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International Outsourcing Through Foreign Direct Investment and Intellectual Property Protection

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Abstract

This paper studies international outsourcing through Foreign Direct Investment (FDI) by Multinational Enterprise (MNE). Outsourcing process is decomposed to two steps—choosing production location and shipping products back to home country. Outsourcing is measured as the ratio of affiliate sales over US parent sales. Based on cost comparison, Factors that affect production cost and factors that affect trade cost both matter. Improved Intellectual Property Protection (IPP) increases outsourcing by reducing the effective cost of skilled labor and by strengthening the impact of R&D. Bilateral data between US and other countries are used for empirical test. Least Squares (LS) regression is applied to positive outsourcing observations and the zero-outsourcing observations are added in the Tobit regression. IPP is significant in LS specifications but not in Tobit specifications. When the outsourced countries are divided into developed countries (DC's) and less developed countries (LDC's). IPP is only significant for the DC's. Possible reasons for different IPP effects are discussed. Industries also have different effects on outsourcing.

Keywords: Outsourcing, Intellectual Property Protection (IPP), Technology Intensity Skilled labor, Unskilled Labor

JEL Classification: F1, F2, J3

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I. Introduction

International outsourcing becomes popular as more intermediate goods produced in foreign countries are imported back to the home countries, and are assembled and marketed back at home. The global outsourcing market was $72 billion (U.S.) in 2002 and is predicted to rise to $100 billion (U.S.) by 2005[2].

International outsourcing is traditionally measured by imports of intermediate goods used for further production. A broader measure includes the final goods produced abroad, but marketed in the parent country, for example, Nike shoes (Feenstra and Hanson, 1996).

The input-output matrix has been used to calculate the level of outsourcing[3], with imported intermediate goods identified by the keyword "part" in the industry description at the disaggregated level. If trade is the only channel of outsourcing, the outsourcing decision is simply based on finding the lowest prices globally.

Foreign direct investment (FDI) has become a more and more important channel of international outsourcing. On the one hand, the foreign country has advantage in labor cost, but does not have the technology know-how. While on the other hand, the Multinational Enterprise (MNE) operating abroad provides the production technique and ships the products back to home country.

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[2] This is reported by Sourcing Interest Group. Numbers reported by other agencies are different caused by the different measures used. The growth rate of outsourcing is predicted to be 10 to 15 percent by most of the agencies.

[3] This measure is used in many papers. See Hijzen, Gorg, and Hine (2003) for example

According to Rugman (1998), over half of the world trade involves MNE. In the past two decades, the affiliate sales back to US have accounted for more than 20 percent of US total imports[4]. Imports from affiliates explain a large portion of outsourcing. When the production involves higher technology intensity, the MNE chooses to operate in the host country and ship the products back to the parent country. This is the trend of outsourcing. It is thus important to examine outsourcing through FDI.

There is neither theoretical nor empirical analysis of outsourcing through FDI. The production fragmentation nature of outsourcing can be well explained by the vertical FDI theory[5] though. This paper is the first empirical study using FDI as the channel of outsourcing. Different from the current measure of international outsourcing that uses trade data, a new measure is developed using the sales data of the parent firms and of the foreign affiliates[6]. The determinants of outsourcing are derived from a simple model and are applied to empirical test.

In the rest of the paper, section II reviews the literature; section III discusses the theoretical model; section IV specified the empirical model and explains the empirical results; section V concludes.

II. Literature Review

[4] the percentage is calculated using BEA data.
[5] See section of literature review for vertical FDI theory.
[6] This measure excludes the pure imports of intermediate goods. As the determinant of such pure import is just price, it's not the interest of study. This paper focuses on the determinants of outsourcing through FDI.

Feenstra and Hanson 's (1996) model serves as the foundation of outsourcing analysis, where outsourcing is modeled as the shift of production from the North to the South. The South has lower cost of unskilled labor and higher capital return. When the technology intensity of the production rises, the relative cost of skilled labor increases faster in the South than in the North. The equilibrium technology intensity of outsourcing is reached when the unit cost is the same and the MNE is indifferent of the production location. When there is capital movement from the North to the South, the southern capital accumulation lowers capital return and lowers the unit cost. The equilibrium technology intensity of outsourcing increases, which means that more technology-intensive production is shifted to the South. The result in the labor market is increasing demand for skilled labor in both the North and the South.

Grossman and Helpman (2002) develop a general equilibrium analysis of outsourcing contract. They study the determinants of outsourcing location in a general equilibrium model. Several factors are recognized as key determinants such as the thickness of the domestic and foreign markets for input suppliers, the searching cost, the cost of customizing inputs, and the contracting environment. Rauch and Watson (2003) apply the contract theory to study firms' propensity of "starting small" with a trial order.

Other papers focus on the effects of international outsourcing. Wage effects, technology innovation and spillovers, and welfare effects are the most studied. Glass and Saggi (1998) find that outsourcing lowers marginal cost, increases profits, frees resources and thus creates incentives for innovation. Pack and Saggi (2001) later examine the vertical technology transfer from the developed country (DC) as an importer to the less developed country (LDC). The transferred technology can diffuse to other LDC firms. Even with such diffusion, both the DC importer and LDC supplier benefit because of the reduced double marginalization[7] problem. Deardorff (2001) examines the effects of "fragmentation," as the splitting of a production process into two or more steps that can be undertaken in different locations but that lead to the same final product. His findings demonstrate ambiguous welfare effect depending on the change in price; fragmentation is a force towards factor price equalization; for countries that gain from fragmentation, some factor owners could lose.

