¿Integración vertical o desintegración? Un modelo de negociación del caso de la maquiladora

Ikuho Kochi[1]
Ramsés Jiménez Castañeda[2]
Raúl Alberto Ponce Rodríguez[3]

Vertical Integration or Disintegration? A Bargaining Model of the Maquiladora's Case

1 Japonesa. Doctora en Economía. Profesora adscrita al Departamento de Ciencias Sociales de la Universidad Autónoma de Ciudad Juárez.
Correo de contacto: ikuho.kochi@uacj.mx

2 Mexicano. Maestro en Ciencias Económicas. Profesor adscrito al Departamento de Ciencias Sociales de la Universidad Autónoma de Ciudad Juárez.
Correo de contacto: rjimenez@uacj.mx

3 Mexicano. Doctor en Economía. Profesor adscrito al Departamento de Ciencias Sociales de la Universidad Autónoma de Ciudad Juárez.
Correo de contacto: rponce@uacj.mx

Fecha de recepción: 1 de marzo de 2011
Fecha de aceptación: 24 de mayo de 2011

Resumen

En este trabajo presentamos un marco teórico para analizar la demanda de insumos extranjeros y domésticos de la industria maquiladora. En particular, caracterizamos la rentabilidad neta de demandar insumos de alta y baja calidad. Argumentamos que las diferencias en la calidad de los insumos entre los factores nacionales y extranjeros pueden explicar la baja integración vertical de la maquiladora con la industria mexicana.

En este artículo demostramos que si la diferencia de calidad y su efecto positivo en la producción marginal compensan la diferencia de precios, la maquiladora puede ser inducida a una integración vertical con los proveedores de insumos extranjeros, aun y cuando el costo unitario de la demanda de insumos extranjeros es estrictamente mayor que la de los insumos domésticos. También demostramos que una depreciación del tipo de cambio mexicano no necesariamente aumenta la demanda de la maquiladora por insumos mexicanos. Esto es consistente con la evidencia reciente que sugiere dicho resultado. Por el contrario, una depreciación del tipo de cambio podría aumentar la demanda de la maquiladora de los insumos importados si los factores nacionales y extranjeros son complementarios. Lo anterior es válido incluso si el proveedor nacional participa en un juego de negociación en el que ofrece un contrato eficiente.

Palabras clave: Integración vertical, teoría de la negociación, conducta de la firma.

Abstract

In this paper we present an analytical framework to study the demands of foreign and domestic factors of production of the maquiladora industry. We derive the net profitability of demanding high instead of low quality inputs. We argue that differences in the quality of inputs between foreign and domestic factors can explain the low vertical integration of the maquiladora with the Mexican industry.

We show that if the difference in quality and its positive effect in marginal production compensates the difference in prices, then the maquiladora can be induced to integrate vertically with foreign suppliers of inputs, even if the unitary cost to demand foreign inputs is strictly higher than that of domestic inputs. We also show that a depreciation of the Mexican exchange rate does not necessarily increase the maquiladora's demand of Mexican inputs. This explains recent empirical evidence showing this phenomenon. Conversely, a depreciation of the exchange rate might increase the maquiladora's demand of imported inputs if foreign and domestic factors are complementary. The above holds even if the domestic supplier participates in a bargaining game offering an efficient contract.

Key words: Vertical integration, bargaining theory, firm behavior.

Introduction

It has been pointed out that corporate strategies in the maquiladora industry of Mexico have changed notably over the years. In the 1960s and 70s the maquiladora plants were primordially utilized for assembly operations that required little skill but a lot of hands (see Buitelaar and Padilla, 2000: 1627-1642). According to Buitelaar and Padilla, the output was typically a large volume of commodity-type products in which quality played a minor role. Nowadays, however, international corporations use maquiladora plants for an ample range of assembly operations and complex manufacturing processes.

The U.S.-Mexico border, in contrast with the U.S.-Canada border where intra-firm trade is highly developed, has historically been one of the least evolved. Hanson (1996: 941-949; 1998a: 1-36; 1998b: 1-32) and Gómez (2004: 74-81) examine the effect of U.S.-Mexico integration when Mexico removed most barriers to foreign trade and lifted restrictions on foreign ownership. The results of this research suggest that U.S.-Mexico integration is contributing to the expansion of the U.S. border economy by relocating complimentary manufacturing activities from the interior to border cities.

Nonetheless, critics of export-led development still refer to the maquiladora industry as an industry with low wages, disarticulation of production, and few backward and forward linkages. It is a fact that in more than 30 years of growth the maquiladora uses very little material inputs that are made in Mexico.[1] Even when the average annual growth of the maquiladora's demand for domestic containers, packing, and raw material input is 23% per year, the maquiladora's vertical in-

1 The literature recognizes that one of the main factors explaining the decision why the maquiladora industry based its operations in Mexico is the low cost of Mexican labor (see Calderón and Ponce, 2001: 271-278). Moreover, suppliers of inputs of the maquiladora are also located relatively close to the maquiladora industry. Hence the maquiladora might have arrived in Mexico with a reliable net of suppliers. These elements can, perhaps, explain why the maquiladora industry shows a low level of vertical integration with the Mexican economy.

