

Are FDI Firms Always More Productive? The Role of Technology Transfer Costs

Bih Jane Liu *

Department of Economics
National Taiwan University

Chu-Ping Lo

Department of Agricultural Economics
National Taiwan University

Tain-Jy Chen

Department of Economics
National Taiwan University

Keywords: FDI, Foreign outsourcing, Technology transfer, Multinational firms

JEL classification: D23, F12, F14, F23, L14, L22, L33

* Correspondence: Bih Jane Liu, Department of Economics, National Taiwan University, Taipei 100, Taiwan. Tel: (02) 2351-9641 ext. 666; Fax: (02) 2351-1826; E-mail: bjliu@ntu.edu.tw. The financial support provided by the National Science Council (NSC 94-2415-H-002-013) is gratefully acknowledged.

airiti

ABSTRACT

In contrast to mainstream literature, which maintains that more productive firms in the industry prefer FDI to outsourcing, we find in this paper that the opposite may also be true. By incorporating technology transfer and organizational costs in the model, we show that the decision made by productive firms to engage in FDI depends crucially on the maturity level of the industry. An FDI cycle emerges from this model, illustrating a negative relationship between industry maturity and the productivity of investing firms. Our statistical test on Taiwan's manufacturing firms supports our argument.

1. INTRODUCTION

In the world of globalization, a firm often faces a choice of where to procure intermediate inputs to maximize its profit. Intermediate inputs can be procured at home, produced by the firm in a foreign country through foreign direct investment (FDI), or outsourced from a foreign country where it has a comparative advantage in producing the inputs in question. Different input sourcing choices involve different organizational forms and hence face different organizational costs and contract costs, where organizational costs refer to the cost of organizing production, and contract costs are the costs of enforcing a contract among firms.¹ Compared to the case of sourcing inputs at home, FDI and outsourcing benefit from low-cost inputs abroad, but they also incur additional costs: FDI requires more organizational costs while outsourcing entails higher contract costs.

Antràs and Helpman (2004) modeled the organizational (sourcing) choice within a North-South framework and argued that the choice depends on a firm's productivity, organizational costs, and contract costs. Specifically, they showed that a high-productivity firm in the North would prefer FDI to outsourcing from the South because FDI allows it to take advantage of low input cost and obtains larger profits, which outweighs the higher fixed costs of organizing such production. A somewhat lower-productivity firm would prefer outsourcing because a low profit expectation does not justify the high fixed cost of organizing FDI. A firm with even lower productivity may be unable to engage in cross-border production at all. Similar results were obtained by Helpman et al. (2004) in an alternative model where firms face a trade-off between proximity and concentration: the most productive firms engaging in FDI, the somewhat less-productive firms exporting, and the least productive firms serving only the domestic market.²

An important factor which appears to be missing in this line of argument is the costs involved in transferring technologies from the North to the South when cross-

¹ A country with a worse contract environment (e.g., a loose intellectual protection) incurs a higher contract cost, as a firm might take advantage of the incomplete nature of the contract to appropriate the production profits.

² One may note that since transportation costs are assumed to be absent in Antràs and Helpman (2004), there is no distinction between domestic sales and exports. Helpman et al. (2004), on the other hand, assume positive transportation costs and firms therefore face the choice of whether or not to export. In this paper, we also assume that there are no transportation costs.

border production is conceived. Technology transfer costs are incurred when a multinational firm attempts to pass on some managerial know-how or production technologies to an overseas subsidiary or outsourcee.³ The magnitude of such costs usually depends, among other factors, upon the learning capacity of subsidiary, the nature of knowledge, and the cultural differences between the home and host countries (Teece, 1977). Since a firm's productivity and an industry's maturity tend to be positively associated with the extent of tacit knowledge and the number of production processes being transferred, we argue that the magnitude of transfer costs may also depend on the productivity of a firm and the maturity of an industry.

The other factor that also affects a firm's organizational choice is the costs of organizing the operations. Antràs and Helpman (2004) assert that organizational costs vary across organizational structures. They argue that organizational costs are always higher for FDI than for outsourcing, which in turn higher than those for the domestic production (across vs. within country boundary). While this assertion is largely true when only the cost of establishing an operation is concerned, we shall argue that when the costs of organizing the production such as monitoring, coordinating and managing the operations are also considered, the maturity of the industry matters. As the organizational costs are no longer fixed, the assertion by Antràs and Helpman (2004) may break down.

In this paper, we consider both the costs of technology transfer and the costs of organizing production. We model the organizational choice among home production, FDI and outsourcing by extending Antràs and Helpman's framework to incorporate technology transfer costs and assuming organizational costs to vary with the maturity of an industry.⁴ We argue that when an industry becomes more mature, the technology gap between the North and the South shrinks, which makes organizing cross-border production easier for FDI firms than for outsourcing firms; however, since more production processes are to be relocated in the South, the technology transfer costs increases by a greater extent in FDI than in outsourcing as FDI involves transferring more tacit knowledge. With such a structure, whether more or less productive firms will invest abroad depends on the product life cycle of the industry.

Specifically, we show that when an industry is at an early stage of the product

³ Teece (1977) estimated that when an FDI project is implemented, the technology transfer costs account for anywhere from 2% to 59% of the project's overall costs.

⁴ Here, we do not change Antràs and Helpman's assumption on contract costs. See Section 5 for a detailed discussion.

life cycle, only the most productive firms can afford high organizational costs; FDI therefore is the optimal organizational mode for them to choose. This result is similar to that found in Antràs and Helpman (2004). However, when the industry becomes more mature, the most productive firms in the North will choose to outsource from the South, the second-tier firms will prefer FDI, and the third-tier firms will remain in the North without engaging in international operations. This is because more mature technology allows firms with lower productivity to pay for relatively smaller technology transfer costs,⁵ while at the same time makes it easier for them to organize overseas operation. On the other hand, firms with higher productivity can obtain a larger profit by engaging in outsourcing and avoiding high technology transfer costs. This suggests that firms engaging in FDI are not always the most productive. These results find some support from newly-industrializing countries, such as Taiwan, where less productive firms have been observed actively engaging in FDI.

This paper is organized as follows. In Section 2, we provide some evidence from Taiwanese firms, which motivate the study of this paper. In Section 3, we set up a model along the lines of Antràs and Helpman (2004). Technology transfer and organizational costs are introduced into the model in Section 4. Equilibrium conditions and strategic choices are presented in Section 5. In Section 6, we illustrate how technology transfer costs reshape organizational forms. The robustness of the model with respect to technology transfer costs is discussed in Section 7. We conclude in Section 8.