If those discussed above are classified as operational outsourcing, where cost minimization underpins the decision, strategic outsourcing is structured so that it is aligned with the company's long-term strategies. The changes that organizations expect from strategic outsourcing can include anything such as achieving a gain in competitive advantage or repositioning the organization in the marketplace (Chamberland, 2003). Chen, Ishikawa and Yu (2004) study the collusive effect of strategic outsourcing that could raise the prices of both intermediate and final goods. They examine different impacts of trade liberalization in the intermediate-good market and in the final-good market.

If outsourcing is regarded as production fragmentation, international outsourcing is basically vertical FDI combined with imports by the parent country. The analysis of

[7] In the absence of diffusion upstream and entry downstream, two firms in bilateral monopoly impose a pecuniary vertical externality upon each other by charging a higher price than the marginal cost.

vertical FDI is supported by the endowment-base theory (Helpman-Krugman, 1985; Helpman, 1984). The production activities have different factor intensity and countries' factor endowments vary. With different endowment/non-factor price equalization, vertical FDI and two-stage production arise (Brainard, 1997). Empirically, factors that lower production cost such as lower labor cost, better infrastructure and economy of scales stimulate vertical FDI (Grubaugh, 1987; Wheeler and Mody, 1992).

Hanson, Mataloni, Slaughter (2003) examine the vertical production network in MNE using firm-level data. They study the affiliates' import of intermediate goods for further processing from the parent firm. They find that demand for imported inputs is higher when affiliates face lower wages for less-skilled labor, lower trade costs, and lower corporate income tax rates. It's not the outsourcing this paper analyzes. However, if the processed goods are shipped back to US, the measured outsourcing should be correlated to the affiliates' import demand.

Swenson's work represents the current empirical study with a specified outsourcing measure as the dependent variable. Swenson (2000) examines the operations of firms located in U.S. foreign trade subzones to study the responsiveness of outsourcing to international cost changes. He finds that firms reduce their reliance on foreign inputs when dollar depreciation increases the relative price of imported inputs. His work (Swenson, 2004) develops and tests a model of outsourcing decision in the presence of sunk entry cost. He further analyzes the production persistence that is consistent with sunk entry cost.

Despite the literature of production fragmentation (including FDI), there has been no specified measure of outsourcing through FDI, nor the determinants of outsourcing through FDI. The next section discusses a simple model of outsourcing through FDI.

III. Theoretical Framework

There are k intermediate inputs. The production of each intermediate input x_i is Cobb-Douglas production function.

$$x_i = A{L^u}_i^{\alpha}{L^s}_i^{\beta} \tag{1}$$

with $L^u{}_i$ representing unskilled labor input and $L^s{}_i$ is skilled labor input. α and β are the positive parameters of the Cobb-Douglas function. A is the productivity parameter.

Both the home and foreign countries use the same production function for each intermediate input. The MNE assembles the intermediate inputs costlessly at home, using the following function:

$$Y = \sum_{i=1}^{k} \lambda_i ({x_{i,H}}^{\rho} + {x_{i,F}}^{\rho})^{1/\rho} , \tag{2}$$

where Y is the final good; $x_{i,H}$ and $x_{i,F}$ are the intermediate goods produced in the home country and the foreign country, respectively; λ_i indicates the share of each x_i used in the final good production; ρ measures the elasticity of substitution between $x_{i,H}$ and $x_{i,F}$.

The production cost in the home country is

$$C_{i,H} = w_H L^u{}_i + q_{i,H} L^s{}_i \,, \tag{3}$$

where w_H is the wage rate for the unskilled worker and $q_{i,H}$ is the wage rate for skilled worker in producing x_i.

The production cost in the foreign country is affected by the local IPP. To keep the proprietary technology within the company, the MNE pays higher wage to the skilled workers. The production cost in the home country is

$$C_{i,F} = w_F L^u{}_i + f(\mu,\phi) q_{i,F} L^s{}_i \tag{4}$$

where μ is the level of IPP. When IPP in the foreign country is low, the MNE has to pay more to the skilled workers to prevent defection. ϕ represent other factors that may cause the MNE to pay the skilled wage rate different than $q_{i,F}$ [8]. $f(\mu,\phi)q_{i,F}$ is the effective marginal cost of the skilled labor with $\frac{\partial f(\mu,\phi)}{\partial \mu} < 0$.

[8] Based on evidence from FDI literature, foreign-invested firms tend to pay higher wages in both developed and developing countries. Possible reasons are: foreign firms engage in relatively more technology- and/or more capital-intensive production in host countries; workers are more effective at rent sharing; higher wages reduce turnover and loss of firm-specific advanced technologies or trade secretes; foreign firms provide more productive on-the-job training. See Ting Gao, 2004; Aitken, Harrison and Lipsey, 1996; Lipsey and Sjöholm, 2001; Feliciano and Lipsey, 1999)

Assume further that the wage rate for the skilled worker in both the home country and the foreign country is determined by the wage rate for the unskilled worker and the technology intensity of x_i. Therefore, $q_{i,j}\,(j = H, F)$ can be written as

$$q_{i,j} = w_j z_i^{\theta_j} , \qquad (5)$$

where z_i is the technology intensity of x_i and θ_j reflects the importance of z_i in determining the skilled wage rate. This specification comes from the evidence of labor economic literature that biased technological change has been an important source of increased (relative) demand for skilled labor and of increased (relative) wage for skilled labor (Berman et al. , 1994; Baltagi and Rich, 2004). For both countries $(j = H, F)$, w_j is the unskilled wage which does not vary across industries. The skilled wage $q_{i,j}$ varies across industry and is determined by the industrial technology intensity and the country specific parameter θ_j. If θ_H is greater than θ_F, the wage gap between the skilled and the unskilled widens faster in the home country (H) than in the foreign country (F).

