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Trade-Off Between Foreign and Domestic Investment:

Theoretical Analysis and Empirical Investigation for

the Case of Thailand

by

Pattama Teanravisitsagool

A thesis submitted to

the Faculty of Graduate Studies and Research

in partial fulfillment of

the requirements for the degree of

Doctor of Philosophy

Department of Economics

Carleton University

Ottawa, Ontario

December 1998

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the Faculty of Graduate Studies and Research
acceptance of the thesis,

**"Trade-Off Between Foreign and Domestic Investment:
Theoretical Analysis and Empirical Investigation
for the Case of Thailand"**

submitted by

Pattama Teanravisitsagool, B.Ed., M.Ed., M.A.

in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

Chair, Department of Economics

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Abstract

This thesis examines the long-run relationship between foreign direct investment (FDI) and domestic investment in Thailand. To explore this relationship, the first part of the thesis develops a sectoral partial equilibrium model that assumes Cournot oligopolistic competition and allows for two important effects emphasized in the industrial organization literature on FDI: technological superiority of foreign firms and spillover of technological knowledge from foreign to domestic firms.

The basic model implies that FDI would completely crowd out domestic investment (i.e., one-to-one replacement) if foreign and domestic firms are identical and there is no spillover effect on domestic firms. FDI would also crowd out domestic investment if foreign firms employ superior technology in the production process and are able to completely appropriate their technology--so that there is no spillover associated with FDI. The extent of the crowding out effect in this case would depend on the technological gap between foreign and domestic firms and the difference in real wage-rental ratio. The effect of FDI on domestic investment is, however, ambiguous if the superior technology of foreign firms benefits domestic firms via technological spillover.

In the second part of the thesis, the long-run relationship implied by the theoretical model is implemented empirically for Thailand, using panel data for eight sectors of the economy for the period from 1971 to 1995. The main finding of the empirical analysis is that FDI has a significantly positive long-run effect on domestic

investment in Thailand. This result holds for all the cases examined, using two different estimation methods: the Dynamic Ordinary Least Square (DOLS), and the Seemingly Unrelated Regression (SUR) estimation. An important implication of this empirical result is that the spillover effects associated with FDI in Thailand outweighed its crowding out effects.

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CHAPTER 1

INTRODUCTION

1.1. Trade-off Between Foreign Direct Investment and Domestic Investment

Foreign direct investment¹ (FDI hereafter) has a number of economic effects on the host country.² Although most of these effects are usually assumed to be beneficial, FDI's effect on domestic investment³--and thereby on the capital formation--has long been the subject of controversy. For example, the opponents of FDI maintain that FDI would crowd out substantial amount of domestic investment. They contend that superior technology employed by foreign firms allows them to produce more efficiently, and use their competitive advantages to drive local

¹ What is generally designated as FDI actually refers to *investment in international production* in a host country that foreign investors retain substantive decision-making control over product and market in the host country. FDI, thus, occurs when citizens of one nation (the 'home' nation) acquire managerial control of activities in some other nation (the 'host' nation). It comes in a package that may include not only equity finance, but often loan finance, and services of such firm-specific assets or production facilities as management expertise, modern technologies, technical skills, and brand name (Graham, 1994).

² These include, for example, the effects on trade-balance, consumption, saving, investment, foreign reserves, factor prices, total factor productivity, and industrial concentration .

³ Domestic investment in this study refers to the investment of local firms.

competitors out of business or foreclose investment opportunities for local investors.⁴²

Indeed, objections to FDI expressed in host nations are often based on fears that FDI will reduce rents appropriated by locally-owned producers (Graham and Krugman, 1991, p.21).⁵

The advocates of FDI, on the other hand, assert that FDI would complement domestic investment. FDI is not just a transfer of funds, but a package that includes new technologies, management skills, and marketing channels. It can, thus, contribute to technological spillover and increase the productivity of local firms (Beladi, and Choi 1995). As a result, investment by domestic firms can become more profitable. FDI inflows would, thus, increase capital formation of the host country beyond their size.

The issue of whether FDI complements or crowds out domestic investment is receiving considerable attention as FDI continues to be a driving force of the globalization process that characterizes the modern world economy. The upward trend of FDI inflows, in absolute terms as well as in relation to various macroeconomics indicators, suggests that international production is becoming a more significant element in the world economy, and underscores the increasingly important role played by multinational corporations (MNCs hereafter) in both developed and

⁴ See Todaro (1997, p.535-539) for a discussion on this argument.

⁵ Grossman (1984), for instance, shows that the inflow of foreign enterprises does have the effect of crowding out local ventures since the supply of domestic entrepreneurs must shrink so as to release the individuals needed to serve as workers in the foreign firms.

developing countries.⁶ This role has been facilitated by the liberalization of FDI that has taken place in most developing countries in the recent years, as part of an overall movement towards more open and market-friendly policies (UNCTAD, 1997). With a commanding presence of FDI inflows, understanding its contribution to capital formation of the host country has grown increasingly important. At present, however, there is little or no systematic analysis of their effects on capital formation.

The effects of FDI on domestic investment have been addressed in two different approaches: (1) studies concerned with broad macroeconomic effects of FDI,⁷ and (2) studies examining microeconomic effects in an industrial organization context.⁸

1.2. FDI Effect on Domestic Investment in a Macroeconomic Framework

In standard macroeconomic analysis, business investment is often represented by the traditional neoclassical investment function which determines the total investment in an economy and not the composition between domestic and foreign

⁶ For instance, FDI inflows grew by 30 and 25 per cent per annum during 1986-1990 and 1991-1996 respectively (UNCTAD, 1997).

⁷ They include, for instance, the effects on exchange rate, trade balance, consumption, saving and income.

⁸ These include, for example, the effects on total factor productivity, industrial concentration, R&D investment, and product differentiation.

direct investment.⁹ The neoclassical theory assumes all firms to be identical and thus assigns no differentiated role for FDI. This theory of investment implies that there are a certain number of investment opportunities available in the economy, which can be exploited either by domestic or foreign firms. If foreign firms take up some of these opportunities through FDI then domestic firms are left with fewer investment opportunities. In such a setting, the question of who invests is irrelevant. Thus FDI has no role in altering the capital formation of the host country. A study by Ruffin and Rassekh (1988) supports this view. It shows that for the period of 1966-85, U.S. portfolio and FDI outflows are perfect substitutes so that FDI by the U.S. leaves total amount of U.S. capital outflows unaffected. The perfect substitution between portfolio and foreign direct investment would imply that it does not matter whether the investment opportunity available in a host country is undertaken either by a foreign firm (financed through FDI) or a domestic firm (financed by portfolio investment).¹⁰ Thus, investment activities of foreign and domestic firms are indistinguishable.

A number of empirical studies, however, provide a different view on the effects of FDI on domestic investment expenditures. For example, to determine the

⁹ In macroeconomic theory and empirical estimations of investment function, interest rate and income are identified as factors that influence investment decision of firms. Interest rate represents borrowing costs of the firm, which is used to compare with the expected return of investment. Income serves as a stimulant to investment expenditures to meet the demand arising from increasing income. See Nickell (1978) for more details on neoclassical investment theory.

¹⁰ The former are reported as FDI inflows and the later as portfolio investment inflows.

relationship between U.S. FDI and capital formation in Canada, Lubitz (1971) and Van Loo (1977) estimate investment expenditure with FDI as an additional explanatory variable.¹¹ These studies differ from the neoclassical investment framework in that they include some special effects based on forward and backward linkages and replacement effect in product market.¹² The results of both studies show that FDI is complementary to domestic investment. Lubitz, for example, finds that a dollar's worth of direct investment can be associated with about two dollars of capital formation. The empirical results in Bangalore (1993), on the other hand, show that FDI has been a substitute for domestic investment in the U.S. economy for the period of 1975-90.¹³

Integrating FDI into a multi-equation macroeconomic model, Jansen (1995) studies the effects of FDI on the level of private investment in Thailand during

¹¹ In Lubitz (1971), investment expenditure is a function of income, cash flow and FDI while Van Loo (1977) includes FDI as an additional explanatory variable besides gross national expenditure. In Van Loo (1977), a simultaneous equation estimation is also carried out to include the indirect effects of the inflows of FDI via expenditure in addition to the direct effect.

¹² The effects of FDI addressed in Lubitz's study include (1) the negative effect via exchange rate appreciation leading to deflationary impact, (2) the bottlenecks which may occur and cause scarcities of some resources needed for other investments and (3) the complementary effects--through forward/backward linkages between firms--that cause the demand for domestic firms' output to rise and thereby stimulate investment. In Van Loo (1977), the effects of FDI cited are (1) replacement effect in product market, (2) forward and backward linkages, and (3) the effects on consumption, and import and export.

¹³ Like in Lubitz's and Vanloo's, Bangalore includes FDI as an additional explanatory variable in the investment equation.

the period of 1970-1991. These effects are examined using two equations. First, FDI is included as an exogenous variable in the investment equation to capture the direct effect of FDI on the level of investment. Second, the share of FDI to total investment is included as an independent variable in the production capacity equation to capture the gain in the efficiency of investment and in production capacity. The efficiency in investment and production capacity are assumed to increase with an increasing share of FDI in total investment because foreign investors also bring superior technology to Thailand. The model is not estimated, but a counterfactual simulation is performed to examine what would have happened if FDI had not increased. The results of the simulation show no evidence of any crowding out of domestic investment by FDI. The empirical results of these studies are, therefore, not conclusive.

1.3. FDI Effect on Domestic Investment in an Industrial Organization

Framework

Neoclassical investment models use a macroeconomic approach and thus ignore the characteristics of MNC which give rise to FDI and distinguish foreign subsidiaries from local firms. In the recent years, however, there has been a remarkable growth in the literature that explains FDI from an industrial organization perspective. These explanations focus on a number of characteristics of MNC that give rise to FDI. When firms establish affiliates abroad and become multinational, they are distinguished from the domestic firms because they bring with them some amount of

proprietary technology--such as internationally recognized brand names, captive access to technology and reservoirs of technical, managerial, and marketing skills.¹⁴ These assets constitute their firm-specific advantages and allow them to compete successfully with local firms who have the superior knowledge of local markets, consumer preferences, and business practices. This is the concept of ownership advantage emphasized in the industrial organization approach to FDI which postulates that MNCs arise as a consequence of the existence of the above mentioned firm-specific assets. These firm-specific assets are much like public goods within a multinational firm. They can be costlessly supplied to additional plants including those located in other countries, and thereby give the firm an efficiency of multi-plant production (or multi-plant economy of scales) and an off-setting cost advantages over domestic firms (provided domestic firms are not MNCs as well).¹⁵

On the one hand, the ownership advantages give rise to a technology gap and cost differential between foreign firms and domestic firms. The greater the ownership advantages of MNCs, the greater is the potential impact on local competitors. A larger technology gap gives the MNCs' subsidiaries a competitive advantage that translate into higher profits. The profit of the local firm, on the other

¹⁴ These assets are also referred to as specialized inputs or headquarters-services (Helpman and Krugman, 1991). The fact that foreign-owned firms do possess income-generating assets relative to local firms might suggest that they should be both more productive and profitable (Dunning, 1992, p.423).

¹⁵ These firm-specific advantages normally cannot be exploited by export or licensing. For more details on multinational theories see Helpman and Krugman (1991), Dunning (1992) and Caves (1996).

hand, is negatively related to the size of technology gap (Kokko, 1996). The ownership advantages of MNCs could thus adversely affects investment by local firms.

On the other hand, it is often suggested that superior technological know-how of foreign subsidiaries can benefit the host countries via spillover of technological knowledge because such knowledge has some public good aspects. MNCs conduct most of the world's R&D, and knowledge transferred from parent companies to the subsidiaries in a host country does, to some extent, leak out to their local competitors. Technology diffusion could also occur through labor turnover as domestic employees move from foreign to domestic firms (Kokko, 1996).¹⁶ Indeed, the host countries often press multinationals for local research expenditures to reap "spillover benefits that may result--including training nationals and informing local firms, especially in developing countries" (Caves, et al., 1996 p. 212).¹⁷

1.4. Scope of the Study

Although a number of studies have examined the effect of FDI on the market structure of local industry or on R&D investment and total factor productivity

¹⁶ These spillovers may take place in the foreign affiliate's own industry--i.e., intra-industry spillover--or among the affiliate's suppliers and customers in other industries--i.e., inter-industry spillovers. However, the latter is beyond the scope of this study.

¹⁷ For an extensive literature review on MNCs and spillovers see Sjöholm (1998), Bracoinr (1997) and Blomström and Kokko (1998, 1996).

of local rival firms, these studies have not been extended to explore the long-run relationship between FDI and domestic investment within the industrial organization framework.¹⁸

The main objective of this thesis is to fill this gap and examine the long-run effect of FDI on domestic investment in Thailand, using a model that incorporates key industrial organization features.

For this purpose, the present study develops a sectoral partial-equilibrium model that incorporates two effects emphasized in the industrial organization literature on FDI: *technological superiority of foreign firms and spillover of technological knowledge from foreign to domestic firms*. This framework establishes the channels through which these effects influence profits of local competitors and thus their investment expenditures.

The rest of the study is organized as follows: In chapter 2, we develop a basic model to derive foreign and domestic investment in the long-run equilibrium. The long-run relationship between foreign and domestic investment is, then, determined in chapter 3. The relationship is discussed in the model with as well as without the spillover effect. In the presence of spillover, the relationship is shown to be ambiguous depending on the relative strength of the two opposite forces--replacement effect in product market and complementary effect generated by

¹⁸ For an extensive literature review of these studies see chapters 14-16 in Dunning (1992).

technological spillover. In the absence of spillover, however, foreign investment is shown to crowd out domestic investment.

Chapters 4 and 5 are devoted to the empirical implementation of the theoretical model. Chapter 4 lays out the empirical framework, and discusses econometric issues and methodologies. Chapter 5 presents key results of the empirical analyses. Estimates of the long-run effects of FDI on domestic investment based on both Dynamic Least Square (DOLS) and Seemingly Unrelated Regression (SUR) estimators are significantly positive in both cases examined. The estimation results thus indicate that FDI increased capital formation in Thailand during the period of 1971-1995.

The concluding chapter 6 summarizes the main findings of the study and discusses some caveats.

CHAPTER 2

BASIC MODEL

This chapter develops a basic theoretical model to derive the relationship between foreign and domestic investment. The model focuses on the long-run equilibrium to examine the long-run link between domestic and foreign investment.