We'd like to thank an anonymous reviewer for the observation above.

tegration is less than 3% of the total maquiladora's demand for the mentioned inputs; the rest of the factors are imported.

A study of the lack of backward linkages between the maquiladora industry and local suppliers in Northern Mexico (Brannon, James and Lucker, 1993: 933-1945) offers three main reasons for the low demand of Mexican inputs: First, the price is too high; second, the quality of the product is inadequate; and third, delivery from Mexican suppliers is unpredictable. They also suggest that Mexico's internal economic structure, after years of high domestic protection, is inadequate for supporting competition with foreign suppliers of inputs on the bases of quality and price.

According to Jiménez and Ponce (in press: 1-50) the dynamic growth in inputs demand by the maquiladora – along with supply restrictions and costly finance access for the domestic suppliers, among other reasons – might account for the lack of integration of the maquiladora's industry with the Mexican suppliers. Moreover, the authors find empirical evidence suggesting that the maquiladora remains vertically integrated with foreign suppliers in spite of the massive depreciations of the Mexican exchange rate over the last twenty years.

Little research has been carried out appertaining the low degree of integration of the maquiladora with the rest of the Mexican industry. Most of the literature does not provide a formal explanation. This is why we have developed a theoretical explanation of this phenomenon. Our model allows us to study the maquiladoras choice for intra-firm trade when it faces vertical and horizontal differentiation.

The subject of this study is the maquiladora's demand of imported and domestic inputs. In our analysis we assume that the quality of domestic and foreign inputs affects both the marginal productivity of the factors of productions and the input's prices. Therefore, the maquiladora's choice of vertical integration considers the profitability of demanding high (foreign) or low quality (domestic) factors of production.

In this paper we show that if the difference in quality between the high and low quality of the factors compensates for the difference in prices (regardless of the effect on the marginal production of the

firm), then the maquiladora is induced to integrate vertically with the foreign firm, even if the unitary cost of demanding foreign inputs is strictly higher than that of its domestic counterpart.

In this paper we also extend our previous analysis of the demand of inputs from the maquiladora to illustrate that a depreciation of the Mexican exchange rate does not necessarily increase neither the maquiladora's demand for Mexican inputs, nor its vertical integration with the Mexican economy when there is vertical differentiation (differences between the quality of factors of production) or horizontal differentiation (differences in transportation costs which affects marginal costs of demanding the foreign and the domestic factor).

Conversely, a depreciation of the Mexican currency might increase the demand of imported inputs. To demonstrate the above we propose a static bargaining game where the maquiladora asks potential suppliers for prices; then the maquila compares price and quality of the suppliers' offers and takes the one that maximizes its gains from intrafirm trade. In this paper we characterize conditions that explain the lack of vertical integration of the maquiladora with Mexican suppliers. In particular the maquiladora might integrate with foreign suppliers even if the unitary cost is strictly higher than that of domestic inputs, and if the domestic supplier offers an efficient bargaining contract.

The rest of the paper is organized as follows: In section 2 we analyze the maquiladora's choice of vertical structure in a framework of revealed profitability of demanding high or low quality inputs; section 3 contains the static bargaining game for the maquiladora and the domestic suppliers; and in the last section, number 4, we draw our conclusions.

Maquiladora's Choice of Vertical Structure

The maquiladora is the downstream unit which produces a final good in a competitive market at price p. The downstream unit demands inputs from two different kinds of suppliers: A foreign and a domestic supplier compete to offer the inputs that produce the maquiladora's output q. The two inputs are substitutes in the downstream produc-

tion function. Then maquiladora must decide how much to demand from each supplier. In doing so, it considers the price w, and quality s of foreign and domestic inputs as shown in figure 1.

Both foreign and domestic supplier have constant marginal costs of production α^* and α, respectively. The foreign upstream supplier produces the factor of production $x^*(s^*)$ with quality s^* at price $w^*(x^*(s^*))$ to be used by the maquiladora. Similarly, the domestic supplier produces the input $x(s)$ with quality s and price $w(x)$.

The bargaining issue for the maquiladora consists of negotiating the intra-firm trade with the domestic and/or foreign suppliers. The intra-firm bargaining is affected by the qualities $S=\{s,s^*\}$, and the price of the inputs. We assume that the foreign supplier offers the high quality input $x^*(s^*)$ while the domestic firm supplies the low quality input $x(s)$.