The MNE's problem is to determine the optimal amount of x_i to produce at home and in the foreign country. The optimal $x_{i,H}$ and $x_{i,F}$ can be solved from profit maximization. Let's assume that the MNE produces a fixed amount of the final good, which is Y_0. The home country is a small open economy and takes the price of the final good, P_0, as given. The profit function of the firm is:

$$P_0 Y_0 - c_{i,H} x_{i,H}^{\frac{1}{\alpha+\beta}} - c_{i,F} x_{i,F}^{\frac{1}{\alpha+\beta}} , \qquad (6)$$

where $c_{i,H}$ and $c_{i,F}$ are the unit cost of the intermediate input for the home country and the foreign country, respectively. $c_{i,H}x_{i,H}^{\frac{1}{\alpha+\beta}}$ and $c_{i,F}x_{i,F}^{\frac{1}{\alpha+\beta}}$ are the corresponding production costs, with $\alpha+\beta>1$ reflecting the increasing scale of economy.

Maximize profit subject to the constraint $Y_0=\sum_{i=1}^{k}\gamma_i(x_{i,H}{}^{\rho}+x_{i,F}{}^{\rho})^{1/\rho}$ and the ratio of $x_{i,H}$ and $x_{i,F}$ is determined as below[9]:

$$\left(\frac{x_{i,F}}{x_{i,H}}\right)^{\frac{1}{\alpha+\beta}-\rho}=\frac{c_{i,H}}{c_{i,F}}, \tag{7}$$

When the affiliates ship the intermediate goods back to the parents, the trade cost is a factor that determines how much to outsource. Since the data are bilateral between the US and the foreign countries, it's only the trade cost back to US matters. Here I consider geographical distance as the only trade barrier. The unit cost of each intermediate input produced abroad is increased to $t(d)c(x_{i,F})$, where d is the distance between the home country and foreign country $t(d)\geq 1$.

FDI is modeled as the channel of outsourcing. The other factor that may play a role is the investment barrier in the foreign country. When the investment barrier is high, the

[9] If the production of the intermediate good x_i is constant return to scale, i.e. $\alpha+\beta=1$; and the intermediate goods produced in the home country and the foreign country are perfect substitute, i.e. $\rho=1$, or if $\frac{1}{\alpha+\beta}-\rho=0$, then there is only corner solution which means that the intermediate good x_i is produced only in the home country or in the foreign country. Here the assume that $\frac{1}{\alpha+\beta}-\rho\neq 0$

effective cost of the intermediate product increases. The investment is treated as additional variable cost, which increases the unit cost of $x_{i,F}$ to $I_F(\tau)t(d)c(x_{i,F})$. $I_F(\tau) \geq 1$ is the investment cost where τ represent the investment barriers[10].

Equation (7) becomes

$$(\frac{x_{i,F}}{x_{i,H}})^{\frac{1}{\alpha+\beta}-\rho} = \frac{c_{i,H}}{I(\tau)t(d)c_{i,F}} \tag{8}$$

The minimum unit costs of $x_{i,F}$ and $x_{i,H}$ given Cobb-Douglas production function are (See Appendix 1 for the derivation of minimum unit cost):

$$c_{i,F} = \frac{\alpha_i + \beta_i}{(A_F \alpha_i^{\alpha_i} \beta_i^{\beta_i})^{\frac{1}{\alpha_i+\beta_i}}} [w_F^{\alpha_i} (f(\mu,\phi) q_{i,F})^{\beta_i}]^{\frac{1}{\alpha_i+\beta_i}} \tag{9}$$

$$c_{i,H} = \frac{\alpha_i + \beta_i}{(A_H \alpha_i^{\alpha_i} \beta_i^{\beta_i})^{\frac{1}{\alpha_i+\beta_i}}} [w_H^{\alpha_i} q_{i,H}^{\beta_i}]^{\frac{1}{\alpha_i+\beta_i}} \tag{10}$$

$f(\mu,\phi)q_{i,F}$ is the effective marginal cost of the skilled labor.

Plug (5), (9), (10), the trade cost and the investment cost into (8):

$$(\frac{x_{i,F}}{x_{i,H}})^{\frac{1}{\alpha+\beta}-\rho} = \left(\frac{A_F}{A_H}\right)^{\frac{1}{\alpha+\beta}} \left(\frac{w_H}{w_F}\right)^{\frac{\alpha}{\alpha+\beta}} f(\mu,\phi)^{-\frac{\beta}{(\alpha+\beta)}} \left(\frac{w_H z_i^{\theta_i^H}}{w_F z_i^{\theta_i^F}}\right)^{\frac{\beta}{\alpha+\beta}} \frac{1}{t(d)} \frac{1}{I(\tau)}$$

[10] The investment barriers considered include restrictions on the ability to acquire control in a domestic company, limitations on the ability to employ foreign skilled labor, restraints on negotiating joint ventures, strict controls on hiring and firing practices, market dominance by a small number of enterprises, an absence of fair administration of justice, difficulties in acquiring local bank credit, restrictions on access to local and foreign capital market. It may be more appropriate to treat the investment cost as fixed cost. There is reason to believe that the cost imposed by the barriers is increasing with production expansion. Adopting the investment cost as variable cost simplifies the derivation of the empirical equation.

