

OUTWARD DIRECT INVESTMENT, REVERSE IMPORT, AND DOMESTIC PRODUCTION: EVIDENCE FROM TAIWANESE MANUFACTURING FIRMS

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Abstract

The current wave of globalization has raised serious concerns of many countries whether increasing outward foreign direct investment (FDI) will cause the hollowing out of their domestic economies. In this paper we use Taiwan as a case study to examine the interrelationship between foreign production and domestic production with a special focus on the role of reverse imports. We show that without considering reverse imports properly, the empirical results may be biased or even reversed. By endogenizing a firm's decisions on reverse imports as well as on domestic and foreign production, we show that foreign production has no significant substitution effect on domestic production, but it may have a significantly negative effect on domestic production indirectly through variables related to firms' characteristics, such as firm size, the export ratio, labor intensity, the destination of the FDI, and the affiliate's rate of return relative to its parent. Demand variables (e.g., market size, GDP per capita) and cost conditions (e.g., relative wages) do not play a significant role in affecting a multinational firm's domestic production.

Key words: foreign direct investment, inverse import, and deindustrialization
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I. *Motivation*

Under rising wages, an appreciating New Taiwan dollar, and a deregulation of foreign

exchange control, Taiwan's outward direct investment (FDI) started to surge after 1987. By 1989 the total outward FDI had exceeded the accumulated outward investment for the previous two decades. Outward FDI continued to accelerate and reached a peak of 7.7 billion U.S. dollars in 2001, of which 38.8% was destined for the PRC (see Appendix I).¹ A similar trend in the ratio of Taiwan's FDI to her gross fixed capital formation in the private sector is also observed. This ratio increased rapidly, from 0.79% in 1987 to a peak of 21.57% in 2001.

The surge of Taiwan's outward FDI has sparked widespread debate on whether Taiwan's economy is hollowing out. The debate has become even more complicated and acute, because outbound investment has reached an excessively high level and is concentrated too much on the PRC.² For those firms whose competitive edge would be lost if they remain in Taiwan, FDI is often defended as a necessary strategy for their growth and development in facing the contest for worldwide markets. For those firms who are competitive in world markets, FDI is regarded as a global logistics strategy aimed at strengthening their competitiveness. However, from another point of view, FDI not only causes export substitution, but also substitutes for domestic production, employment, and investment. The continuous drop of manufacturing employment share in Taiwan after the peak of 35.2% in 1987 seems to provide evidence for such a view (see Appendix I).

Whether or not foreign affiliates' production (investment) is a substitute for or a complement to the parent firms' production (investment), employment, and exports has been extensively discussed in the literature, but the results are inconclusive. The complex channels through which domestic production and foreign production interact with each other may be an important contributing factor causing this inconclusiveness. Lipsey and Weiss (1984) and Svensson (1996), for example, study the relationship between domestic and foreign production (exports) from the perspective of horizontal or vertical linkage. They show that an increase in foreign production exerts a negative impact on the domestic production of final goods exported to host markets and third countries, while it spurs the exports of intermediate goods from the home country. The net effect, according to Svensson (1996), is negative.

Lipsey and Weiss (1984), Rugman (1990), and Grubert and Mutti (1991), on the other hand, consider the demand side. They argue that outward FDI may increase the total demand for all of the parent firms' products through more efficient and quicker deliveries and distribution and also the commitment-to-market effects on consumers. Under such a situation, foreign production and domestic production may be complementary. Head and Ries (2001) consider both the vertical linkage and demand effects and identify the conditions under which a positive or negative relationship between FDI and exports exists. The financial side is another channel through which domestic investment and foreign investment may interact with each other. As shown by Stevens and Lipsey (1992), domestic investment and foreign investment are significantly, positively correlated, a reflection of the same financial constraints that a firm faces in all its investment decisions. Moreover, according to the OLI theory (Dunning, 1980),

¹ The official statistics reported in Appendix 1 seriously underestimate the actual amount of outward investment. It is said that the official investment statistics for Asia may represent no more than one-fifth of actual investment, while those for the PRC are only one-tenth.

² Before 1991 Taiwan's outward investment concentrated primarily in Southeast Asia and North America. When the restriction on indirect investment to the PRC was lifted in 1991, mainland China soon became the largest recipient of Taiwan's investment, accounting for 38.82% of Taiwan's outward direct investment for the period of 1959-2001. See Appendix I.

a firm's characteristics also play important roles on the decisions of domestic and foreign production. A firm with intangible assets, being in the mature stage of a product cycle, and facing high transaction cost on exports and licensing may locate production abroad rather than at home, implying a substitution between foreign production and domestic production.

In addition to the above channels, domestic and foreign production may also interact with each other through the "reverse imports" of a portion of foreign production exported back to the home market.³ To maximize its worldwide profit, a multinational firm, given cost and demand conditions at home and overseas, will determine domestic production, foreign production, and reverse imports simultaneously. Reverse imports are thus a natural result of a firm's profit-maximizing behavior. Without taking reverse imports into consideration, the relationship between domestic and foreign production may be seriously biased.

Reverse imports have been gaining much attention in Taiwan. According to a survey on FDI by the Ministry of Economic Affairs in 1995, 27% of Taiwanese firms engaged in the operation of reverse imports. The average figure of these reverse imports as the percentage of their foreign affiliate production is close to 40%, a figure that is worth serious discussion in the impacts of outward direct investment on parent production.

Whether an increasing outward FDI hollows out its domestic economy is not just the concern of Taiwan, but also the concern of many countries (e.g., Japan and Singapore) under the wave of globalization and the rise of the People's Republic of China. This paper uses Taiwan as a case study to examine the inter-relationship between foreign and domestic production. Unlike previous studies where reverse imports are often ignored, we endogenize firms' decision-making on reverse imports as well as on domestic and foreign production. We show that the effect of foreign production on domestic production may be seriously biased if reverse imports are not taken into consideration.

In section II we set up a simple theoretical model to examine how the presence of reverse imports affects the relationship between foreign production and domestic production. The testable hypotheses derived from the theoretical model are modified to take into account the heterogeneity of firms (e.g., firm size, capital-labor intensity, export ratio, vertical FDI vs. horizontal FDI, performance of affiliate production, and marketing channel). To test these hypotheses, we set up an econometric model in section III and run a full information maximum likelihood regression to solve for the censored and selection problems involved in the empirical data. Section IV discusses the empirical results. The last section concludes the paper.

II. *The Theoretical Model and Testable Hypotheses*

Suppose that there are two types of firms in the domestic country, H_1 and H_2 . Firm H_1 is a multinational firm; that is, H_1 not only produces Y_1 in the domestic country, but also sets up an affiliate abroad to produce the differentiated good Z , of which a portion α will be shipped back to the home country and the other portion $(1 - \alpha)$ will be sold in the host market. Ratio

³ We follow the usage of "reverse imports" by Bayoumi and Lipworth (1997). The phenomenon of reverse imports is also discussed in the standardized stage of the product cycle. See, for example, Vernon (1966), Gagnon and Rose (1995), and Bayoumi and Lipworth (1997).