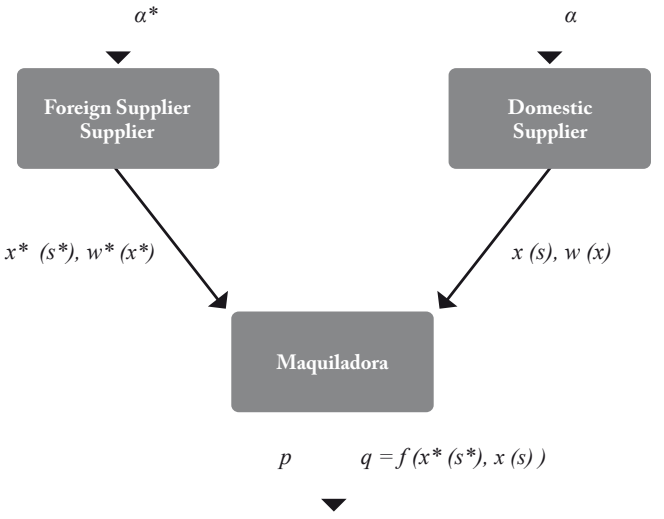

Fig. 1. Choice of Vertical Integration of the Maquiladora

The maquiladora can find it profitable to demand the high quality input because the marginal productivity is affected by the input's quality. For example, the maquiladora might want to produce a target output $\bar{f}$

which can be produced by the technology $\bar{f} = f(x_1(s_1).....x_m(s_m))$, where the production is a function of $x_1 \ldots x_m$ inputs with quality $s_1 \ldots s_m$, if the maquiladora reaches a trade agreement with the domestic firm. Similarly, $\bar{f}$ can be produced if the maquila is integrated vertically with a foreign firm through the technology $\bar{f} = f(x_1^*(s_1^*).....x_m^*(s_m^*))$. In this case, the maquiladora demands $x_1^* \ldots x_m^*$ inputs with qualities $s_1^* \ldots s_m^*$, where $s_c^* > s_c \forall c=1 \ldots\ldots m$.

If the marginal productivity is positively affected by the quality of the inputs, then $\frac{\Delta f(x_1^*(s_1^*).....x_m^*(s_m^*))}{\Delta x_c^*(s_c^*)} dx_c^*(s_c^*) > \frac{\Delta f(x_1(s_1).....x_m(s_m))}{\Delta x_c(s_c)} dx_c(s_c)$, for given $x_c^*(s_c^*)$ and $x_c(s_c)$. In words, an increase in the use of an input with high quality will have a proportionally higher increase in marginal production. The difference in marginal productivity is then given by $\left\{ tg\ \tau^* \big|_{\Delta x^*(s^*)} - tg\ \tau \big|_{\Delta x(s)} \right\} > 0$, where $\Delta x^*(s^*) = \Delta x(s)$ (see figure 2).

Given these conditions, the upstream firm has the incentive to demand the high quality inputs by its positive effect in marginal production, which is valued at market price p.

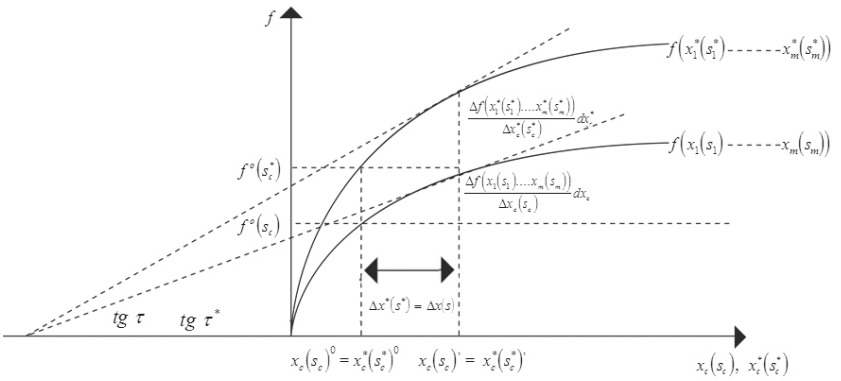

Fig. 2. Marginal Productivity and Quality of Inputs

The maquiladora must then consider the net benefit of demanding high quality inputs, therefore it not only considers the effect of

quality for productivity but also the relation between quality and price of the inputs where $w_c^* > w_c \; \forall \; c=1 \ldots m$.[2]

Another important characteristic that explains the maquiladora's demand for factors of production is the horizontal differentiation related to its demand of imported and domestic factors, defined as the transportation cost given by T^* and T for the imported and domestic inputs, respectively. Now we can use a more general framework and define the unitary cost to demand inputs from a foreign supplier which is given by $w_c^* + T^*$, while $w_c + T$ is to demand inputs from a domestic supplier

Finally, the maquiladora's budget, the unitary costs, and the quality of the inputs will define the net benefit of demanding high quality inputs and, therefore, the proportion of foreign and domestic inputs to be demanded.

A fixed budget, $\overline{B}_p$, for the downstream adds the restriction issue for the firm and represents one of the mechanisms of incentives to optimize the downstream's resources in order to maximize its profit. Because $w_c^* > w_c$, the demand for high quality inputs reduces the disposable budget of the firm to demand the rest of the inputs.

