An Empirical Assessment of Labor Costs in U.S. Vertical FDI: A Multinomial Logit Approach

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Abstract

The paper develops a multinomial logit framework to assess the impact of labor costs on the production location choice of U.S. multinational firms. The benefit of the framework is that it reduces the bias of the coefficient estimates by allowing for the impact of labor costs of a third country . Applying the approach to the BEA data on U.S. direct investment abroad in the manufacturing industries, I find the correlation between labor costs and the probability of being the production location is sensitive to whether the U.S. is in the production location choice set or not. Secondly, the marginal effects of labor costs on U.S. vertical foreign direct investment location are quantitatively small.

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1 Introduction

U.S. trade with its foreign affiliates has been a fast growing component of U.S. international trade. The value of U.S. trade in goods with affiliates grew by 67 percent from 1993 to 2003. Currently about 20 percent of U.S. international trade is the trade between U.S. parent firms and their foreign affiliates.

A distinctive pattern in this trade is that affiliate-to-parent trade grows much faster than parent-to-affiliate trade. Between 1993 and 2003, affiliate-to-parent trade grew by 96 percent while parent-to-affiliate trade grew by just 41 percent. The unbalanced growth of U.S. off-shore production has led to heated public debates about to what extent American workers, particularly manufacturing workers, are losing jobs to foreign cheap labors. The primary purpose of this study is to estimate the impact of labor costs on the production location choice of U.S. manufacturing firms.

The study develops a new empirical approach that can reduce the bias of the estimates of the impact of labor costs. The approach is a multinomial logit model in which firms choose the country of the lowest production cost as the production location. The model takes into account not only the role of domestic labor costs and the labor costs of the host country, as the existing production location choice models do, but it also allows the impact of labor costs in all other competing production locations to affect the production location choice, a source of estimation bias if omitted.

To illustrate the point of reducing estimation bias, consider the manufacturing activity of U.S. affiliates in Canada. The activity of U.S. affiliates in Canada is not only affected by U.S. domestic labor costs or the labor costs in Canada. It is also affected by the labor costs in Mexico, a competing production location. Suppose the labor costs in Mexico declined sharply while the labor costs in Canada increased slightly. Suppose U.S. firms responded to the changing labor costs by moving production plants from Canada to Mexico. The proposed framework takes into account the the changing Mexican labor costs when analyzing the fluctuating activity of U.S. affiliates in Canada. But the existing framework will not. Thus the estimates from the existing models will overestimate the role of labor costs of Canada in affecting the production activity in Canada. The multinomial logit approach will take into account of the labor costs in Mexico and thus will yield consistent estimates.

I apply the approach to the BEA data on U.S. direct investment abroad in the manufacturing industries. The estimates suggest a complex role of skilled worker costs in the production location choice. The impact of skilled worker compensation is sensitive to whether the sample includes U.S. parent companies. When the production activity of U.S. parent companies is included, high costs of skilled workers are associated with lower probability of being the production location. When U.S. parent companies are excluded from the sample, the correlation between labor costs and the probability of being the production location becomes industry specific.

In contrast, higher costs of unskilled labor are generally found to be associated with higher probability of being the production location. The finding is robust to whether

U.S. parent companies are included in the sample or not. Marginal effects of costs of skilled or unskilled labor are quantitatively small. These findings together suggest that some omitted factors rather than labor costs are driving the production location choice.

The rest of the essay proceeds as follows. Section II reviews the literature of production off-shoring. Section III develops the multinomial logit framework of production location choice. Section IV describes the data and presents summary statistics. Section V reports the maximum likelihood estimates and analyzes their implications. Finally section VI concludes.

2 Literature Review

The first vein of economic literature identifies production costs as the main driving force behind production relocation. Helpman (1994) introduced a vertical FDI model, in which multinational enterprises operate headquarters in one country and production in another. Vertical FDI arises from factor price differences across countries.

The second body of related literature explores market thickness as a major factor in the formation of vertical production networks. The idea is that matching between input supplier and final goods producer is a complex process that involves risks on both sides. In particular, the quality of a match depends on the number of potential suppliers (hence the terminology 'market thickness') in the market and on their expertise, i.e. whether their knowledge and experience are suitable for the manufacturing of the type of intermediate inputs required by the brand of the final good. In McLaren (2000), potential buyers of an intermediate input find it more attractive to outsource the thicker the market for the input is. And similarly, sellers of an intermediate input find it more attractive to operate the larger the number of potential buyer is.

The third vein explores search cost in the choice of production location. Information can play a large role in finding a supplier of input. Grossman and Helpman (2004) introduce information in international outsourcing. Their hypothesis is that when Northern firms seek partners, they must spend resources on information gathering as they search for potential partners who match their production requirements. Northern firms may be dissuaded from seeking outsourcing partners in South if the costs of information gathering are high in those locations.

A number of empirical studies have found supportive evidence that production cost matters in production location decision. Hanson, Mataloni and Slaughter (2005) study trade in intermediate inputs for further processing between U.S. parent firms and their foreign affiliates. They find that demand for imported inputs is higher when affiliates face lower wages for less-skilled labor and lower trade costs. Braconier, Norback and Urban (2005) also find support for vertical FDI. They explore how wage costs for high-skilled and less-skilled labor in host countries affect the level of affiliate activities conducted by foreign MNEs. They find that more FDI is conducted in countries where less-skilled labor is relatively cheap. Moreover, rough calculations suggest that more than 20 percent of US affiliate sales in 1998 can be attributed to skilled-wage cost premia.