2. EVIDENCE

To motivate the discussion in the following sections, we use Taiwanese exporting firms as a case to show how the choice among home production, FDI, and outsourcing is related to productivity and the maturity of an industry. One may note that this case may not fit exactly to the North-South model developed in Section 3,⁶ as the survey data

⁵ Note that technology transfer costs are positively related with a firm's productivity. See Section 4 for discussion.

⁶ The North-South framework as discussed in Section 3 may be an appropriate model for Taiwan for the following reasons. (1) More than half of Taiwan's FDI goes to Mainland China and Southeast Asian countries. In 2002, it accounted for 55.89% of Taiwan's cumulative outward direct investment; by 2009, it had grown to 67.44%. (2) Almost all of Taiwan's international sourcing was sourced from Mainland China and Southeast Asian countries. In 2002, it was 91.5%; in 2009, it was 96.2%. (3) Moreover, the technology of most industries in Mainland China or Southeast Asian countries still lags behind that of Taiwan.

does not allow us to distinguish between the productions of intermediate inputs and final goods. Nevertheless, it provides a case for how the relationship between organizational modes and productivity may vary with the product cycle, which is indeed the main idea of this paper.

The sample consists of Taiwanese firms that were covered by the Export Orders Survey conducted by the Taiwan government in 2002. The survey includes 1,328 manufacturing firms in 20 industries.⁷ It provides the information about how firms allocate their production (aiming for exports) at home and abroad through FDI and outsourcing, and on how they use three sources of production to fill the export orders. We first divide the sample firms into three groups, in line with the maturity of the industry to which they belong. As a small open economy, Taiwan's industrial development depends crucially on exports. The maturity of the industry is therefore judged by the average annual export growth rate of the industry over the past ten years (1991–2000), following the premises of the product cycle theory (Vernon, 1966). Those industries that registered an average growth rate in excess of the world average growth rate during 1991–2000 (of 7%) were grouped together and denoted as growing industries; those industries that fell between 0 and 7% were denoted as sluggish industries; finally, those that registered a negative growth rate were denoted as mature industries.⁸

Table 1 provides the summary statistics of firm-level labor productivity for the three groups of firms according to organizational mode.⁹ Firms that filled part of their export orders with their overseas subsidiaries are denoted as FDI mode (foreign direct investment or the *V* mode); those that outsourced part of their export orders abroad to overseas factories are denoted as outsourcing mode (the *O* mode); and those that processed all export orders at home are denoted as domestic production mode (the *N* mode). To ensure comparability across industries, the labor productivity of firm *i* is defined as the output per employee of firm *i* relative to the weighted average of per-capita output of the industry to which firm *i* belongs.

⁷ Here, we exclude manufacturers with employees below 10 and pure traders.

⁸ Growing industries include electronics, information and communications, chemicals, basic metals, precision instruments, electrical equipment, and plastics and rubber. Mature industries include footwear, plywood, household appliances, processed food, toys, games and sports, animal and plant products, leather, and ceramic products. Sluggish industries include textile, machinery, transportation and furniture.

⁹ Since the data of capital at the firm level is not available from the survey, the labor productivity we use here does not consider the labor intensity of technology a firm adopts.

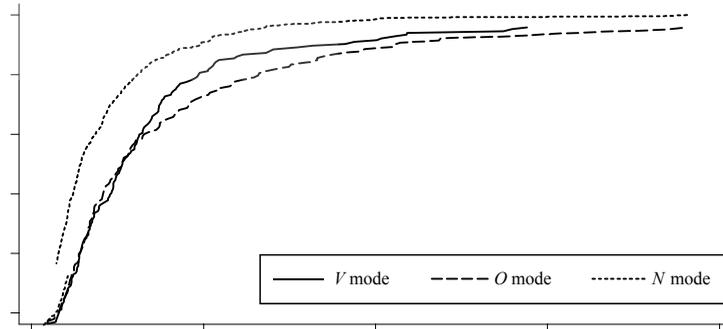
Table 1 Labor Productivity under Different Organizational Modes

	Mean	Std. Dev.	No. of Firms
Growing Industries:			
Domestic Production	0.89	0.94	485
FDI	1.15	1.05	164
International Outsourcing	1.38	1.46	137
Sluggish Industries:			
Domestic Production	0.82	0.70	305
FDI	0.81	1.03	56
International Outsourcing	0.84	0.70	47
Mature Industries:			
Domestic Production	1.00	0.83	93
FDI	0.93	0.83	18
International Outsourcing	1.20	1.34	23

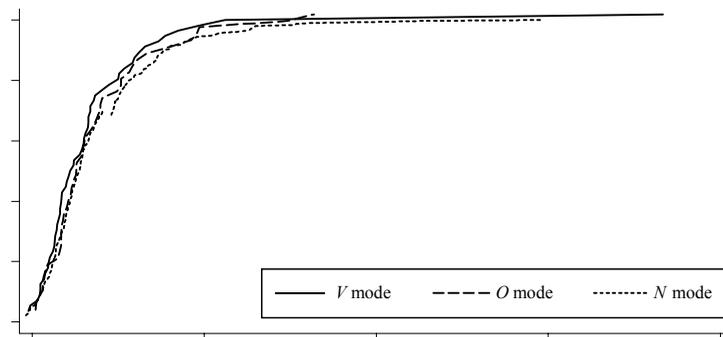
Data Source: Export Orders Survey conducted by the Taiwan government in 2002; authors' calculation.

It can be seen from Table 1 that among all three organizational modes, irrespective of the maturity of the industry, firms in the outsourcing mode have the highest mean productivity, indicating that outsourcing firms tend to be the most productive among their peers. In mature industries, the lowest mean productivity was found to be FDI firms, suggesting that FDI tends to be undertaken by the least productive firms when the industry has reached the mature stage. Similar observation is found for the sluggish industries, although the mean productivity of FDI firms does not seem to deviate very much from other organizational modes. When industries are in the growth stage, the mean productivity of FDI firms is between that of domestic production and that of outsourcing firms. These statistics are at odds with the popular argument in the literature where it is posited that the most productive firm would prefer FDI, the somewhat productive firms engage in outsourcing, and the least productive firms choose to stay home (e.g., Antràs and Helpman, 2004; Helpman et al., 2004).