The total disposable budget of the downstream, B_{-p}, is negatively related to the input's quality. If the firm demands an input with high quality, the price of these inputs will be higher than those inputs of low quality and thus the disposable budget of the firm, B_{-p}, is reduced, where $B_{-p} = \overline{B}_p - \{w_c^* + T^*\} x^*$.

We propose a Lagrangian for the maquiladora's intrafirm trade with both foreign and domestic suppliers in order to analyze the net benefit of the maquiladora's input demand. The Lagrangian will define the minimization cost problem constrained to a production target, $\bar{f}$, for the maquiladora and the proportion of imported and domestic inputs to be demanded by the downstream. This is stated in the following equation:

2 We also assume that the price is an strictly increasing function of quality. Then $\partial w_c^* / \partial s_c^* > 0, \partial^2 w_c^* / \partial s_c^{*2} > 0$ and $\partial w_c / \partial s_c > 0, \partial^2 w_c / \partial s_c{}^2 > 0$.

$$\delta^T = \delta^* + \delta^d \tag{1}$$

where δ^* and δ^d are the cost minimization choices subject to the available technologies for the maquiladora's intra-firm trade with foreign and domestic upstreams. Total cost of production depends on the product of the inputs and the cost corresponding cost of transportation.

Assuming the downstream integrates with a foreign firm, the Lagragian is defined by:

$$\delta^* = \{w_1^* + T_1^*\} * x_1^*(s_1^*) + ...\{w_m^* + T_m^*\} * x_m^*(s_m^*) + \gamma^*\left[\bar{f} - f(x_1^*(s_1^*).....x_m^*(s_m^*))\right] \tag{2}$$

In equation (2) γ^* is the corresponding multiplier for δ^*. The first order condition for (2) is given by $\partial\delta^*/\partial x_c^*(s_c^*)$:

$$\partial\delta^*/\partial x_c^*(s_c^*) \tag{2a}$$

Similarly, the vertical integration with domestic firms considers the demand of input with lower quality and the interaction of the exchange rate. Since the gross income from the maquiladora's sales, and therefore the budget of the maquiladora, is denominated in dollars while the payment of the inputs is in pesos, then the cost structure of the maquiladora is negatively related with the exchange rate e of the domestic currency. If the downstream chooses to integrate vertically with the domestic supplier, the cost minimization choices of the maquila can be expressed by the Lagragian defined in δ^d:

$$\delta^d = \left\{\frac{w_1 + T_1}{e}\right\} * x_1(s_1) + ...\left\{\frac{w_m + T_m}{e}\right\} * x_m(s_n) + \gamma\left[\bar{f} - f(x_1(s_1).....x_m(s_m))\right] \tag{3}$$

The first order condition for $\partial\delta^d/\partial x_c(s_c)$ is:

$$\frac{\partial\delta^T}{\partial x_c} = \frac{\partial\delta^d}{\partial x_c} = \gamma\frac{\partial f(x_1(s_1)..... x_m(s_m))}{\partial x_c(s_c)} - \left\{\frac{w_c + T_c}{e}\right\} = 0 \tag{3a}$$

When a cost minimizing maquila chooses the inputs between two quality inputs offered in the market and defines the target production $\bar{f}$, then it reveals, in the first place, that inputs and outputs are feasible; in the second place, that the firm's decisions are more profitable than other ones available. If the inputs with higher quality are revealed to be slightly more profitable, relative to the low quality factor, then:

$$\gamma^* \frac{\partial f\left(x_1^*(s_1^*)...x_m^*(s_m^*)\right)}{\partial x_c^*(s_c^*)} - \left\{w_c^* + T_c^*\right\} \geq \gamma \frac{\partial f\left(x_1(s_1)...x_m(s_m)\right)}{\partial x_c(s_c)} - \left\{\frac{w_c + T_c}{e}\right\} \quad (4)$$

Rearranging and denoting Θ as the difference in profitability when demanding high instead of low quality factors, we have:[3]

$$\Theta = \left[\gamma^* f'_{s_c^*}\left(x_1^*(s_1^*)..x_m^*(s_m^*)\right) - \gamma f'_{s_c}\left(x_1(s_1)..x_m(s_m)\right)\right] - \left\{w_c^* + T_c^* - \frac{w_c + T_c}{e}\right\} \geq 0 \quad (4a)$$

If (4a) holds, the profit maximization choice for a firm with differentiated quality inputs s_c^* and s_c with prices $w_c^* > w_c$, reveals that the net profit of choosing s_c^* instead of s_c is non negative. In this case, the difference in quality and its positive effect on marginal production compensate the difference in prices $\{w_c^* - w_c\} > 0$. This induces the maquiladora to integrate vertically with the foreign firm, even if the unitary cost to demand foreign inputs is strictly higher than that of the domestic factors, even if $\{w_c^* + T_c^*\} > \left\{\frac{w_c + T_c}{e}\right\}$.