Swenson (2005) estimates the impact of production cost differences on the cross-country pattern of U.S. overseas assembly activities between 1980 and 2000. She constructs an aggregate measure of competitor country cost. She then examines how U.S. outsourcing decisions are affected by the changes in country and competitor costs. Her study finds that when a country's own costs rise, the share of U.S. overseas assembly activities in that location decline. Conversely, a country's share grows when competitor country costs increase.

Using data from 1982 through 1992, Brainard and Riker (2001) derive the implied substitutability between labor employed by the U.S. parent firms and their affiliates. They find that U.S. affiliated employment abroad is a substitute for employment in the U.S., but the magnitudes are small. For example, a 10 percent decline in high-income affiliate wages would be associated with 1.1 percent fall in U.S. employment.

Harrison and McMillan (2006) study how US employment responds to industry level wages in low- and high-income affiliates from 1977 to 1999. They find high-income affiliates and U.S. parent employment are complements while low-income affiliates are substitute for U.S. employment. They estimate that a 10 percent increase in high income affiliate wages is associated with a 1.27 percent decline in U.S. employment and that a 10 percent fall in low-income wages is associated with a 0.5 percent reduction in US employment. They find similar pattern of the wage elasticity of labor demand using cost share as the dependent variable.

The theories of market thickness and search costs have not been well explored by the empirical studies. The challenge to identify these impacts is to find a convincing proxy for the unobservable number of suitable suppliers in the case of market thickness and for the information gathering cost in the case of search costs. To my knowledge, only Swenson (2005) has studied the empirical impact of market thickness. She defines market thickness as the number of countries that exported to the U.S. in a particular four-digit industry during the period examined. She finds that the market thickness of an industry affects how FDI responds to own country costs and competitor country costs. That is, market thickness increases the detrimental effects of own country cost and the beneficial effects of competitor country costs.

3 An Empirical Model of Production Location Choice

3.1 The Model

Consider a firm m in industry i who has to decide on one location to set up a production plant among the set of K countries to produce goods to sell in the home country market. The production technology is assumed to be constant returns to scale. The firm is a price taker in both the factor market and the goods market. I use a flexible functional form - the translog function - to approximate the unit cost. The log of the unit cost of firm m in industry i producing in country j, denoted as C^i_{mj}, is

$$C^i_{mj} = \alpha^i_j + \sum_{h=1}^{H} \alpha^i_h \ln w^h_j + \frac{1}{2} \sum_{h=1}^{H} \sum_{g=1}^{H} \beta^i_{hg} \ln w^h_j \ln w^g_j + \mu^i_{mj} \quad (1)$$

where the ws are factor prices. The log of the unit cost of firm m is a linear function of H factor prices. The error term μ^i_{mj} captures the higher order polynomials, the unobserved components of the unit cost and idiosyncratic disturbances. The translog cost function is based on the class of constant-returns-to-scale production functions [1]. The parameter β_i is the partial derivative of the log of the unit cost function with respect to the log of the price of factor i. With the CRS production functions, β_i is the cost share of factor i and is a parameter in the underlying production function. It is assumed that production technology is industry specific only. This assumption implies that the β of a factor varies across industries but remains the same across countries within an industry. Meanwhile, the βs of different factors are different within an industry because of the different cost shares of different factors. Factor prices are assumed to be different across countries but equalized across industries within the same country.

We can express equation (1) in a compact way:

$$C^i_{mj} = X'_j \gamma^i + \mu^i_{mj} \quad (2)$$

where X is the vector that consists of the constant term, the log of factor prices and

[1] See page 640 to 644 in William Greene's *Econometric Analysis*.

their products, and γ^i is a vector of parameters that consists of the constant term and the β_is.

We can now express the probability that location j has the lowest unit cost in industry i among K countries conditional on μ^i_{mj} as

$$\begin{aligned} prob(C^i_{mj} \leq C^i_{mk}, \forall k \neq j \mid \mu^i_{mj}) &= prob(-\mu^i_{mk} \leq (X'_k - X'_j)\gamma^i - \mu^i_{mj}) \\ &= \prod_{k=1,k\neq j}^{K} F[(X'_k - X'_j)\gamma^i - \mu^i_{mj}] \end{aligned} \tag{3}$$

where $F[.]$ is the cumulative distribution function of μ^i_{mk}. The unconditional probability that location j has the lowest cost becomes

$$\begin{aligned} P^i_{mj} &= prob(C^i_{mj} \leq C^i_{mk}, \forall k \neq j) \\ &= \int_{-\infty}^{\infty} \prod_{k=1,k\neq j}^{K} F[(X'_k - X'_j)\gamma^i - \mu^i_{mj}] f(-\mu^i_{mj}) d(-\mu^i_{mj}) \end{aligned} \tag{4}$$

Under the assumption that the error terms μ^i_{mj} are independently and identically distributed as type I extreme, we obtain a multinomial logit model of production location choice. The unconditional probability that firm m in industry i chooses location j among K countries is given by [2]

$$P^i_{mj} = \frac{\exp(-X'_j\gamma^i)}{\sum_{k=1}^{K}\exp(-X'_k\gamma^i)} \tag{5}$$

[2]Appendix A derives equation (5).