2.1. The Basic Model

The long-run relationship between foreign and domestic investment is analyzed using a traditional Cournot oligopolistic model of an industry which consists of n_d identical domestic firms and n_f identical foreign subsidiaries.¹⁹ Products are assumed to be homogeneous for simplicity.²⁰ We choose to model the relationship between FDI and domestic investment in an oligopolistic industry because MNC activities are generally thought to be most pronounced in sectors characterized by

¹⁹ Foreign subsidiaries are wholly-foreign owned firms.

²⁰ The assumption that the products are homogenous not only simplifies the analysis, but also represents an interesting case where domestic and foreign firms produce identical goods. However, as shown in section 3.3.3 and in the Appendix I.D, the assumption of product differentiation does not lead to much different results. In other words, nothing crucial hinges on this assumed homogeneity of product.

oligopolistic market structure.²¹ Also the Cournot oligopolistic model is used tractably.²²

The model incorporates two key features which have been emphasized in the FDI literature: *technological superiority of foreign firms and spillover of technological knowledge from foreign to domestic firms*. As discussed in chapter 1, the possession of firm-specific assets (specialized inputs)--such as patented or unpatented proprietary technology, trade mark, managerial or marketing know-how, and control of market entry--gives the foreign firm technological superiority (or ownership advantages). However, it has been suggested, particularly in economic growth literature, that such technical and managerial know-how, to some extent, spills over to the local rival firms. MNCs may, for instance, introduce new technologies that are imitated by local producers.²³ FDI could, thus, be an important source of technology which essentially alters the total factor productivity and profitability of local firms. Hence, the technology spillovers should be explicitly included into the local firm's production function.

²¹ For more details on this issue see Caves (1996, p. 86) and Dunning (1992, p.429).

²² Given the downward sloping demand curve (of oligopolistic industry), foreign firms have no incentive to increase their output even though they hold cost advantage. However, the model could be extended easily for the analysis in different market structure.

²³ This benefit is enhanced when the foreign investor's knowledge is absorbed by domestic workers, increasing the domestic stock of human capital and making the local labor force permanently more productive.

The model also accounts for *the restrictions on foreign ownership*. The restrictions imposed on foreign ownership can be quite complex and can differ across industries. We simplify our analysis by assuming that restrictions on foreign ownership take the form of a *quota on the number of foreign subsidiaries*.

Both foreign and domestic firms are assumed to produce using constant-returns-to-scale production functions. Following Helpman and Krugman (1991), we assume that, besides labor and physical capital, the specialized inputs are essential in production so that each firm incurs fixed cost to produce some specialized inputs. Outputs of the two types of firms in industry i in period t are given by²⁴

$$q_j = A_j f(l_j, k_j) \quad j = d, f, \quad (2.1)$$

where q_d , l_d and k_d are, respectively, the quantity of output produced, labour employed, and capital stock used by a domestic firm, while q_f , l_f and k_f are the corresponding variables for a foreign firm. For simplicity, we assume that k_f is totally financed by foreign equity and borrowing from the parent companies. In other words, additions to foreign capital stock equal FDI recorded in the balance of payment of the host country.²⁵ The function $f(\cdot)$ is the internal technology of each firm which is

²⁴ The subscripts i and t are suppressed for notational ease.

²⁵ This assumption is made in a number of studies such as Pain (1993), Pentecost (1987), and Cushman (1985, 1988), among others.

linearly homogenous in factors k and l . Variables A_f and A_d are (Hicks-neutral) technology indexes for foreign and domestic firms.²⁶ Under the assumption that a foreign firm has technological superiority over a domestic firm, A_f is greater than A_d .²⁷

We assume that spillovers of foreign firms' know-how to local firms are related to the extent of foreign presence. Thus the relative technology of local firms is considered a function of the number of foreign firms. We, therefore, express

$$A_d = g(n_f) A_f, \quad 0 < g(\cdot) < 1, \text{ and } g(\cdot) \text{ is concave.} \quad (2.2)$$

The function $g(\cdot)$ measures the spillover effect on the local firm. It is assumed that the spillover benefit for local firms increases with the number of foreign firms but at a decreasing rate.²⁸ We assume $g(\cdot) < 1$ to ensure that the technology of a

²⁶ This model may also be modified to the case of the labour-augmenting type of technology.

²⁷ Since product homogeneity is assumed, the difference is not product technology, which entails the developments of goods that have few substitutes. But domestic and foreign firms are different in process technology which encompasses the production and marketing of a given product.

²⁸ The extent of foreign presence could also be measured by the combined output of foreign firms. In such case, the magnitude of spillover effect depends not only on the number of foreign firms but also on output of the foreign firm. However, as shown in section 3.3.1 and in Appendix I.D, defining the spillover effects as a concave function of foreign firms' combined output does not lead to much different results from those of the present case.

foreign firm is always superior to that of a domestic firm regardless of the magnitude of spillover effect on the latter. We also assume $g(\cdot) > 0$ to allow the output of a domestic firm to be positive even when there is no spillover effect.

Letting w_b and w_{kj} denote the wage rate and user cost of capital in country j , the total costs of domestic and foreign firms can be written as

$$C_j(w_b, w_{kj}; q_j) = c_j(w_b, w_{kj}, A_j) q_j + F_j(w_b, w_{kj}), \quad j = d, f. \quad (2.3)$$

The term $c_j(w_b, w_{kj}, A_j) q_j$ is the total variable cost required to produce q_j units of output, where $c_j(w_b, w_{kj}, A_j)$ is the variable unit cost.²⁹ All producers are assumed to face the same labor cost which are determined exogenously. Because foreign firms are assumed to finance their investment totally by equity and borrowing from their parent companies, the foreign firms could hold liquidity-related advantage over domestic firms, i.e., $w_{kd} \geq w_{kf}$. We assume that w_{kd} and w_{kf} are related and $w_{kf} = w_{kd} + d$, where $d \leq 0$.

Plant-specific fixed costs are denoted by F_j . These costs include plant-building cost, and the cost of producing the specialized inputs. We assume that $F_f < F_d$.³⁰

²⁹ This cost function can be derived by postulating usual cost minimization problem. With a constant-returns-to-scale technology, unit variable cost equals the marginal cost, and is a function of factor prices, and technology parameter i.e., independent of output level. We denote the marginal cost and average variable cost by c_j , $j = d, f$, hereafter.

³⁰ Suppose that the fixed cost necessary to install a manufacturing plant of every firm in the industry are equal. However, a domestic firm has to incur the fixed

In this model, firms are assumed to face the following linear inverse demand¹⁶³¹

$$p(Q) = a - b \sum_{j=1}^n q_j = a - b(Q_d + Q_f), \quad p'(Q) < 0, \text{ and } n = n_d + n_f \quad (2.4)$$

where p is the price; a is the saturation level of consumption for the good if it were free; b is the absolute value of the slope of industry demand curve;³² q_j is output of firm j ; Q_d and Q_f are total outputs of all domestic and all foreign firms respectively, and $Q (\equiv Q_d + Q_f)$ is total industry output.

To sum up, in this model, foreign firms differ from domestic firms in four ways. First, they have superior technology, i.e., $A_f > A_d$. Second, they have a lower set up cost, i.e., $F_f < F_d$. Third, they may have lower cost of capital, i.e., $w_{kf} \leq w_{kd}$. Fourth, they are subject to restriction in the form of a quota on the number of them, i.e., they do not have free entry.

cost to produce firm-specific assets, while a foreign subsidiary incurs a negligible cost to produce the specialized input required in its production. This is because once produced by headquarters or parent companies, the firm-specific assets become public good within the multinational firm.

³¹ For simplicity, the linear inverse demand function is for a nontraded- sector but it could be modified to analyze the relationship between FDI and domestic investment in a traded-sector. This modification is discussed in section 3.3.2. and Appendix 1.D.

³² For a linear inverse demand curve, the (absolute) price elasticity of demand is $\varepsilon_Q = \frac{p}{Qb}$. So, the term b is inversely related to (absolute) price elasticity of demand.

Despite their disadvantages, domestic firms coexist with foreign firms in the long-run equilibrium as they are protected by (quota) restriction that does not allow foreign firms to enter freely. As will be seen in the next section, in the long-run equilibrium, some domestic firms will survive the industrial competition if total output of foreign firms falls short of aggregate market demand. This situation occurs if there is a binding restriction on the number of foreign firms.

2.2. Optimal Capital Stock and Equilibrium Investment

Having laid out the basic model in the preceding section, we now determine optimal net capital stocks of domestic firms and of foreign firms in industry i .³³ Assuming a representative domestic firm, the aggregate optimal net capital stocks of domestic firms in the industry is derived as the product of the number of domestic firms in long-run equilibrium and optimal capital stock of each firm. The total optimal capital stock of all foreign firms in the industry is derived in the same manner. The number of foreign firms--a policy variable in this model--is determined exogenously while the number of domestic firms is determined endogenously.

Using profit-maximization conditions for firms in a Cournot oligopolistic market (i.e., each firm maximizes profit along residual demand curve, assuming that other firms hold their outputs constant), we derive, first, the short-run equilibrium

³³ This section presents only solutions and a brief derivation while a detailed derivation is provided in Appendix I.A.

output for a domestic and a foreign firm. In the short-run equilibrium, the number of domestic firms is also exogenously fixed. After determining output in the short-run, the equilibrium price is obtained by substituting the short-run output into the inverse demand function. The short-run solution is then used to derive the long-run equilibrium solution. In the long-run, domestic firms enter freely, and the number of domestic firms adjusts until each domestic firm earns zero profit.³⁴

By determining the number of domestic firms using zero profit condition (i.e., price equals average cost of domestic firm) and the first order condition of profit maximization (i.e., marginal cost equals marginal revenue), we derive the long-run equilibrium output for a domestic and a foreign firm, respectively, as follows:

$$q_d = \left(\frac{F_d}{b} \right)^{1/2} \quad (2.5)$$

$$q_f = \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right). \quad (2.6)$$

Since there is free entry in the long-run and the variable unit cost is constant, the long-run equilibrium output of a domestic firm, in (2.5), depends only on

³⁴ To derive the solutions in the long-run equilibrium, we set short-run profit of the domestic firm equal to zero. In other words, the long-run equilibrium is reached when price equals average cost of domestic firms.

price elasticity of demand and its fixed cost. Because the foreign subsidiary uses superior technology (i.e., it has cost advantage), it produces more output than its domestic rival.³⁵ In (2.6), $\left(\frac{c_d - c_f}{b}\right)$ represents the effect of technology advantage, which is bigger the wider is the technology gap. Note that $q_d = q_f$, when the foreign firm holds no technology advantage over the domestic firm, and $w_{kf} = w_{kd}$.

The number of domestic firms in long-run equilibrium is given by³⁶

$$n_d = \frac{\left\{ \left(\frac{a - c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right\} - \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}}{\left(\frac{F_d}{b} \right)^{1/2}}. \quad (2.7)$$

The relation (2.7) may be described briefly as follows: The first term in the numerator of the expression on the right hand side is the aggregate quantity demanded (industry demand) which, in equilibrium, is equal to total quantity supplied.³⁷ The second term represents the total output of $\bar{n}_f$ foreign firms. The denominator is the equilibrium

³⁵ In other words, since the foreign firm produces more efficiently, it enjoys a larger market share.

³⁶ We assume, for simplicity, that n_d could be treated as a continuous variable.

³⁷ $\left(\frac{a - c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} = n_d \left(\frac{F_d}{b} \right)^{1/2} + \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}$, where the market size in a conventional context defined as the quantity would be demanded if the price equals the marginal cost, c_d , is $\left(\frac{a - c_d}{b} \right)$.

output of a domestic firm. As can be seen from (2.7), at least one domestic firm would survive the industrial competition if the foreign firms' output falls short of market demand.³⁸

The corresponding long-run equilibrium price is given by³⁹

$$P = c_d + b \left(\frac{F_d}{b} \right)^{1/2}. \quad (2.8)$$

The long-run equilibrium price, given in (2.8), depends upon unit cost (c_d), which in its turn depends on the magnitude of spillover. Because spillover effect depends on the number of foreign firms, a change in the latter will affect the equilibrium product price.

Next we determine the optimal net capital stock of foreign and domestic firms. Assuming no uncertainty and making use of Shepard's lemma, the long-run net capital stock of a domestic and a foreign firm can be derived, respectively, as

³⁸ This situation occurs if there is a binding restriction on the number of foreign firms. If the foreign firms have free entry, the number of domestic firms in the long-run equilibrium would be given by

$$n_d = \left(\frac{a - c_d}{c_d - c_f} \right) \left[\left(\frac{F_f}{F_d} \right)^{1/2} - 1 \right] - \left[1 + \left(\frac{F_f}{F_d} \right)^{1/2} n_f \right], \text{ which is negative if } c_f < c_d, \\ \text{or } F_f < F_d.$$

³⁹ Clearly, firms in oligopolistic market are able to charge a price higher than the marginal cost.

$$k_d(w_l, w_{kd}) = \frac{a_{kd}(w_{kd}, w_l)}{g(\bar{n}_f) A_f} \left(\frac{F_d}{b} \right)^{1/2}, \text{ and} \quad (2.9)$$

$$k_f(w_l, w_{kf}) = \frac{a_{kf}(w_{kf}, w_l)}{A_f} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}, \quad (2.10)$$

where $\frac{a_{kd}(w_{kd}, w_l)}{g(\bar{n}_f) A_f}$ and $\frac{a_{kf}(w_{kf}, w_l)}{A_f}$ are capital stock per unit of output demanded by a domestic and a foreign firm, respectively.⁴⁰ As shown in (2.9), the per-unit optimal capital stock of a domestic firm decreases with an increasing spillover; because the marginal productivity of capital increases with spillover.

Using (2.7) and (2.9), the aggregate stationary-state net capital stock of domestic firms is, then, given by

$$K_d(w_l, w_{kd}; \bar{n}_f) = \left(\left\{ \left(\frac{a - c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right\} - \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\} \right) \frac{a_{kd}(w_l, w_{kd})}{g(\bar{n}_f) A_f} \quad (2.11)$$

⁴⁰ The capital stock per unit of output demanded by a firm that exhibits constant-returns-to-scale is a function of factor prices and firm-specific assets only, i.e., independent of output level.