α is henceforth referred to as the reverse-import ratio from the affiliate abroad. Firm H_2 , a pure domestic firm, operates only at home and produces Y_2 to compete with Y_1 , where Y_1 and Y_2 are homogeneous.

Let C_i and F_i denote, respectively, the constant marginal cost and the sunk cost of production for good i , where $i = Y_1, Y_2, Z$. Let P_1 denote the inverse demand for Y_1 and Y_2 , and P_2 and P_3 are the inverse demands for the reverse imports of good Z sold in the domestic market and for good Z sold in the host market, respectively.⁴ The profit functions of H_1 and H_2 (denoted as π_1 and π_2) can be written as

$$\pi_1 = (P_1 - C_{Y_1})Y_1 + (P_2 - C_Z - S)\alpha Z + (P_3 - C_Z)(1 - \alpha)Z - F_{Y_1} - F_Z, \quad (1a)$$

$$\pi_2 = (P_1 - C_{Y_2})Y_2 - F_{Y_2}, \quad (1b)$$

where S is the unit transportation cost for the reverse imports. To simplify the analysis, we assume that the inverse demand functions are linear: $P_1 = a_1 - b_1(Y_1 + Y_2) - r(\alpha Z)$, $P_2 = a_2 - b_2(\alpha Z) - r(Y_1 + Y_2)$, $P_3 = a_3 - b_3(1 - \alpha)Z$, where a_i can be used to measure the size of market i , and r is the extent of product differentiation between Y_1 (Y_2) and the reverse imports αZ .⁵

To better understand how a multinational firm's decisions on foreign and domestic production interact through reverse imports, we differentiate (1a) with respect to Y_1 , Z , and α , respectively:

$$\frac{d\pi_1}{dY_1} = [(P_1 - C_{Y_1}) - b_1 Y_1] - r(\alpha Z) = 0, \quad (2a)$$

$$\frac{d\pi_1}{dZ} = (-r\alpha)Y_1 + \alpha(P_2 - C_Z - S - b_2\alpha Z) + (1 - \alpha)(P_3 - C_Z) = 0, \quad (2b)$$

$$\frac{d\pi_1}{d\alpha} = (-rZ)Y_1 + (P_2 - C_Z - S - b_2\alpha Z)Z - [P_3 - C_Z - b_3(1 - \alpha)Z]Z = 0. \quad (2c)$$

From (2a), we see that through reverse imports (αZ), an increase in foreign production Z not only directly displaces domestic production (the second term), but also lowers the demand for domestic production (i.e., P_1 in the first term). Similarly, an increase in domestic production directly substitutes for reverse imports (the first term in (2b)) and indirectly lowers the demand for reverse imports (the second term in (2b)) and hence has a negative impact on foreign production. Moreover, (2c) shows that the profit-maximizing reverse-import ratio will depend on a firm's decisions on domestic and foreign production. The above results imply that domestic production and foreign production will substitute for each other through reverse imports, and the extent of substitution will depend on the extent of product differentiation between domestic and foreign production (i.e., r).

As to the decision of a pure domestic firm, its profit-maximizing level of Y_2 will satisfy the following condition:

$$\frac{d\pi_2}{dY_2} = (P_1 - C_{Y_2}) - b_1 Y_2 = 0. \quad (2d)$$

⁴ Since national markets are viewed as being segmented by government policies and transport costs, we assume that H_1 is able to discriminate in pricing between countries.

⁵ When $b_1 = b_2 = r$, they are perfect substitutes; when $r = 0$, they are unrelated.

Since the data of Y_2 is not available for empirical purposes in the next sections, we will thus substitute Y_2 away from (2a)~(2c).⁶ Solving Y_2 from (2d) and then substituting it into (2a)~(2c), we can solve for the structural equations of Z , α , and Y_1 :

$$Y_1 = \frac{A_1 - 3r\alpha Z}{3b_1}, \quad (3a)$$

$$Z = \frac{2b_1(a_3 - C_Z) - B_3\alpha - 3b_1r\alpha Y_1}{4b_1b_3(1 - 2\alpha) + \alpha^2 D_1}, \quad (3b)$$

$$\alpha = \frac{-B_3 - 3rb_1Y_1 + 4b_1b_3Z}{D_3Z}, \quad (3c)$$

where $D_3 \equiv 4b_1(b_2 + b_3) - r^2 > 0$, $B_3 \equiv 2b_1(a_3 - a_2 + S) + r(a_1 - C_{Y_2})$, and $A_1 \equiv a_1 - 2C_{Y_1} + C_{Y_2}$.

The above equations imply that Z , α , and Y_1 will not only directly interact with each other, but also indirectly affect each other through a change in exogenous factors such as market size (denoted by a_i), cost factor (C_j , S), and the extent of product differentiation (r):

$$Y_1 = F_{Y_1}(a_1, a_2, a_3, C_{Y_1}, C_{Y_2}, C_Z, S, r; \alpha, Z), \quad (4a)$$

$$Z = F_Z(a_1, a_2, a_3, C_{Y_1}, C_{Y_2}, C_Z, S, r; \alpha, Y_1), \quad (4b)$$

$$\alpha = F_\alpha(a_1, a_2, a_3, C_{Y_1}, C_{Y_2}, C_Z, S, r; Y_1, Z).^7 \quad (4c)$$

The larger the host demand is relative to the domestic demand for good Z (i.e., a_3/a_1), the more incentive H_1 will have to produce abroad. Thus, foreign production (Z) increases, which in turn raises reverse imports (αZ) and lowers domestic production Y_1 .

As to the cost factors, the larger the affiliate cost of production is relative to the parent cost of production (C_Z/C_{Y_1}), the lower the foreign production Z is, but the larger the domestic production Y_1 will be. The reverse-import ratio, however, will not be affected directly. Although an increase in transportation cost (S) increases the cost of reverse imports and has a negative impact on foreign production and the reverse-import ratio, it has no direct effect on domestic production. Compared to the case where foreign production and domestic production are unrelated (i.e., $r=0$), producing a somehow differentiated product abroad will not only reduce a firm's foreign production and lower the reverse-import ratio, but also decrease its domestic production Y_1 . The above results from the structural form equations (4a)~(4c) are summarized in Table 1. We can also solve (3a)~(3c) simultaneously to obtain the reduced-form equations. See Appendix II for the reduced-form equations as well as their determinants. The results are also summarized in Table 1.

⁶ For pure domestic firms, we only observe that there is no outward investment. However, we cannot observe whether or not they are expanding their domestic production.

⁷ $\partial\alpha/\partial r < 0$, if measured at $r=0$.