Equation (5) shows that the probability of locating in country j is a nonlinear function of both factor prices in the host country and the factor prices in all competing countries. Clearly, equation (5) implies that as long as the firms in the industry adopt the same production technology, the unconditional probability that country j is chosen by any of the firms in that industry will be the same.

To carry out the analysis further, I now make the assumption that only the location with the lowest unit cost gets to produce the goods and sell the goods to the home country; all other locations do not produce and hence there are no sales from those locations to the home country.

Let Z_m^i denote the value of sales associated with firm m's output level, which is assumed to be predetermined. This assumption can be quite restrictive because generally the value of sales is a function of the price, which is in turn a function of production cost. But the assumption may be justified in the situation of competitive markets. Consider Walmart asks her suppliers to bid for her order of 1 million pairs of socks. The lowest bidder wins the order and he configures the international production chain so as to maximize his profit. In situations like this, the volume of sales is predetermined and the producer has little market power over the price of the good. Therefore the value of sales can be treated as predetermined. Given P_{mj}^i, the probability that the location j has the lowest unit cost, the expected value of sales to the home country by firm m

from location j, V^i_{mj}, is

$$V^i_{mj} = P^i_{mj} Z^i_m + (1 - P^i_{mj})0 = P^i_{mj} Z^i_m \tag{6}$$

Under the assumption of technology homogeneity within industry, we can aggregate the expected value of sales over all firms in industry i at location j and express the expected value of sales of industry i from country j as

$$V^i_j = \sum_{m=1}^{M} P^i_j Z^i_m = P^i_j Z^i_w \tag{7}$$

where Z^i_w is the total sales of industry i to the home country. By equation (7), it is clear that we can infer the probability that a location has the lowest unit cost from that location's share in the total sales to the home market, a quantity we are able to observe

$$P^i_j = \frac{V^i_j}{Z^i_w} \tag{8}$$

Let S^i_j denote the observed share of sales from location j. The observed share may deviate from the probability given in equation (8) due to random disturbances and measurement errors. Therefore I express the observed share as

$$S^i_j = P^i_j + \varepsilon^i_j \tag{9}$$

3.2 Empirical Specification and Interpretations

The empirical specification is based on equation (9). The share of sale from country j in industry i at time t is a nonlinear function of factor prices of all countries:

$$S_{jt}^{i} = \frac{\exp(-X_{jt}'\gamma^{i})}{\sum_{k=1}^{K}\exp(-X_{kt}'\gamma^{i})} + \varepsilon_{jt}^{i} \tag{10}$$

In addition to factor prices as measured by worker compensation and capital interest rate, the vector X_{jt} also includes control measures such as trade costs, infrastructure and macroeconomic environment [3]. I use SAS full information maximization likelihood (FIML) procedure to estimate equation (10). Heteroskedasticity and autocorrelation in the error terms are handled by using the generalized lease square estimator to estimate the variance-covariance matrix [4].

An important property of the model is the Independence from Irrelevant Alternatives (IIA). The property means that the ratio of the probabilities of any two alternatives is independent from the choice set. IIA implies that adding another alternative or changing the characteristics of a third alternative does not affect the relative odds between the two alternatives considered. In the context of the model, the IIA can be violated if there exist countries that are close substitutes as production locations. The

[3] The size of country j's market, a common control factor in the literature, is not included because of the assumptions made earlier of constant returns to scale and the predetermined output level.

[4] According to the SAS User's Guide, the estimator of the variance-covariance of the coefficients for FIML can be selected with the COVBEST= option. The specification GLS selects the generalized least-squares estimator of the covariance matrix, which is computed as in Dagenais (1978).

decrease (increase) of the production cost of a third country may reduce (improve) the probability of other countries to be the production location. The impact will be larger for countries that are closer substitutes for that third country than for countries that are distant substitutes. Hence the relative odds ratio between those two types of countries may change, violating the IIA. There are ways to get around the restrictive IIA. One of them is to use alternative models such as nested logit model (McFadden 1984). I will take up the issue in my future research.

Equation (10) can be used to estimate a number of useful elasticities. In this study, I derive and compute two elasticities - *the own factor price elasticity* and *the competitor factor price elasticity.* The own factor price elasticity measures how the share of sales of a country responds to the change in the factor prices in that country other things being equal. It can be expressed as [5]

$$\frac{\partial S^i_{jt}}{\partial X_{jt}} \frac{1}{S^i_{jt}} = (-\gamma^i)(1 - S^i_{jt}) \tag{11}$$

Note that X_{jt} is a vector of the log of the factor prices in country j. Equation (11) implies that the elasticity is a function of the parameter γ^i, which is determined by the underlying production technology and the country's share in the sales. The own factor price effect is larger the smaller the share of sales of the country. The direction of own factor price effect depends on the sign of the parameter γ^i only. If γ^i is positive, then

[5] Appendix B derives equation (11).

the own factor price effect is negative, meaning that the increase in the factor prices will cause the share to decrease and conversely. Conversely, if γ^i is negative, then the own factor price effect is positive, meaning that the increase in the factor prices will cause the share to increase.