$$= (\frac{A_F}{A_H})^{\frac{1}{\alpha+\beta}} (\frac{w_H}{w_F}) f(\mu,\phi)^{-\frac{\beta}{(\alpha+\beta)}} (\frac{z_i^{\theta_H}}{z_i^{\theta_F}})^{\frac{\beta}{\alpha+\beta}} \frac{1}{t(d)} \frac{1}{I(\tau)} \tag{11}$$

Take natural log of (11)

$$(\frac{1}{\alpha+\beta} - \rho) \ln \frac{x_{i,F}}{x_{i,H}} = \frac{1}{\alpha+\beta} \ln \frac{A_F}{A_H} + \ln \frac{w_H}{w_F} - \frac{\beta}{\alpha+\beta} \ln f(\mu,\phi) + \frac{\beta}{\alpha+\beta} (\theta_H - \theta_F) \ln z_i + \ln \frac{1}{t(d)} + \ln \frac{1}{I(\tau)} \tag{12}$$

The empirical equation is

$$\ln \frac{x_{i,F}}{x_{i,H}} = \gamma_1 \ln \frac{A_F}{A_H} + \gamma_2 \ln \frac{w_H}{w_F} + \gamma_3 \ln f(\mu,\phi) + \gamma_4 \ln z_i + \gamma_5 \ln \frac{1}{t(d)} + \gamma_6 \ln \frac{1}{I(\tau)} \tag{13}$$

III. Empirical Test

In the empirical part, bilateral outsourcing between the US and many other countries are studied. Outsourcing share is measured as the ratio of foreign affiliate sales to US over the US parents sales.

1. Data

A panel dataset is constructed which includes 46 covering the years of 1989, 1994, and 1999. Of the 46 countries, 26 are developing countries. Six industries are included. The three years are the benchmark years of the BEA data, where the sales of foreign affiliates back to US, and the sales of US parents are obtained. The productivity data are from the CD of World Labor Market. The wage rate is proxied by the index of compensation for labor. IPR protection is measured by the GP index 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 coverage, membership in international patent agreements, provisions for loss of protection, and enforcement measures. The GP index ranges from 0 to 5 with a bigger number indicating higher IPP. Industrial technology intensity is measured by R&D performed by and for the affiliates as a share of sales by affiliates. The descriptive statistics are reported in Appendix 2.

The functional forms for $t(d)$ and $I_F(\tau)$ are

$$t(d) = e^{(d-d_{US-CAN})/2400} \tag{14}$$

By specifying the shipping cost as above, Canada is treated as the benchmark. Shipping from Canada to US doesn't increase the unit cost of the intermediate input. The distance difference is adjusted by 2400, which is roughly half the distance between the east coast and the west coast in kilometers.

$$I_F(\tau) = e^{Ave(\tau)} \quad . \tag{15}$$

The investment cost is the index developed by Carr, Markusen and Maskus (2001). I eliminate IPP from it as IPP is examined separately in the regression.

The GP index, as a measure of IPP, ranges from 0 to 5. The functional form of $f(\mu,\phi)$ is assumed as

$$f(\mu,\phi)=e^{\frac{5-\mu}{5}}e^{\phi}. \quad (16)$$

The revised IPP index, $\frac{5-\mu}{5}$, ranges from zero to one with decreasing IPP level. $e^{\frac{5-\mu}{5}}$ is thus the effect of IPP on skilled wage. the effective cost of skilled labor is not affected with perfect IPP ($\mu=5$), but e times higher with the poorest IPP ($\mu=0$).

Use the functional forms above and rewrite the empirical equation as

$$\ln\frac{x_{i,F}}{x_{i,H}}=\phi\gamma_3+\gamma_1\ln\frac{A_F}{A_H}+\gamma_2\ln\frac{w_H}{w_F}+\gamma_3(\frac{5-\mu}{5})+\gamma_4\ln z_i+\gamma_5\ln t(d)+\gamma_6\ln I(\tau). \quad (17)$$

$\phi\gamma_3$ is a constant which captures other factors that affect the skilled wage that MNE pays and it could be either positive or negative. γ_1 is expected to be positive as higher productivity in the foreign country encourages US outsourcing. γ_2 is also expected to be positive because higher wage gap between the US and the foreign country is the incentive to outsource. Higher IPP lowers the effective cost of skilled labor and γ_3 should be negative[11]. Based on the assumption of equation (5), γ_4 should be positive if the wage gap between the skilled and the unskilled increases faster in the US than in other countries, and negative otherwise. We will find out which is supported by the data. Investment cost and trade cost discourage outsourcing and the coefficients of these two should be negative.

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[11] Based on the functional form of $f(\mu,\phi)$, μ is measured by GP index, but the revised IPP index, $\frac{5-\mu}{5}$, is used as a regressor. A higher value of this transform index actually indicates lower IPP protection.

There are 448 observations left after cleaning the data set. 247 of them have no sales from foreign affiliates back to US, which means “0” outsourcing. I first run the LS (least square) regression using the positive outsourcing data; Secondly, the Tobit model is applied to all the 448 observations; lastly, instrumental variables are added to address the issue of endogeneities of wage rate and R&D share. For all the regressions, industry dummies are added to capture industrial characteristics not modeled in the equation. I do not want to use country dummies because that would sweep out some of the important variation. Region dummies are discussed later in this section. The dependent variable and the independent variables are in ratios[12] and there is no worry about the data being non-stationary over time.

