estimated coefficients are shown together with the standard errors in parentheses. ***, **, and * denote 1%, 5%, and 10% levels of significance respectively. All variables are in log format.

Table 7: Summary Statistics of the variables in the count model

Variable	Observations	Mean	Std. Dev.	Min	Max
JV	2365	0.920	1.735	0	25
WO	2365	2.825	5.972	0	84
IPR	2365	3.177	0.860	1.08	4.24
GDPC	2365	13794	7548	1979	25674
EDU	2365	8.9	3.542	1.6	15.6
LABOR/GDP	2365	0.0003	0.0016	0.00001	0.0105
R&D/SALES	2365	0.018	0.024	0	0.084
EMPLOYEE	2365	364.281	475.709	7.6	2667.9

Notes: JV denotes counts of U.S. firms having joint ventures activity in 1995. WO denotes counts of U.S. firms having wholly owned affiliates activity in 1995. IPR denotes the IPR index developed by Ginarte and Park (1997). GDPC denotes real GDP per capita in U.S. dollars. LABOR/GDP denotes labor force adjusted by real GDP. EDU denotes percentage of population over 25 year old having higher than secondary level of education. R&D/SALES denotes R&D expenditures as a fraction of total sales by industry of U.S. parents in U.S. dollars. EMPLOYEE denotes numbers of employees of U.S. parents by industry measured in thousands.

Table 8: Correlation matrix of the variables in the count model

	IPR	GDP	EDU	IPR*EDU	LABOR/GDP	R&D/SALES	EMPLOYEE
IPR	1						
GDP	0.745	1					
EDU	0.384	0.333	1				
IPR*EDU	0.718	0.580	0.890	1			
LABOR/GDP	-0.282	-0.275	-0.094	-0.197	1		
R&D/SALES	0	0	0	0	0	1	
EMPLOYEE	0	0	0	0	0	0.156	1

Table 9: Counts of JV model

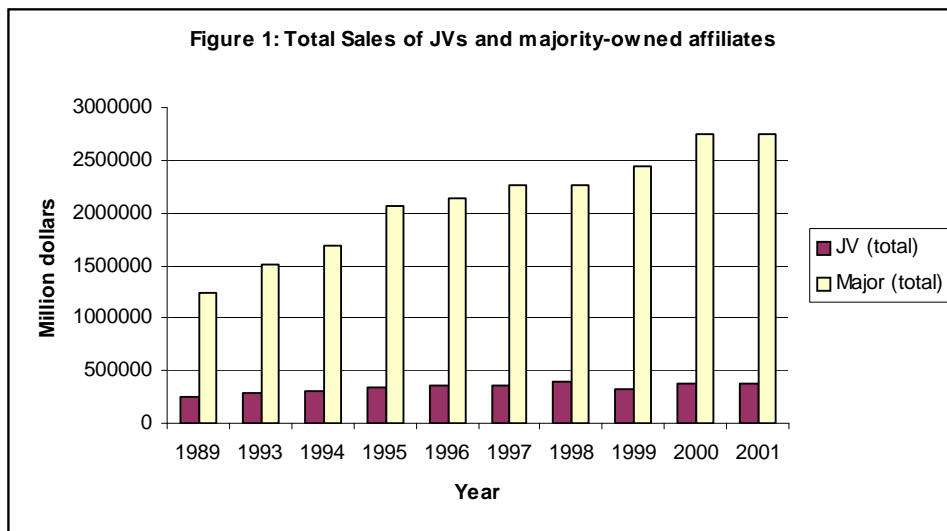
Variable	Poisson		Negative Binomial		Zero-inflated	
	JV	Marginal effect	JV	Marginal effect	JV	Marginal effect
constant	0.075 (0.296)		0.133 (0.302)		1.037*** (0.286)	
IPR	-0.274*** (0.107)	-0.233** (0.092)	-0.261** (0.105)	-0.222** (0.090)	-0.369*** (0.099)	-0.414*** (0.115)
GDP	2.3e-05*** (6.68e-06)	1.9e-05*** (1.0e-05)	1.9e-05*** (7.14e-06)	1.6e-05*** (1.0e-05)	1.2e-05* (6.99e-06)	1.3e-05* (1.0e-05)
EDU	-0.123*** (0.037)	-0.105*** (0.032)	-0.141*** (0.039)	-0.120*** (0.033)	-0.150*** (0.039)	-0.168*** (0.044)
IPR*EDU	0.041*** (0.012)	0.035*** (0.010)	0.044*** (0.012)	0.037*** (0.010)	0.049*** (0.012)	0.055*** (0.013)
LABOR/GDP	-78.393*** (29.094)	-66.777*** (24.876)	-84.205*** (30.958)	-71.555*** (26.368)	-78.298*** (30.216)	-87.735** (34.016)
R&D/SALES	3.679** (1.442)	3.134** (1.246)	3.567** (1.526)	3.031** (1.314)	3.485** (1.498)	3.905** (1.697)
EMPLOYEE	0.0005*** (5.8e-05)	0.0004*** (0.00005)	0.0005*** (6.47e-05)	0.0004*** (0.00006)	0.0004*** (6.04e-05)	0.0005*** (0.00007)
Inflate WO					-0.660*** (0.081)	0.132*** (0.013)
Constant					0.340*** (0.107)	
# of obs.	2365		2365		2365	
Zero obs.	1387		1387		1387	

Estimated coefficients are shown together with the standard errors in parentheses. ***, **, and * denote 1%, 5%, and 10% levels of significance respectively.