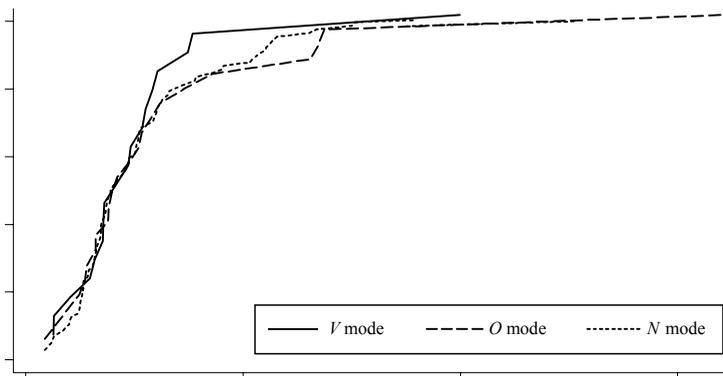
In order to gain further insights, we plotted the entire distributions of the three organizational modes. The cumulative distributions of labor productivity are illustrated in Figure 1, with the horizontal axis denoting labor productivity and the vertical axis denoting the cumulative distribution. As we can see, the productivity distributions in the growth-stage industries under the outsourcing and FDI modes lie to the right of the domestic production mode (Figure 1(a)), demonstrating that while the domestic



(a) Growing Industries



(b) Sluggish Industries



(c) Mature Industries

Data Source: Export Orders Survey conducted by the Taiwan government in 2002; authors' calculation.

Figure 1 Cumulative Distribution of Labor Productivity

Table 2 Kolmogorov-Smirnov Test for Different Organizational Modes

	$A < B$	$A > B$	Combined K-S
Growth Industries:			
<i>O</i> Mode vs. <i>N</i> Mode	0.0041 (0.9960)	-0.1719 (0.0020)***	0.1719 (0.0040)***
<i>V</i> Mode vs. <i>N</i> Mode	0.0082 (0.9830)	-0.1936 (0.0000)***	0.1936 (0.0000)***
<i>V</i> Mode vs. <i>O</i> Mode	0.1019 (0.2040)	-0.0525 (0.6620)	0.1031 (0.4200)
Sluggish Industries:			
<i>O</i> Mode vs. <i>N</i> Mode	0.0483 (0.8270)	-0.0691 (0.6780)	0.0691 (0.9900)
<i>V</i> Mode vs. <i>N</i> Mode	0.1353 (0.1770)	-0.0179 (0.9700)	0.1353 (0.3520)
<i>V</i> Mode vs. <i>O</i> Mode	0.1622 (0.2610)	-0.0274 (0.9620)	0.1622 (0.5120)
Mature Industries:			
<i>O</i> Mode vs. <i>N</i> Mode	0.0575 (0.8850)	-0.1201 (0.5875)	0.1201 (0.9800)
<i>V</i> Mode vs. <i>N</i> Mode	0.1487 (0.5130)	-0.1093 (0.6970)	0.1487 (0.8920)
<i>V</i> Mode vs. <i>O</i> Mode	0.1618 (0.5890)	-0.0942 (0.8360)	0.1618 (0.9540)

Note: 1. *V* mode, *O* mode and *N* mode refer to the cases of FDI, international outsourcing, and domestic production, respectively.

2. *A* and *B* refer to the first mode and the second mode, respectively. Figures in parentheses are *P*-values.

3. *, **, and *** indicate significance at the 10%, 5%, and 1% confidence interval, respectively.

Data Source: Export Orders Survey conducted by the Taiwan government in 2002; authors' calculation.

production mode tends to be chosen by the low-productivity firms, outsourcing and FDI are the dominant strategies for the high-productivity firms.¹⁰ Although we cannot reject the hypotheses of identical distributions of outsourcing and FDI modes by using the Kolmogorov-Smirnov test of first-order stochastic dominance (Table 2), Figure 1(a) nevertheless suggests that FDI tends to be associated with less productive firms as compared to outsourcing.

For firms in the mature stage, the organizational mode choice is somewhat different. Figure 1(b) shows that when industries move from the growth stage toward the mature stage, the productivity distribution of the FDI mode shifts toward left. When the industries are in the mature stage (Figure 1(c)), the productivity distribution of the FDI mode lies to the farthest left of those of the other two modes, implying that FDI

¹⁰ See Conover (1999) for the Kolmogorov-Smirnov test.

tends to be chosen by the least productive firms.

In the following section, we incorporate technology transfer costs into Antràs and Helpman's (2004) framework to show that whether or not the FDI mode is preferred by the most productive firms depends on the maturity level of the industry.

3. THE MODEL

Assume that in the North-South world, there are $J + 1$ industries which produce a homogeneous good and J continuum of differentiated products.¹¹ Consumers in the North and South have identical and homothetic preferences, which can be expressed as follows:

$$U = x_0 + \frac{1}{u} \sum_{j=1}^J X_j^u, \quad 0 < u < 1, \quad (1)$$

where x_0 represents the demand for the homogeneous good, X_j is an index of aggregate demand in industry j , and u is a parameter representing the degree of substitution across differentiated-product industries.

The aggregate demand in industry j is a constant elasticity substitution function of the demand for different varieties $x_j(i)$:

$$X_j = \left[\int x_j(i)^\alpha di \right]^{\frac{1}{\alpha}}, \quad 0 < \alpha < 1, \quad (2)$$

Assume that $\alpha > u$ so that varieties are more substitutable within an industry than across industries. This leads to an inverse demand function for variety i in industry j :

$$p_j(i) = X_j^{u-\alpha} x_j(i)^{\alpha-1}, \quad (3)$$

The production of any variety requires a combination of high-tech and low-tech components, $h_j(i)$ and $m_j(i)$, respectively. The output of each variety is derived from an industry-specific Cobb-Douglas production function:

¹¹ The homogeneous good is used as a numeraire, which can be freely produced and traded in both countries in equilibrium.

$$x_j(i) = \theta h_j(i)^{1-z_j} m_j(i)^{z_j}, \quad (4)$$

where z_j ($0 < z_j < 1$) indicates the maturity level of industry j . A more mature industry (a larger z_j) tends to have a larger share of low-tech components in its final-good production. The productivity parameter θ is firm-specific where a larger θ implies higher productivity.

Following Antràs and Helpman (2004), we assume that because of the technology gap between the North and South, only the North knows how to produce the final-good variety, $x_j(i)$, and the high-tech components, $h_j(i)$. However, the low-tech components $m_j(i)$ can be produced not only by the North but also by the South if the associated blueprint and/or tacit knowledge are transferred from the North to the South. We assume that labor is cheaper in the South than in the North, i.e., $w_N > w_S$,¹² and it takes one worker to produce one unit of $h_j(i)$ or $m_j(i)$.

A Northern firm (the final-good producer) has three organizational forms from which to choose, with the choice being largely dependent upon where, and how, the firm obtains its low-tech components. The choices faced are: (1) vertical integration in the North (i.e., domestic production or the N mode) where $m_j(i)$ is produced by the parent firm in the North;¹³ (2) outsourcing (the O mode), where $m_j(i)$ is produced by an independent producer in the South; and (3) FDI (the V mode), where $m_j(i)$ is produced by a subsidiary in the South.