Equations (4) and (4a) can give us the elements to analyze the conditions that guarantee that the maquiladora find a positive profit for integrating vertically with a domestic firm. Therefore, in order to demand low quality inputs, it should be satisfied:

3 We denote $f'_{s_c^*}\left(x_1^*(s_1^*)....x_m^*(s_m^*)\right) = \frac{\partial f\left(x_1^*(s_1^*).....x_m^*(s_m^*)\right)}{\partial x_c^*(s_c^*)}$ and $f'_{s_c}\left(x_1(s_1)....x_m(s_m)\right) = \frac{\partial f\left(x_1(s_1).....x_m(s_m)\right)}{\partial x_c(s_c)}$

$$\frac{uc}{e} \leq -\{tg\,\tau^* - tg\,\tau\} + uc^* \tag{5}$$

Where $uc = w_c + T_c$, and

$$uc^* = w_c^* + T_c^* \tag{5a}$$

$$tg\,\tau^* - tg\,\tau = \gamma^* f'_{s_c^*}\left(x_1^*(s_1^*)\ldots x_m^*(s_m^*)\right) - \gamma\, f'_{s_c}\left(x_1(s_1)\ldots x_m(s_m)\right) \tag{5b}$$

The above leads us to conclude:

$$\left(\frac{uc}{e}\right) \leq k(uc^*) \tag{6}$$

Where $k = -\{tg\,\tau^* - tg\,\tau\} + 1$.

The marginal costs of the domestic and foreign firms are defined by (5a). Equation (5) states that the maquiladora finds slightly more profitable the vertical integration with a domestic firm if the difference in unitary costs denominated in foreign currency uc/e is at least lower than the sum of the difference in marginal productivity by the difference between the high and low quality factors and the marginal cost of demanding the foreign input. In equation (6), k defines the difference in marginal productivity if the maquiladora uses a domestic input instead of a foreign one.

Since the marginal productivity of the foreign input (high quality input) is higher than that of the domestic factor (low quality factor), then $k < 1$ in equation (6) asserts that the unitary cost of demanding a domestic input must be k times lower than the unitary cost of the foreign factor in order the unitary cost of domestic input compensates the difference in marginal productivity. Otherwise, the maquiladora will demand the foreign input even if the market prices are $w_c^*(x^*(s^*)) > w_c(x(s))$.

The Bargaining Game of Vertical Integration

Following Perry (1978: 561-570), Patrick and Tirole (1986: 920-939) consider a buyer – the downstream unit or maquiladora – and a sample of potential suppliers, all involved in a bargaining game where the parties meet, bargain and trade at date 1. If the players reach an agreement, the service will be traded. The agreement corresponds to a flow of inputs from the supplier. The maquiladora asks and receives the offers from *h* potential suppliers and compares the quality of the inputs and the unitary costs of the vertical integration among all offers and takes the offer that maximizes the gains from trade.

We explore a game of bargaining, but no negotiation, between the maquiladora and the domestic supplier where the valuation of the trade for the maquiladora is determined by:

$$v_{maq} = p * f\left(x_{j1}\left(s_{j1}\right)....x_{jm}\left(s_{jm}\right)\right)\Big|_{x_{jc}} - \frac{1}{r_j} uc\ x_{jc} \qquad (7)$$

where $j = \{f, d\}$ and $c = \{1.....m\}$, $r_j = \{r_j \to \Re \mid r_j = \{1, e\} \text{ for } j = \{f, d\}\}$.

The variable $j = \{f, d\}$ is an index defining the foreign and domestic suppliers for the inputs to be used by the maquiladora for all *c=1……m*. The variable r_j represents an index denoting $r_j = \{1, e\}$ for $j = \{f, d\}$ with $r_f = 1$ for the vertical integration of the maquiladora with the foreign supplier, while $r_d = e$ for the intra-firm trade with a domestic supplier. The variable v_{maq} is the net benefit from trading x_{jc} inputs. The first term of equation (7) is the contribution of a volume of inputs x_{jc} to the maquiladora's output f evaluated at price p in the final good market, and the second term $\frac{1}{r_j} uc`x_{jc}$ is the cost of vertical trade.