TABLE 1. EXPECTED SIGNS

	Z	α	Y_1
Variables from the theoretical model:			
1. Structural equation:			
Foreign affiliate production, Z		?	—
Ratio of reverse imports, α	?		—
Domestic production, Y_1	—	—	
Market size: a_3/a_1	+	?	—
Cost factors: C_Z/C_{Y_1}	—	U	+
Transportation cost: S	—	—	u
The extent of product differentiation: r	—*	—*	—
2. Reduced-form equation:			
Market size: a_3/a_1	+	?	—
Cost factors: C_Z/C_{Y_1}	—	+	+
Transportation cost: S	—	—	+
The extent of product differentiation: r	—*	—*	—
Firms' characteristics:			
1. Parent firm's characteristics:			
No. of employees (1000 persons)	+	+	+
Capital-labor ratio	+		+
Export ratio	+		—
2. Affiliate's characteristics			
High labor-intensive		+	—
Upstream or downstream products vs. Similar products		+	+
Invested in the PRC and Hong Kong		—	—
Performance of foreign production			+
Relative rate of return to investment			—
Marketing through firms in Taiwan		+	

Note: * means if measured at $r=0$.

In addition to the cost and demand conditions derived from the theoretical model, the characteristics of parent firms and affiliates may also affect the interrelationship among domestic production, foreign production, and the reverse-import ratio. In the following, we first discuss the expected effects of the parent firm's characteristics.

(1) Firm size. Firm size might reflect such factors as managerial talent, economies of scale, the ability to finance funds internally and externally, and the ability to adopt a global logistic strategy. We expect that a larger firm is able to set up a larger scale of production abroad and thus have a larger foreign production, a higher reverse-import ratio, and a higher probability to expand its domestic production after increasing its investment abroad, as compared to a smaller firm.

(2) Capital-labor intensity. The unit labor cost in Taiwan's manufacturing sector increased significantly from 73.08 in 1987 (1996=100) and reached a peak of 101.89 in 1994. In response to this increasing labor cost, Taiwanese firms tend to move their labor-intensive stage of production abroad while keeping the capital-intensive stage of production at home. We thus expect a firm with a higher capital-labor intensity at its parent production to have a higher ratio of foreign production. We also expect that the firm will expand its domestic investment after investing abroad as it represents an advantage for it to use Taiwan's relatively less expensive factor (i.e., capital) more intensively.

(3) Export ratio. A firm's export ratio reflects the extent of its involvement in the competitive world market. We expect that a firm with a higher export ratio tends to be more sensitive to cost factors and thus more likely will substitute low-cost foreign production for high-cost domestic production. Thus, the export ratio has a positive impact on foreign production, but a negative impact on domestic production.

As to the affiliate's characteristics, we consider the following factors:

(1) Labor intensity. As mentioned above, Taiwan no longer has a comparative advantage in labor-intensive goods. We therefore expect that Taiwan's outward investment in high labor-intensive goods tends to more likely substitute for the domestic production of similar goods either directly or indirectly through reverse imports.

(2) Vertical FDI vs. horizontal FDI. Since trade and FDI substitute for each other under the Heckscher-Ohlin framework, it implies that a horizontal FDI has a negative impact on domestic production (Mundell, 1966). Empirical studies such as Lipsey and Weiss (1984), Svensson (1997), and Head and Ries (2001), on the other hand, show that vertical FDI has a positive effect on domestic production. Combining these lines of studies, we therefore expect a vertical FDI to have a higher reverse-import ratio as compared with a horizontal FDI.

(3) Investment in the PRC and Hong Kong. To lower the impact of reverse imports from the PRC, Taiwan's government adopted a "positive-listing" approach to PRC imports in 1993. That is, only items listed in the "positive list" are allowed to be imported.⁸ The imports from other countries, however, are basically liberalized. Thus, we expect that the reverse-import ratio from affiliates in mainland China and Hong Kong is smaller than those from other countries. Moreover, Taiwan and the PRC share the same culture and language, and we thus expect investment in mainland China and Hong Kong to be more likely to substitute for investment in Taiwan as compared to investment in other countries.

(4) Performance of affiliate production and relative rate of return in affiliate operation to domestic operation. Since good performance of affiliate production adds extra value to the parent firm, we expect a firm with good performance to more likely expand its domestic production than a firm with bad performance. However, if the affiliate's rate of return is better than domestic production, then the firm will be less likely to expand its domestic production.

(5) Marketing channel through Taiwan. If the parent firm in Taiwan takes the main responsibility of the marketing task for its affiliate's production, then we expect the reverse import ratio to be larger than the case where the marketing channel is not through Taiwan.

III. *The Empirical Model*

In this section we will first describe the data we use for this study and then set up an empirical model to examine the inter-relationship of firms' behaviors on foreign production, reverse imports, and domestic production. We will also test whether the proposed factors in sections II are statistically significant in affecting these behaviors.

Our data related to both parent and foreign production are taken mainly from the survey "Diversification and Internationalization in Manufacturing Sectors" conducted by the Minis-

⁸ Since July 1996, the "positive-listing" approach had been replaced by the "negative-listing" approach to regulate manufacturing imports from the PRC.

TABLE 2. SUB-SAMPLE MEANS FOR OUTWARD DIRECT INVESTMENT (FDI), REVERSE IMPORT, AND DOMESTIC PRODUCTION

	FDI (1)	Reverse Imports (RI)		Domestic Production		
		No RI (2)	RI (3)	Contraction (4)	No change (5)	Expansion (6)
% of Foreign Affiliate Production	30.00%	28.09%	35.19%	58.28%	27.55%	13.99%
Ratio of Reverse Imports	10.29%	--	38.20%	8.10%	10.47%	11.55%
Parent Firm's characteristics:						
Multinational Firm:						
No. of employees (thousands)	0.42	0.41	0.42	0.21	0.30	0.84
Capital-labor ratio	1.02	1.04	0.95	0.75	0.86	1.59
Export ratio	0.38	0.39	0.36	0.52	0.37	0.31
Pure Domestic Firm:						
No. of employees (thousands)	0.11	-	-	-	-	-
Capital-labor ratio	0.68	-	-	-	-	-
Export ratio	0.16	-	-	-	-	-
Number of firms	527	385	142	99	299	129
(percentage of firms)	(14.95%)	(73.06%)	(26.94%)	(18.79%)	(56.74%)	(24.47%)

Data sources: Computed from the survey of "Diversification and Internationalization in Manufacturing Sectors" taken by the Ministry of Economic Affairs in August 1995, and the survey of "The Operations of Industrial and Commercial Corporations" conducted by the Ministry of Economic Affairs Taiwan, R.O.C. in 1994.

try of Economic Affairs in August 1995. This survey randomly selected firms from Taiwan's manufacturing sector and provided information on whether the firms were engaged in foreign production or not. If they were, it was then asked what would be the percentage of foreign affiliate production to their total production, the percentage of reverse imports, the changes in their domestic production, and the characteristics of their foreign affiliates at the firm level. However, the survey did not provide data on the basic characteristics of the parent firms in Taiwan in the case of the multinational firms nor on the changes in the domestic production in the case of the pure domestic firms. The characteristics of the parent firms such as firm size, the capital-labor intensity, and the export ratio have therefore been taken from the survey entitled "The Operations of Industrial and Commercial Corporations," also conducted by the Ministry of Economic Affairs in 1994. These two surveys have been merged to obtain 3,520 firm-level observations. Table 2 summarizes the sample's basic statistics. The definitions and measurements of the variables are provided in Appendix II.