A Northern firm has to bear the fixed costs in order to enter the industry. Upon entry, the productivity level of the firm is randomly drawn.¹⁴ After observing the productivity level, the firm decides whether or not to enter the market. Once it enters the market, it then decides where, and how, to acquire the low-tech components, and is faced with the additional costs of organizing the production of the final good by combining the low-tech inputs with the high-tech inputs. Moreover, the firm also faces the technology transfer costs if it relocates the production of low-tech components in the South either through outsourcing or FDI. We will discuss the technology transfer costs and the organizational costs in more details in the following section.

¹² In equilibrium, as in Antràs and Helpman (2004) model, the wage rate in each country, which is assumed to be fixed, represents its productivity of producing the homogenous good x_0 . We also assume labor supply is large enough in every country so that both countries produce x_0 .

¹³ For simplicity, we do not consider the case of domestic outsourcing here.

¹⁴ See Melitz (2003) and Helpman et al. (2004) for an example of the Pareto distribution.

4. TECHNOLOGY TRANSFER AND ORGANIZATIONAL COSTS

In this section, we will discuss how the technology transfer costs and organizational costs vary across different organizational mode and industry maturity.

We start out with the discussion of technology transfer costs. As pointed out by Teece (1977), technology transfer costs can be substantial when relocating production abroad. Technology transfer not only involves physical items such as blueprints, but also embraces firm-specific tacit know-how, which, irrespective of whether it is the knowledge underlying R&D, production, marketing or other activities, is the embodiment of a firm's competitive advantage (Kogut and Zander, 1993).

In this paper, we argue that technology transfer costs (i.e., the costs involved in transferring firm-specific assets) are a function of a firm's productivity (θ) and the industry's maturity (z). Specifically, the technology transfer cost for the organizational mode K ($K \in \{V, O, N\}$) can be written as $T_K(\theta, z) = \theta^{\frac{\alpha}{1-\alpha}} g_K(z)$,¹⁵ where $0 < \alpha < 1$ and $g_K(0) = 0$.

A firm with higher productivity (θ) tends to be endowed with a greater stock of tacit knowledge, which, according to Teece (1977), is often difficult to transfer. Therefore, more technology transfer costs will be incurred if firm-specific tacit knowledge is to be transferred. This suggests that the technology transfer costs a firm faces are positively related to its productivity, i.e., $\partial T_K(\theta, z)/\partial \theta > 0$. Moreover, as implied by (4), a more mature industry (i.e., a larger z) has a larger share of low-tech production processes. This also increases the costs of technology transfer if low-tech production is to be relocated to the South. In other words, the more mature an industry is, the more production processes have to be transferred and the larger the costs are involved in technology transfer; we then have $g'_K(z) > 0$.

For simplicity, we assume that the technology transfer occurs for the FDI (V) and outsourcing (O) modes, but not for the domestic production mode (N), i.e., $g_N(z) = 0$ for all z . Since the transfer of firm-specific assets is rather limited across firms in the outsourcing mode as compared to that within the firm's boundaries in the FDI mode, it is reasonable to assume:¹⁶

¹⁵ It will be shown later that relaxing this assumption would not alter our analysis in the wrong direction.

¹⁶ Technology transfer may unavoidably unveil some core knowledge out. Thus, the technology transfer

$$g_V(z) > g_O(z) > g_N(z) = 0 \text{ or } T_V(z) > T_O(z) > T_N(z) = 0, \quad \forall z. \quad (5)$$

As $g_K(z)$ is assumed to be concave, we have $g'_V(z) > g'_O(z)$.

We now move to the discussion of organizational costs. Different organizational structures will involve different organizational costs, denoted as $f_K(z)$ for the organizational mode K . Antràs and Helpman (2004) considered organizational costs as mainly the fixed costs of establishing the operation such as searching, monitoring and information. As organizational costs are often higher when organizing production across firm (or country) boundary than within firm (or country) boundary, they asserted that the fixed organizational costs are ranked as below:

$$f_V > f_O > f_N. \quad (6)$$

The assertion in (6), however, may break down, if in addition to the cost of establishing an operation, the costs of organizing the production such as monitoring, coordinating and managing the operations are also considered. In fact, the costs of organizing production are crucial in determining firms' profitability as they serve to reduce market frictions and transactional hazards associated with bounded rationality and opportunism (Williamson, 1985). When both the costs of establishing and the costs of organizing the operations are taken into account, $f_K(z)$ will vary with the product life cycle.

Case 1: Newly-Developed Stage

In the early stage of the product life cycle, the technology gap between the North and the South is large, by definition, and the costs of organizing integrated production across the border (i.e., the FDI mode) are larger. Thus, among the three modes, a FDI firm has the highest organizational costs while a domestic production firm has the lowest costs, with an outsourcing firm lying in between. Namely, we have

$$f_V(z) > f_O(z) > f_N(z). \quad (7a)$$

is refrained when the intermediate input producer is in different entities from the parent company of the final good. As a result, FDI involves greater technology efforts relative to international outsourcing.

Case 2: Growth Stage

As the industry matures within its life cycle, the industry-specific technology becomes widely diffused throughout the world, and production routines are standardized. All these make the costs of organizing cross-border integrated production to decline, which may ultimately fall below the costs of organizing outsourcing (the O mode) where extra efforts are needed in inter-firm coordination.¹⁷ We then have

$$f_O(z) > f_V(z) > f_N(z). \quad (7b)$$

Case 3: Mature Stage

When the industry is fully mature and there is virtually no technology gap between the North and the South, the organizational cost in the case of FDI may even be lower than those for integrated production in the North (the N mode), because in the later case, the firm needs to manage two completely different production methods ($h(i)$ and $m(i)$) and may suffer from managerial diseconomies of scope.¹⁸ The ranking of the organizational costs then becomes

$$f_O(z) > f_N(z) > f_V(z). \quad (7c)$$

5. EQUILIBRIUM

The model is set up in an incomplete contract environment where property rights are essential to the firm organization (Grossman and Hart, 1986; Hart and Moore, 1990). With the incomplete nature of the contract, contract costs arise due to the possible opportunistic behaviors. Following Antràs and Helpman (2004), we assume that both the Northern firm (the final-good producer) and the low-tech component producer can-

¹⁷ When the industry reaches such a stage of maturity, communication may be more cost effective within the firm's boundaries than in an arms-length relationship.