The maquiladora will take the contract with the supplier that maximizes the gains from trade v_{maq}. If the maquila trades with a foreign supplier, then $v_{maq} = p * f\left(x_{f1}\left(s_{f1}\right)....x_{fm}\left(s_{fm}\right)\right)\Big|_{x_{jc}} - uc\ x_{jc}$; and if it trades with a domestic supplier, then $v_{maq} = p * f\left(x_{d1}\left(s_{d1}\right)....x_{dm}\left(s_{dm}\right)\right)\Big|_{x_{jc}} - \frac{1}{e} uc\ x_{dc}$. Total valuation if the maquila trades with the foreign and the domestic supplier is:

$$v_{maq}{}^{T} = p * f\left(x_{j1}\left(s_{j1}\right)....x_{jm}\left(s_{jm}\right)\right)\Big|_{x_{jc}} - \sum_{\forall j=\{f,d\}} \frac{1}{r_j} uc\ x_{jc} \qquad (8)$$

We assume that v_{maq} is a strictly concave function. The payoff for the domestic supplier is defined by the expected gain from trade with the maquiladora, where the domestic supplier offers a price for a volume of trade of x_{jc} and the maquiladora responds by taking or leaving the offer. The price offered by the domestic upstream represents the unitary cost for the maquiladora designated by *uc*. The expected payoff for the domestic supplier is:

$$\pi^{d} = \left[uc - \alpha\right] x_{jc} * \left[1 - F\left(uc\right)\right] \qquad (9)$$

The price of trade offered by the domestic supplier is *uc*; α is the cost of production for the domestic supplier; x_{jc} is the quantity of domestic supplier production (input's demand for the maquiladora); and $[1 - F(uc)]$ is the probability of trade at *uc*.

The supplier's beliefs on v_{maq} are represented by a cumulative probability distribution (v_{maq}) with density $f(v_{maq})>0$ on an interval $\left[\underline{v}_{maq}, \bar{v}_{maq}\right]$, where $F\left[\bar{v}_{maq}\right]=1$ and $F\left[\underline{v}_{maq}\right]=0$. We assume that the domestic upstream is adverse to risk. If the agreement between the domestic supplier and the maquiladora is not reached, then both parties can find at least another firm to trade, and thereby there is no cost attached to the possibility of no trade.

Now we characterize the elements that determine the offer *uc* of the domestic supplier, which is given by:

$$uc = \alpha + \frac{1}{h}\Psi\left(uc^{*}, e, k\right) \qquad (10)$$

The price for a domestic supplier α is a function of the marginal cost α plus an intrafirm gain Ψ which depends of the maquiladora's valuation of the intrafirm trade and the *h* offers received by the maquiladora. The derivative $uc_{\alpha} > 0$, because an increase in marginal costs, is traduced positively in the price *uc*, while $uc_{h} < 0$ represents the competitive process of different offers received by the maquiladora, which

exerts pressure in the bargaining price and therefore $lim_{h\to\infty} uc = \alpha$. If $(uc - \alpha) > 0$, then the gain from intra-firm trade for the domestic supplier is positive. The efficient contract is obtained if $uc = \alpha$.

The extra gain Ψ is a function of the outside bargaining option for the maquiladora represented by the offer of the foreign supplier uc^*. Thus $\frac{\partial uc}{\partial uc^*} > 0$ because a reduction of the offered price of the outside option reduces the price offered by the domestic supplier by the competitive process to get the contract with the maquiladora. Similarly, $\frac{\partial uc}{\partial k} < 0$, a reduction in k, implies a proportionally higher difference in marginal productivity valuated at price p in the final good market. In order to keep profitable to demand the domestic inputs for the maquiladora, the unitary price uc should be reduced.

An interesting element of analysis is the effect of e in the offer of the domestic supplier. An increase of the exchange rate reduces the unitary cost to demand domestic input x_{dc}, which increases the valuation of the maquiladora holding a contract with a domestic firm. Formally, from (7) $\partial v_{maq} / \partial e = \frac{1}{e^2} uc(x_{dc}) x_{dc}$.

The extensive form of the intra-firm trade game and the payoffs for the players is shown in the figure 3.

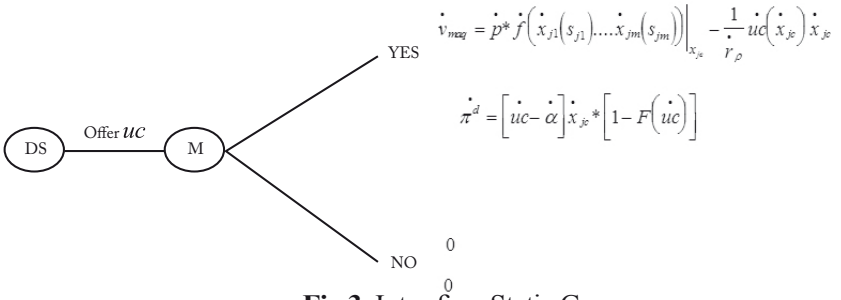

Fig 3. Intra-firm Static Game

Now that we characterized the equilibrium of the game, it's easy to prove the following:

LEMMA 1. *A domestic supplier with quality* s *offers the maquiladora the efficient contract* $uc = \alpha$.

$$uc = Arg\ Max \quad \{[1 - Fuc]\pi^d(uc)\}. \tag{11}$$

The maquiladora accepts the domestic supplier's offer if $uc = \alpha \leq ek(uc^*)$

Proof: We argument by contradiction. Suppose that the domestic firm offers $uc > \alpha$, then the maquiladora is better off by rejecting the contract, since there are other suppliers with contracts at α. By duality, the optimality conditions of (8) are equivalent to those of (1).