Table 2 shows that out of 3520 sample firms, 527 firms (14.95%) have invested abroad. For these multinational firms, the average percentage of foreign production relative to their total production is 30% and the average ratio of reverse imports from foreign affiliates is 10.29%.

Of the 527 multinational firms, 26.94% are engaged in the operation of reverse imports, of which the average ratio of reverse imports is 38.20% (column (3) in Table 2). Compared to multinational firms with no reverse imports, firms with reverse imports tend to have a higher percentage of foreign production (35.19% vs. 28.09%). Moreover, about a quarter of multinational firms (24.47%) have decided to expand their scale of domestic production, 18.79% have chosen to contract their domestic production, and the rest (56.74%) have not changed the scale of domestic production. Multinational firms that decide to contract their

domestic production have a much higher percentage of foreign production (58.28% vs. 13.99%), as compared to the case of expanding domestic production. The above data statistics imply that reverse imports seem to play an important role in influencing the interrelationship between foreign production and domestic production. In this section we set up an empirical model to explicitly examine them.

There are two linkages from the theoretical framework in section II to the empirical model worth noting. First of all, in order to correctly infer the inter-relationships among foreign production, reverse imports, and domestic production, we take into account the selectivity bias which may arise from the heterogeneity between domestic firms and multinational firms. The first equation will then be a censored equation considering both the decision of investing abroad and the amounts of foreign production. The reverse imports (the second equation) and domestic production (the third equation) will be observed only when the firms become multinational firms. Secondly, for multinational firms, their foreign productions, reverse imports, and domestic productions are simultaneously interrelated among each other as suggested by the theoretical model in section II. However, due to the selectivity described above and the partial observability of all the endogeneous variables, reverse imports and domestic production do not enter the equation of foreign production, and domestic production does not enter the equation of reverse imports so as to ensure the estimation model is logically consistent. The proof is provided in Appendix IV. Consequently, the econometric model can be outlined as follows.

$$\text{Foreign production: } z_i^* = X_{1i}\beta_1 + \varepsilon_{1i}, \quad (5a)$$

$$\text{Reverse import: } \alpha_i^* = \gamma_1 z_i + X_{2i}\beta_2 + \varepsilon_{2i}, \quad \text{if } z_i^* > 0, \quad (5b)$$

$$\text{Domestic production: } Y_{1i}^* = \gamma_2 z_i + \gamma_3 \alpha_i + X_{3i}\beta_3 + \varepsilon_{3i}, \quad \text{if } z_i^* > 0, \quad (5c)$$

where $i = 1, 2, \dots, N$. In the above expression, z_i^* denotes the underlying foreign production for firm i ; α_i^* and Y_{1i}^* denote respectively the underlying ratio of reverse imports and the underlying domestic production and they can be observed only if firm i 's foreign production is positive. The vector $X_i = (X_{1i}, X_{2i}, X_{3i})$ includes market size, cost factors, the extent of product differentiation, and the firm's heterogeneity.

In the regression of foreign production (5a), we consider the behaviors of multinational firms as well as pure domestic firms. We use the percentage of a firm's foreign production relative to its total production as a measure of foreign production (investment) z^* . Since z^* is observed only for multinational firms, z is censored as follows: $z = z^*$, if a firm invests overseas; $z = 0$ otherwise. Foreign production is assumed to be a function of market size and cost variables, but not a function of domestic production (Y_1) and the reverse-import ratio (α), because of the logistical consistency problem as proved in Appendix IV.

In the regression of reverse imports (5b), a selection problem arises, because the decisions of the reverse-import ratio (α) are made by multinational firms only. Moreover, α is censored as follows: the reverse-import ratio (α^*) is observed as α if a multinational firm has reverse imports, and 0 otherwise. Similarly, the regression of domestic production (5c) also faces a selection problem, because the data of domestic production (Y_{1i}^*) is available for multinational firms only. The domestic production (Y_{1i}^*) is observed as three ordered categories: it falls into category 1 ($Y_{1i} = 1$) if a multinational firm contracts its domestic production after investing

abroad; falls into category 2 ($Y_{li}=2$) if it keeps the same scale of domestic production; and falls into category 3 ($Y_{li}=3$) if it expands its domestic production.

To sum up, the estimation model can therefore be written as follows:

$$\begin{cases} z_i = z_i^* & \text{if } z_i^* > 0 \\ z_i = 0 & \text{if } z_i^* \leq 0 \end{cases}$$

$$\begin{cases} \alpha_i = \alpha_i^* & \text{if } z_i^* > 0 \text{ and } \alpha_i^* > 0 \\ \alpha_i = 0 & \text{if } z_i^* > 0 \text{ and } \alpha_i^* \leq 0 \end{cases}$$

$$\{Y_{li} = k \quad \text{if } z_i^* > 0 \text{ and } c_{k-1} \leq Y_{li}^* \leq c_k, k = 1, 2, 3.$$

The set of thresholds c_k ($k=0, 1, 2, 3$) are constants such that $c_0 = -\infty$, $c_3 = \infty$, and $c_1 < c_2$ are unknown. Without loss of generality, we normalize c_1 to be zero. We assume that the error terms $(\varepsilon_{1i}, \varepsilon_{2i}, \varepsilon_{3i})$ follow an iid trivariate normal distribution with mean and variances as follows:

$$\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \\ \varepsilon_{3i} \end{pmatrix} \sim N \left(\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \rho_{12}\sigma_1\sigma_2 & \rho_{31}\sigma_1 \\ \rho_{12}\sigma_1\sigma_2 & \sigma_2^2 & \rho_{23}\sigma_2 \\ \rho_{31}\sigma_1 & \rho_{23}\sigma_2 & 1 \end{pmatrix} \right).$$