The equilibrium domestic investment (I_d) equals $\delta_d K_d$ ($\equiv \delta_d n_d k_d$), where δ_d is the rate of depreciation of domestic capital ($0 < \delta_d < 1$). Hence, the equilibrium investment is given by

$$I_d(w_l, w_{kd}; \bar{n}_f) = \delta_d \left\{ \left(\frac{a - c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right\} - \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\} \frac{a_{kd}(w_l, w_{kd})}{g(\bar{n}_f) A_f} \quad (2.12)$$

Using (2.10), the optimal capital stock of foreign firms in the stationary-state for the restricted number of foreign subsidiaries ($\bar{n}_f$) is given by

$$K_f(w_l, w_{kf}; \bar{n}_f) = \bar{n}_f \frac{a_{kf}(w_l, w_{kf})}{A_f} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\} \quad (2.13)$$

As equilibrium investment of $\bar{n}_f$ foreign subsidiaries (I_f) equals $\delta_f K_f$ ($\equiv \delta_f \bar{n}_f k_f$), where δ_f is the depreciation rate of foreign capital ($0 < \delta_f < 1$), it is given by⁴¹

$$I_f(w_l, w_{kf}; \bar{n}_f) = \delta_f \bar{n}_f \frac{a_{kf}(w_l, w_{kf})}{A_f} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}. \quad (2.14)$$

⁴¹ Since we assume that foreign capital stock is financed entirely by equity and borrowing from the parent companies, FDI and I_f are identical and are used interchangeably to denote investment in the host country by foreign firms.

2.3. Summary

This chapter develops a sectoral partial-equilibrium model that allows for two important effects emphasized in the industrial organization literature on FDI: technology superiority of foreign firms and spillover of technological knowledge from foreign to domestic firms. From the model, using Cournot profit maximization principle and zero profit condition for the long-run equilibrium, we derive equilibrium domestic and foreign investment as functions of variables influencing a firm's profit.

CHAPTER 3

THE EFFECT OF FDI ON DOMESTIC INVESTMENT

Using the analysis of long-run equilibrium in the preceding chapter, we determine the relationship between domestic and foreign investment in this chapter. For this purpose, we first write (2.12) generally as⁴²

$$I_d = G^d(a, w_{kd}, w_l, \bar{n}_f). \quad (3.1)$$

We also write (2.14) generally as

$$I_f = G^f(w_{kd}, w_l, \bar{n}_f) \quad (3.2)$$

As (3.1) and (3.2) indicate, although equilibrium domestic investment is not an explicit function of I_f , I_f and I_d are related via $\bar{n}_f$. To derive the relationship between I_d and I_f , we, first, differentiate I_d in (3.1) totally, and obtain

$$dI_d = \frac{\partial G^d}{\partial a} da + \frac{\partial G^d}{\partial w_{kd}} dw_{kd} + \frac{\partial G^d}{\partial w_l} dw_l + \frac{\partial G^d}{\partial \bar{n}_f} d\bar{n}_f, \quad (3.3)$$

⁴² As addressed earlier, $w_{kf} = w_{kd} + d$, where $d \leq 0$. Also recalling that free entry is not permitted for foreign firms, I_f is independent of the market size (a).

where $\frac{\partial G^d}{\partial \bar{n}_f}$ measures the effect of $\bar{n}_f$ on I_d , holding other variables constant.

Totally differentiating I_f , in (3.2), gives

$$dI_f = \frac{\partial G^f}{\partial w_{kd}} dw_{kd} + \frac{\partial G^f}{\partial w_l} dw_l + \frac{\partial G^f}{\partial \bar{n}_f} d\bar{n}_f. \quad (3.4)$$

Using (3.3) and (3.4) to eliminate $d\bar{n}_f$, and rearranging, we obtain

$$dI_d = \pi_a da + \pi_{w_{kd}} dw_{kd} + \pi_{w_l} dw_l + \pi_{I_f} dI_f, \quad (3.5)$$

$$\text{where } \pi_a = \frac{\partial G^d}{\partial a}, \quad \pi_{w_{kd}} = \left(\frac{\partial G^d}{\partial w_{kd}} - \frac{\partial G^f}{\partial w_{kd}} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right), \quad \pi_{w_l} = \left(\frac{\partial G^d}{\partial w_l} - \frac{\partial G^f}{\partial w_l} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right),$$

$$\text{and } \pi_{I_f} = \left(\frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right).$$

Equation (3.5) shows that domestic investment depends on market size (a), real user cost of domestic capital (w_{kd}), real wage rate (w_l), and foreign investment (I_f). Since the legal restriction is imposed on the number of foreign firms, the major shift in policy could be seen as the change in foreign investment. Hence, in the empirical analysis, I_f (or FDI) is used as an exogenous variable. As our main interest is in the partial effect of I_f on I_d , we discuss this effect in details below. Partial effects of other variables are then discussed briefly.

3.1. Partial Effect of Foreign Investment : π_{I_f}

According to (3.5), π_{I_f} depends on $\frac{\partial G^d}{\partial \bar{n}_f}$ and $\frac{\partial G^f}{\partial \bar{n}_f}$. Recalling that

$I_f = \delta_f K_f = \delta_f \bar{n}_f k_f$, and $I_d = \delta_d K_d = \delta_d n_d k_d$, we have

$$\frac{\partial G^f}{\partial \bar{n}_f} = \delta_f \left(\bar{n}_f \frac{\partial k_f}{\partial \bar{n}_f} + k_f \right), \quad \text{and} \quad (3.6)$$

$$\frac{\partial G^d}{\partial \bar{n}_f} = \delta_d \left(n_d \frac{\partial k_d}{\partial \bar{n}_f} + k_d \frac{\partial n_d}{\partial \bar{n}_f} \right). \quad (3.7)$$

Using the capital demand by domestic and foreign firms (k_d and k_f) given in (2.9) and (2.10), and the relation (2.7) determining the number of domestic firms (n_d), we can derive the expression for $\frac{\partial k_d}{\partial \bar{n}_f}$, $\frac{\partial k_f}{\partial \bar{n}_f}$, and $\frac{\partial n_d}{\partial \bar{n}_f}$. These expressions are shown in

Appendix I.B. We provide an intuitive discussions of the factors that determine $\frac{\partial G^f}{\partial \bar{n}_f}$ and $\frac{\partial G^d}{\partial \bar{n}_f}$ below.

3.1.1. The Effect of $\bar{n}_f$ on I_f : $\frac{\partial G^f}{\partial \bar{n}_f}$

As (3.6) indicates, a change in number of foreign subsidiaries can affect foreign investment through two channels.

First, there is the reduction in foreign investment due to a decrease in each firm's capital demand. This effect is illustrated in Figure 3.1.b below. Figure 3.1.b shows a representative foreign firm in its long-run equilibrium, F^* , where marginal revenue is equal to marginal cost. The long-run average curve, LAC_f , lies below the demand curve, D_f because, with the restriction on entry, the foreign firm is earning above the normal profit. If a foreign firm enters the market, the residual demand curve of each firm in the industry shifts down and so does the marginal revenue curve. The cost curves of the foreign firm, however, remain the same, and as a result, the output of the foreign subsidiary decreases with an increasing number of foreign firms.⁴³ Demand for capital of each foreign firm, thus, decreases with an increasing number of foreign subsidiaries.

Second, there is an increase in foreign investment due to an increasing number of foreign firms for a given capital demand of each firm. The net effect of an increasing number of foreign subsidiaries on foreign investment is, thus, ambiguous depending on the relative sizes of the increase in investment due to an increasing number of the foreign firms and the decrease in investment of each firm due to the decreasing output.

⁴³ Note that there is no spillover effect on the foreign firms.

3.1.2. The Effect of $\bar{n}_f$ on I_d : $\frac{\partial G^d}{\partial \bar{n}_f}$

The net effect of a change in number of foreign firms on domestic investment also represents two effects.⁴⁴ First is the effect on each domestic firm's capital demand for a given number of domestic firms. As a larger knowledge base is available for the domestic firm, the use of its capital stock becomes more efficient, and thus it requires less capital to produce a given quantity of output. As a result, the capital demand of each domestic firm decreases with respect to the number of foreign firms. This effect is illustrated in Figure 3.1.a.

Figure 3.1.a shows a domestic firm with horizontal marginal cost curve MC_d . The demand for the firm's output is represented by the residual demand curve D_d . Corresponding to the residual demand curve D_d is a marginal revenue curve MR_d . The profit maximizing output is q_d^* , determined by the intersection of the marginal cost and marginal revenue curves. The associated long-run average cost curve is represented by LAC_d . Assuming that n_d is a continuous variable, LAC_d is tangent to the demand curve D_d in the long-run equilibrium. The domestic firm is in the long-run equilibrium at H^* where the firm is earning just normal profit, and at the level of output q_d^* long-run average cost being equal to price and marginal revenue being equal to marginal cost.

⁴⁴ See equation (3.7).

An entry of a new foreign firm would cause a downward shift of the residual demand of each firm in the industry. The residual demand curve of a domestic firm would shift down from D_d to D'_d and the marginal revenue curve would shift down correspondingly. On the other hand, the entry by a foreign firm also generates a positive technological spillover to domestic firms, in which case the unit cost of production incurred by the domestic firm decreases.⁴⁵ This would cause the downward shifts of the average cost curve of the domestic firm from LAC_d to LAC'_d , and the marginal cost curve from MC_d to MC'_d . The equilibrium market price would decrease as a result,⁴⁶ and consequently, the market demand would increase. Since the firm produces using constant-returns-to-scale technology, the residual demand and the marginal cost curves would shift with the same magnitude leaving the output of each domestic firm unchanged.

Second, there is the effect on the number of domestic firms, for a given capital demand of each domestic firm. As illustrated in Figure 1.a., if the output of each domestic firm remains unchanged, the number of domestic firms may either remain intact, increase, or decrease with an increasing number of foreign firms. This second effect clearly indicates as to how each domestic firm's profit is affected in the short-

⁴⁵ The technology gap between the foreign and domestic firms is also narrowed.

⁴⁶ If the cost of production were not affected, some domestic firms would have been driven out of the market to the extent that residual demand curves of the rest of the domestic firms would have shifted back to the original level, and there would be no change in market price and market demand.

run--although its profit is not affected in the long-run.⁴⁷ The decrease (increase) in the number of domestic firms in the long-run implies that in the short-run the domestic firms experience loss (gain beyond the normal profit) as a result of an increasing number of foreign firms. However, as mentioned earlier, this study focuses only on the long-run effect of the foreign investment.

Figure 3.1 Long-run equilibrium output

⁴⁷ However, the model could be modified by assuming fixed factor or cost disadvantage; the feature of the model that would allow FDI to have a long-run effect on the domestic firms' profit.

From the above analysis, it follows that *the partial effect of $\bar{n}_f$ on I_d is ambiguous*, and it would be positive if the number of domestic firms increases with an increasing number of foreign firms. If an entry of a foreign firm drives out some domestic firms, i.e., $\frac{\partial n_d}{\partial \bar{n}_f} < 0$, the partial effect of $\bar{n}_f$ on I_d would be negative. The negative partial effect of $\bar{n}_f$ on I_d could still result even if when $\frac{\partial n_d}{\partial \bar{n}_f}$ is positive since the decrease in domestic investment due to a reduction in capital demand of each firm could outweigh the positive effect on the number of domestic firms. In other words, for the partial effect of $\bar{n}_f$ on I_d to be positive the increase in the number of domestic firms has to be big enough to outweigh the reduction in each firm's capital demand, the situation which is likely to occur if the spillover effect is relatively large.⁴⁸

3.1.3. The Effect of I_f on I_d : $\frac{\partial G^d}{\partial G^f}$

As can be seen from sections 3.1.1 and 3.1.2, the partial effects of $\bar{n}_f$ on both I_d and I_f are ambiguous. It follows that, with spillover effect in the model, the partial effect of I_f on I_d is ambiguous. In other words, the theoretical model does not predict a definite nature of the long-run relationship between I_d and I_f . To set stage for the empirical analyses in chapters 4 and 5, we discuss different possibilities of the long-

⁴⁸ See equation B3.5 in Appendix I.B.

run relationship between the foreign and the domestic investment in the model with and without spillover effect.

Model with spillover: In the model with spillover effect, the long-run effect of foreign investment on domestic investment is ambiguous. Ambiguous results are perhaps not surprising. On the one hand, the entry by a foreign subsidiary replaces some amount of output previously supplied by domestic firms. On the other hand, it simultaneously generates an expansion in market demand. In addition, the spillover effect, which is assumed to increase with the number of foreign firms, has narrowed the technology gap between the foreign and the domestic firms, lowering thereby the effect of cost advantage.

Neutral long-run relationship: In the borderline case, the number of domestic firms may increase with an increasing number of foreign subsidiaries. However, an increase in domestic investment due to an increase in the number of domestic firms could simply be canceled out by its decrease due to a decrease in per-unit capital demand.

Positive long-run relationship: A positive long-run relationship between the foreign and the domestic investment would result if an increase in the number of domestic firms is big enough so that an induced domestic investment outweighs the decrease in the domestic investment caused by the decrease in per-unit capital demand. For an illustration purpose, we provide concrete examples of the positive relationship using numerical simulation on some plausible values in Appendix

I.E. The positive relationship between I_d and I_f is chosen for illustration because it is of interest to show that benefit from technological spillover in some market structure could be big enough to offset the replacement effect in product market, and so that an increase in I_f essentially generates net complementary effect on I_d .

Negative relationship: For some market structures, the increase in market demand could simply be more than absorbed by foreign firms so that only smaller market share is left for domestic firms. In this case, some domestic firms could be driven out of the market, and thus domestic investment decreases with an increasing foreign investment.

Model without spillover: In the model without spillover effect, foreign investment would crowd out domestic investment.⁴⁹ An entry of a new foreign firm would cause a downward shift of each firm's residual demand curve, while the average cost curve would remain the same as there is no spillover effect. Domestic firms experience loss, and, graphically, the new demand curve would lie below the average cost indicating that the market price no longer covers the unit cost of production. Some domestic firms would be driven out of the market.⁵⁰ The demand

⁴⁹ There is no spillover effect on domestic firms either because the foreign firms are able to appropriate their technology completely (i.e., they are able to internalize the full value of efficiency benefits), or because foreign and domestic firms use the same technology.

⁵⁰ The change in number of domestic firms with respect to number of foreign firms is given by $\frac{\partial n_d}{\partial n_f} = - \frac{\left(\frac{F_d}{b}\right)^{1/2} + \left(\frac{c_d - c_f}{b}\right)}{\left(\frac{F_d}{b}\right)^{1/2}}.$

$$\frac{\partial G^d}{\partial G^f} = - \frac{\delta_d}{\delta_f} \frac{a_{kd} A_f}{a_{kf} A_d} \left(\equiv \left(\frac{a_{kd}}{A_d} \right) / \left(\frac{a_{kf}}{A_f} \right) \right). \quad (3.10)$$

As can be seen in (3.10), if foreign firms have superior technology and there is no spillover, the partial effect of I_f on I_d would depend on the technology gap, the difference in wage-rental ratio, and the difference in capital intensity. If the foreign and the domestic firms use the same capital intensity, the technology gap is relatively big, and the wage-rental ratio faced by the domestic firms is not much lower than that faced by the foreign firms (i.e., w_{kd} is not much higher than w_{kf}), then it is likely that the crowding out effect of I_f on I_d would be more than complete. However, if the technology gap is not relatively big, and the wage-rental ratio faced by the domestic firms is much lower than that faced by the foreign firms, the crowding out effect is likely to be incomplete.