The competitor factor price elasticity measures how the share of sales of a country responds to the change in factor prices in a competitor country other things being equal. It is expressed as follows [6]

$$\frac{\partial S^i_{jt}}{\partial X_{kt}} \frac{1}{S^i_{jt}} = (\gamma^i) S^i_{kt} \tag{12}$$

By equation (12), the magnitude of the elasticity is a function of the parameter γ^i and the competitor country share in the sales. The absolute value of the cross factor price effect is larger the larger the share of the competitor country is. The direction of cross factor price effect also depends on the sign of the parameter γ^i only and is the opposite of that of the own price effect - if γ^i is positive, the competitor factor price effect is positive, meaning that the increase in the factor prices will cause the share to increase and conversely, if γ^i is negative, the competitor factor price effect is negative, meaning that the increase in the factor prices will cause the share to decrease.

[6] Appendix B derives equation (12).

3.3 The Endogeneity of Worker Compensation

The endogeneity of wage can arise in two different ways. One is associated with the quality of labor. The other is associated with the simultaneous equation system. When the demand for labor and the price of labor are simultaneously determined, wage is endogenous to the production activity of U.S. foreign affiliates.

One way to get around the first type of endogeneity is to explicitly control for productivity. The productivity is measured as the value added of all industries of that country divided by the total number of industry employees working in that country. By construction, productivity is not industry specific but country specific only [7].

The second type of endogeneity is likely to be rather weak in my study. This is because the Bureau of Economic Analysis only publishes data in country and industries where the identification of any individual US firm is impossible; if not, the data were then suppressed to avoid the disclosure of information on an individual company [8]. In other words, the sample consists of U.S. affiliates that are small enough such that reporting their operation data will not lead to the identification of the affiliate itself. Therefore it's reasonable to assume that these affiliates are price takers in the foreign factor market.

[7] An alternative way to explicitly control for productivity is GDP per capita as in Braconier et al. In their appendix, Hanson, Mataloni and Slaughter noted that in the results that are not reported, they had use the average wage of the affiliate wage and the outsider wage (which is computed from UNIDO Industry Database) to address the endogeneity problem.

[8] See page M-8 of methodology in USDIA: 1999 Benchmark Survey.

4 Data and Descriptive Statistics

4.1 Data Sources

The data of operations of U.S. parent companies and their affiliates come from the annual surveys of U.S. investment abroad conducted by the Bureau of Economic Analysis (BEA). The surveys cover the universe of U.S. direct investment abroad. The surveys collect data on items such as balance sheets, income statements, sales of goods and services, employment and compensation of employees, U.S. trade in goods, research and development expenditures, and external financial position. The data set published for public use is aggregated to industry level.

I use the BEA data of majority-owned foreign affiliates (MOFA) and nonbank U.S. parent companies in the manufacturing industries. The Bureau of Economic Analysis defines a U.S. parent as a U.S. person who has direct investment - that is, a 10 percent or more direct or indirect ownership interest in a foreign business enterprise. A foreign affiliate is a foreign business enterprise that is directly or indirectly owned or controlled by one U.S. person to the extent of 10 percent or more of the voting securities for an incorporated business enterprise or an equivalent interest for an unincorporated business enterprise. An MOFA is a foreign affiliate in which the combined direct and indirect ownership interest of all US parents exceeds 50 percent. The data on control variables are drawn from the BEA annual surveys, the 2005 World Development Indicators by

World Bank and the LABORSTA database by the International Labor Organization[9].

4.2 The Variables

The dependent variable measures the production activity of foreign affiliates. There are two versions of the dependent variable. The first version is the ratio of the sales of affiliates in the host country to the U.S. market over the sales of all U.S. affiliates and parent companies to the U.S. market. This measure will be appropriate if U.S. parent companies are close substitutes for U.S. foreign affiliates. The second version is the ratio of the sales of affiliates in the host country to the U.S. market over the total sales of all U.S. foreign affiliates to the U.S. market. This measure is more appropriate if the nature of the U.S. parent company is considerably different from that of its foreign affiliates. The truth should lie in between. The two sets of results based on the two versions of the dependent variable can be seen as the lower and the upper bound of the real effects.

The value of sales of U.S. parent companies to the U.S. market may be a biased measure of the real production activity of U.S. parent companies. The bias may arise when parent companies resell goods imported from their foreign affiliates to the U.S. market with little production involved in the U.S.. In such cases, the sales figures overstate the production activity of U.S. parent companies. Similarly, the sales figures of foreign affiliates can overstate the production activity of U.S. affiliates. How large is

[9] Appendix C reports the complete list of data sources. Appendix D lists the sample countries

the bias? Not much. According to my calculation, no more than one ninth of the sales of U.S. parent companies can be attributed to the aforementioned ‘double counting’.

The control variables consist of labor costs, capital costs, trade costs, measures of infrastructure and macroeconomic environment. The cost of unskilled workers is measured by the annual compensation for affiliate employees in the food industry - the least skill intensive industry. The cost of skilled workers is measured by the annual compensation for affiliate employees in the financial service industry - the most skill intensive industry. To make the costs comparable over time, I deflated all compensation data using the U.S. GDP price index. To make the costs comparable across countries, I control for cross-country productivity differences, with productivity being measured by country level value added per industrial worker. Lending interest rate is the measure of capital costs. Trade costs are proxied by the distance between the host country and the U.S., language barrier and whether a bilateral free trade agreement exists. The quality of infrastructure is measured by the number of main telephone lines per 1000 people, the percentage of road paved and air freight. Finally, I measure the state of macroeconomic environment with the standard deviation of inflation rates and GDP per capita.