Thus, condition (6) establishes that in an equilibrium with positive demands for the domestic and foreign supplier, $x_{fc} > 0$ and $x_{dc} > 0$, it must be that $uc = \alpha \leq ek(uc^*)$.

The next Lemma points out that a reduction in the unitary costs from domestic trade promoted by a depreciation of the exchange rate does not necessarily increase the intra-firm trade of the maquiladora with domestic supplier.

LEMMA 2. *In a perfect information game if nature moves by depreciating the exchange rate, the vertical integration with the domestic supplier might not increase. In particular, a depreciation of the exchange rate will increase maquiladora's integration with foreign supplier if for* $f_{x_c x_c} = \partial^2 f / \partial x_c \partial x_c$, $f_{x_c^* x_c} = \partial^2 f / \partial x_c^* \partial x_c > 0$, *and a concave function of* ${v_{maq}}^T$, *it is satisfied that* $\left\{ f_{x_c x_c} - \Phi f_{x_c^* x_c} \right\} \geq 0$, *which implies* $d\Phi / de \leq 0$.

Proof: The solution for the maquiladora's problem in (8), with positive demands of the foreign and domestic inputs $x_c^* > 0$ and $x_c > 0$, leads to the following first order conditions:

$$\begin{aligned} pf_{x_c} - \frac{w_c}{e} = 0 \Rightarrow \quad & x_c > 0 : x_c = x_c(p, w_c, e, w_c^*) \\ pf_{x_c^*} - w_c^* = 0 \Rightarrow \quad & x_{*c} > 0 : x_c^* = x_c^*(p, w_c, e, w_c^*) \end{aligned} \tag{12}$$

Totally differentiate the optimality conditions to obtain:

$$\frac{\partial^2 v_{maq}}{\partial^2 x_c} dx_c + \frac{\partial^2 v_{maq}}{\partial x_c \partial x_c^*} dx_c^* = -\frac{\partial^2 v_{maq}}{\partial x_c \partial \widetilde{w}_c} \frac{\partial uc_c}{\partial e}$$

$$\frac{\partial^2 v_{maq}}{\partial x_c^* \partial x_c} dx_c + \frac{\partial^2 v_{maq}}{\partial^2 x_c^*} dx_c^* = -\frac{\partial^2 v_{maq}}{\partial x_c^* \partial uc_c^*} \frac{\partial uc_c^*}{\partial e}$$

For $uc = w_c + T/e$ and $uc^* = w_c^* + T^*$.

The system is equivalent to:

$$\begin{bmatrix} pf_{x_c x_c} & pf_{x_c x_c^*} \\ pf_{x_c^* x_c} & pf_{x_c^* x_c^*} \end{bmatrix} \begin{bmatrix} dx_c \\ dx_c^* \end{bmatrix} = \begin{bmatrix} -w_c/e^2\, de \\ 0 \end{bmatrix} \qquad (13)$$

where $f_{x_c x_c} = \partial^2 f/\partial x_c \partial x_c > 0$, $f_{x_c^* x_c^*} = \partial^2 f/\partial x_c^* \partial x_c^* > 0$, and $f_{x_c x_c^*} = \partial^2 f/\partial x_c \partial x_c^* \gtrless 0$. It follows that the demand of inputs for changes in the exchange rate are given by:

$$\frac{dx_c}{de} = \frac{-\{w_c/e^2\} f_{x_c x_c}}{p\left\{f_{x_c x_c} f_{x_c^* x_c^*} - f_{x_c x_c^*}^2\right\}} > 0$$

$$\frac{dx_c^*}{de} = \frac{-\{w_c/e^2\} f_{x_c^* x_c}}{p\left\{f_{x_c x_c} f_{x_c^* x_c^*} - f_{x_c x_c^*}^2\right\}} \gtrless 0 \qquad (14)$$

By the concavity of v_{maq} it follows $f_{x_c x_c} f_{x_c^* x_c^*} - \left(f_{x_c x_c^*}\right)^2 > 0$. Decreasing marginal returns of inputs for x_c implies that $dx_c/de > 0$. From (5) $sign\,(f_{x_c^* x_c}) \Rightarrow sign\left(dx_c^*/de\right)$. To analyze the effect of a change in e in the vertical integration, we define the index of integration with the domestic supplier as: $\Phi = \dfrac{x_c(p, w_c, e, w_c^*)}{x_c^*(p, w_c, e, w_c^*)}$