Complete crowding out : If the foreign and the domestic firms are identical, a complete crowding out between the foreign and the domestic investment would prevail as anticipated. Equation (3.10) then reduces to⁵¹

$$\frac{\partial G^d}{\partial G^f} = -1. \quad (3.11)$$

⁵¹ Assuming that $w_{kd} = w_{kf}$.

As a passing note, with spillover effect, the sign and size of the long-run relationship depend on various factors including the price elasticity of demand, the fixed cost, the number of foreign firms, the technology gap, and the magnitude of spillover effect. Because these variables are likely to differ across industries, the long-run relationship between the foreign and the domestic investment could be rendered industry-specific.

3.2. Partial Effect of Other Variables on the Domestic Investment

After the long-run effect of the foreign investment on the domestic investment is determined, we now discuss briefly the signs of other underlying structural parameters in (3.5).⁵²

(1) The market size (a) is expected to have a positive effect on domestic investment, i.e., $\pi_a > 0$, regardless of spillover effect.

(2) The partial effect of the real wage on domestic investment is expected to be ambiguous regardless of spillover, i.e., $\pi_{w_t} \gtrless 0$.⁵³ Under the assumption that there is a substitution between capital and labour, the capital demand of each domestic firm is

⁵² Detailed derivations of the partial effect of each explanatory variable on domestic investment are provided in the Appendix I.C.

⁵³ This partial effect is measured by $\pi_{w_t} \left(= \frac{\partial G^d}{\partial w_t} - \frac{\partial G^f}{\partial w_t} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right)$.

positively affected by an increase in the real wage, i.e., $\frac{\partial k_d}{\partial w_l} > 0$. However, the number of domestic firms decreases with an increasing wage rate as the price-cost margin of a firm shrinks, i.e., $\frac{\partial n_d}{\partial w_l} < 0$. Hence, $\frac{\partial G^d}{\partial w_l}$ is ambiguous. The partial effect $\frac{\partial G^f}{\partial w_l}$ is, however, positive. Taken together these effects and the partial effect of the foreign on the domestic investment, the partial effect of the real wage rate on the domestic investment is ambiguous.

(3) The partial effect of the user cost of capital on the domestic investment is expected to be negative if there is no spillover effect and to be ambiguous if there is spillover effect.⁵⁴

(3.1) In the model with spillover effect, $\frac{\partial G^d}{\partial w_{kd}}$ and $\frac{\partial G^f}{\partial w_{kd}}$ are both negative

while $\frac{\partial G^d/\partial \bar{n}_f}{\partial G^f/\partial \bar{n}_f}$ is ambiguous.

(3.2) In the model without spillover, $\frac{\partial G^d}{\partial w_{kd}}$, $\frac{\partial G^f}{\partial w_{kd}}$, and $\frac{\partial G^d/\partial \bar{n}_f}{\partial G^f/\partial \bar{n}_f}$ are

all negative.

⁵⁴ This partial effect is measured by $\pi_{w_{kd}} \left(= \frac{\partial G^d}{\partial w_{kd}} - \frac{\partial G^f}{\partial w_{kd}} \frac{\partial G^d/\partial \bar{n}_f}{\partial G^f/\partial \bar{n}_f} \right)$.

3.3. Some Extensions of the Model

In this section, we consider some modifications and extensions of the basic model. We intend to show that the basic results in this chapter are not affected much by these variations.⁵⁵

An alternative spillover function : We consider a different definition of the spillover function. It could be argued that spillovers are generated by the combined output of foreign firms (Q_f) instead of merely by their number. In this case, we can express technology of a local firm as

$$A_d = g(Q_f)A_f = g(q_f(\bar{n}_f), \bar{n}_f) A_f \quad (3.12)$$

where $g(\cdot)$ is concave in q_f and $\bar{n}_f$.

In this case, the number of foreign subsidiaries can affect the magnitude of spillovers through two channels: (1) indirectly, via its effect on equilibrium output of the foreign firm, and (2) directly via function g . Since the effect of the number of foreign firms on the output of a foreign firm is negative, this specification does not guarantee that the spillover effect would increase with an increasing number of foreign firms. It then follows that the effect of an increasing number of the foreign

⁵⁵ Detailed derivations of all these cases are provided in Appendix I.D.

firms on the capital demand of a domestic firm is ambiguous. However, the alternative specification of spillover neither introduces additional variables into I_d and I_f functions nor changes the basic results of chapter 2 that the long-run relationship between foreign and domestic investment is ambiguous in the model.

Traded sector : Our analysis can be easily modified to apply to a traded sector. For this purpose, the linear inverse demand function (2.4) can be re-written as

$$p = z - b\bar{Q}, \quad p'(\bar{Q}) < 0. \quad (3.13)$$

where p is price; b is the absolute value of the slope of industry demand curve, and the intercept term z now depends on the domestic market size (a), the foreign market size (a^*), and the host country's exchange rate (e). The variable $\bar{Q}$ represents the aggregate demand by both the domestic and the foreign residents.

In this case, the optimal capital stock of a domestic firm remains the same as that in chapter 2. The number of domestic firms, however, would be a function of, *inter alia*, the domestic market size (a), the foreign market size (a^*), and the exchange rate (e). Thus, the domestic investment in the long-run equilibrium can be written generally as

$$I_d = G^d(a, a^*, e, w_l, w_{kd}, \bar{n}_f). \quad (3.14)$$

The foreign investment in the long-run equilibrium is still written as (3.2).

Differentiating (3.14) and (3.2) totally, and eliminating $d\bar{n}_f$, we obtain

$$dI_d = \pi_a da + \pi_{a^*} da^* + \pi_e de + \pi_{w_{kd}} dw_{kd} + \pi_{w_l} dw_l + \pi_{I_f} dI_f \quad (3.15)$$

$$\text{where } \pi_a = \frac{\partial G^d}{\partial a}, \quad \pi_{a^*} = \frac{\partial G^d}{\partial a^*}, \quad \pi_e = \frac{\partial G^d}{\partial e}, \quad \pi_{w_{kd}} = \left(\frac{\partial G^d}{\partial w_{kd}} - \frac{\partial G^f}{\partial w_{kd}} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right),$$

$$\pi_{w_l} = \left(\frac{\partial G^d}{\partial w_l} - \frac{\partial G^f}{\partial w_l} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right), \text{ and } \pi_{I_f} = \left(\frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right).$$

As can be seen from (3.15), the long-run relationship between the foreign and the domestic investment is not affected by the modification of the inverse demand function (i.e., the relationship is ambiguous). The relation (3.15) differs from the relation (3.5) only in that, in the former, the foreign market size (a^*) and the exchange rate (e) are additional explanatory variables of domestic investment.

Product differentiation : We now consider the case where the product of the domestic and the foreign firms are differentiated (i.e., there are two varieties of output in the model). In this case, the inverse demand curves for the two types of firms are given by

$$p_m = a_m - b(Q_m + \theta Q_j), \quad m, j = d, f, \quad (3.16)$$

where p_m is price; a_m is the saturation level of consumption for good if it were free; b is the absolute value of the slope of the industry demand curve; Q_d is the total output of all domestic firms; Q_f is the total output of all foreign firms; and θ measures the degree of product differentiation ($0 \leq \theta \leq 1$). If $\theta = 0$, the products produced by the foreign and the domestic firms are completely differentiated. If $\theta = 1$, the products are homogenous.

In this case, the optimal capital stock of a domestic firm remains the same as that in chapter 2.⁵⁶ The number of domestic firms, however, now depends also on the degree of product differentiation. Nevertheless, the change in the number of domestic firms with respect to the number of foreign firms is ambiguous. Therefore, the effect of an increasing number of foreign firms on domestic investment remains ambiguous.

For a foreign firm, its equilibrium output now depend as well on the degree of product differentiation. The difference between the equilibrium output of a foreign and a domestic firm is due not only to the technology gap, but also to the degree of product differentiation. In this case, the effect of an increasing number of foreign firms on the output of a foreign firm would be ambiguous. The net effect of number of foreign firms on foreign investment would thus be ambiguous. We, then, again conclude that

⁵⁶ The degree of product differentiation affect neither per-unit capital demand nor long-run equilibrium output.

the relationship between the foreign and the domestic investment derived in this chapter is also applicable to the case of product differentiation.

3.6. Summary

Using long-run equilibrium analysis in chapter 2, this chapter examines the long-run relationship between FDI and domestic investment. Several principal conclusions emerge from the theoretical investigation. First, foreign investment would completely crowd out domestic investment, (i.e., one to one replacement) if foreign and domestic firms are identical, and there is no technological spillover from the former to the latter.

Second, if foreign firms employ superior technology in the production process and are able to completely appropriate their technology--so that there is no spillover benefit for domestic firms; the foreign investment would crowd out domestic investment. The extent of the crowding out, however, would depend on the technology gap between foreign and domestic firm and the difference in real wage-rental ratio.

Third, if the superior technology of foreign subsidiaries benefits domestic firms in the form of technological spillover, the long-run relationship between foreign and domestic investment becomes ambiguous as two opposite forces are at work simultaneously. On one hand, foreign investment generates technological spillover which in turn reduces cost of production incurred by domestic firms. The expansionary or complementary effect of foreign investment can, therefore, be seen in the expansion

of market demand encouraged by a reduction in market price (made possible by the reduction in production cost). On the other hand, however, there is also a substitution effect of foreign investment. An increase in foreign investment would reduce market share of domestic firms if the market price remains the same. Therefore, the net effect of foreign investment on domestic investment is ambiguous depending on the relative strength of the above described complementary and substitution effects.

In this chapter, we also discuss some modifications of the model and show that the long-run relationship between foreign and domestic investment derived from the original model can be adopted to the modified versions of the model.

CHAPTER 4

DATA AND METHODOLOGY

The long-run relationship between FDI and domestic investment in Thailand during the period of 1971-1995 is estimated using the recently developed analysis of cointegrating relations in panel data. Controlling for sector specific features, we test whether there was a long-run relationship between FDI and domestic investment and, if so, what was the nature of the relationship.

Because it is difficult to extract reasonable estimates of long-run relationship between variables from a short span of data available for each sector, we use a panel data set including all eight sectors for the period of 1971-1995 to estimate the relationship.⁵⁷ A panel data set offers a number of advantages over traditional cross section or pure time series data sets. The most obvious advantage is that the number of observations is typically much larger in panel data. The larger number of observations are likely to produce more reliable parameter estimates and, most importantly, enable us to specify and test more sophisticated models which incorporate less restrictive behavioural assumptions. Another advantage is that panel data set may alleviate the

⁵⁷ Adding the cross-section dimension to the time dynamics offers a real advantage in the testing for non-stationarity and cointegration. The hope of the econometrics of non-stationary panel data is to combine the best of both worlds: the method of dealing with non-stationarity from the time series and the increased data and power from the cross-section (McKoscy and Kao, 1997).

problem of multicollinearity because when the explanatory variables vary in two dimensions they are less likely to be highly related. Finally, the use of panel data allow us to control for sectoral heterogeneity in investment behaviour.⁵⁸

The rest of the chapter discusses the following topics: (1) basic framework and testable hypotheses, (2) the data and the measurement of variables, and (3) econometric issues and methodology.

4.1. Basic Framework

To explore empirically the long-run relationship between foreign and domestic investment, equation (3.5) is approximated by the following linear relation:

$$I_d = \beta_1 a + \beta_2 w_{kd} + \beta_3 w_l + \beta_4 I_f \quad (4.1)$$

where the expected signs of the coefficients are $\beta_1 > 0$, $\beta_2 \leq 0$, $\beta_3 \leq 0$, and $\beta_4 \leq 0$. Although the general model does not yield definite predictions about β_4 , it is of interest to consider three hypotheses that imply specific restrictions on β_4 . Each hypothesis is described briefly below.

The first hypothesis is that foreign and domestic investment are perfect substitutes, that is $\beta_4 = -1$. This hypothesis is implied by the model when there are no

⁵⁸ A detailed account of the benefits and limitations of panel data can be found in Baltagi (1995, p.3-7) and Nerlove and Balestra (1995, p.22-23).

technological differences or spillover. In this case, the complete crowding out between foreign and domestic investment arises as the product supplied by foreign firms simply absorbs the market demand that would otherwise be supplied by domestic firms. The complete crowding out implies that there is no long-run effect of FDI inflows on aggregate capital formation of the host country.⁵⁹

The second hypothesis is that the long-run effect of foreign on domestic investment is neutral, i.e., $\beta_4 = 0$.⁶⁰ This hypothesis represents the borderline case where FDI is associated with spillovers that benefit domestic firms, but the complementary and substitution effects of FDI on domestic investment completely offset each other. In this case, an increase in FDI inflows has no net long-run effect on domestic investment and, consequently, the capital formation of the host country increases only by the same amount as FDI.

Finally, the third hypothesis is that in the long-run foreign and domestic investment are complements, i.e., $\beta_4 > 0$. This hypothesis assumes that the complementary effect outweighs the substitution effect so that the long-run effect of FDI on domestic investment is positive.

⁵⁹ Although the crowding out could be more than complete; i.e., minus one is not the lower bound of $\frac{\partial G^d}{\partial G^f}$, the key quantity of interest is whether or not the crowding out is complete.

⁶⁰ This neutral relationship can prevail only if domestic firms benefit from technological spillover.

4.2. The Data

We use annual panel data set for eight sectors and 25 years (from 1971 to 1995) to estimate the relation in (4.1). The variables used for the empirical analysis of the investment relationship include real domestic investment, real GNP, real wage rate, real user cost of capital, and FDI. Unfortunately, as is true of most developing countries, the data on domestic investment and total investment at the disaggregate level (e.g. 3-4 digit SIC industry) are not available for Thailand. Due to this limitation, we explore the long-run relationship between foreign and domestic investment at the broader aggregation level (e.g. roughly 1 digit SIC).⁶¹ This leaves us with eight broad sectors: (1) agriculture, (2) construction, (3) mining and quarrying, (4) manufacturing, (5) transportation and communication, (6) wholesale and retail trade, (7) financial institution and real estate, and (8) services. We describe briefly below how each variable in (4.1) is measured.⁶²

(1) Domestic investment (I_d) is measured by subtracting from total private investment the measure of foreign direct investment.