4.3 Summary Statistics

Table 1 reports the summary statistics of the sample with U.S. parent companies excluded. The mean of the share of sales to the U.S. market by affiliates in a single foreign country is just around 2.2 percent. But the distribution of the shares is uneven with the largest share being as big as 76 percent. The most favored foreign affiliate location is Canada. Canada claims 76 percent, 72 percent and 67 percent of all foreign affiliates' sales to the U.S. in transportation equipment industry, primary-and-fabricated metals industry, and food industry, respectively. Table 1 also presents the summary statistics of the sample that includes U.S. parent companies. Not surprisingly, among all countries, the US parent companies claim the largest share of the sales to the U.S. market, which is in the range of 91 percent in the transport equipment industry and 98 percent in the food industry.

The cost of unskilled labor was the lowest in India and the highest in Japan. The cost of skilled labor was the lowest in India and the highest in Switzerland. The lowest productivity was in China in 1989 and the highest in Ireland in 2003. In terms of the cost of capital, Japan had the lowest lending interest rate - 2 percent in 2003, and Brazil had the highest - 15040 percent in 1997.

The time variation in the share of sales to the U.S. ranges from 0 to 16 percentage points if the U.S. is not in the sample, and from 0 to 4 percentage points if the U.S. is included in the sample. The time variation in annual worker compensation ranges from 1,100 dollars in Ecuador to 41,800 dollars in Switzerland from 1989 to 2003, and from 1,260 dollars in Ecuador to 39,050 dollars in Switzerland between 1994 and 2003. The small variation in the shares and the large variation in workers' compensation indicate small labor cost effects.

5 Empirical Findings

5.1 The Findings with U.S. Parent Companies in the Sample

Table 2 reports the estimates of the impact of labor costs on the location choice of U.S. foreign direct investment. The coefficient of the cost of skilled workers is positive and significant in four out of five manufacturing industries, suggesting that higher costs of skilled workers are associated with lower probability of being the production location for U.S. companies. The estimates seem to support the theory of cost-saving driven foreign direct investment.

The coefficient of the cost of unskilled workers is positive and significant in the primary-and-fabricated metals industry, suggesting that higher costs of unskilled workers are associated with lower probability of being the production location for U.S. firms. However, the coefficients are negative and significant in the food industry and the chemicals industry, suggesting that an increase in the costs of unskilled labor is associated with higher probability of being the production location of U.S. firms. The estimates thus are not entirely consistent with the cost-driven theory. Rather, the estimates indicate that the role of unskilled labor costs is rather sensitive to individual manufacturing industry.

There is strong evidence on the role of productivity. The coefficients are negative and significant in all industries except the primary-and-fabricated metal industry, suggesting that higher productivity is associated with higher probability of being the production location.

As for the role of capital costs, I find mixed evidence. In industries such as food and chemicals, higher lending interest rates are associated with lower probability of being the production location. In machinery and transportation equipment industries, the correlation is just the opposite: higher lending interest rates are associated with higher probability of being the production location. The finding of an ambiguous role of capital costs is in line with previous studies.

The finding on trade costs is largely consistent with trade theories. The coefficient of distance is positive and significant except the chemicals industry, suggesting that longer distance away from the U.S. reduces the probability of being chosen as production location. The role of trade agreement is also expected: the coefficient of the bilateral free trade agreement is negative and significant with the exception of transportation equipment industry, suggesting that the trade agreement is associated with higher probability of being a production location.

In summary, the results indicate robust roles of the costs of skilled workers, productivity and trade costs in the local choice of U.S. firms. The role of unskilled worker compensation is industry specific. However, can the estimates be biased by the dominant presence of U.S. parent companies? How will the role of labor costs differ if we exclude U.S. parent companies from the sample?

5.2 The Results without U.S. Parent Companies in the Sample

Table 3 reports the estimates of the impact of labor costs on the location choice of U.S. foreign direct investment. The role of skilled worker compensation now becomes mixed. The coefficient of the cost of skilled workers is positive and significant only in two out of five industries. The sign suggests that higher costs of skilled workers are correlated with lower probability of being the production location. In the primary-and-fabricated metals industry, the coefficient is negative and significant, suggesting that higher costs of skilled workers are associated with lower probability of being the production location for U.S. companies.

The finding on the role of unskilled worker compensation is again inconsistent with the cost-saving theory. The coefficients are negative and significant in the rest four industries, suggesting that an increase in the costs of unskilled labor is associated with higher probability of being the production location of U.S. firms. The coefficient of the cost of unskilled workers is positive and significant only in the chemicals industry, which means that higher costs of unskilled workers are associated with lower probability of being the production location for U.S. firms.

The role of productivity in production location choice is reversed. The coefficients are positive and significant in two out of the five industries, suggesting that higher productivity is associated with lower probability of being the production location. How do we interpret the puzzling findings on unskilled worker compensation and productivity? The results seem to suggest the rather limited role of productivity-adjusted labor costs and the existence of omitted factors that are really the driving force in production location choice.

The role of capital costs is still mixed. In the machinery industry, higher lending interest rates are associated with lower probability of being the production location. In the primary-and-fabricated metals and the transportation equipment industries, the correlation is just the opposite: higher lending interest rates are associated with higher probability of being the production location.