Let $I_{1i} = 1$, if a firm has foreign production; and $I_{1i} = 0$ otherwise. Let $I_{2i} = 1$, if a firm has reverse imports; and $I_{2i} = 0$ otherwise. Similarly, let $I_{3ik} = 1$, if the domestic production of a multinational firm falls in category k ; and $I_{3ik} = 0$ otherwise. Thus, the likelihood function will have the following expression:

$$L(\beta_1, \gamma_1, \beta_2, \gamma_2, \gamma_3, \beta_3, \sigma_1, \sigma_2, c_2, \rho_{12}, \rho_{23}, \rho_{31}) = \prod_{i=1}^N \left[\int_{-\infty}^{\frac{X_{1i}\beta_1}{\sigma_1}} g(\varepsilon_{1i}) d\varepsilon_{1i} \right]^{1-I_{1i}}$$

$$\prod_{k=1}^3 \left[\int_{-\infty}^{\frac{-r_1 z_i - X_{2i}\beta_2}{\sigma_2}} \int_{c_{k-1} - r_2 z_i - X_{3i}\beta_3}^{c_k - r_2 z_i - X_{3i}\beta_3} f(z_i - X_{1i}\beta_1, \varepsilon_{2i}, \varepsilon_{3i}) d\varepsilon_{2i} d\varepsilon_{3i} \right]^{I_{1i}(1-I_{2i}) I_{3ik}}$$

$$\prod_{k=1}^3 \left[\int_{c_{k-1} - \gamma_2 z_i - \gamma_3 \alpha_i - X_{3i}\beta_3}^{c_k - \gamma_2 z_i - \gamma_3 \alpha_i - X_{3i}\beta_3} f(z_i - X_{1i}\beta_1, \alpha_i - \gamma_1 z_i - X_{2i}\beta_2, \varepsilon_{3i}) d\varepsilon_{3i} \right]^{I_{1i} I_{2i} I_{3ik}}, \quad (6)$$

where g is the univariate standard normal probability density function (PDF) and f is the trivariate standard normal PDF. To solve for the endogeneity as well as censored and selection problems, we maximize equation (6) with respect to all the parameters to obtain the full information maximum likelihood estimates (FIMLE).

IV. Empirical Results

Table 3 presents the empirical results for three cases. In the first case (column (1)), we take foreign production as given and run the regression for domestic production only. It shows that after controlling for demand and cost conditions and firms' characteristics, foreign production significantly substitutes for domestic production at the 1% significance level. In the

second case, we endogenize firms' decisions on domestic and foreign production and run these two regressions simultaneously. Columns (2A) and (2B) display the FIMLE results. Still, we obtain a significant substitution effect even when foreign production is endogenized. The signs of estimates for demand variables (measured by the relative market size and GDP per capita) and cost variables (measured by relative wage) in the above two cases, however, are inconsistent with those derived from the theoretical model. For example, the population in the host market relative to Taiwan (i.e., the relative market size) is shown to have a significantly positive effect on domestic production while the relative wage in the host market relative to that in Taiwan is shown to have a significantly negative impact on the domestic production.

To understand how the role of reverse imports plays in the relationship of domestic and foreign production, in the third case we add the regression of the reverse-import ratio to the system. Columns (3A), (3B), and (3C) report the FIMLE results from maximizing (6). It turns out that when the reverse-import ratio is endogenized, foreign production has a significantly negative effect on the reverse-import ratio, but an insignificant effect on domestic production, although the latter sign remains negative as that in cases (1) and (2). The reverse-import ratio, however, does not have a significant direct effect on domestic production.

The signs of the estimates for the demand and cost variables, which are shown to be opposite to the theoretical results in the regression of domestic production in cases (1) and (2), now appear the same as expected for all three regressions ((3A)~(3C)). Specifically, we show that the larger market size and GDP per capita and the lower labor cost in the host country have a significantly positive effect on a firm's foreign production and the reverse-import ratio, but have an insignificant negative effect on domestic production. This implies that even though the reverse-import ratio does not affect the domestic production significantly, without taking reverse imports into consideration will likely lead to biased or even reverse results regarding the impacts of firms' foreign production on domestic production.

Columns (3A)~(3C) show that a firm's characteristics play significant roles on its decisions of foreign production, the reverse-import ratio, and domestic production. From column (3A), we show that a Taiwanese firm with a larger scale in production, higher capital-labor intensity in technology, and higher export ratios significantly increases its percentage of foreign production. This confirms the popular belief that searching for cheap labor and a huge host market are the main significant factors triggering Taiwan's outward direct investment. Column (3B) shows that a Taiwanese firm with a large production scale and marketing foreign output through its domestic firms has a significantly larger ratio of reverse imports. Compared to a horizontal FDI firm, a Taiwanese firm with a vertical FDI significantly increases its reverse-import ratio which shows a significant linkage between foreign and domestic production through the trade of intermediate inputs. The ratio of reverse imports from the PRC is lower (though not significantly) than that from other countries, a result reflecting Taiwan's restriction on imports from the PRC.

Column (3C) reveals that although the direct substitution effect of foreign production on domestic production is not significant, a significant substitution effect, however, will come through a firm's characteristics. Specifically, a Taiwanese firm's foreign production will more likely substitute for its domestic production when the parent firm in Taiwan is small, export-oriented, adopting a labor-intensive technology in their foreign production, and investing in the PRC. Also compared to vertical FDI, horizontal FDI is more likely to be a substitute for domestic production. Considering that all these situations are in fact quite common in the

TABLE 3. THE COEFFICIENT ESTIMATES (Standard Deviation) OF

	Domestic Production	Foreign Production	Domestic Production
	(1)	(2A)	(2B)
Foreign production	-1.80(0.213)***		-1.84(0.249)***
Reverse imports			
Constant	1.62(0.378)***	-0.53(0.036)***	1.59(0.390)***
Relative market size	0.14(0.055)***	0.14(0.007)***	0.15(0.058)***
GDP per capita	0.77(0.258)***	0.92(0.054)***	0.81(0.278)***
Relative wages	-0.72(0.311)***	-1.11(0.063)***	-0.76(0.335)**
Transportation cost	0.21(0.175)		0.22(0.178)
Parent firm's characteristics:			
No. of employees (1000 persons)		0.72(0.164)***	
Small firm	-0.41(0.129)***		-0.41(0.129)***
Large firm	0.37(0.141)***		0.36(0.141)***
Capital-labor ratio	0.59(0.356)	0.16(0.063)***	0.59(0.357)
Export ratio	-0.62(0.156)***	0.26(0.032)***	-0.61(0.160)***
Affiliate's characteristics			
Labor-intensive	-0.42(0.145)***		-0.42(0.145)***
Upstream or downstream products	0.12(0.146)		0.11(0.146)
Investing in the PRC and Hong Kong	-0.65(0.273)**		-0.64(0.275)**
Performance of foreign production	3.10(0.974)***		3.10(0.975)***
Relative rate of return	-2.05(0.744)***		-2.04(0.744)***
Marketing through Taiwan		0.37(0.012)***	
σ_1			
σ_2			
C_1	2.15(0.110)***		8.45(0.996)***
ρ_{12}			
ρ_{23}			
ρ_{31}			0.02(0.077)
Number of observations	527		3520

Note: Industry dummies such as textile, electrical, and electronic products are included in the regression.

* significant at the 10% level, ** significant at the 5% level, and *** significant at the 1% level, two-tailed test.

case of Taiwan,⁹ the regression result implies a serious problem of displacement by Taiwan's production to its overseas production. Moreover, although good performance in overseas operations significantly helps Taiwanese firms expand their domestic production, a better rate of return than the parent operation in Taiwan just does the opposite.