It follows that $d\Phi/de = \dfrac{x_c^* \dfrac{\partial x_c^*}{\partial e} - x_c \dfrac{\partial x_c}{\partial e}}{\Phi^2}$, using equations (14), we conclude that:

$$d\Phi/de = \frac{-\{w_c/e^2\}}{p\left\{f_{x_c x_c} f_{x_c^* x_c^*} - f_{x_c x_c^*}^{\ 2}\right\}}\left\{\frac{1}{\Phi^2 x_c}\right\}\left\{f_{x_c x_c} - \Phi f_{x_c^* x_c}\right\}\gtreqless 0 \qquad (15)$$

The concavity of v_{maq} implies that the Hessian is negative semidefinite, which implies $p\left\{f_{x_c x_c} f_{x_c^* x_c^*} - f_{x_c x_c^*}^{\ 2}\right\} > 0$, $w_c/e^2 \in \Re_+ \left(\Phi^2 x_c\right)^{-1} \in \Re_+$.

Consequently, $\left\{f_{x_c x_c} - \Phi f_{x_c^* x_c}\right\}\gtreqless 0 \ \Rightarrow\ d\Phi/de \lesseqgtr 0$.

Intuition suggests that depreciations of the exchange rate tend to increase the vertical integration of the maquiladora industry with the domestic firms, since the costs denominated in dollars of consuming domestic inputs is lower. However, our model suggests that this is a special case, which holds true only if $\left\{f_{x_c x_c} - \Phi f_{x_c^* x_c}\right\} \leq 0 \ \Rightarrow\ d\Phi/de \geq 0$.

Concluding Remarks

Empirical research suggests a negative relationship between the trend of depreciation of the Mexican exchange rate and the vertical integration between the maquiladora and the Mexican industry. This phenomenon is counterintuitive, since we could expect that the massive depreciations of the Mexican exchange rate in the last two decades would have reduced the price of domestic factors relative to foreign inputs of production and would have induced the maquiladora to integrate more broadly with the Mexican industry. However, a depreciation of the exchange rate might actually increase the maquiladora's demand of imported instead of domestic inputs. In this case, the vertical integration of maquila with the Mexican industry would fall.

In this paper we present an analytical framework to analyze the demands of foreign and domestic factors of production. We derive the net profitability to demand high instead of low quality inputs. Differences in the quality of inputs between foreign and domestic factors

can explain the low vertical integration of the maquiladora with the Mexican industry.

We show that if the difference in quality and its positive effect in marginal production compensates for the difference in prices, then the maquiladora can be induced to integrate vertically with the foreign suppliers of inputs even if the unitary cost to demand foreign factors is strictly higher than that of domestic factors. We also show that a depreciation of the Mexican exchange rate does not necessarily increase the maquiladora's demand for Mexican inputs. Conversely, it might increase the maquiladora's demand of imported inputs if foreign and domestic factors are complementary. The above holds true even if the domestic supplier participates in a bargaining game offering an efficient contract where the offer price is at marginal cost, and the marginal costs of demanding high quality inputs is strictly higher than those of the domestic factors.

The horizontal differentiation of factors of production is included, but not developed in this work. Similarly, another important issues that could affect the maquiladora's vertical integration – such as asset specificity, vertical control, and market foreclosure, among others – have not been studied at the moment. More research on these subjects is needed.

References

Brannon, J., D. D. James y G. W. Lucker. (1993). "Generating and Sustaining Backward Linkages Between Maquiladoras and Local Suppliers in Nothern Mexico", en *World Development 22, 12*. pp. 933-1945.

Buitelaar, R. y R. Padilla. (2000). "Maquila, Economic Reform and Corporate Strategies", en *World Development 28, 9*. pp. 1627-1642.

Calderón C. y R. A. Ponce Rodríguez. (2001). "Determinantes y pronóstico de la demanda de trabajo de la industria maquiladora", en *Revista Comercio Exterior 51*. pp: 271-278.

Gómez V. M. (2004). "El desarrollo de la industria de la maquila en México", en *Problemas del desarrollo 35*, *138*. pp.74-81.

Hanson G. (1996). "Economic Integration, Intraindustry Trade, and Frontier Regions", en *European Economic Review 40*. pp: 941-949.
Hanson G. (1998a). "North American Economic Integration and Industry Location. National Bureau of Economic Research", en *Working Paper No. 6587.* pp: 1-36.
-----. (1998b). "U.S.-Mexico Integration and Regional Economies: Evidence from Border City Pairs, National Bureau of Economic Research", en *Working Paper No. 6587.* pp: 1-32.
Jiménez R. y R. A. Ponce Rodríguez. "Determinantes de la proveeduría nacional a la industria maquiladora: el caso de Ciudad Juárez", en *Sociedad, Economía y Territorio*. pp. 1-50. [En prensa.]
Patrick R. y J. Tirole. (1986). "The Logic of Vertical Restraints", en *The American Economic Review 76, 5*. pp: 920-939.
Perry M. (1978). "Vertical Integration: The Monopsony Case", en *The American Economic Review 68, 4*. pp: 561-570.