¹⁸ A domestic production firm may face coordination and managerial challenges when the industry evolves to a more mature stage, since different production processes call for different managerial styles, specialized personnel, incentive schemes, and so on (Argyres, 1999). As a result, diseconomies of scope will arise, which then generate endogenous pressure on the domestic production firm for vertical disintegration within the firm's boundaries.

not sign an enforceable contract ex ante. The two parties will therefore bargain over the surplus in agreement between the parties. Using a generalized Nash bargaining game, we assume that the Northern final-good producer obtains a fraction of the ex post surplus while the remaining surplus is attributed to the low-tech input provider.¹⁹

We assume that the North has a better contract environment than the South. Compared to the case of outsourcing, the Northern firm has more leverage under vertical integration, with such leverage power increasing in a better contract environment (Grossman and Hart, 1986; Antràs and Helpman, 2004). These assumptions imply that the Northern firm can appropriate a larger fraction of revenue under vertical integration than under outsourcing as²⁰

$$\beta_N > \beta_V > \beta_O. \quad (8)$$

The potential revenue from the sale of the final good will be $R(i) = p(i)x(i)$, where $p(i)$ is the price of the final good. Note that, for the purpose of simplicity, we drop the industry index j from all of the variables. Based on Equations (3) and (4), the revenue is given by

$$R(i) = X^{u-\alpha}\theta^\alpha h(i)^{\alpha(1-z)}m(i)^{\alpha z}. \quad (9)$$

Since the delivery of inputs is not contractible ex ante, the producers of $h(i)$ and $m(i)$ will maximize their own payoffs by choosing their own quantities of output noncooperatively. Let's drop the firm notation hereafter for simplicity. A representative final-good producer, which is also the $h(i)$ producer, maximizes $\beta_K R - w_N h - w_N f_K(z) - w_N T_K(\theta, z)$. The first-order condition associated with h leads to optimal

¹⁹ The distribution of the surplus is essential to the ownership of the residual rights. By vertically integrating the production of components, the Northern firm is effectively buying the right to fire the low-tech producer and seizes its production. Following Antràs and Helpman (2004), we assume that the contractual breach results in a loss of a fraction $1 - \delta_k$ of the final-good production because that the low-tech components cannot be effectively applied without proper cooperation of the low-tech producer.

²⁰ If the Northern firm and the low-tech input producer fail to agree in the relation-specific cooperation, the Northern firm can recoup an amount $\delta_k x(i)$, yielding the revenue $\delta_k^\alpha R(i)$, where $R(i)$ is indicated in (9). Then, the firm receives its outside option plus a fraction of the quasi rents $(1 - \delta_k^\alpha)R(i)$ by Nash bargaining. In equilibrium, the Northern firm gets $\delta_k^\alpha R(i) + \beta_O(1 - \delta_k^\alpha)R(i)$ while the remaining $(1 - \beta_O)(1 - \delta_k^\alpha)R(i)$ is attributed to the low-tech input producer. With some algebra and assuming the better contract environment (e.g., better legal protection) in the North than in the South (i.e., $\delta_N > \delta_S$), it can be easily shown that $\beta_N = \delta_N^\alpha R(i) + \beta_O(1 - \delta_N^\alpha)R(i) > \beta_V = \delta_S^\alpha R(i) + \beta_O(1 - \delta_S^\alpha)R(i) > \beta_O$.

choice of $h = \alpha(1 - z)\beta_K(R/w_N)$ in equilibrium.²¹ On the other hand, the firm that delivers m in the South maximizes $(1 - \beta_K)R - w_S m$, which results in the optimal choice of $m : m = \alpha z(1 - \beta_K)(R/w_S)$.

The joint operating profits for the producers of $h(i)$ and $m(i)$ can be written as

$$\begin{aligned} \pi_K &= R - w_N h - w_S m - w_N f_K(z) - w_N T_K(\theta, z) \\ &= R\{1 - \alpha[\beta_K(1 - z) + (1 - \beta_K)z]\} - w_N f_K(z) - w_N T_K(\theta, z). \end{aligned} \quad (10)$$

Further, we can incorporate the optimal solutions of h and m into (10), which leads to:

$$\pi_K(\theta, \beta_K, z) = \theta^{\frac{\alpha}{(1-\alpha)}} [\psi_K(\beta_K) - w_N g_K(z)] - w_N f_K, \quad (11)$$

where

$$\psi_K(\beta_K) = \frac{\{1 - \alpha[\beta_K(1 - z) + z(1 - \beta_K)]\} X^{\frac{(u-\alpha)}{(1-\alpha)}}}{\left[\frac{1}{\alpha} \left(\frac{w_N}{\beta_K(1 - z)} \right)^{1-z} \left(\frac{w_S}{z(1 - \beta_K)} \right)^z \right]^{\frac{\alpha}{(1-\alpha)}}}.$$

The solution is similar to Antràs and Helpman's (2004) model except that technology transfer cost (g_K) is added. We can simulate $\psi_K(\beta_K)$ to obtain $\psi_V(\beta_V) > \psi_O(\beta_O) > \psi_N(\beta_N)$ when w_N is sufficiently larger than w_S .²²

²¹ It will not alter our results if we assume that the producers of $h(i)$ and $m(i)$ also bargain over the division of the technology transfer costs, where the former bears λ ($0 \leq \lambda \leq 1$) share of the cost, and the latter bears the remaining.

²² As mentioned in (8), a better contract environment will allow firms to appropriate a larger fraction of revenue when engaging in FDI than in international outsourcing. Thus, without considering the technology transfer cost, the marginal profit is greater in FDI mode than in international outsourcing mode, $\psi_V > \psi_O$ when the industries are immature. We further assume that the North-South wage gap is large relative to the difference between β_N and β_O , such that a firm would obtain a greater marginal profit from outsourcing in the South than from domestic production in the North. This is equivalent to assuming that the slope of the profit line is steeper in the international outsourcing mode than in the domestic production mode, i.e., $\psi_O > \psi_N$. See Antràs and Helpman (2004) for a detailed discussion.

6. THE CHOICE OF ORGANIZATIONAL FORMS

To illustrate how a firm chooses its optimal organizational form, we need to know how its profit is affected by technology transfer costs and organizational costs. As we can see that the marginal profit of mode K (i.e., $\psi_K(\beta_K) - w_N g_K(z)$) is related to the technology transfer costs, while the intercept of the profit line ($f_K(z)$) is related to the organizational costs. In the following, we will show the rankings of $\psi_K(\beta_K) - w_N g_K(z)$ and $f_K(z)$ under different organizational modes change with the product life cycle of the industry.

It can be shown that under the assumptions of Antràs and Helpman (2004), the rankings are $\psi_V > \psi_O > \psi_N$ and $f_V > f_O > f_N$, respectively. However, when we consider technology transfer costs ($g_K(z)$) and assume organizational costs ($f_K(z)$) to vary with the industry maturity (see Section 3), these rankings may change and reshape a firm's organizational form as implied by (11).