2. Empirical Results

Insert Table 1 here

Table 1 reports the results of LS regression using the positive outsourcing observations. As specified in equation (17), the dependent variable is outsourcing, which is the affiliate sales back to US as a share of sales of the US parents. In the first column, all the coefficients are significant and the signs are as predicted except that of IPP. Higher IPP, as a protection of proprietary technology, may increase affiliates R&D expenditure[13]. Considering this effect of IPP through R&D expenditure, I add an interactive term between IPP and R&D share. The results are in column 2. All the coefficients are significant including the interactive term. IPP has positive effect on outsourcing (negative

[12] Distance and IPP are not in ratios, but they only vary across country.
[13] Later in this section, instruments are added to deal with the endogeneity of R&D expenditure.

coefficient on the revised IPP index[14]) and R&D has positive effect on outsourcing. The coefficient of the interactive term is negative which means that higher IPP protection (lower index) strengthens the R&D effect. At last let's take a look at the industry effect. Industry dummies are added for food, chemical, metal, transportation and electronic industries. The estimated coefficients reflect the industry effect compared with being machinery industry. Both columns reports significant higher outsourcing for the electronic industry. Electronic industry is characterized by the production of many components used as intermediate inputs. These component vary in technology intensity as well as skill requirement of the labor. The data demonstrate that the electronic industry fits in the production fragmentation analysis.

Insert Table 2 here

Table 2 presents the results of Tobit model[15] after 247 zero-outsourcing observations are added back. In column one, the only significant coefficients are those of investment cost, R&D shares, and the interactive term. IPP is significant but has the wrong sign. The zero observations account for more than fifty percent of all the 448 observations. Looking back at the data, I found that countries in South America account for a large portion of the zero observations. The South America dummy is added and it equals one for South American countries. Column two reports the results with this dummy variable. All the coefficients are significant now except that of distance. IP, however, still has the wrong sign. The dummy variable is negative and significant, which implies that being South

[14] See note 1.

[15] Taking natural log of the zero-outsourcing observations would cause missing values. The dependent variable in the Tobit specifications are natural log of one plus outsourcing share. The zero-outsourcing observations remain zeros in the log form. Because of the existence of zero R&D shares, the same method is also applied when taking natural log R&D shares. Other regressors do not have such problem.

American countries decreases outsourcing. The reason could be the political instability of some South American countries or the financial crises they experienced during this time period. Let's now come back to distance which is not significant in the Tobit model. In all the three specifications of the LS estimation, the coefficients of distance are significant. Distance, therefore, matters for those have determined to outsource, i.e., operate abroad and ship back the intermediates. The zero observations could be due to either zero operation abroad or zero shipment back to the US. The data indicate that the latter reason dominates. The Tobit model explains not only the share of outsourcing, but also the decision of outsourcing in the first place. The interpretation is that distance is not statistically significant in explaining this decision. This evidence supports the decomposition of outsourcing process as choosing production location and shipping the products back home. Distance determines trade cost and is only significant is the second step of outsourcing.

Wage ratio and R&D expenditure are suspected to be endogenously determined rather than being the exogenous variables specified in section III. Instrumental variables are added to deal with the endogeneity problem. Valid instruments are the ones that are correlated with the wage ratio or the R&D expenditure but uncorrelated with unobserved errors to the outsourcing share. I consider the endowments of capital and land, infrastructure, education in the host country. The other two instruments are the net foreign property and the number of employees in foreign affiliates in each industry. Each of the six instruments is possible determinant of wage rate. The empirical study shows evidence that technological opportunity affects R&D intensity (Nelson and Wolff, 1997).

All the instrumental variables except land endowment are likely to increase technological opportunity.

The data of the land area, capital formation, education, and infrastructure are from the World Development Indicator. Land is in squared kilometers; capital formation is in percentage of GDP; education is the enrolment ratio for secondary school; infrastructure is proxied by electricity capacity per capita. The other two instruments, net property of the affiliate and number of employees in the affiliate, are from BEA data.

Insert Table 3 and 4 here

Table 3 and table 4 report the results with the above instruments. In table 3, the Two-stage Least Square (2SLS) regression results are in column one. All the coefficients are significant except IPP. After adding the interactive term between IPP and R&D, column 2 reports significance of IP, R&D, and the interactive term. Higher IPP has direct effect on lowering skilled labor cost as well as indirect effect on strengthening the R&D effect[16]. Only the electronic industry has significant impact on outsourcing.

Results of the Tobit model with instruments are in table 4. In column one, distance and R&D are not significant, IPP is significant but has the wrong sign, and the interaction is not significant, either. In column two, South America dummy[17] is added to account for the zero outsourcing observations of these countries. The interaction between IPP and

[16] The explanation of the coefficients is the same as for table 1.
[17] Other two dummies for Asian countries and European countries were also added, but neither of them was significant.

R&D is also included. All the variables are significant except distance and IP. The food, chemical, and transportation industries have significant negative impact on outsourcing.

In the 3rd column of table 3 and the 3th column of table 4, I add dummy variable for developed countries. The coefficients of the developed dummy are negative and significant for both the LS and the Tobit estimations. This provides evidence that the first step of international outsourcing is basically vertical FDI which most often has the developing countries as the host country.

Insert Table 5 here

As described earlier, of the 46 countries, 26 are less developed countries (LDC's) and 20 are developed countries (DC's). It's interesting to see if the determinants behave differently for the DC's and LDC's. I divide the 447 observations into two groups: DC's and LDC's. Tobit regression is applied to each group. The results are presented in Table 5. Column one is for the LDC's. Distance is not significant, nor is IPP. The effect on outsourcing of being chemical or transportation industry is negative and significant; while positive and significant for being electronic industry. In column two, for the DC's, all the regressors are significant with the right signs except the insignificant industry effects. Significant IPP in column two indicates that higher IPP does lower the effective cost of skilled labor and stimulates outsourcing. The insignificant IPP for the LDC's could be due to two reasons: (i) the use of unskilled labor dominates in the LDC's; (ii) the skilled labor cost in the LDC's is so low that it is stilled favorable even with the poorest IPP. Based on the data, the average R&D share in the DC's is nearly twice that in the LDC's (8.3% in the DC's and 4.2% in the LDC's). Lower R&D share indicates higher intensive use of unskilled labor in the LDC's. As discussed in equation (5), industrial technology intensity (proxied by R&D share) determines the skilled wage cost. Lower R&D share leads to lower skilled wage. Therefore, both reasons suggested above could contribute the insignificant IPP for the LDC's.