(2) The market size or the market demand parameter (a) is proxied by real gross national product (GNPR) as we assume that market size of each sector is systematically related to GNPR of the host country.

⁶¹ The sector classification is in accordance with the industry-origin basis commonly used in a country's national account.

⁶² Data and sources of data are provided in Appendix II.A.

(3) The real wages used in the regression are annual employee compensations by sector deflated by the consumer price deflator. Two alternative approaches are considered. First, we assume that, in the long-run, labour is perfectly mobile across sectors so that wages are equalized among sectors (i.e., wages are not sector specific). In this case, the average level of employee compensation for the whole country is used in all sectors. The second approach allows for wage differences across sectors. Since employee compensation is not available for all sectors, however, the missing data have to be approximated. To do so, we approximate employee compensation in construction, and mining and quarrying sectors by the average compensation for the whole country.⁶³ This approximation is motivated by the assumption that the skill mix in these sectors most closely reflected the skill mix in the country as a whole. Compensation in banking and trade sectors are approximated by employee compensation in the manufacturing sector on the assumption that both sectors have similar skill mix.

(4) For estimation of the real user cost of capital, not only are data on taxes not available, but it is also difficult to develop a satisfactory measure of price expectation.⁶⁴ We, thus, resort to ignoring taxes⁶⁵ and assuming perfect foresight in

⁶³ This assumption is perhaps arbitrary. However, using the different proxy for the compensation of the mining and quarrying sector may not lead to a significant change in the estimation results.

⁶⁴ Although ex-ante expectations of the capital goods prices are required only the ex-post outturns are actually observed. Moreover, the user cost of capital would depend on the *ex-ante* real interest rate, which itself depends on unobservable expectation of inflation.

measuring the one-period user cost of capital. Hence, the real user cost of capital is measured as

$$w_k = \frac{[(r + \delta)p_k - \Delta p_{k,t-1}]}{P_d}$$

where r denotes the minimum loan rate (MLR); δ denotes the depreciation rate, which is defined as at the beginning of a period capital stock divided by capital depreciation allowances; P_k is the nominal price of capital good defined as nominal capital stock divided by real capital stock while $\Delta P_{k,t-1}$ is the annual appreciation of the nominal price of capital goods, and P_d is the GDP deflator. Since the above formula accounts for neither taxes nor uncertainty, the measure of real user cost of capital is, to some degree, subject to measurement errors.

(5) Finally, the nominal foreign direct investment (FDI) at the sectoral level is measured from the balance of payments data. Hence, the FDI measure includes both equity and lending from parent companies.⁶⁶ To obtain FDI in real terms (FDIR),

⁶⁵ This is equivalent to assuming that taxes are passed on to customer completely. In practice, however, the return yielded by an investment project is taxed in a number of ways. Profits earned by firms are subject to corporate income tax, and the owners of these firms may be subject to further taxation on dividends and capital gains. Other features of tax systems, such as capital allowances, provide tax relief for some of the costs associated with investment.

⁶⁶ In other words, FDI is defined as a cross-border capital transfer (i.e., excluding retained earnings of the foreign affiliates and local borrowing). Note that, even though this variable is not strictly equivalent to foreign capital formation (I_f), the use of FDI figures from the balance of payments as a proxy variable for capital formation by foreign subsidiaries is a customary practice in the literature; see Hartman (1984) and Cantwell (1995) for a justification of this practice.

specific measurement errors occur in domestic investment and its explanatory variables, then it is likely that sector-specific effects and the included regressors are correlated, contrary to the assumption of random effects model.

We, thus, choose the fixed-effect form and write (4.1) as⁶⁹

$$I_{d,it} = \alpha_i + \lambda_t + \beta_1 a_{it} + \beta_2 w_{kd,it} + \beta_3 w_{l,it} + \beta_4 I_{f,it} + \varepsilon_{it},$$

$$i = 1, 2, \dots, 8 \text{ and } t = 1, 2, \dots, 25 \quad (4.2)$$

where α_i is the sector-specific constant which is time-invariant; λ_t is the unobservable time-specific effect which is sector-invariant, and ε_{it} is the error term which varies across sectors and over time. The error term measures the departure from the long-run equilibrium. The subscript i refers to the sector and t refers to the time period.⁷⁰ In fixed-effect model the intercept terms (α_i and λ_t) are included to account for sector specific and time-specific effects of factors that are not explicitly included in the regression. In the context of the model in chapter 2, time-specific constants, λ_t ,

correlation arising between cross-sectional characteristic and included explanatory variables (Greene, 1995, p. 479).

⁶⁹ The specification includes N sector-specific constants but only $t-1$ time-specific constants to avoid dummy variable trap.

⁷⁰ Note that the subscripts i of β 's are included to represent the most general specification in which the slope coefficients are allowed to differ across sectors. The subscript i of β 's are dropped when the slope coefficients are constrained to be the same across sectors.

capture, for instance, the difference between w_{kd} and w_{kf} (i.e., the constant d). Also, the sector-specific constants may be present as a result of differences in the market size (a) which are not related to GNPR.

4.3.1. Unit Root Tests

If individual series are stationary, then conventional panel regression techniques can be applied to (4.2). However, the application of these techniques is complicated by the possible nonstationarity of the series involved. As a preliminary step in the estimation procedure, we test whether the time series used in the regression are stationary.

When applied to sectoral time series, the augmented-Dickey-Fuller tests (ADF) for each sector generally do not reject the presence of a unit root except for the real user cost of capital in some sectors, as shown in Table B4.1 (in the Appendix II.B). Further, as shown in Table B4.2, the first differences of all the variables are stationary confirming that all variables are integrated of order one. As is well-known, however, these unit root test procedures have limited power in finite sample like ours. Levin and Lin (1992, 1993)⁷¹ derive the limiting distributions for unit root tests on panel data, and show that the panel framework can provide dramatic improvements in statistical power compared to performing a separate unit root test for each individual time series.

⁷¹ The test in Levin and Lin (1992) constrain the dynamics of the augmented Dickey-Fuller to be the same across sectors.

As shown in Table 4.1, the unit root tests in panel data confirm that the variables are nonstationary, again except for the real user cost of capital.⁷²

Table 4.1 Results of Panel Unit Root Tests

	<u>Test Statistics</u>
	Levin and Lin 1992
Investment at constant prices	2.78
FDI at constant price	-2.01
Real user cost of capital	-7.07***
Real Wage	1.74

Note : The critical values at the 1% significance level is -5.94 for Levin and Lin (1992).

4.3.2. Cointegration Test for Panel Data

Since the theoretical model suggests a long-run relationship between the variables in relation (4.1) which are all nonstationary (with the exception of the user cost of capital), we seek to test whether the relation is cointegrated using recent developments in the econometric analysis of nonstationary variables as applied to panel data (i.e., cointegration analysis for panel data). If the theoretical model is valid, then over time actual domestic investment will move together with its predicted

⁷² However, stationarity of the real user cost of capital will not pose limitation on the application of cointegration test. As will be seen later, the rest of the variables in the regression cointegrate to yield an $I(0)$ variable, which is then cointegrated with real user cost of capital.

values, i.e., the variables in the model together form a linear combination that is stationary, even though each of the series individually contains a unit root. If disequilibrium forces cause a deviation between the predicted and the actual domestic investment, the difference between the two, measured by ε_{it} , should close through time to exhibit stationarity (i.e., the deviation is not permanent). In other words, the stationarity of ε_{it} would provide evidence of cointegration between the actual and the theoretical predicted investment.⁷³

The basic idea of cointegration is that if there is a long-run relationship between two or more nonstationary variables, a regression containing all these relevant variables--the cointegrating equation--will have a stationary error term, even if none of the variables taken alone is stationary. In other words, in order for the variables to be related in the long-run, they must be cointegrated. Thus the test for cointegration of variables in the relation (4.1) is also a test for the presence of any long-run equilibrium relationship among these variables (4.1).

Many empirical studies purge the nonstationarity in data by differencing and using the differenced variables in the estimation process. Differencing, thus, avoids the spurious correlation problem. However, differencing also means that valuable information from economic theory concerning long-run equilibrium properties of the data is discarded.⁷⁴ The cointegrating approach, on the other hand, exploits rather than

⁷³ See Hamilton (1994, p.571-629) for more details on cointegration tests.

⁷⁴ For example, if $Y = \alpha + \gamma X$ is the long-run relationship between two variables, differencing yields $\Delta Y = \gamma \Delta X$. But in the absence of an error correction term

discards the relevant information about the shared trend that is embodied in the level because the relationship is estimated in level. Obviously, this is an advantage of the cointegration approach (Coe and Helpman, 1995).

The absence of any cointegrating relationship among a set of nonstationary variables renders the statistical test of significance invalid. Only if the variables in the equation are cointegrated does the regression yield consistent estimates of coefficients and a meaningful statistical inference can be drawn about the models estimated in levels.⁷⁵ Thus, we must test for the presence of cointegration before accepting the estimation results of our specifications as valid and making statistical inferences on their implied long-run relationship.⁷⁶ To apply a (single-equation) residual-based test for cointegration analysis for panel data, we proceed in the following manner. We estimate the cointegrating relationship using Dynamic Ordinary Least Square (DOLS) estimation and panel data techniques (as discussed below), and

$(Y - \alpha + \gamma X)_{-1}$, the difference equation is misspecified and it is not possible to solve it for the long-run relationship between the levels of Y and X (Mills, 1991, p.271).

⁷⁵ In other words, if the error term is nonstationary, the estimated relationship is spurious.

⁷⁶ In fact, the results for fixed effect cointegrating regression (or least square dummy variable [LSDV] estimation) of panel data are somewhat more encouraging than those in time series. Kao (1997) shows that even with spurious regression, (i.e., under null hypothesis of no cointegration), the OLS estimator is consistent. However, since the t -statistics still diverge, we need to test the null hypothesis of no cointegration to assure that we base our statistical inference on appropriate tests of significance.

then test whether the estimated residuals from these cointegrating equations are stationary using unit root tests for panel data.

4.3.3. Estimation procedure

We now discuss the following econometric issues and estimation procedure before turning to the estimation results.

The first concerns small-sample bias and thus the choice of suitable estimators for the cointegrating vector. As is well-known in time series literature, even though the estimation by OLS of the cointegration regression yield ‘super-consistent’ estimates,⁷⁷ the estimates for the coefficients in level specifications with nonstationary data are biased in finite samples, and so are their standard errors (and hence t-values and the tests of significance) as well as the R^2 statistics unless the independent variables are strictly exogenous (see Banerjee et al., p.162 and Cuthbertson et al., 1992, p.139). In general, small-sample bias present in long-run parameter estimates using OLS

⁷⁷ As more observations are added, the OLS estimate of the cointegrating vector converges to the true parameter values much faster than in the case where the variables are stationary. This attractive (large-sample) econometric property of cointegrated equations is referred to as super consistency (Engle and Granger 1987). The intuition behind the super consistency result is that, for values of the parameters which do not cointegrate the nonstationary series, the residual series will itself be nonstationary and therefore have a very large estimated variance. When the estimated parameters are close to the true cointegrating parameters, the residual becomes stationary and its variance shrinks. Since OLS minimizes the residual variance, it will be extremely good at picking out the cointegrating parameters if they exist (Coe and Helpman, 1995).

estimation method results from two possible sources.⁷⁸ The first source of bias is the joint dependence of some of the series in the cointegrating vector, i.e., simultaneity bias. While the basic model developed in chapter 2 is not meant to be a complete description of all possible interactions between foreign and domestic investment, it does show that domestic investment and FDI are simultaneously determined. It is, thus, likely that FDI is contemporaneously correlated with the disturbance term. The contemporaneous correlation between the disturbance term and the regressors in (4.2) may also arise because of measurement errors of the regressors. The second source of bias is the omission of the short-run dynamics in the model with the presence of serial correlation/heterogeneity (Muscatelli and Hurn, 1995). The problem of small-sample bias carries over to panel data analysis. As argued by Kao and Chiang (1997), there is no reason to presume that this bias will become negligible in panel regression due to the introduction of the cross-section dimension. With the small-sample bias of the OLS estimator, only limited confidence can be placed on the standard errors and thus on t-statistics estimated based on the OLS regression.⁷⁹

⁷⁸ The asymptotic bias is $\hat{\beta}_{OLS} - \beta \approx \frac{\delta_{NT}}{T} = \frac{-3\Omega_{\epsilon}^{-1}\Omega_{\epsilon u} + 6\Omega_{\epsilon}^{-1}\Delta_{\epsilon u}}{T}$ where the nuisance parameter $\Omega_{\epsilon u}$ is due to the endogeneity of the regressor and $\Delta_{\epsilon u}$ is due to the serial correlation. See Chaing and Kao (1997) for the detailed proof.

⁷⁹ The OLS estimators have a non-negligible bias in finite sample and their limiting distributions are normally distributed with non-zero means. The limiting distribution of OLS contain nuisance parameters which are present because of possible long-run weak exogeneity and serial correlation in the errors (Kao and Chiang, 1997).

To deal with the small-sample bias, Phillips and Hansen (1990) suggest Fully-Modified estimators (FM) which involve essentially a non-parametric correction of the standard OLS cointegrating regression. Whilst one cannot use conventional instrumental variable regression to eliminate the bias in a cointegrating framework, Phillips and Hansen employ a semi-parametric correction which exploits the non-stationarity of the series and focuses on the 'long-run' covariance matrix.⁸⁰ This long-run covariance matrix is partitioned into its various sub-matrices needed for the asymptotic bias correction and for the long-run covariance matrix to be positive, semi-definite covariance smoothing techniques, commonly known as Newey-West (1987) adjustment, is used in constructing it. They suggest that the dependent variable should be adjusted by the sub-matrices of the covariance matrix so that the resulting disturbance term will be uncorrelated in the long-run with the independent variables.⁸¹

An alternative estimation procedure for dealing with small-sample biases is DOLS method. The DOLS method adds leads and lags of the first-difference term of independent variables to account for short-run dynamic responses between dependent

⁸⁰ Even if a conventional instrumental variable regression could be employed to take care of the bias, it would have been hard to find a satisfactory instrumental variable for FDI. One candidate for instrumental variable would be lagged FDI. However, this choice of candidate is reasonable only if there is no serial correlation associated with the error term in the equation containing lagged FDI. As will be discussed shortly, the error term in the equation is likely to be correlated, hence this candidate might not completely solve the simultaneity biases.