Table 10: Counts of WO model

Variable	Poisson		Negative Binomial		Zero-inflated	
	WO	Marginal effect	WO	Marginal effect	WO	Marginal effect
constant	-2.279*** (0.380)		-2.037*** (0.336)		-1.799*** (0.341)	
IPR	0.454*** (0.103)	0.962*** (0.212)	0.468** (0.102)	0.999*** (0.214)	0.442*** (0.101)	1.117*** (0.252)
GDP	8.0e-05*** (6.37e-06)	1.7e-04*** (1.0e-05)	8.3e-05*** (6.86e-06)	0.0002*** (2.0e-05)	8.3e-05*** (6.81e-06)	0.0002*** (0.00002)
EDU	0.209*** (0.042)	0.443*** (0.086)	0.168*** (0.039)	0.357*** (0.084)	0.184*** (0.040)	0.465*** (0.102)
IPR*EDU	-0.058*** (0.011)	-0.122*** (0.023)	-0.056*** (0.011)	-0.119*** (0.024)	-0.060*** (0.011)	-0.151*** (0.029)
LABOR/GDP	-78.891*** (36.395)	-167.067** (76.947)	-61.766 (38.081)	-131.796 (80.736)	-59.061 (39.691)	-149.440 (99.708)
R&D/SALES	12.364*** (1.581)	26.183*** (3.448)	11.702*** (1.410)	24.969*** (3.144)	11.819*** (1.405)	29.905*** (3.783)
EMPLOYEE	0.0003*** (0.00008)	0.0007*** (0.0002)	0.0003*** (0.00007)	0.0007*** (0.0002)	0.0003*** (0.00007)	0.0007*** (0.0001)
Inflate WO					-20.667*** (-1.024)	
Constant					-1.024*** (0.134)	
# of obs.	2365		2365		2365	
Zero obs.	995		995		995	

Estimated coefficients are shown together with the standard errors in parentheses. ***, **, and * denote 1%, 5%, and 10% levels of significance respectively.



Appendix

Table A1: Lists of countries in the sales analysis

Argentina	Australia	Austria	Belgium	Brazil	Canada	Chile	Columbia	Costa Rica
Denmark	Ecuador	Egypt	Finland	France	Germany	Greece	Guatemala	Honduras
Hong Kong	India	Indonesia	Ireland	Israel	Italy	Japan	Korea	Luxembourg
Malaysia	Mexico	Netherlands	New Zealand	Nigeria	Norway	Panama	Peru	Philippines
Portugal	Saudi Arabia	Singapore	South Africa	Spain	Sweden	Switzerland	Taiwan	Thailand
Trinidad and Tobago		Turkey	England	United Arab Emirate		Venezuela		

Table A2: Lists of countries in the count data analysis

Argentina	Australia	Austria	Belgium	Brazil	Canada	Chile	Columbia	Costa Rica
Denmark	Egypt	Finland	France	Germany	Greece	Guatemala	Hong Kong	India
Indonesia	Ireland	Israel	Italy	Japan	Korea	Malaysia	Mexico	Netherlands
New Zealand	Norway	Panama	Peru	Philippines	Portugal	Singapore	South Africa	Spain
Sweden	Switzerland	Thailand	Trinidad and Tobago	Turkey	England	Venezuela		

Table A3: Lists of industries in the count data analysis

1	Agriculture, forestry, and fishing	29	Farm and garden machinery
2	Mining	30	Construction, mining, and materials handling machinery
3	Crude petroleum extraction (no refining) and gas	31	Industrial machinery and equipment
4	Oil and gas field services	32	Computer and office equipment
5	Construction	33	Household appliances
6	Food and kindred products	34	Household audio and video, and communications equipment
7	Grain mill and bakery products	35	Electronic components and accessories
8	Beverages	36	Electronic and other electric equipment, not elsewhere classified
9	Other food and kindred products Mfg.	37	Motor vehicles and equipment
10	Tobacco products	38	Other transportation equipment, nec
11	Textiles products and apparel	39	Transportation equipment
12	Lumber, wood, furniture, and fixtures	40	Transportation
13	Paper and allied products	41	Communication
14	Printing and publishing	42	Electric, gas, and sanitary services
15	Industrial chemicals and synthetics	43	Petroleum wholesale trade
16	Drugs	44	Retail trade
17	Soap, cleaners, and toilet goods	45	Insurance
18	Agricultural chemicals	46	Real estate
19	Chemical products, not elsewhere classified	47	Hotels and other lodging places
20	Integrated petroleum refining and extraction	48	Advertising
21	Petroleum refining without extraction	49	Equipment rental (except automotive and computers)
22	Petroleum and coal products, not elsewhere classified	50	Computer and data processing services
23	Rubber products	51	Business services, not elsewhere classified
24	Miscellaneous plastics products	52	Motion pictures, including television tape and film
25	Glass products	53	Health services
26	Stone, clay and nonmetallic mineral products	54	Engineering, architectural, and surveying services
27	Ferrous	55	Management and public relations services
28	Nonferrous		