We classify the product life cycle of an industry into three stages, i.e., the newly-developed stage, the growth stage, and the mature stage, using z_a and z_b as the cutting points. Here, z_a satisfies Condition (1) $g_V(z_a) - g_O(z_a) = (\psi_V - \psi_O)/w_N$ and Condition (2) $(\psi_O - \psi_N)/w_N > g_O(z_a)$, while z_b satisfies Condition (3) $g_V(z_b) = (\psi_V - \psi_N)/w_N$.

Case 1: Newly-Developed Stage ($0 < z \leq z_a$)

When an industry is at the newly-developed stage (i.e., $0 < z \leq z_a$), the technology transfer costs and organizational costs are small such that $\psi_V - w_N g_V(z) \geq \psi_O - w_N g_O(z) > \psi_N$ and $f_V(z) > f_O(z) > f_N(z)$ (see equation (7a)).²³ Since the rankings are the same as Antràs and Helpman (2004), their results still hold (see Figure 2).

Proposition 1 When an industry is at the newly-developed stage, the most productive firms engage in FDI in the South; somewhat less productive firms outsource low-tech components from the South; firms with even lower productivity acquire components in the North; and the least productive firms exit the market altogether.

²³ Conditions (1) and (2) for z_a (i.e., $g_V(z_a) - g_O(z_a) = (\psi_V - \psi_O)/w_N$ and $(\psi_O - \psi_N)/w_N > g_O(z_a)$) together with $g_V(z) > g_O(z)$ and $g'_K(z) > 0$ guarantee the inequalities to hold.

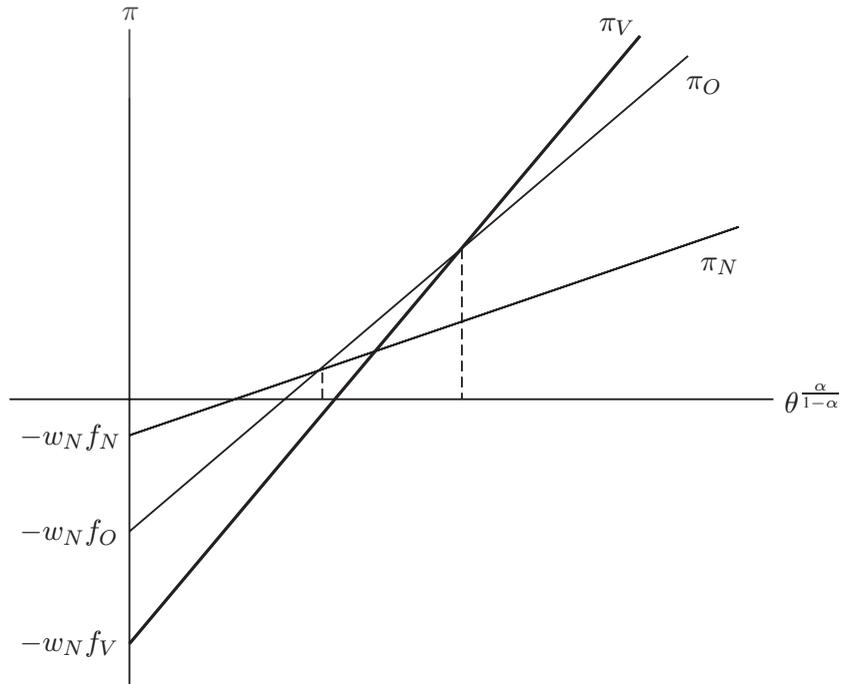


Figure 2 Optimal Choice of Organizational Form for Industries at the Newly-Developed Stage

Case 2: Growth Stage ($z_a < z \leq z_b$)

When the maturity of an industry (z) increases further such that $z_a < z \leq z_b$, the slopes of the profit curves for different organizational forms are ranked as:²⁴

$$\psi_O - w_N g_O(z) > \psi_V - w_N g_V(z) \geq \psi_N. \tag{12}$$

With equation 7(b), the intercepts of the profit lines are ranked as:

$$w_N f_O(z) > w_N f_V(z) > w_N f_N(z), \tag{13}$$

where we argue that the cost of inter-firm coordination exceeds that of intra-firm coordination when an industry is at the growth stage.

²⁴ Both $z_a < z$ and Condition (3) for z_b (i.e., $g_V(z_b) = (\psi_V - \psi_N)/w_N$) guarantee the first and the second inequality in (12) to hold, respectively. Moreover, from Condition (1) and Condition (3), we have $g_V(z_b) - g_V(z_a) = (\psi_O - \psi_N)/w_N - g_O(z_a)$. With the inequality $(\psi_O - \psi_N)/w_N > g_O(z_a)$ from Condition (2), we obtain $g_V(z_b) - g_V(z_a) > 0$, which implies $z_b > z_a$ because of $g_K(z) > 0$.

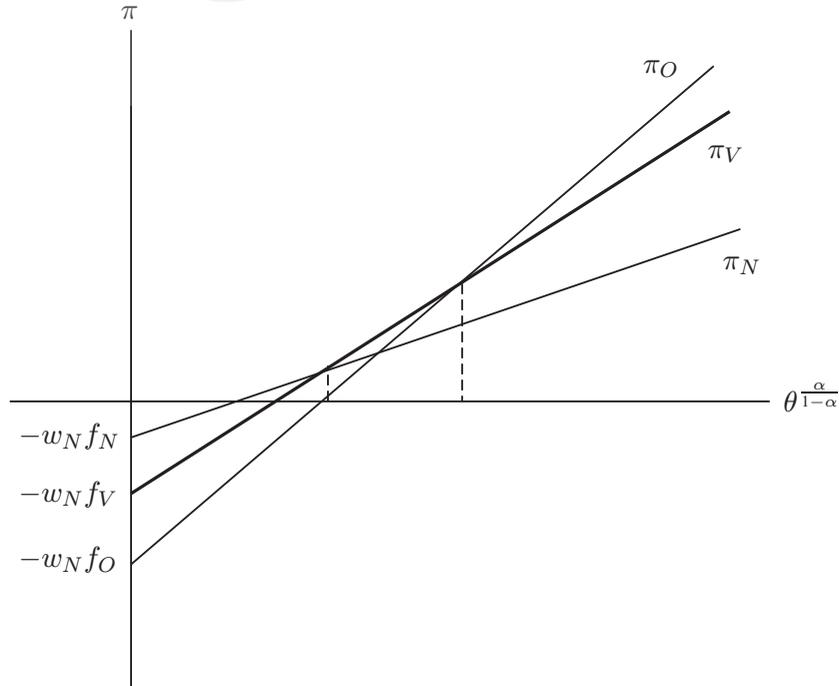


Figure 3 Optimal Choice of Organizational Form for Industries at the Growth Stage

In the case of the FDI mode, the cost of technology transfer increases with the number of production processes being transferred, which, in turn, lowers the marginal profit and makes the slope of the profit line (π_V) flatter relative to the international outsourcing mode (π_O , see Figure 3). The shrinkage of the technology gap between the North and South, on the other hand, results in the organizational costs of intra-firm integration being reduced to a level below those of inter-firm sourcing. The intercept of the FDI mode ($-w_N f_V$) therefore moves closer to the origin as compared to the international outsourcing mode ($-w_N f_O$). As a result, a firm with higher productivity will prefer international outsourcing to FDI. Thus, we have:

Proposition 2 When an industry is at the growth stage, the most productive firms prefer international outsourcing from the South; somewhat less productive firms engage in FDI in the South; firms with even lower productivity acquire components in the North; and the least productive firms exit the market altogether.