The finding on physical distance is still largely consistent with trade theories. The coefficient of distance is positive and significant except the chemicals industry, suggesting that the probability of being chosen as production location decreases the further way the country is from the U.S.. The role of trade agreement is less certain: the coefficient of the bilateral free trade agreement is negative and significant in two industries but negative and significant in other two industries. Finally, the role of language barrier turns out to be important. The coefficients of the language barrier are positive and significant in three industries, suggesting lower language barrier is correlated a higher probability of being the production location.

In conclusion, when U.S. parent firms are excluded from the sample, we find mixed roles of labor costs. The findings raise two questions, at least. The first is whether the estimates are biased because of the dominant presence of Canada and Mexico. The second is whether factors other than the labor costs play more significant roles in the production location choice. These questions will be addressed in future research.

5.3 Marginal Effects of Labor Costs

Following the formula set out in equation (11), I compute the own factor price elasticity of the cost of skilled workers, unskilled workers and productivity for the US. Table 4 presents the estimates. Compared with the estimates in Brainard and Riker (2001), Muendler et al. (2005) and Harrison and McMillan (2006), who estimate the impact of foreign wages on the employment of US workers, the elasticities implied by the nonlinear model are much smaller. In food, primary-and-fabricated metals, transportation equipment industries, a 100 percent increase in the annual compensation of skilled workers is associated with a decrease of 4.3 percent, 3.9 percent and 7.5 percent in the probability of being the production location, respectively. On the other hand, such an increase in the cost of skilled workers in the chemicals industries is associated with an increase of 1 percent in the probability of being chosen.

Turning to the impact of the cost of unskilled workers, I find that in food, chemicals and transportation equipment industries, a 100 percent increase in the annual compensation of unskilled workers is associated with an increase of 1.6 percent, 4.4 percent and 3.6 percent in the probability of being chosen, respectively. However in the primary-and-fabricated metals industry, the increase is associated with a decrease of 3.9 percent in the probability of U.S. being chosen.

The quantitative impact of productivity is much larger in the machinery and transportation equipment industry than in the food and chemicals industries. When the annual output of U.S. industrial workers increases by 100 percent, the probability of production location inside the US increases by 20 percent and 15 percent in machinery and transportation equipment industries, and by 2.3 percent and 1.3 percent in food and chemicals industries, respectively.

Following the formula in equation (12), I compute the competitor factor price effect to get a sense of how factor price changes in the neighboring countries may affect the production share of U.S. parent companies. In table 5, I show the quantitative impact of the change in Canada on the share of U.S. parent companies. The effects are very small. A 100 percent increase in the compensation for skilled workers in Canada is associated with an increase of less than 1.1 percent in the probability of U.S. being chosen. However, a 100 percent increase in the compensation for unskilled workers in Canada is associated with a decrease of less than 0.05 percent in the probability of being the production location in all industries. The only exception is the primary-and-fabricated metals industry, where the response would be a 0.08 percent increase in the probability of U.S. being the production location. A 100 percent increase in the productivity in Canada is only associated with a less than 0.7 percent decrease in the probability of US being chosen. The impact of factor prices in Mexico on U.S. parent companies, shown in table 6, is even smaller - the change in the probability of U.S. being the production location due to the change in factor prices in Mexico is close to zero.

5.4 Factor Prices in Developed vs. Developing Countries

Do U.S. firms respond differently to the change in labor costs in developed and developing countries? To answer the question, I introduce two interactive terms into the basic model, allowing the marginal effect of labor costs to be a linear function of a country's development level, the latter being measured by productivity. Table 7 presents the estimates when U.S. parent companies are included. The coefficients of the interactive terms provide cutoff values of productivity. The marginal effect of labor costs will be opposite for countries that fall on different sides of these cutoff lines.

Table 8 reports the marginal effects of labor costs evaluated at individual country level productivity in 2003. The computed results show that U.S. firms' response to labor costs does not differ much between developed and developing countries. In food, chemicals, machinery and transportation equipment industries, U.S. firms respond similarly to the change in the costs of skilled workers, regardless of development level. Turning to the costs of unskilled labor, again I find that U.S. firms respond similarly: an increase in the unskilled worker compensation is associated with lower probability of being the production location. The only exception is the primary-and-fabricated metals industry, which responded differently to the cost of unskilled workers between high-productivity and low-productivity countries. In high productivity countries, an increase in the cost of unskilled workers is associated with lower probability of being the production location while in low productivity countries higher costs of unskilled labor are associated with higher probability of being the production location. But overall, I did not find strong evidence that U.S. firms respond differently to cost changes in developed and developing countries.

5.5 The Goodness of Fit

In order to get a sense of how well the factor prices explain the production location choice, I estimate a new multinomial logit type model, in which I replace the factor prices and other economic factors with a set of country dummies. The comparison of the fitting between the basic model and the dummy model is shown in table 9. Column one shows the fitting of the basic model while column two shows the fitting of the new model. Note that with nonlinear models, which include multinomial logit models, the R-squared and the adjusted R-squared measures are no longer bounded between 0 and 1. Table 9 shows that the basic model outperforms the dummy model when U.S. parent companies are included in the sample while the fitting of the two models is similar when U.S. parent companies are excluded from the sample.

6 Conclusion

The fast growing U.S. off-shore production has lead to a heated public debate over to what extent U.S. workers are losing jobs to cheap foreign labor. This study provides empirical estimates on the role of labor costs in the production location choice of U.S.

manufacturing industry.