In addition to the FIMLE results for the structural-form equation, we also run them for the reduced-form equations. Table 4 shows that the results for all reduced-form equations are qualitatively the same as those from the structural-form equations except for the variables of market size and GDP per capita in the regression of reverse imports. Moreover, for the sensitivity analysis, we treat foreign production (investment) as a categorical variable (i.e., 1 through 12 indicate different levels of foreign production). The results, which are summarized in Appendix V, are also qualitatively the same as those discussed above. This shows that our conclusions are quite robust.

⁹ About 80.65% of firms adopt labor-intensive technology in their foreign production. Due to a small market in Taiwan, most firms are export-oriented.

FIMLE — STRUCTURAL FORM

Foreign Production	Reverse Imports	Domestic Production
(3A)	(3B)	(3C)
	-0.77(0.368)**	-0.85(0.858) 0.28(0.688)
-0.53(0.036)***	-1.00(0.232)***	2.22(0.431)***
0.14(0.007)***	0.11(0.061)*	-0.01(0.117)
0.92(0.054)***	0.76(0.376)**	-0.22(0.708)
-1.11(0.062)***	-0.86(0.446)*	0.50(0.827)
	-0.18(0.114)	0.31(0.182)*
0.74(0.161)***	1.00(0.479)**	-0.40(0.142)***
		0.31(0.167)*
0.15(0.062)***		0.38(0.387)
0.26(0.032)***		-0.84(0.195)***
	0.09(0.090)	-0.45(0.156)***
	0.35(0.082)***	0.13(0.175)
	-0.07(0.165)	-0.51(0.293)*
		3.36(1.089)***
		-2.50(0.829)***
0.37(0.012)***	0.43(0.071)***	
	0.64(0.078)***	
		2.28(0.267)***
		0.52(0.151)***
		-0.18(0.232)
		-0.41(0.226)*
	3520	

V. *Concluding Remarks*

Taiwanese firms have been accelerating their outward direct investment, especially to the PRC, over the past ten years. Although the government policy of “avoid haste, be patient” to slow down PRC investment was adopted in 1995, this accelerating trend is likely to continue in the future. For this reason, the effects and the seriousness of this trend on Taiwan’s economy have become an important issue for Taiwan’s government. In fact, this is not just the concern of Taiwan, but under the wave of globalization and the rise of the PRC it is also a concern of Japan and many other countries. Although there have been extensive studies on the effect of foreign affiliate production on domestic production or exports, whether foreign production is a substitute for or a complement of domestic production is still inconclusive. One difficulty in reaching conclusive results is due to the complex channels through which foreign production has an impact on domestic production. Unable to separate the effects from different channels may cause different conclusions to be drawn in different empirical studies. In this paper, by

TABLE 4. THE COEFFICIENT ESTIMATES (Standard Deviation) OF FIMLE — REDUCED FORM

	Foreign Production (1)	Reverse Imports (2)	Domestic Production (3)
Constant	-0.53(0.036)***	-0.28(0.247)	2.37(0.380)***
Relative market size	0.14(0.007)***	-0.001(0.039)	-0.10(0.056)*
GDP per capita	0.92(0.052)***	-0.02(0.198)	-0.79(0.304)***
Relative wages	-1.10(0.059)***	-0.06(0.242)	1.16(0.382)***
Transportation cost		-0.17(0.144)	0.27(0.210)
Parent firm's characteristics:			
No. of employees (1000 persons)	0.70(0.152)***		
Small firm		-0.01(0.003)	-0.36(0.125)***
Large firm		-0.04(0.089)	0.22(0.131)*
Capital-labor ratio	0.16(0.079)**	0.03(0.264)	0.24(0.295)
Export ratio	0.26(0.034)***	-0.18(0.105)*	-0.91(0.153)***
Affiliate's characteristics			
Labor-intensive		0.10(0.093)	-0.40(0.142)***
Upstream or downstream products		0.34(0.083)***	0.15(0.154)
Investing in the PRC and Hong Kong		-0.04(0.182)	-0.43(0.240)*
Performance of foreign production		-0.21(0.601)	2.82(0.950)***
Relative rate of return		-0.60(0.437)	-2.23(0.749)***
Marketing through Taiwan		0.34(0.083)***	
σ_1	0.37(0.012)***		
σ_2		0.55(1.096)	
C_2			2.01(1.059)**
ρ_{12}			0.04(0.050)
ρ_{23}			0.02(0.494)
ρ_{31}			-0.29(0.497)
Number of observation		3520	

Note: Industry dummies such as textile, electrical, and electronic products are included in the regression.

* significant at the 10% level, ** significant at the 5% level, and *** significant at the 1% level, two-tailed test.

using Taiwan as a case study and by incorporating demand and cost conditions and firms' characteristics, we examine the interrelationship between domestic production and foreign production with a special focus on the channel of reverse imports.

We show that when the reverse-import ratio is endogenized, foreign production does not significantly substitute for domestic production even though the reverse-import ratio is shown to have an insignificant effect on domestic production. This is in contrast to the case where the reverse-import ratio is not endogenized and as a result the significant substitution effect at the 1% significance level is obtained. Unlike the case where the reverse-import ratio is not endogenized and inconsistent results are derived, the effects of market size, GDP per capita, and relative wage on domestic production also turn out to be consistent with those expected. All these results imply that by excluding reverse imports from the regression, we are likely to obtain biased or even reverse results.

Although foreign production does not significantly substitute for domestic production directly, it may substitute for domestic production indirectly through firms' characteristics. The substitution effect is more likely to occur when parent firms are small, export-oriented, adopting labor-intensive technology in their foreign production, and investing in similar

products and in the PRC. Considering the fact that in 1995, 80.82% of multinational firms were small firms with fewer than 100 employees in Taiwan, 76.09% were investing in similar products abroad, and 54.65% were destined to invest in the PRC, the total substitution effect may therefore be significant to some extent in the case of Taiwan. A more recent survey shows that the structure of Taiwan's outward direct investment in 2000 has switched from small firms toward large firms and is concentrated on the PRC. Furthermore, over 55% of Taiwanese multinational firms are small firms, around 70% of investment cases are horizontal FDI, and more than 73.6% are destined for the PRC. All this may help explain why along with an increase in outward direct investment, the unemployment rate in Taiwan continues to increase.