⁸¹ Phillips-Hansen tests thus refer to Wald tests which are modified by semi-parametric correction for serial correlation and for endogeneity. The resulting test statistics (termed fully-modified Wald tests) have limiting χ^2 distributions and therefore allow inference to proceed in a conventional way.

and independent variables, and thereby to remove the nuisance parameter in order to obtain each coefficient, with nice limiting distribution properties.⁸² As shown in Kao and Chiang (1997), the limiting distributions of DOLS estimators are asymptotically normal with zero means. In view of t-statistics and the tests of significance, since the standard errors of estimates are estimated based on DOLS regression, they are unbiased. The DOLS procedure was recently used in Stock and Watson (1993) for cointegration test in time series and in Chiang et al. (1997) for a cointegration test in panel data. In their most recent study, Kao and Chiang (1997) use Monte Carlo simulation to examine the sampling behavior of OLS, FM, DOLS and show that these estimators are all asymptotically normally distributed. More importantly, however, while the FM estimator does not improve upon the OLS estimator in general, the DOLS out-performs both the OLS and the FM estimators, and may be more promising than the OLS and the FM in estimating the cointegrated panel regression.

This study, therefore, adopts the DOLS method for dealing with the small-sample biases. We rewrite equation (4.2) in the most general form to account for dynamic nature of the investment process (and thereby to estimate the long-run effect jointly with the short-run dynamics) as follows:

⁸² One lead of the first-difference term of independent variables serve to orthogonize the error term in the presence of feed back from the domestic investment to explanatory variables.

$$\begin{aligned}
I_{d,it} = & \alpha_i + \lambda_t + \beta_{i1} a_{it} + \sum_{j=-q_1}^{q_2} c_{ij} \Delta a_{i,t-j} + \beta_{i2} w_{kd,it} + \sum_{j=-q_1}^{q_2} d_{ij} \Delta w_{kd,i,t-j} + \beta_{i3} w_{l,it} \\
& + \sum_{j=-q_1}^{q_2} h_{ij} \Delta w_{l,i,t-j} + \beta_{i4} I_{f,it} + \sum_{j=-q_1}^{q_2} f_{ij} \Delta I_{f,i,t-j} + v_{it}, \\
& i = 1, 2, \dots, 8 \text{ and } t = 1, 2, \dots, 25
\end{aligned} \tag{4.3}$$

where Δ denotes first difference and v_{it} is the error term. By construction, the error term v_{it} has zero mean, and is uncorrelated to all explanatory variables not only contemporaneously but also in all lags and leads.⁸³ The coefficients of the difference terms account for short-run dynamic responses between the left- and the right-hand-side variables. Although asymptotically these effects are dominated by the long-run relationship, they are not negligible in a finite sample size. Based on the general model, we discuss different versions of equation (4.3) in chapter 5.

Given the short span of data available, we include only one lag and one lead of the first-difference term of the market size, the real user cost of capital and the real wage to avoid inefficiency due to insufficient degrees of freedom. We, however, include two lags and two leads of the first-difference term of FDI.⁸⁴

⁸³ For proof and more detailed discussion on DOLS see Kao and Chiang (1997). The method of correcting correlation between regressors and disturbances could also be found in Hamilton (1994, p.608-610).

⁸⁴ Due to the difference in the dynamic behavior between domestic investment and different explanatory variables in different sectors, the number of leads and lags need not be identical either amongst sectors or amongst explanatory variables. However, here we set $q_1 = 1$ and $q_2 = 1$ for all variables (except for FDI) and for all sectors. As will be seen in chapter 5, the estimation results are robust to the change in number of leads and lags of the first-difference term of FDI.

The second econometric issue concerns heteroscedasticity and autocorrelation problems. When dealing with investment across sectors, we expect tremendous variation in the scale of the variables in the model. For example, foreign and domestic investments in manufacturing sector are considerably larger than those in either the agricultural or construction sectors resulting in different variations amongst these sectors. We, thus, expect to find heteroscedasticity in the disturbance terms. With respect to the time series dimension, it is likely that the disturbances are serially related. When dealing with an economic relationship like investment, it is likely that an unobserved shock this period will affect the behavioural relationship for at least the next (few) period(s). For example, if there is a banking or financial crisis that affects investment expenditures in one year, there is no reason to believe that this disruption would not be carried into the next year. As is well-known, in the presence of heteroscedasticity and serial correlation, the standard errors of estimates are biased and inconsistent.⁸⁵ To compute the robust standard errors of the estimates, we use heteroscedasticity-consistent matrix and the order-one autocorrelation-consistent matrix correction method by Newey-West (1987).

The last econometric issue concerns the possibility of cross-sectional correlation in the disturbance terms. A non-zero contemporaneous covariance could arise from measurement errors. For example, the real user cost of capital in each sector

⁸⁵ If the autocorrelation is positive, the standard errors of coefficient estimated by least-squares estimators is greater than it would have been had the errors been distributed randomly (see Kennedy, 1992 p.120).

may be subject to common measurement error so that the contemporaneous error term contain the same factors. Also, because business investment responds to factors across the economy as a whole as well as those that are specific to each sector, the disturbances in the investment equations will include factors that are common to all sectors such as the perceived general situation of the economy. In other words, some non-observable factors (included in the error terms) may affect investment decision of all (or some) sectors at the same time. This gives rise to a non-zero contemporaneous covariance between the disturbances of different sectors. Therefore, the assumption that all sectors act independently may be too restrictive a hypothesis.

If the disturbances are correlated across sectors within each period, the DOLS estimators are inefficient.⁸⁶ To guard against this possibility it would seem reasonable to use techniques that allow for the correlation of the disturbances across sectors--i.e. the correlated shocks--within each period. Hence, to account for sectoral correlation, we also estimate the relationship using Seemingly Unrelated Regression (SUR) estimators in all cases. In the next chapter, we present the results from both DOLS and SUR estimators.⁸⁷

⁸⁶ For a detailed discussion on contemporaneous correlation see, for example, Greene (1995, p.489).

⁸⁷ Leads and lags of the first difference term of the explanatory variables are included in SUR estimation. In other words, SUR could be thought of as DOLS estimation with the correction for sectoral correlation.

4.4. Summary

In this chapter, we lay out the empirical framework and discuss econometric issues. Since the theoretical model implies long-run relationship between the domestic investment, the real user cost of capital, the real wages, and FDI, we seek to estimate equation that is cointegrated. We choose the Dynamic OLS as a suitable estimator to estimate the cointegrating vector so that small-sample biases could be dealt with. To deal with autocorrelation and heteroscedasticity problems, we compute standard errors of estimates using heteroscedasticity-consistent and the order-one autocorrelation-consistent matrix correction method by Newey-West (1987). We also estimate the relationship using SUR method to account for sectoral correlation.

CHAPTER 5

EMPIRICAL RESULTS

In this chapter we explore empirically the relationship between FDI and domestic investment in Thailand. As a starting point, we present some descriptive evidence on the co-movements of these two series. We then proceed to a more formal analysis using econometric methods. In this analysis, we test whether there was a long-run relationship between foreign and domestic investment, and if so, what was the nature of the relationship.

5.1. Co-movement of FDI and Private Domestic Investment

We first briefly discuss the behaviour of FDI and private investment in Thailand during the period of 1971 to 1995. Figure 5.1 shows the movement in FDI and domestic private investment at the aggregate and the sectoral levels. Levels of FDI were modest through the 1970s. Following a mild increase in the early 1980s, a very sharp increase can be observed in most sectors after 1986 that took FDI inflows to unprecedented heights.⁸⁸ The massive influx of FDI into Thailand since 1987

⁸⁸ FDI, as measured on the balance of payment basis, rose from an average of around \$260 million prior to 1986 to \$352 million in 1987, \$1.1 billion in 1988, and reached a peak in 1990 at about \$2.3 billion (UNCTAD, 1997). The rapid rise in the inflows of FDI significantly increased its importance in Thailand's capital formation.

coincided with the implementation of FDI liberalization.⁸⁹ The significant increase in FDI thus appears to reflect largely the effect of FDI liberalization.

Domestic private investment also exhibits a sharp rise over the period 1987-1995. Indeed, Figure 5.1 suggests that FDI and domestic private investment tended to move together in most sectors during the period of 1971-1995. One can interpret this information as evidence of a positive long-run relationship between FDI and domestic investment. It can, of course, be argued that some other factors accounted for the movement of domestic investment. However, an examination of economic developments and policies during the period does not suggest any factor that could independently explain the sharp rise in domestic investment.

To further examine whether FDI exerted a significant independent effect on the domestic investment in Thailand, our empirical analysis in the next section examines this relation more rigorously and attempts to control for other factors.

⁸⁹ The Board of Investment (BOI) has been aggressive in specifically promoting foreign investment by conducting overseas investment missions and making direct approaches to foreign firms since the late 1980s. An offshore data processing zone (DPZ) was developed to permit free passage of materials and data and liberal employment of foreign personnel by regional communication firms, i.e., multinationals which set up regional offices in Bangkok, banks and export printing firms, among others. This DPZ project was undertaken to provide more opportunities for and facilitate more new foreign investment. Moreover, export-oriented firms were permitted to operate with majority foreign ownership (See Akarasanee, 1991).

Figure 5.1. Movement of FDI and domestic private investment, 1971-1995

5.2. Empirical Results

In the empirical analysis, we are interested in the long-run relationship between FDI and domestic investment at the sectoral level. However, since time series data available for each sector are not sufficiently long to have precise estimates of the relationship for each sector, we constrain the long-run relationship between FDI and domestic investment to be the same for all sectors. Thus, in the empirical testing, we consider the following two cases that represent different restrictions on the intercepts, and the short-run slope coefficients:

(1) Intercepts differ across sectors while the short- and the long-run slope coefficients are the same, i.e., $\alpha_i \neq \alpha$, $c_{ij} = c_j$, $d_{ij} = d_j$, $h_{ij} = h_j$, $f_{ij} = f_j$, and $\beta_{ij} = \beta_j$. In this case, the sectoral heterogeneity is uniquely reflected in the intercept terms.

(2) Intercepts and the short-run slope coefficients differ but long-run slope coefficients are the same, i.e., $\alpha_i \neq \alpha$, $c_{ij} \neq c_j$, $d_{ij} \neq d_j$, $h_{ij} \neq h_j$, $f_{ij} \neq f_j$, and $\beta_{ij} = \beta_j$. This case also allows for short-run dynamic behaviour of investment to differ across sectors.

In each case, we run regression of the following three versions:

Version 1. Factor prices are not sector-specific in the long-run In this version, we assume that while market sizes are different, factor prices are the same across sectors. Since the factor prices (e.g. w_k and w_l) are not sector specific, the time dummies are included to control for their variations. The inclusion of time dummies

also helps overcome the empirical problem associated with measurement errors of factor prices. This version is based on the following specifications:⁹⁰

$$I_{d,it} = \alpha_i + \lambda_t + \beta_1 a_{it} + \sum_{j=-q_1}^{q_2} c_{ij} \Delta a_{i,t-j} + \beta_4 I_{f,it} + \sum_{j=-q_1}^{q_2} f_{ij} \Delta I_{f,i,t-j} + v_{it},$$

$i = 1, 2, \dots, 8$ and $t = 1, 2, \dots, 25$ (5.1)

where α_i denotes sector-specific effect which is time-invariant, and λ_t denotes the time-specific effect which is sector-invariant, and v_{it} is the remaining stochastic disturbance term.

Version 2. Factor prices are sector specific in the long-run In this version, we assume that both market size and factor prices are different across sectors (i.e., they are sector specific variables). Thus, instead of time dummies, we include these explanatory variables explicitly. In this version the regression is based on the following specification:⁹¹

$$I_{d,it} = \alpha_i + \beta_1 a_{it} + \sum_{j=-q_1}^{q_2} c_{ij} \Delta a_{i,t-j} + \beta_2 w_{kd,it} + \sum_{j=-q_1}^{q_2} d_{ij} \Delta w_{kd,i,t-j} + \beta_3 w_{l,it}$$

$$+ \sum_{j=-q_1}^{q_2} h_{ij} \Delta w_{l,i,t-j} + \beta_4 I_{f,it} + \sum_{j=-q_1}^{q_2} f_{ij} \Delta I_{f,i,t-j} + v_{it},$$

$i = 1, 2, \dots, 8$ and $t = 1, 2, \dots, 25$ (5.2)

⁹⁰ The difference in the market size which is not related to GNPR is captured by α_i . For w_k and w_b we would obtain the same results if include explicitly the series for the whole economy and drop four time dummies.

⁹¹ Since the real user cost of capital is sector specific, the constant d ($= w_{kd} - w_{kf}$) is also sector specific. It is, thus, captured by α_i .

Version 3. Factor prices are sector specific and include time-specific effects

This version also assumes that the market size and factor prices are sector specific. In addition to these variables, time dummies are included to control for other economy-wide changes over time. The inclusion of time dummies would also control for additional variables specified in the modified relation (3.14). In the modified relation, for example, the domestic investment depends on the foreign level of economic activities (a^*)⁹² and the exchange rate (e) in addition to the explanatory variables specified in relation (4.1). The effect of these two explanatory variables could also be accounted for by time-specific constants.⁹³ The empirical specification for this case is

$$\begin{aligned}
 I_{d,it} = & \alpha_i + \lambda_t + \beta_1 a_{it} + \sum_{j=-q_1}^{q_2} c_{ij} \Delta a_{i,t-j} + \beta_2 w_{kd,it} + \sum_{j=-q_1}^{q_2} d_{ij} \Delta w_{kd,i,t-j} + \beta_3 w_{l,it} \\
 & + \sum_{j=-q_1}^{q_2} h_{ij} \Delta w_{l,i,t-j} + \beta_4 I_{f,it} + \sum_{j=-q_1}^{q_2} f_{ij} \Delta I_{f,i,t-j} + v_{it}, \\
 & i = 1, 2, \dots, 8 \text{ and } t = 1, 2, \dots, 25
 \end{aligned} \tag{5.3}$$

To minimize the loss of degrees of freedom, we include one lead and one lag of the first-difference term of all other variables while we include two lags and two leads

⁹² The foreign level of economic activities could be represented by weighted GDPR of main trading partners of Thailand.

⁹³ It is also the case that the proxy of foreign economic activities and domestic GNPR are closely related with the correlation coefficient has already built into the estimation. It should also be noted that foreign economic activities could affect each sector differently because some are traded sectors while others are nontraded sectors. However, these differences will be captured by the allowance of difference in the slope coefficients.

of the first-difference term of FDI.⁹⁴ The estimates are, however, robust to changes in the number of leads and lags of the first-difference term of FDI.⁹⁵

As discussed earlier, only if the error terms are stationary, and thus variables in the equation are cointegrated can a meaningful statistical inference be drawn about the models estimated in levels. We thus tested for the presence of cointegration before accepting the estimation results of a specification as valid and proceeding with the statistical inferences. As reported in the last row of each Table presented below, the null hypothesis that error terms contain unit root is rejected in all cases based on test statistic of Levin and Lin (1992) indicating that the variables in the equation (4.1) are cointegrated.⁹⁶ Hence, we are confident that the interpretation and statistical inference documented below are based on non-spurious regressions.