The study innovates in empirical modeling. I introduce a multinomial logit framework of location choice that can reduce the bias of the estimates of the impact of production costs. The framework does so by fixing the problem of omitted variables in the existing empirical models. The multinomial logit approach builds on the translog cost function and uses cost minimization as the decision rule of production location. The model shows that the probability of being the production location is a nonlinear function of production costs of all countries in the choice set and that a country's share in the total sales to the U.S. market is directly related to the probability of that location having the lowest production cost.

I apply the multinomial logit approach to the BEA data of majority-owned U.S. affiliates and their parent companies in manufacturing industries. The estimates show small effects of labor costs in production location choice. The impact of skilled worker compensation is nuanced. The impact depends crucially on whether the U.S. is included in the production location choice set. I find that when U.S. parent firms are included in the sample, higher costs of skilled workers are correlated with a lower probability of being chosen as the production site. However, when U.S. parent firms are excluded from the choice set, the impact of skilled worker compensation becomes industry specific. Surprisingly, the estimates show that higher cost of unskilled labor is associated with a higher probability of being the production location, after the differences in productivity are taken into account. The finding seems inconsistent with the cost-saving theory of

U.S. off-shore production. More research is in order to examine the role of unskilled labor costs. Furthermore, the results show that U.S. multinational firms do not seem to respond differently to worker compensation in developed and developing countries. In addition to the role of labor costs, I find a robust role of trade barrier in the production location choice. Shorter distance from the U.S., lower language barrier and a bilateral trade agreement all contribute to the probability of being the production location.

There are several future research directions in order. One is to use different measures of U.S. foreign affiliates' activity and worker compensation and find whether the role of labor costs will be different. Secondly, the finding of small role of labor costs leaves one wonder about the roles of market thickness and search cost. Future empirical works should explore more in that direction. Finally but not lastly, industry level data suffer from aggregation problems. Estimates may improve with the application of the multinomial logit approach to firm-level data and more refined classification of industries.

Table 1: Countries by Literacy Group

1	2	3
4	5	6
7	8	9

Table 2: Liberalization Dates

1	2	3
4	5	6
7	8	9

Table 3: Summary Statistics

1	2	3
4	5	6
7	8	9

Table 4: Summary Statistics Centered on the Liberalization Date

1	2	3
4	5	6
7	8	9

5

6

Table 5: The Effects of Trade Liberalization on Skill Acquisition - the Basic Model

1	2	3
4	5	6
7	8	9

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Appendix A: Derivation of Equation (5)

Let $\eta^i_{mj} = -\mu^i_{mj}$. The unconditional probability can be expressed as

$$\int_{-\infty}^{\infty} \prod_{k=1,k\neq j}^{K} F[(X'_k - X'_j)\gamma^i + \eta^i_{mj}] f(\eta^i_{mj}) d(\eta^i_{mj})$$

$= \int_{-\infty}^{\infty} (\prod_{k=1,k\neq j}^{K} \exp(-\exp((X'_k - X'_j)\gamma^i + \eta^i_{mj}))) \exp(-\eta^i_{mj}) \exp(-\exp(-\eta^i_{mj})) d(\eta^i_{mj})$

$= \int_{-\infty}^{\infty} (\prod_{k=1}^{K} \exp(-\exp((X'_k - X'_j)\gamma^i + \eta^i_{mj}))) \exp(-\eta^i_{mj}) d(\eta^i_{mj})$

$= \int_{-\infty}^{\infty} \exp(-\sum_{k=1}^{K} \exp(-(X'_k - X'_j)\gamma^i + \eta^i_{mj})) \exp(-\eta^i_{mj}) d(\eta^i_{mj})$

$= \int_{-\infty}^{\infty} \exp(-\exp(-\eta^i_{mj})(\sum_{k=1}^{K} \exp(-(X'_k - X'_j)\gamma^i))) \exp(-\eta^i_{mj}) d(\eta^i_{mj})$ (A-1)

Define $t = \exp(-\eta^i_{mj})$. We can further simplify equation (A-1):

$$\int_{-\infty}^{\infty} \exp(-\exp(-\eta^i_{mj})(\sum_{k=1}^{K} \exp(-(X'_k - X'_j)\gamma^i))) \exp(-\eta^i_{mj}) d(\eta^i_{mj})$$

$= \int_{0}^{\infty} \exp(-t \sum_{k=1}^{K} \exp(-(X'_k - X'_j)\gamma^i))(dt)$

$= \dfrac{\exp(-t \sum_{k=1}^{K} \exp(-(X'_k - X'_j)\gamma^i))}{-\sum_{k=1}^{K} \exp(-(X'_k - X'_j)\gamma^i)} \Big|_0^{\infty}$

$= \dfrac{1}{\exp(X'_j\gamma^i)(\sum_{k=1}^{K} \exp(-X'_k\gamma^i))}$

$$= \frac{\exp(-X_j'\gamma^i)}{\sum_{k=1}^{K}\exp(-X_k'\gamma^i)} \text{ (A-2)}$$