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**APPENDIX 1: TAIWAN'S OUTWARD DIRECT INVESTMENT (FDI) AND
MANUFACTURING EMPLOYMENT SHARE**

	Total FDI (US\$ million)	Destination of FDI				The Ratio of FDI to Gross Fixed Capital Formation %	Manufacturing Employment Share %
		The PRC %	Asia %	U.S.A. %	Others %		
1959-79	59.3	0	72.68	14.84	12.48	-	-
1980	42.1	0	7.60	76.25	16.15	0.65	32.9
1981	10.8	0	62.04	14.81	23.15	0.16	32.4
1982	11.6	0	78.45	21.55	0	0.19	31.8
1983	10.6	0	62.26	27.36	10.38	0.17	32.3
1984	39.3	0	16.79	77.61	5.60	0.54	34.2
1985	41.3	0	10.17	86.44	3.39	0.62	33.7
1986	56.9	0	14.76	80.84	4.39	0.73	34.1
1987	102.8	0	20.72	68.19	11.09	0.88	35.2
1988	218.7	0	31.69	56.38	11.93	1.38	34.6
1989	931.0	0	31.84	54.64	13.52	4.76	33.9
1990	1552.2	0	38.84	27.62	33.54	8.51	32.0
1991	1830.2	9.52	50.80	16.27	23.41	9.56	30.8
1992	1134.3	21.78	32.61	17.01	28.60	4.22	29.9
1993	4829.3	65.61	13.74	10.96	9.70	15.66	28.4
1994	2579.0	37.31	21.69	5.58	35.42	7.64	27.8
1995	2449.6	44.61	19.09	10.13	26.17	6.33	27.1
1996	3394.6	36.21	19.49	7.99	36.30	9.07	26.7
1997	7228.1	59.96	11.33	7.57	21.14	17.26	28.0
1998	5330.9	38.17	10.89	11.23	39.71	12.87	28.1
1999	4521.8	27.71	18.50	9.84	43.95	10.71	27.7
2000	7684.2	33.93	11.08	11.21	43.78	15.5	28.0

Source: Statistics on Overseas Chinese and Foreign Investment, Outward Investment, Indirect Mainland Investment, R.O.C., May 2001. *Taiwan Statistical Data Book 2002.*

APPENDIX II: REDUCED-FORM EQUATIONS

1. The Subgame Perfect Nash Equilibrium (SPNE)

$$Z = \frac{b_3 B_2 + (a_3 - C_Z) D_2}{2b_3 D_2}, \quad (\text{A-1})$$

$$\alpha = \frac{b_3 B_2}{b_3 B_2 + (a_3 - C_Z) D_2}, \quad (\text{A-2})$$

$$Y_1 = \frac{A_2 r^2 + 2b_1 b_2 A_1 - 3r b_1 (a_2 - C_Z - S)}{6b_1 D_2}, \quad (\text{A-3})$$

$$Y_2 = \frac{A_2}{3b_1}, \quad (\text{A-4})$$

where $A_2 \equiv a_1 + C_{Y_1} - 2C_{Y_2}$, $B_2 = b_1(a_2 - C_Z - s) - r(a_1 - C_{Y_1})$, and $D_2 = b_1 b_2 - r^2 > 0$. Here, we assume that $b_3 B_2 + (a_3 - C_Z) D_2 > 0$ to ensure a positive Z . Moreover, we assume $B_2 > 0$ to ensure a positive α .

Totally differentiating (A-1)~(A-4) with respect to all exogenous variables, we obtain

$$Z = F_Z(a_1, a_2, a_3, C_{Y_1}, C_{Y_2}, C_Z, S, r), \quad (\text{A-5})$$

- + + + u - - -

$$\alpha = F_\alpha(a_1, a_2, a_3, C_{Y_1}, C_{Y_2}, C_Z, S, r), \quad (\text{A-6})$$

- + - + u - - -

$$Y_1 = F_{Y_1}(a_1, a_2, a_3, C_{Y_1}, C_{Y_2}, C_Z, S, r), \quad (\text{A-7})$$

+ - u - + + -

$$Y_2 = F_{Y_2}(a_1, a_2, a_3, C_{Y_1}, C_{Y_2}, C_Z, S, r). \quad (\text{A-8})$$

+ u u + - u u u

Note that $\frac{\partial Z}{\partial r} < 0$, $\frac{\partial \alpha}{\partial r} < 0$ and $\frac{\partial Y_1}{\partial r} < 0$, if measured at $r=0$.

APPENDIX III: VARIABLE DEFINITIONS (3520 observations)

Variables	Explanation	Minimum (Maximum)	Mean (SD)
Foreign production	Fraction of foreign affiliate production relative to the total production for a given firm.	0.000 (0.950)	0.045 (0.156)
Reverse imports	Fraction of foreign affiliate production transported back to Taiwan.	0.000 (1.000)	0.015 (0.100)
Relative wages	Wages in the host country relative to that of Taiwan.	0.000 (3.190)	0.919 (0.351)
Relative market size	Population in the host country relative to that of Taiwan/10.	0.000 (5.730)	0.548 (1.476)
GDP per capita	GDP per capita in the host country relative to that of Taiwan.	0.000 (3.333)	0.944 (0.385)
Transportation cost	Days needed from the main port in the host country to that of Taiwan/10.	0.000 (3.500)	0.104 (0.292)
Export ratio	Export/total sales.	0.000 (1.000)	0.191 (0.319)
Capital-labor ratio	(Total amount of capital /number of employee)*10 ⁻⁵ .	0.000 (7.619)	0.027 (0.268)
Labor intensity	Dummy; 1 if high labor intensity in foreign affiliate production; 0, otherwise.	0.000 (1.000)	0.121 (0.326)
No. of employees	The number of employees in parent firm*10 ⁻⁵ .	0.0002 (1.033)	0.015 (0.044)
Small firm	Dummy; 1 if the number of employees in parent firm < 100; 0, otherwise.	0.000 (1.000)	0.700 (0.458)
Large firm	Dummy; 1 if the number of employees in parent firm > 300; 0, otherwise.	0.000 (1.000)	0.103 (0.303)
Up- or down-stream products	Dummy; 1, if parent firm produces up- or down-stream products; 0, otherwise.	0.000 (1.000)	0.024 (0.152)
Similar products	Dummy; 1, if parent firm produces similar products as foreign affiliates; 0, otherwise.	0.000 (1.000)	0.115 (0.320)
Investing in the PRC	Dummy; 1, if invested in the PRC; 0, otherwise.	0.000 (1.000)	0.082 (0.275)
Marketing through Taiwan	Dummy; 1 if parent firm or other firms in Taiwan takes the main responsibility of marketing task for foreign affiliate production; 0 otherwise.	0.000 (1.000)	0.069 (0.253)
Performance of affiliate production	Category; 0.1 if planning to close down; 0.2 if bad; 0.3 if acceptable ; 0.4 if good.	0.000 (0.400)	0.049 (0.118)
Relative rate of return	The relative rate of return of foreign affiliate production vs. domestic production; 0.1 if terrible; 0.2 if worse; 0.3 if the same; 0.4 if better; 0.5 if excellent.	0.000 (0.500)	0.050 (0.123)