2.1 Summary of Empirical Results

Putting all the results from the above specifications, I find the following results that describe the determinants of outsourcing.

Result 1

Wage, productivity, and investment cost, as determinants of production and operation cost, are factors that affect the choice of production location. They are significant for all the specification.

Result 2

Distance explains the share of outsourcing, but not the decision of outsourcing or not. In the LS estimation using positive outsourcing observations, distance decreases the share of outsourcing. This is consistent with the gravity theory of trade. Being far away just lowers the imports back to US, which is the second step of outsourcing activity. In the Tobit analysis, when zero-outsourcing decisions account for more than half of the observations, distance is not significant in any of the specifications. In comparing the

LDC's group and DC's group, distance is significant for DC's but not for LDC's. The interpretation is that the effects of production cost in LDC's dominate.

Result 3

Based on the model, IPP influences outsourcing through changing the effective cost of skilled labor as well as its interaction with R&D. For the LS specifications, IPP and R&D are significant, so is the interaction between the two. The Tobit results, however, reveal insignificant coefficients of IPP. The interaction between IPP and R&D is always significant, though. IPP level itself, modeled as an influence on skilled wage, is significant for LS specifications but insignificant for Tobit specification. The explanation is that IPP is more likely to affect outsourcing share after the outsourcing decision has been made. In the Tobit specification with half of the observations of dependent variable being zero, other variables dominate in determining outsourcing or not in the first place.
IPP behaves differently for the LDC's and DC's, too. LDC's have insignificant IPP effect due to possible reasons discussed earlier.

Result 4

The industrial effects are explained by the industry dummies. LS specification demonstrate positive and significant effect on outsourcing for being electronic industry. In the Tobit results, food, metal, and chemical industries reveal negative impact and electronic industry reveals positive impact on outsourcing compared with the machinery. Therefore, industrial characteristics matter more in determining outsourcing or not. For the positive outsourcing data, only being the electronic industry significantly increases outsourcing share.

Result 5

Being developed countries significantly decreases outsourcing, which proves the nature of outsourcing as vertical FDI

Result 6

In nearly all the regression results, the coefficients (γ_4) of R&D are positive and significant. According to the empirical equation(12) and (13), $\gamma_4 = \frac{\beta}{\alpha+\beta}(\theta_H - \theta_F)$. α and β are positive constants, so $(\theta_H - \theta_F)$'s are positive. θ_H is for US and θ_F is for all the other countries. As discussed earlier about equation (5), the positive $(\theta_H - \theta_F)$ means that wage gap between the skilled and the unskilled widens faster in the home country (H) than in the foreign country (F) when experiencing same technology advancement. It would be interesting to find out $(\theta_H - \theta_F)$ country by country. However, the data set only has three years and six industries which do not allow regressions for each country. Using the results of Table 5, we can have a rough comparison between US vs. LDC's and US vs. DC's. In column one for LDC's, γ_4(the coefficient of R&D) is 0.028. In column two for DC's, γ_4(the coefficient of R&D) is 0.0023. $(\theta_H - \theta_F)$ between US and LDC's is ten times that between US and DC's. With the increase in technology intensity, the wage gap between skilled labor and unskilled labor widens faster in the US than in both LDC's and other DC's. However, the rate that the gap widens in other DC's is much closer to that of the US. In other words, with the same increase in technology intensity, the LDS's that usually have advantage in unskilled labor cost also have advantage in skilled labor cost.

IV. Conclusion

This paper studies international outsourcing through FDI by MNE. Outsourcing process is decomposed to two steps—choosing production location and shipping products back to home country. Outsourcing is measured as the ratio of affiliate sales over US parent sales. Based on cost comparison, Factors that affect production cost and factors that affect trade cost both matter. IPP affects outsourcing through its influence on effective wage cost as well as R&D expenditure. Improved IPP increases outsourcing by reducing the effective cost of skilled labor and by strengthening the impact of R&D. LS regression is applied to positive outsourcing observations and the zero-outsourcing observations are added in the Tobit regression. IPP is significant in LS specifications, but not in Tobit specifications. The outsourced countries are divided into developed countries (DC's) and less developed countries (LDC's). IPP is only significant for the DC's. The different results of the LS estimation and the Tobit estimation demonstrate how the determinants affect the share for those who have positive outsourcing, and for those who face the decision of outsource or not. Possible reasons of different IPP effects are discussed. Industry effects also demonstrate different impact on outsourcing. This is the first empirical paper that uses FDI data to analyze outsourcing. Most of the results are consistent with the theoretical analysis. In the future, I plan to do the empirical study at disaggregated industry levels which can provide more variation in R&D. With the additions of extremely high R&D sectors and extremely low R&D sectors, IPP effect could be better analyzed.