Appendix B: Factor Price Elasticities

Own Factor Price Elasticity

$$\frac{\partial S_{jt}^i}{\partial X_{jt}} = \frac{\exp(-X_{jt}'\gamma^i)(-\gamma^i)(\sum_{k=1}^{K}\exp(-X_{kt}'\gamma^i)) - (\exp -X_{jt}'\gamma^i))^2(-\gamma^i)}{(\sum_{k=1}^{K}\exp(-X_{kt}'\gamma^i))^2}$$

$$= \frac{\exp(-X_{jt}'\gamma^i)(-\gamma^i)(\sum_{k=1,k\neq j}^{K}\exp(-X_{kt}'\gamma i))}{(\sum_{k=1}^{K}\exp(-X_{kt}'\gamma^i))^2}$$

$$= (-\gamma^i)S_{jt}^i(1 - S_{jt}^i) \text{ (B-1)}$$

Deviding both sides of equation (B-1) by S_{jt}^i, we obtain the expression of the own factor price elasticity

$$\frac{\partial S_{jt}^i}{\partial X_{jt}}\frac{1}{S_{jt}^i} = (-\gamma^i)(1 - S_{jt}^i) \qquad \text{(B-2)}$$

Competitor Factor Price Elasticity

$$\begin{aligned} \frac{\partial S_{jt}^i}{\partial X_{jt}} &= \frac{\exp(-X_{jt}'\gamma^i)\exp(-X_{kt}'\gamma^i)\gamma i}{(\sum_{k=1}^{K}\exp(-X_{kt}'\gamma^i))^2} \\ &= (\gamma^i)(S_{jt}^i)(S_{kt}^i) \end{aligned} \qquad \text{(B-3)}$$

Deviding both sides of equation (B-3) by S^i_{jt}, we obtain the expression of the own factor price elasticity

$$\frac{\partial S^i_{jt}}{\partial X_{kt}} \frac{1}{S^i_{jt}} = (\gamma^i)(S^i_{kt}) \tag{B-4}$$

Appendix C: Data Sources and Definitions of the Variables

Country's Share of Sales to the U.S. Market

Data source: The Annual Survey of US Direct Investment Abroad at the Bureau of Economic Analysis website

There are two definitions. The first one applies to the sample when U.S. is included. The country's share of sales to the U.S. market is defined as total sales to the U.S. by majority-owned nonbank affiliates in the country divided by total sales to the US by all majority-owned nonbank affiliates and nonbank US parent companies.

The second definition applies to the sample when U.S. is excluded. The country's share of sales to the U.S. market is defined as total sales to the U.S. by majority-owned nonbank affiliates in the country divided by total sales to the U.S. by all majority-owned nonbank affiliates.

Compensation per Worker (in thousands of constant U.S. Dollars)

Data sources: The Annual Survey of U.S. Direct Investment Abroad at the Bureau of Economic Analysis website and Budget of the United States Government at the Government Printing Office website

I use compensation per worker by affiliates in the financial service industry to measure the cost of skilled labor in the country and compensation per worker by affiliates in the food industry to measure the cost of unskilled labor in the country. The compensation and employment data are obtained from the BEA data and are deflated with the GDP price index obtained from the GPO website.

Compensation per skilled worker is defined as total compensation of employees by affiliates in the financial service industry in the country divided by total number of employees of the affiliates in the financial service industry in the country. Similarly, compensation per unskilled worker is defined as total compensation of employees by affiliates in the food industry in the country divided by total number of employees of the affiliates in the food industry in the country.

In benchmark surveys, data on compensation and employment of employees are collected for US parents and foreign affiliates. Compensation of employees consists of wages, salaries and employee benefits. Employment is measured as the number of full-time and part-time employees on the payroll at the end of the fiscal year.

Lending Interest Rate

Data source: 2005 World Development Indicators by World Bank and Common Database at United Nations Statistics Division.

Productivity (in constant U.S. Dollars per worker)

Data source: 2005 World Development Indicators by World Bank

Productivity is defined as total value added in industry divided by total number of employees in industry.

Air Freight (in million tons per km)

Data source: 2005 World Development Indicators by World Bank

Percentage of Roads Paved

Data source: 2005 World Development Indicators by World Bank

According to World Bank, paved roads are roads surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones, as a percentage of all the country's roads, measured in length. (International Road Federation)

GDP per Capita (in constant U.S. Dollars)

Data source: 2005 World Development Indicators by World Bank

The Standard Deviation of Inflation Rates

Data source: 2005 World Development Indicators by World Bank

The standard deviation of inflation rates is calculated on the basis of inflation rates in the previous three years.

Distance

Data source: CIA The World Factbook

I use the service at http://www.timeanddate.com/worldclock/distance.html to find the distance between the country and the US. The geographic coordinates of a country, which are obtained from the CIA website, include rounded latitude and longitude figures for the purpose of finding the approximate geographic center of an entity and is based on the Gazetteer of Conventional Names, Third Edition, August 1988, US Board on Geographic Names and on other sources.

Language Barrier

Data source: CIA The World Factbook

Language is a categorical variable. When English is the official language of the country, the variable takes the value of 0. When English is the predominant foreign language of the country, the variable takes the value of 1. In all other cases, the variable takes the value of 2.

Bilateral Free Trade Agreement

Data source: Office of the United States Trade Representative

Bilateral free trade agreement is a dummy variable. It takes the value of 1 if the country has signed a bilateral free trade agreement with the US and zero otherwise.

Appendix D: Sample Countries

Argentina, Austria, Australia, Belgium, Brazil, Canada, Chile, China, Columbia, Costa Rica, Czechoslovak, Germany, Denmark, Ecuador, Finland, France, Great Britain, Greece, Honduras, India, Indonesia, Ireland, Israel, Italy, Japan, Mexico, Malaysia, the Netherlands, Panama, Peru, Philippine, Poland, Portuguese, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, the United States.