APPENDIX IV: LOGICAL CONSISTENCY PROOF

As defined before, let $I_{3i1} = 1$ if a multinational firm has contracted its domestic production, and $I_{3i1} = 0$ otherwise. Let $I_{3i3} = 1$ if a multinational firm has expanded its domestic production, and $I_{3i3} = 0$ otherwise. Consider the following model where a firm's reverse imports (α_i) and domestic production (I_{3i1} and I_{3i3}) enter the equation of foreign production (z_i^*) and domestic production (I_{3i1} and I_{3i3}) enters the equation of reverse imports (α_i^*):

$$\text{Foreign production: } z_i^* = \gamma_1 \alpha_i + \gamma_2 I_{3i1} + \gamma_3 I_{3i3} + X_{1i} \beta_1 + \varepsilon_{1i},$$

$$\text{Reverse import: } \alpha_i^* = \gamma_4 z_i + \gamma_5 I_{3i1} + \gamma_6 I_{3i3} + X_{2i} \beta_2 + \varepsilon_{2i}, \quad \text{if } z_i^* > 0,$$

$$\text{Domestic production: } Y_{li}^* = \gamma_7 z_i + \gamma_8 \alpha_i + X_{3i} \beta_3 + \varepsilon_{3i}, \quad \text{if } z_i^* > 0,$$

$$\begin{cases} z_i = z_i^* & \text{if } z_i^* > 0 \\ z_i = 0 & \text{if } z_i^* \leq 0 \end{cases}$$

$$\begin{cases} \alpha_i = \alpha_i^* & \text{if } z_i^* > 0 \quad \text{and} \quad \alpha_i^* > 0 \\ \alpha_i = 0 & \text{if } z_i^* > 0 \quad \text{and} \quad \alpha_i^* \leq 0 \end{cases}$$

$$\{ Y_{li} = c \quad \text{if } z_i^* > 0 \quad \text{and} \quad c_{k-1} \leq Y_{li}^* \leq c_k, \quad k = 1, 2, 3. \}$$

The joint probability distribution of (z_i, α_i, Y_{li}) is then given by the following expressions:

$$\text{Prob}(z_i^* \leq 0) = \int_{-\infty}^{-\frac{X_{1i}\beta_1}{\sigma_1}} g(\varepsilon_{1i}) d\varepsilon_{1i}$$

$$\text{Prob}(z_i^* > 0, \alpha_i^* \leq 0, Y_{li}^* \leq 0) = \int_{-\infty}^{\frac{-r_4 z_i - \gamma_5 - X_{2i} \beta_2}{\sigma_2}} \int_{-\infty}^{-r_7 z_i - X_{3i} \beta_3} f(z_i - \gamma_2 - X_{1i} \beta_1, \varepsilon_{2i}, \varepsilon_{3i}) d\varepsilon_{2i} d\varepsilon_{3i}$$

$$\text{Prob}(z_i^* > 0, \alpha_i^* \leq 0, 0 < Y_{li}^* \leq c) = \int_{-\infty}^{\frac{-r_4 z_i - X_{2i} \beta_2}{\sigma_2}} \int_{-r_7 z_i - X_{3i} \beta_3}^{c - r_7 z_i - X_{3i} \beta_3} f(z_i - X_{1i} \beta_1, \varepsilon_{2i}, \varepsilon_{3i}) d\varepsilon_{2i} d\varepsilon_{3i}$$

$$\text{Prob}(z_i^* > 0, \alpha_i^* \leq 0, c < Y_{li}^*) = \int_{-\infty}^{\frac{-r_4 z_i - \gamma_6 - X_{2i} \beta_2}{\sigma_2}} \int_{c - r_7 z_i - X_{3i} \beta_3}^{\infty} f(z_i - \gamma_3 - X_{1i} \beta_1, \varepsilon_{2i}, \varepsilon_{3i}) d\varepsilon_{2i} d\varepsilon_{3i}$$

$$\text{Prob}(z_i^* > 0, \alpha_i^* > 0, Y_{li}^* \leq 0) = \int_{-\infty}^{-\gamma_4 z_i - \gamma_8 \alpha_i - X_{3i} \beta_3} f(z_i - \gamma_1 \alpha_i - \gamma_2 - X_{1i} \beta_1, \alpha_i - \gamma_4 z_i - \gamma_5 - X_{2i} \beta_2, \varepsilon_{3i}) d\varepsilon_{3i}$$

$$\text{Prob}(z_i^* > 0, \alpha_i^* > 0, 0 < Y_{li}^* \leq c) = \int_{-\gamma_4 z_i - \gamma_8 \alpha_i - X_{3i} \beta_3}^{c - \gamma_4 z_i - \gamma_8 \alpha_i - X_{3i} \beta_3} f(z_i - \gamma_1 \alpha_i - X_{1i} \beta_1, \alpha_i - \gamma_4 z_i - X_{2i} \beta_2, \varepsilon_{3i}) d\varepsilon_{3i}$$

$$\text{Prob}(z_i^* > 0, \alpha_i^* > 0, c < Y_{li}^*) = \int_{c - \gamma_4 z_i - \gamma_8 \alpha_i - X_{3i} \beta_3}^{\infty} f(z_i - \gamma_4 z_i - \gamma_6 - X_{1i} \beta_1, \alpha_i - \gamma_4 z_i - \gamma_6 - X_{2i} \beta_2, \varepsilon_{3i}) d\varepsilon_{3i}$$

The conditions for logical consistency is then $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_5 = \gamma_6 = 0$.

APPENDIX V. THE COEFFICIENT ESTIMATES OF FIMLE — WHEN FOREIGN
PRODUCTION IS A CATEGORICAL VARIABLE

	Foreign Production (1)	Reverse Imports (2)	Domestic Production (3)
Foreign production		-0.05*	-0.14***
Reverse imports			0.02
Constant	-6.87***	-1.02***	2.54***
Relative market size	1.95***	0.12**	0.10**
GDP per capita	13.41***	0.83**	0.25***
Relative wages	-1.20***	-0.93**	
Transportation cost		-0.19*	
Parent firm's characteristics:			
No. of employees (1000 persons)	11.92***	1.13*	
Small firm			-0.46***
Large firm			0.39***
Capital-labor ratio	2.16*		0.42*
Export ratio	3.52***		-0.74***
Affiliate's characteristics			
Labor-intensive		0.07	-0.46***
Upstream or downstream products		0.35***	0.18
The PRC and Hong Kong		-0.07	-0.74***
Textiles		0.07	-0.15
Electrical and electronic products		0.18***	-0.10
Performance of foreign production			3.61***
Relative rate of return			-2.72***
Marketing through Taiwan		0.43***	
σ_1	1.60***		
σ_2		-0.44***	
C_2			0.89***
ρ_{12}			1.13***
ρ_{23}			-0.01
ρ_{31}			-0.40**
Number of observations		3520	

Note: Industry dummies such as textile, electrical, and electronic products are included in the regression.

* significant at the 10% level, ** significant at the 5% level, and *** significant at the 1% level, two-tailed test.