⁹⁴ A great loss of degrees of freedom is caused by including leads and lags of the first difference of the independent variables in the estimating procedure, particularly when we allow for sectoral difference.

⁹⁵ The results of the specifications with the difference number leads and lags of the first difference term of FDI are shown in Table A5.1 in Appendix III.

⁹⁶ In each case we regressed the residual of our pooled cointegrating regression on the lagged residual. The t-statistic on the coefficient on lagged residual is then compared against the tabulated critical values in Table 1 of Levin and Lin (1992). If the test statistic is statistically significant, then the null of no cointegration can be rejected.

5.2.1. Long-run Relationship Between FDI and Domestic Investment

Case 1: Sector specific intercepts, common short- and long-run slope coefficients ($\alpha_i \neq \alpha$, $c_{ij} = c_j$, $d_{ij} = d_j$, $h_{ij} = h_j$, $f_{ij} = f_j$, and $\beta_{ij} = \beta_j$)

This case examines the existence and the nature of the long-run relationship between FDI and domestic investment assuming that the short-run dynamic behaviours of investment are the same across sectors. Table 5.1 reports the key results of the three versions for both DOLS and SUR estimation.

Consider first the long-run effect of FDI. As shown in columns (i) and (iv), the estimated coefficient of FDI in the first version is positive and statistically significant. The statistical significance of the estimated coefficients in the SUR model increases significantly as anticipated. The results of the second version are reported in columns (ii) and (v). These results show that even including the market size, the real user cost of capital, and the real wage explicitly (i.e., these variables are sector specific), the long-run effect of FDI is also positive and statistically significant. The results of the third version are reported in columns (iii) and (vi). These results indicate that even adding sector-specific variables and controlling for economy-wide changes, the long-run effect remains significantly positive. Indeed, the sizes of the coefficient and its statistical significance are comparable in all versions. The results in case 1, therefore, suggests that there is a strong positive effect of FDI on domestic investment. Both null hypotheses; $\beta_4 = 0$ and $\beta_4 = -1$, are rejected at 1% significance level in all specifications.

The effect of market size in the second and third versions is significantly positive as predicted by the model, although its coefficient in the first version using DOLS estimation is statistically insignificant. The results of all versions show that the real user cost of capital and the real wage both have significantly positive coefficients. As discussed in chapter 3, there is no clear theoretical prediction on the sign of the coefficients of the real wage regardless of spillover. The effect the real user cost of capital is expected to be negative in the model without spillovers, and ambiguous in the model with spillovers. However, the positive effect of FDI implies that the effects of w_{kd} and w_l are consistent with prediction of the model with spillovers.⁹⁷

⁹⁷ As discussed in chapter 3, the positive long-run relationship of FDI is implied by the model where there is spillover effect.

Table 5.1 Sector-specific intercepts, common short-run and long-run slope coefficients^a (t-statistic in parentheses)

Dependent variable : I_d

	DOLS ^f (i)	DOLS ^e (ii)	DOLS ^f (iii)	SUR ^f (iv)	SUR ^e (v)	SUR ^f (vi)
<i>GNPR</i>	-0.19 (-0.93)	0.02 (0.16)	0.68** (2.17)	0.04*** (5.30)	0.01** (2.02)	0.20*** (3.05)
w_{kd}	— —	469,510*** (4.47)	495,300*** (4.03)	— —	404,078*** (12.18)	461,439** (15.18)
w_l	— —	1.65** (2.87)	2.24*** (3.07)	— —	1.17*** (3.96)	1.98*** (4.80)
<i>FDI</i>	1.95*** (2.67)	2.24*** (3.69)	2.25*** (3.47)	1.60*** (9.63)	1.81*** (8.05)	2.00*** (6.38)
(t-stat. for $H_0 : \beta_4 = 0$)	(2.67)	(3.69)	(3.47)	(9.63)	(8.05)	(6.38)
(t-stat. for $H_0 : \beta_4 = -1$)	(4.04)	(5.33)	(5.01)	(15.63)	(12.49)	(9.56)
Adjusted R^2 ^b	0.76	0.80	0.79	—	—	—
Std. error of regression	16,277	14,806	15,192	—	—	—
F-stat. for all $\alpha_i = \alpha$ ^c	—	11.84***	—	—	—	—
Cointegration tests						
Levin and Lin (1992) ^d	-2.34**	-3.06***	-2.95***	-1.88**	-2.77***	-2.34**

Note: **, *, and *** test statistic is significant at 10%, 5%, and 1% significance level respectively.

^a The coefficients and t-statistics for the leads and lags of the first difference term of the independent variables are not reported in the table.

^b The adjusted R^2 and the standard error of the SUR estimator are not available.

^c The F-test uses the DOLS pooled regression--which constrain the intercepts and slopes to be the same for all sectors-- as the restricted regression

^d The critical value at the 10% significance level is -1.44, at 5% is -1.81, and at 1% is -2.48 for Levin and Lin (1992). Test statistics that are negative and greater in absolute value than the critical value indicate that the equations are cointegrated.

^e The regression includes sector-specific constants but excludes time-specific effect.

^f This regression includes time- and sector-specific constants. When GNPR, lead and lag of its first-difference term are included, we dropped four time-specific constants. The results would be the same as those of the specification where GNPR, lead and lag of its first-difference term are dropped and $t-1$ time dummies are included.

Case 2. Sector-specific constants, sectoral short-run slope coefficients and common long-run slope coefficients ($\alpha_i \neq \alpha_j$, $c_{ij} \neq c_j$, $d_{ij} \neq d_j$, $h_{ij} \neq h_j$, $f_{ij} \neq f_j$, and $\beta_{ij} = \beta_j$)

Since the short-run dynamic behaviour of investment could differ across sectors, this case allows for the short-run slope coefficients to be specific to each sector. Table 5.2 reports the key results of the regression under the assumption that intercepts and the short-run coefficients differ across sectors. The results of the first version, in column (i) and (iv), show that FDI has a significantly positive effect on domestic investment. This effect is also significantly positive with a comparable size in the second version--where the market size, the real user cost of capital, and the real wage are sector specific--as shown in columns (ii) and (v). Even after accounting for the economy-wide changes (in version 3), in addition to other explanatory variables (i.e., the market size, the real user cost of capital, and the real wage), the coefficient of FDI remains significantly positive. These results are shown in column (iii) and (vi). Comparing the results of the third version to those of the second version, it is interesting to note that the effect of FDI becomes more significant in the third version when we include time dummies in the regression. Its statistical significance increases from the second version noticeably. In general, the size of the FDI's coefficient is comparable in all specifications, and it is also comparable to that in case 1.

The coefficient of GNPR is positive as expected and is statistically significant in most specifications. The real user cost of capital has positive long-run coefficients

which are statistically significant in all specifications. The real wage also has a positive effect in all specifications, although its effect is statistical insignificant in the second version. As in case 1, the significantly positive effect of FDI on domestic investment implies that the effects of these explanatory variables are consistent with those in the model with spillovers.

The estimates in this case are robust to changes in assumptions on the short-run effects of each explanatory variable.⁹⁸ Although the null hypothesis on common short-run coefficients cannot be rejected, allowing for differences in short-run effects improves the goodness of fit of the regressions to some extent: the adjusted R^2 increases from the range of 0.76-0.80 in case 1 to the range of 0.81-0.95.

⁹⁸ The results of different variations on short-run slope coefficients are reported in Tables A5.2.1 and A5.2.2 in Appendix III.

Table 5.2 Sector-specific intercepts and short-run coefficients, common long-run slope coefficients. (t-statistic in parentheses)^a

Dependent variable : I_d	DOLS ^f (i)	DOLS ^e (ii)	DOLS ^f (iii)	SUR ^f (iv)	SUR ^e (iv)	SUR ^f (vi)
<i>GNPR</i>	— —	0.012 (1.54)	0.75** (2.52)	— —	0.020*** (4.92)	0.81*** (3.52)
w_{kd}	— —	281,280*** (3.46)	627,730*** (5.82)	— —	233,534*** (11.5)	— (7.67)
w_l	— —	0.52 (1.40)	2.15*** (4.01)	— —	0.18 (1.49)	1.23*** (3.70)
<i>FDI</i>	2.41***	2.30**	2.98***	2.24***	2.58***	2.81***
(t-stat. for $H_0 : \beta_4 = 0$)	(3.22)	(1.57)	(5.71)	(18.99)	(3.23)	(19.06)
(t-stat. for $H_0 : \beta_4 = -1$)	(4.55)	(2.26)	(7.63)	(25.74)	(4.45)	(27.57)
Adjusted R^2 ^b	0.81	0.95	0.85	—	—	—
Std. error of regression	14,400	7,312	12,790	—	—	—
F-stat. for common short-run coefficients ^c	2.01**	1.78	1.53	—	—	—
<u>Cointegration tests</u>						
Levin and Lin (1992) ^d	-4.17***	-3.78***	-5.37***	-2.05**	-2.67***	-2.97***

Note: *, **, and *** test statistic is significant at 10%, 5%, and 1% significance level respectively.

^a The coefficients and t-statistics for the leads and the lags of the first difference term of the independent variables are not reported in the table.

^b The adjusted R^2 and the standard error of the SUR are not available.

^c The F-test uses the DOLS regression in Table 5.1 as the restricted regression.

^d The critical value at the 10% significance level is -1.44, at 5% is -1.81, and at 1% is -2.48 for Levin and Lin (1992). Test statistics that are negative and greater in absolute value than the critical value indicate that the equations are cointegrated.

^e The regression includes sector-specific constants but excluded time-specific effect.

^f The regression includes sector-specific and time-specific constants.

5.3. Summary

This chapter, based on the basic framework developed in chapter 2, investigates empirically the long-run relationship between FDI and domestic investment in Thailand, using a panel data set of eight sectors for the period of 1971 to 1995.

Two cases are considered in implementing the basic model, each corresponds to the restrictions on the intercepts and the short-run coefficients. The estimation constrains the long-run slope coefficients to be the same for all sectors. In each case, we estimate the model in three versions corresponding to the assumption on whether or not the real user cost of capital, and the real wage are sector-specific variables.

The main finding of the empirical analysis is that FDI has a significantly positive long-run effect on domestic investment. This result holds for both cases, and under both the DOLS and the SUR estimation.

The long-run effect of the market size is significantly positive as expected. The coefficients of the real user cost of capital and the real wage are also positive and statistically significant in most specifications. The positive effect of FDI implies that these results are consistent with the model with spillover.

CHAPTER 6

CONCLUSION

This study examines the long-run relationship between FDI and domestic investment in Thailand. To explore this relationship, the study develops a sectoral partial-equilibrium model that allows for two important effects emphasized in the industrial organization literature on FDI: technological superiority of foreign firms and spillovers of technological knowledge from foreign to domestic firms.

The basic model implies that FDI would completely crowd out domestic investment (i.e., one-to-one replacement) if foreign and domestic firms are identical and there is no spillover effect on domestic firms. FDI would also crowd out domestic investment if foreign firms employ superior technology in the production process and are able to completely appropriate their technology--so that there is no spillover associated with FDI. The extent of the crowding out effect in this case would depend on the technological gap between foreign and domestic firms. The effect of FDI on domestic investment is, however, ambiguous if the superior technology of foreign firms benefits domestic firms via technological spillovers. The ambiguity arises as a result of two opposite forces which are at work simultaneously. On the one hand, FDI reduces the demand for the goods of domestic firms. On the other hand, FDI generates spillover effect that increases productivity and reduce the cost of production incurred by domestic firms. The net effect can, thus, be either an expansion or contraction of

the size of domestic firms. Although the long-run relationship between foreign and domestic investment would have an important implication on the economic welfare of the host country, it is beyond the scope of the theoretical analysis in this study. It would, however, be interesting to explore further the implication for the economic welfare.

The long-run relationship implied by the theoretical model is implemented empirically for Thailand, using panel data for eight sectors of the economy for the period from 1971 to 1995. A key empirical issue is whether the spillover effect is strong enough to imply a positive long-run relationship between FDI and domestic investment.

The main finding of the empirical analysis is that FDI has a significantly positive long-run effect on domestic investment in Thailand. This result holds for various restrictions on the intercepts and short-run coefficients, and under both the DOLS and the SUR estimation. An important implication of this empirical result is that the spillover effects associated with FDI in Thailand outweighed its crowding out effect. The empirical evidence supporting the contagion theory for the case of Thailand would strengthen the conclusion that the positive relationship between FDI and domestic investment is driven by the spillover effect implied by the model. However, since the data on total factor productivity (TFP) are not readily available at the sectoral level, we are precluded from carrying out a direct test for the effect of FDI on total factor productivity (TFP) to reaffirm the technological spillover contributed by FDI.

Analyzing the effect of FDI on TFP would thus be an interesting topic for future research.

It could be argued that strong positive link between FDI and domestic investment may reflect the effect of some neglected factors that simultaneously influence FDI and domestic investment. The empirical model does attempt to control for a number of factors. It first controls for the real user cost of capital, the real wage, and the market size explicitly. The result of this version shows a significantly positive effect of FDI. In addition to these factors, the empirical model includes time dummies to control for economy-wide changes over time. Despite the control for economy-wide changes, the effect of FDI remains significantly positive. Thus, the results suggest that there is a strong independent effect of FDI on domestic investment.

It is possible, however, that certain biases in our measures could have led to an overestimation of the magnitude of the coefficient of FDI. First, the FDI data measured on balance of payment basis may be an underestimated proxy of foreign subsidiaries' investment, because they do not include reinvested retained earnings, depreciation allowances, acquisitions, and local borrowing. Second, the requirement on local equity participation in some industries has created joint ventures in which case foreign equity capital finances only part of the total investment.⁹⁹ It should also

⁹⁹ However, in the theoretical model, we assume full foreign ownership to simplify the analysis. Although the magnitude of the effect could be altered if we relax this assumption, the qualification of the results may not be affected.

be noted that if there are both intra- and inter-industry spillover, the relationship at the sectoral level would capture both of these effects.¹⁰⁰

It would be interesting to explore if the long-run effect of FDI differs across sectors. However, the time series data available for each sector is not sufficiently long to obtain satisfactory estimates of sector-specific effects of FDI.¹⁰¹ Identifying sector-specific effect of FDI would be an interesting topic for future research.