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Table 1 LS estimation (with positive observations of the independent variable)

Independent variable: Affiliate sales to US/Sales of US parents

Dependent Variables	(i) Coefficient (t-statistic)	(ii) Coefficient (t-statistic)
C	4.595**	7.410*
	(2.1)	(2.49)
Log(Wage ratio) (US/Foreign)	3.225*	3.119*
	(4.9)	(4.676)
Log(Productivity) (Foreign/US)	3.743*	3.486*
	(3.275)	(3.007)
Log(Distance)	-1.928*	-1.901*
	(-4.075)	(-3.997)
Log(Investment cost)	-1.882*	-1.976*
	(-3.681)	(-3.78)
Log(R&D) (Affiliate)	0.362**	0.831*
	(2.171)	(2.533)
IP(inverse)	-4.123**	-12.866**
	(-1.843)	(-2.17)
IP(inverse)*log(R&D)		-1.532***
		(-1.696)
FOOD	-0.552	-0.556
	(-0.846)	(-0.869)
CHEM	-0.355	-0.344
	(-0.604)	(-0.601)
META	0.021	0.031
	(0.035)	(0.054)
TRAN	-0.956	-0.907
	(-1.477)	(-1.415)
ELEC	1.799*	1.744*
	(2.871)	(2.869)

Table 2 Tobit (with both positive and zero observations and of the independent variable)

Independent variable: Sales affiliates to US/Sales of US parents

Independent Variables	(i) Coefficient (t-statistic)	(ii) Coefficient (t-statistic)	(iii) Coefficient (t-statistic)
C	0.0109 (1.53)	-0.0045 (-0.6)	0.0199* (2.74)
Log(Wage ratio) (US/Foreign)	0.0007 (0.87)	0.0044* (3.78)	0.0029** (2.23)
Log(Productivity) (Foreign/US)	0.0017 (0.77)	0.0057* (2.4)	0.0049** (2.08)
Log(Distance)	0.0002 (0.15)	-0.0017 (-1.22)	-0.0021 (-1.49)
Log(Investment cost)	-0.0055* (-2.87)	-0.0059* (-3.2)	-0.0057* (-3.13)
Log(R&D) (Affiliate)	0.0117* (2.96)	0.0137* (3.57)	0.0145* (3.76)
IP(inverse)	0.0115*** (1.91)	0.0154** (2.56)	0.0089 (1.35)
IP(inverse)*R&D	-1.0382*** (-1.66)	-1.4022* (-2.3)	-1.4484** (-2.39)
S. America dummy (=0 for S. American countries)		-0.0191* (-5.19)	-0.0169* (-4.66)
Developed dummy (=1 for developed countries)			-0.0049** (-2.29)
FOOD	-0.0033 (-1.51)	-0.0037*** (-1.72)	-0.0035*** (-1.63)
CHEM	-0.001 (-0.49)	-0.0013 (-0.65)	-0.0011 (-0.59)
META	-0.001 (-0.45)	-0.0007 (-0.34)	-0.0005 (-0.27)
TRAN	-0.0028 (-1.23)	-0.0026 (-1.2)	-0.0024 (-1.1)
ELEC	0.0042** (1.95)	0.0042** (1.99)	0.0042** (2.03)

Table 3 LS with instruments

Independent variable: Sales affiliates to US/Sales of US parents

Dependent Variables	(i) Coefficient (t-statistic)	(ii) Coefficient (t-statistic)	(iii)Coefficient (t-statistic)
C	9.412**	47.102*	27.74**
	(2.3)	(2.496)	(2.44)
Log(Wage ratio) (US/Foreign)	4.215*	4.960**	5.622**
	(2.725)	(1.857)	(2.08)
Log(Productivity) (Foreign/US)	5.170*	4.643	8.474**
	(2.488)	(1.3)	(2.19)
Log(Distance)	-1.704*	-1.100	-2.374*
	(-3.444)	(-1.233)	(-2.64)
Log(Investment cost)	-1.859*	-3.565*	-1.730
	(-2.816)	(-2.58)	(-1.57)
IP(inverse)	-2.180	-122.537**	-14.83***
	(-0.75)	(-2.182)	(-1.87)
Log(R&D) (Affiliate)	1.447*	7.382*	3.118**
	(2.615)	(2.53)	(2.5)
IP(inverse)*R&D		-20.409**	
		(-2.15)	
Developed dummy (=1 for developed countries)			-7.738**
			(-2.03)
S. America dummy (=0 for S. American countries)			
FOOD	0.184	0.784	2.086
	(0.21)	(0.516)	(1.2)
CHEM	-1.062	0.0445	-1.269
	(-1.35)	(0.31)	(-0.96)
META	0.645	1.385	2.617
	(0.748)	(0.913)	(1.5)
TRAN	-0.935	0.3675	0.490
	(-1.103)	(0.233)	(0.31)
ELEC	1.814*	1.6705	2.045***
	(2.443)	(1.312)	(1.67)