Case 3: Mature Stage ($z_b < z \leq 1$)

When $z_b < z \leq 1$, it can be shown that an increase in the costs of technology

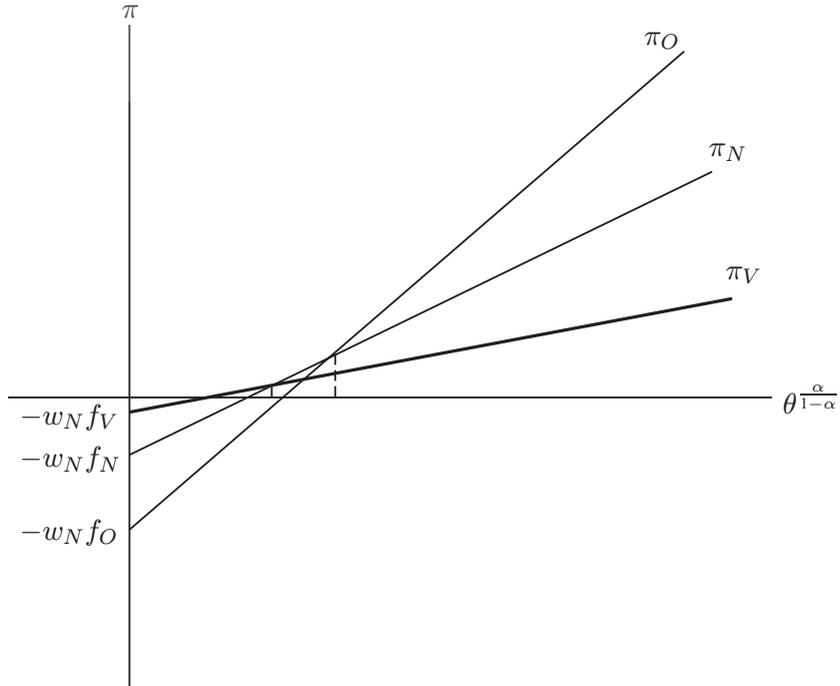


Figure 4 Optimal Choice of Organizational Form for Industries at the Mature Stage

transfer reduces the marginal profit of the FDI mode to the lowest level among the three organizational forms while the cost of technology transfer, $g_V(z)$, increases further with an increase in z :

$$\psi_O - w_N g_O(z) > \psi_N > \psi_V - w_N g_V(z). \tag{14}$$

On the other hand, diseconomies in managing disparate production methods (i.e., input production and final-good production) make the organizational cost of the domestic production higher than that of the FDI mode. Thus, in 7(c) we have the ranking of the intercepts of the profit lines as:

$$w_N f_O(z) > w_N f_N(z) > w_N f_V(z). \tag{15}$$

From Figure 4, we have

Proposition 3 When an industry is at the mature stage, the most productive firms

will choose international outsourcing; somewhat less productive firms will prefer to carry out all production activities domestically; firms with even lower productivity will engage in FDI overseas; and the least productive firms exit the market altogether.

Moreover, if the technology-transfer costs become excessively high (i.e., in a highly mature industry indexed by an even larger z), leading to either a much flatter slope π_V or a larger X-axis intersection (resulting from a smaller $f_V(z)$), the use of FDI in the South to produce low-tech components may no longer be a viable option. In this case, no FDI will occur.

7. DISCUSSION

From Figures 2 to 4, we can see clearly how the dynamics of technology transfer costs and organizational costs determine the optimal organizational form for a multinational firm.

When an industry is in the early stage of the product life cycle, it is optimal to transfer only a small proportion of the production processes abroad, whereas large organizational costs are incurred if firms undertake FDI in the South. We argue that, at this stage, the technology transfer cost is negligible for a multinational firm; in order to cover large organizational costs, FDI will be the preferred option for the most productive firms.

However, as the industry evolves, more production processes are to be moved abroad, FDI may become less attractive to firms with high productivity because of the enormous technology transfer costs involved in transferring both tangible and intangible assets abroad, which are positively associated with the productivity. At this stage, it is the firms with medium-level productivity that will consider investing abroad as they bear relatively lower technology transfer costs; the fall in organizational costs also triggers them to choose a FDI mode.

When the industry reaches the mature stage, it is the least productive firms that will choose FDI because the costs of organizing cross-border integrated production have fallen to allow them to exploit the wage differential between the North and the South with minimal technology transfer costs.

The above results imply that the most productive firms will not always choose FDI. An FDI cycle similar to the product cycle therefore emerges, highlighting the negative relationship between the heterogeneous productivity of the FDI firms and the

maturity of the industry.²⁵

Empirical evidence provided by the Taiwan data, as discussed in section 2, seems to be consistent with the FDI cycle presented above. As a newly industrialized country, Taiwan owns few frontier industries; most of its industries are either at the growth or mature stage of the product life cycle. FDI is not such an attractive option for firms with the highest productivity, because substantial technological transfer costs will be incurred should they choose to invest abroad; outsourcing, however, is more desirable for highly productive firms to exploit the lower wages in developing countries. In comparison, FDI is more appealing to firms with low productivity, who are blessed with low technology transfer and organizational costs because their technologies fit the absorption capacity of the South.

In the case of Taiwanese firms, two additional factors tend to skew the choice toward FDI. One is the fact that more than half of Taiwan's outward direct investment projects were destined toward China, with which Taiwan shares similar cultures and ethnic value. The shorter psychological distance reduces the costs of managing cross-border production, making FDI more attractive.