Table 4 Tobit with instruments

Independent variable: Sales affiliates to US/Sales of US parents

Independent Variables	(i) Coefficient	(ii) Coefficient	(iii) Coefficient
C	0.0122	0.0284*	0.0276*
	(1.49)	(3.28)	(3.35)
Log(Wage ratio)	0.001	0.0025***	0.0024**
(US/Foreign)	(0.74)	(1.66)	(1.72)
Log(Productivity)	0.002	0.0057**	0.0058**
(Foreign/US)	(0.73)	(2.0)	(2.11)
Log(Distance)	0.0011	-0.0076	-0.0008
	(0.69)	(-1.63)	(-0.53)
Log(Investment cost)	-0.007*	-0.007*	-0.0082*
	(-3.19)	(-3.33)	(-3.86)
Log(R&D)	0.0146*	0.01**	0.0234*
(Affiliate)	(3.36)	(2.36)	(4.78)
IP(inverse)	0.0288**	0.0281**	0.0304**
	(2.08)	(2.04)	(2.28)
IP(inverse)*R&D	-0.0048	-0.0049	-0.0095**
	(-1.01)	(-1.05)	(-1.99)
S. America dummy		-0.015*	-0.0153*
(=0 for S. American countries)		(-2.66)	(-4.46)
Asia		0.008	
(=0 for Asian countries)		(0.86)	
Euro		-0.0019	
(=0 for European countries)		(-0.32)	
Developed dummy			-0.0113*
(=1 for developed countries)			(-4.74)
FOOD	-0.0043***	-0.0056**	-0.0036
	(-1.63)	(2.17)	(-1.4)
CHEM	-0.0031	-0.0024	-0.0039*
	(-1.29)	(-1.03)	(-1.65)
META	-0.0005	-0.0018	0.0013
	(-0.21)	(-0.74)	(0.54)
TRAN	-0.0027	-0.0025	-0.0014
	(-1.03)	(-0.95)	(-0.55)
ELEC	0.0038***	0.0038***	0.0042**
	(1.56)	(1.66)	(1.77)

Table 5 Less Developed Countries (LDC's) vs. Developed Countries (DC's)

Independent variable: Sales affiliates to US/Sales of US parents

Independent variable	LDC's	DC's
C	0.015 (0.689)	0.0096** (3.89)
Log(Wage ratio) (US/Foreign)	0.007** (2.25)	0.0025** (2.83)
Log(Productivity) (Foreign/US)	0.012*** (1.83)	0.004*** (1.59)
Log(Distance)	-0.003 (-0.9)	-0.0016** (-2.12)
Log(Investment cost)	-0.012** (-2.21)	-0.0016** (-2.47)
Log(R&D) (Affiliate)	0.028** (2.38)	0.0023* (4.68)
IP(inverse)	0.019 (1.49)	-0.0089** (-2.48)
S. America dummy (=0 for S. American countries)	0.023* (4.2)	
FOOD	-0.008 (-1.2)	-0.0005 (-0.59)
CHEM	-0.012* (-2.23)	0.0006 (0.86)
META	-0.0004 (-0.07)	0.0002 (0.22)
TRAN	-0.0123** (-2.11)	-0.0007 (-0.85)
ELEC	0.008*** (1.6)	0.0008 (0.99)

Appendix 1 Deriving Unit Cost for Cobb-Douglas Function

Minimize $C_{i,H} = w_H L^u{}_i + q_{i,H} L^s{}_i$ (1)

Subject to $x_i = AL^u{}_i{}^\alpha L^s{}_i{}^\beta = 1$ (2)

$$Lagrange = w \cdot L^u{}_i + q_i \cdot L^s{}_i + \lambda(1 - AL^u{}_i{}^\alpha L^s{}_i{}^\beta)$$

$$\frac{\partial La}{\partial L^u{}_i} = w - \lambda \cdot A \cdot \alpha \cdot L^u{}_i{}^{\alpha-1} \cdot L^s{}_i{}^\beta = 0 \quad (3)$$

$$\frac{\partial La}{\partial L^s{}_i} = q - \lambda \cdot A \cdot \beta \cdot L^u{}_i{}^\alpha \cdot L^s{}_i{}^{\beta-1} = 0 \quad (4)$$

$$\frac{\partial La}{\partial \lambda} = 1 - AL^u{}_i{}^\alpha L^s{}_i{}^\beta = 0 \quad (5)$$

From (3) and (4),

$$\frac{w}{q} = \frac{\alpha \cdot L^s{}_i}{\beta \cdot L^u{}_i}; \quad (6)$$

$$L^s{}_i = \frac{\beta w}{\alpha q} \cdot L^u{}_i. \quad (7)$$

Plug (7) into (1),

$$1 = A \cdot L^{u^\alpha} \cdot \left(\frac{\beta w}{\alpha q} \cdot L^u{}_i\right)^\beta. \quad (8)$$

Solve for $L^u{}_i$

$$L^u{}_i = \left(\frac{q^\beta \cdot \alpha^\beta}{A \cdot w^\beta \beta^\beta}\right)^{\frac{1}{\alpha+\beta}} \quad (9)$$

$$L^s{}_i = \frac{\beta w}{\alpha q} \cdot \left(\frac{q^\beta \cdot \alpha^\beta}{A \cdot w^\beta \beta^\beta}\right)^{\frac{1}{\alpha+\beta}} \quad (10)$$

Plug (9) and (10) into (1) and the minimum unit cost is

$$c_{i,H} = \frac{\alpha_i + \beta_i}{(A_H \alpha_i{}^{\alpha_i} \beta_i{}^{\beta_i})^{\frac{1}{\alpha_i+\beta_i}}} [w_H{}^{\alpha_i} q_{i,H}{}^{\beta_i}]^{\frac{1}{\alpha_i+\beta_i}}$$

Appendix 2 Descriptive Statistics

	Mean	Max	Min.	Std. Dev.	Obs.
Outsourcing measure	-8.518456	-0.942745	-14.95868	3.045278	369
Log(Wage ratio) (US/Foreign)	0.754786	4.258681	-0.457425	1.079099	612
Log(Productivity) (Foreign/US)	-0.653039	-0.001876	-2.615032	0.631303	630
Log[(Distance$_{US-Canada}$)/2400]	1.509268	2.344111	0.429182	0.511915	714
Log(Investment cost)	3.504323	4.287866	2.506138	0.398126	546
IP(inverse)	0.426849	0.934000	0.152000	0.190043	822
Log(R&D) (Affiliate)	-5.480021	0.000000	-9.553646	1.300540	352