Moreover, Taiwanese firms mainly serve as contract manufacturers for Western multinational firms, good relationships with which are their major assets. If they attempt to fill the export orders by sourcing from developing countries, there is a risk that Western buyers will eventually bypass them and contract directly with their sourcing partners (Liu et al., 2007). This implies that, in addition to organizational costs, the risk of contracting, which is measured as the present value of the erosion of expected future revenue if orders are lost, should be added as part of organizational costs when choosing the international outsourcing mode. The more mature the industry is, the lower the technological barrier to enter the industry, and the more likely that they will be bypassed. When the risk of contracting is added to the organizational costs, the profit line of the international outsourcing mode will shift downward relative to the FDI mode, making FDI preferable to outsourcing.

²⁵ The dynamics of the FDI cycle discussed here is different from that of the product cycle in Antràs (2005), although both are in a framework of an incomplete contract. Antràs (2005) shows that when an industry is at the newly invented stage, low-tech inputs are produced in the North; when the maturity level of the industry is low, the production is relocated in the South through FDI; when the maturity level of the industry is high, the production is outsourced from the South. The dynamics of the product cycle stems from the assumption that the output elasticity of low-tech inputs increases overtime, i.e., $z'(t) > 0$. The dynamics of the FDI cycle, however, originates from firms' heterogeneity as well as industry maturity, which affect the cost of technology transfer. As a result, even when the maturity level of the industry is high, FDI can still be carried out by less productive firms, who bear lower costs of transferring intangible assets.

8. CONCLUSION

In an incomplete contract model, Antràs and Helpman (2004) demonstrate that the more productive firms will prefer FDI, and less-productive firms will prefer international outsourcing. The empirical study by Head and Ries (2003) with regard the case of Japan, Girma et al.'s (2005) study on the UK, and Wagner's (2006) study on Germany provide some support for this assertion. These studies, however, do not control for the maturity of the industry, which we argue, may significantly affect the choice of the mode of international operations. By extending Antràs and Helpman's model to incorporate technology transfer and organizational costs, we show in this paper that it is not always the most productive firms that choose FDI.

When an industry is newly developed, the Antràs-Helpman assertion that only the most productive firms will engage in FDI is substantiated; however, as the industry evolves through the product life cycle, the technology transfer costs begin to play an important role in the choice of organizational mode. The more mature the industry is, the greater the likelihood that the less productive firms will engage in FDI. In other words, alongside the product life cycle, an FDI cycle emerges, thereby highlighting the interplay of firm heterogeneity and industry maturity. For instance, when an industry is at its early stage, it is the most productive firms that choose FDI; when the industry is at the growth stage, the somewhat less-productive firms will choose FDI; and as the industry reaches the mature stage, the least productive firms will choose FDI. This implies that those firms engaging in FDI are not always the most productive firms, and that a negative relationship exists between the productivity of firms that engage in FDI and the current state of maturity of the industry in question.

The FDI cycle has an important policy implication for developing countries which hope to attract FDI with investment subsidies. For example, a lump-sum investment subsidy offered by a host country to attract multinational firms to invest in a newly emerged industry, may actually attract multinational firms with low-productivity and hence low technology transfer costs. This, however, may run counter to the target of industrial upgrading that the host country is aiming for. With the FDI cycle in mind, the policy makers will have to formulate their investment policies more carefully in order to attract the right types of multinational firms that are consistent with their development needs.

REFERENCES

- Antràs, P. (2005), "Incomplete Contracts and the Product Cycle," *American Economic Review*, 95, 1054–1073.
- Antràs, P. and E. Helpman (2004), "Global Sourcing," *Journal of Political Economy*, 112, 552–580.
- Argyres, N. S. (1999), "The Impact of Information Technology on Coordination, Evidence from the B-2 Stealth Bomber," *Organization Science*, 102, 162–180.
- Conover, W. J. (1999), *Practical Nonparametric Statistics*, New York: Wiley.
- Girma, S., R. Kneller, and M. Pisu (2005), "Exports versus FDI: An Empirical Test," *Review of World Economics*, 141, 193–218.
- Grossman, S. and O. Hart (1986), "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94, 691–719.
- Hart, O. and J. Moore (1990), "Property Rights and the Nature of the Firm," *Journal of Political Economy*, 98(6), 1119–1158.
- Head, K. and J. Ries (2003), "Heterogeneity and the FDI versus Export Decision of Japanese Manufacturers," *Journal of the Japanese and International Economies*, 17, 448–467.
- Helpman, E., M. J. Melitz, and S. R. Yeaple (2004), "Export versus FDI with Heterogeneous Firms," *American Economic Review*, 94, 300–316.
- Kogut, B. and U. Zander (1993), "Knowledge of the Firm and the Evolutionary Theory of the Multinational Corporation," *Journal of International Business Studies*, 24, 625–645.
- Liu, B. J., A. Y. Lu, and A. C. Tung (2007), "Export Outsourcing: Cost Disadvantage and Reputation Advantage," in P. A. Yotopoulos and D. Romano (eds), *The Asymmetries of Globalization*, 187–222, New York: Routledge.
- Melitz, M. J. (2003), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71, 1695–1725.
- Teece, D. J. (1977), "Technology Transfer by Multinational Firms: The Resource Costs of Transferring Technological Know-How," *Economic Journal*, 87, 242–261.
- Vernon, R. (1966), "International Investment and International Trade in the Product Cycle,"

airiti

Are FDI Firms Always More Productive? The Role of Technology Transfer Costs (Liu, Lo, and Chen)

Quarterly Journal of Economics, 80, 190–207.

Wagner, J. (2006), “Exports, Foreign Direct Investment, and Productivity: Evidence from German Firm Level Data,” *Applied Economics Letters*, 13, 347–349.

Williamson, O. E. (1985), *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*, New York: Free Press.

對外投資廠商是否一定是生產力較高的廠商？—當技術移轉成本存在時

劉碧珍*

國立台灣大學經濟學系

羅竹平

國立台灣大學農業經濟學系

陳添枝

國立台灣大學經濟學系

關鍵詞: 對外投資、委外生產、技術移轉、多國企業

JEL 分類代號: D23, F12, F14, F23, L14, L22, L33

* 聯繫作者: 劉碧珍, 國立台灣大學經濟學系, 台北市 100 中正區徐州路 21 號。電話: (02) 2351-9641 分機 666; 傳真: (02) 2351-1826; E-mail: bjliu@ntu.edu.tw。

摘 要

與跨國委外生產相比,對外投資需負擔較高的沉入成本(sunk costs),因此傳統文獻多認為生產力較高的廠商會選擇對外投資,生產力次之的廠商會選擇進行委外生產。本文發現若考慮技術移轉成本以及組織成本時,上述結論只有在產業處於發展初期時才能成立;但隨著產業越趨成熟,高生產力的廠商反而會選擇委外生產,至於低生產力的廠商則選擇對外投資。本文將此一對外投資廠商的生產力與產業發展程度呈現負相關的現象,稱作對外投資循環(FDI cycle)。