¹⁰⁰ As argued by Blömmstrom and Kokko (1998), the technological spillover may take place in the foreign affiliates' own industry or among the affiliates' suppliers and customers in other industries.

¹⁰¹ A great loss of degrees of freedom is caused by including the leads and lags of the first difference of the explanatory variables.

APPENDIX I : THE BASIC MODEL

A. Model and Derivation

Outputs of the two types of firms in industry i in period t are given by

$$q_j = A_j f(l_j, k_j) \quad j = d, f, \quad (\text{A2.1})$$

where q_d , l_d and k_d are, respectively, the quantity of output produced, labour employed, and capital stock used by a domestic firm, while q_f , l_f and k_f are the corresponding variables for a foreign firm. The subscripts d and f denote a domestic and a foreign firm receptively. For simplicity of exposition, the subscript i and t are suppressed. The function $f(\cdot)$ is the internal technology of each firm which is linearly homogenous in factors k and l . Variables A_f and A_d are (Hicks-neutral) technology indexes for foreign and domestic firms. Under the assumption that a foreign firm has ownership advantages over a domestic firm, A_f is greater than A_d .

The spillover of foreign firm's know-how to local firms is assumed to depend on the extent of foreign presence. Thus, relative technology of local firms is considered a function of the number of foreign subsidiaries. We, therefore, express

$$A_d = g(n_f) A_f, \quad 0 < g(\cdot) < 1, \text{ and } g(\cdot) \text{ is concave.} \quad (\text{A2.2})$$

The function $g(\cdot)$ measures the spillover effect on the local firm. It is assumed that the spillover benefit for domestic firms increases with the number of foreign subsidiaries but at a decreasing rate.

Letting w_l and w_{kj} denote wage rate and user cost of capital in country j , the total costs of domestic and foreign firms can be written as

$$C_j(w_l, w_{kj}; q_j) = c_j(w_l, w_{kj}, A_j) q_j + F_j(w_l, w_{kj}), \quad j = d, f. \quad (\text{A2.3})$$

$c_j(w_l, w_{kj}, A_j) q_j$ is the total variable cost required in producing q_j units of output and $c_j(w_l, w_{kj}, A_j)$ is the unit variable cost, given the technology index A_j . $F_i(\cdot)$ are the plant-specific fixed costs and $F_f < F_d$.

In this model, firms are assumed to face the following linear inverse demand

$$p(Q) = a - b \sum_{j=1}^n q_j = a - b(Q_d + Q_f), \quad p'(Q) < 0 \quad (\text{A2.4})$$

where p is price; a is the saturation level of consumption for the good if it were free; b is the absolute value of the slope of industry demand; and q_j is an output of firm j . The variables Q_d and Q_f are outputs of all domestic and all foreign firms respectively, and $Q (\equiv Q_d + Q_f)$ is an industry output.

Equations (A2.1)-(A2.4) are given in the text as equations (2.1)-(2.4).

Short-Run Equilibrium

Given the cost function in (A2.3), the short-run equilibrium output produced by a domestic and a foreign firm are derived as follows:

In Cournot equilibrium, taking its rivals' output as given, firm j picks its output, q_j to maximize the following profits:

$$\pi_j = p(Q) q_j - c_j(w_b, w_{kj}, A_j) q_j - F_j(w_b, w_{kj}), \quad j = 1, \dots, n. \quad (\text{A2.5})$$

Using (A2.4) and setting $\frac{\partial \pi_j}{\partial q_j} = 0$, one obtains the first-order condition that

$$a - bQ - bq_j = c_j, \quad (\text{A2.6})$$

Equation (A2.6), where arguments of the c_j function are omitted to ease the notation, can be solved to derive firm i 's reaction function:

$$q_j = \frac{1}{2} \left(\frac{a - c_j}{b} - Q_{-j} \right), \quad (\text{A2.7})$$

where $Q_{-j} (\equiv Q - q_j)$ are the combined outputs of all other firms, which are treated as constant by firm j under the Cournot behavioral assumption. Let q_d and q_f denote output produced by a domestic and a foreign firm respectively. Noting that $Q = n_d q_d + n_f q_f$, reaction functions for domestic and foreign firms can, then, be written as

$$q_d = \frac{1}{b(n_d + 1)}(a - c_d - bn_f q_f), \quad (\text{A2.8})$$

$$q_f = \frac{1}{b(n_f + 1)}(a - c_f - bn_d q_d). \quad (\text{A2.9})$$

Solving (A1.8) and (A1.9) one obtains the short-run equilibrium output of a representative domestic firm and a foreign firm as follows:¹⁰²

¹⁰² Throughout this study, we make two weak assumptions about the Cournot equilibrium. First, we assume that each firm's reaction curve slopes downward, i.e., $p'(Q) + q_j p''(Q) < 0$, $j = 1, 2, \dots, n$. This assumption is weak and standard in Cournot analysis. It holds if industry marginal revenue slopes downward, i.e., $p'(Q) + Q p''(Q) < 0$.

Second, we assume that the demand curve facing each firm intersects that firm's marginal cost curve from above, i.e., $\frac{\partial^2 C_j}{\partial q_j^2} > p'(Q)$, $j = 1, 2, \dots, n$.

The second condition is met if the marginal cost is non-decreasing, i.e., if $\frac{\partial^2 C_j}{\partial q_j^2} \geq 0$. It is among the weaker known stability conditions for Cournot equilibrium (Dixit, 1986).

$$q_d = \frac{1}{(n_d + n_f + 1)} \left\{ \left(\frac{a - c_d}{b} \right) - n_f \left(\frac{c_d - c_f}{b} \right) \right\}, \quad (\text{A2.10})$$

$$q_f = \frac{1}{(n_d + n_f + 1)} \left\{ \left(\frac{a - c_d}{b} \right) + (n_d + 1) \left(\frac{c_d - c_f}{b} \right) \right\}, \quad (\text{A2.11})$$

Note that $c_d > c_f$, given the assumption that $A_d < A_f$, and $w_{kf} \leq w_{kd}$. In equilibrium, the lower-cost foreign firms produce more output. In the short-run equilibrium, the number of domestic and foreign firms are exogenously fixed.

Using (A2.4), (A2.6), (A2.10), and (A2.11) one obtains the corresponding equilibrium price as follows:

$$\begin{aligned} p &= c_d + \frac{b}{(n_d + n_f + 1)} \left\{ \left(\frac{a - c_d}{b} \right) - n_f \left(\frac{c_d - c_f}{b} \right) \right\} \\ &= c_f + \frac{b}{(n_d + n_f + 1)} \left\{ \left(\frac{a - c_d}{b} \right) + (n_d + 1) \left(\frac{c_d - c_f}{b} \right) \right\} \end{aligned} \quad (\text{A2.12})$$

Long-Run Equilibrium

Domestic firms are assumed to have free entry, so that in the long-run equilibrium domestic firms enter the market until each domestic firm's profit is zero.

By setting the short-run profit of a domestic firm to zero (i.e., setting

$\pi_d = p(Q) q_d - c_d(w_l, w_{kd}, A_d) q_d - F_d = 0$) and using (A2.4), one obtains the zero profit condition

$$\frac{F_d}{q_d} + c_d = a - b . \quad (\text{A2.13})$$

As it is assumed that the number of foreign firms is restricted, let $n_f = \bar{n}_f$. Using (A2.6), (A2.10), and (A2.13), one derives the number of domestic firms in the long-run equilibrium as

$$n_d = \frac{\left\{ \left(\frac{a - c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right\} - \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}}{\left(\frac{F_d}{b} \right)^{1/2}} . \quad (\text{A2.14})$$

By determining the number of domestic firms, one also obtains the following long-run equilibrium output produced by a domestic firm:

$$q_d = \left(\frac{F_d}{b} \right)^{1/2} . \quad (\text{A2.15})$$

Given our assumption of free entry and constant returns to scale technology for domestic firm, the long-run equilibrium output of a domestic firm depends only on price elasticity of demand and its fixed cost. The long-run output produced by a

domestic firm is higher, the higher is the fixed cost, or the higher is the price elasticity of demand.

Substituting (A2.14) into (A2.11) to derive the long-run equilibrium output of a foreign firm gives

$$q_f = \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right). \quad (\text{A2.16})$$

In (A2.16), $\left(\frac{c_d - c_f}{b} \right)$ represents the effect of technological advantage.

Substituting (A2.14) into (A2.12), the corresponding long-run equilibrium price is, then, given by

$$P = c_d + b \left(\frac{F_d}{b} \right)^{1/2}. \quad (\text{A2.17})$$

Equations (A2.14)-(A2.17) are given as (2.7), (2.5), (2.6), and (2.8) in the text.

Aggregate optimal capital stocks, and equilibrium investment of domestic and foreign firms in the j th industry are derived next. By Shepard's lemma, from the cost function (A2.3), the following conditional capital demand of a domestic and a foreign firm are derived respectively:

$$k_d^e(w_l, w_{kd}; q_d) = \frac{a_{kd}(w_l, w_{kd})}{g(\bar{n}_f)A_f} q_d, \quad (\text{A2.18})$$

$$k_f^e(w_l, w_{kf}; q_f) = \frac{a_{kf}(w_l, w_{kf})}{A_f} q_f, \quad (\text{A2.19})$$

where $\frac{a_{kd}(w_l, w_{kd})}{g(\bar{n}_f)A_f}$, and $\frac{a_{kf}(w_l, w_{kf})}{A_f}$ are capital demand per unit of output of a domestic and foreign firm respectively. For notational convenience, $a_{kj}(w_l, w_{kj})$ is referred to as a_{kj} hereafter. Equations (A2.16) and (A2.17) are conditional factor demand equations, relating the stock of investment to total output and relative factor prices.

Equations (A2.18) and (A2.19) are used to derive both the short-run and the long-run capital stocks of domestic firms and foreign firms. Equations (A2.10) and (A2.18) give the short-run capital stock while (A2.15) and (A2.18) give the long-run capital stock of a domestic firm. Similarly, the short-run capital stock of a foreign firm is given by (A2.11) and (A2.19), and the long-run capital stock is derived from equations (A2.16) and (A2.19). The long-run net capital stock of a domestic and a foreign firm are given, respectively, by

$$k_d(w_l, w_{kd}) = \frac{a_{kd}}{g(\bar{n}_f)A_f} \left(\frac{F_d}{b} \right)^{1/2}, \text{ and} \quad (\text{A2.20})$$

$$k_f(w_l, w_{kf}) = \frac{a_{kf}}{A_f} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}. \quad (\text{A2.21})$$

Optimal capital in (A2.20) and (A2.21) are functions of variables affecting profits of a firm. Per-unit capital demand of a firm that exhibits constant returns to scale is a function of factor prices and firm-specific assets only, i.e., independent of output level.

The aggregate optimal capital stock is obtained by multiplying the number of firms in the long-run equilibrium to the stationary-state capital stock of a representative firm. This gives

$$K_d(w_b, w_{kd}, \bar{n}_f) = \left(\frac{\left\{ \left(\frac{a-c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right\} - \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d-c_f}{b} \right) \right\}}{\left(\frac{F_d}{b} \right)^{1/2}} \right) \frac{a_{kd}(w_b, w_{kd})}{g(\bar{n}_f) A_f} \left(\frac{F_d}{b} \right)^{1/2} \quad (\text{A2.22})$$

Since K_d is the stationary-state domestic capital stock, the equilibrium investment (I_d) equals $\delta_d K_d \left(\equiv \delta_d n_d k_d \right)$, where δ_d is the rate of depreciation of domestic capital ($0 < \delta_d < 1$). Hence, the equilibrium investment is given by

$$I_d(w_b, w_{kd}, \bar{n}_f) = \delta_d \left(\frac{\left\{ \left(\frac{a-c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right\} - \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d-c_f}{b} \right) \right\}}{\left(\frac{F_d}{b} \right)^{1/2}} \right) \frac{a_{kd}(w_b, w_{kd})}{g(\bar{n}_f) A_f} \left(\frac{F_d}{b} \right)^{1/2} \quad (\text{A2.23})$$

Using (A2.21), the optimal capital stock of foreign subsidiaries in the stationary-state for the restricted number of foreign subsidiaries ($\bar{n}_f$) is given by

$$K_f(w_l, w_{kf}; \bar{n}_f) = \bar{n}_f \frac{a_{kf}(w_l, w_{kf})}{A_f} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\} \quad (\text{A2.24})$$

As equilibrium investment of $\bar{n}_f$ foreign subsidiaries (I_f) equals $\delta_f K_f$ ($\equiv \delta_f \bar{n}_f k_f$),

where δ_f is the depreciation rate of foreign capital ($0 < \delta_f < 1$), thus

$$I_f(w_l, w_{kf}; \bar{n}_f) = \delta_f \bar{n}_f \frac{a_{kf}(w_l, w_{kf})}{A_f} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}. \quad (\text{A2.25})$$

Equations (A2.20)-(A2.25) are given in the text as (2.9)-(2.14).

B. The Partial Effect of I_d on I_f : $\frac{\partial G^d}{\partial G^f}$

B.1. The Partial Effect of $\bar{n}_f$ on I_f : $\frac{\partial G^f}{\partial \bar{n}_f}$

The partial effect of $\bar{n}_f$ on I_f is given by

$$\frac{\partial G^f}{\partial \bar{n}_f} = \bar{n}_f \frac{\partial k_f}{\partial \bar{n}_f} + k_f \quad , \quad (\text{B3.1})$$

where $\frac{\partial k_f}{\partial \bar{n}_f} = \frac{a_{kf}}{A_f} \frac{\partial q_f}{\partial \bar{n}_f} = -\frac{a_{kf} c_d g'(\bar{n}_f)}{A_f b g(\bar{n}_f)}$. The partial effect $\frac{\partial G^f}{\partial \bar{n}_f}$ is, thus, expressed

as¹⁰³

$$\frac{\partial G^f}{\partial \bar{n}_f} = \delta_f \frac{a_{kf}}{A_f} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) - \bar{n}_f \frac{c_d}{b} \frac{g'(\bar{n}_f)}{g(\bar{n}_f)} \right\} \quad (\text{B3.2})$$

The first term on the right hand side of (B3.2) measures the output of a new foreign firm. The second term with the negative sign captures the total reduction in outputs of the existing $\bar{n}_f$ foreign firms induced by a decrease in cost advantage.

¹⁰³ As can be seen from (B3.2), the foreign investment is likely to increase with an increasing number of foreign subsidiaries in the industry where the technology gap between foreign and domestic firms is big.

B.2. The Partial Effect of $\bar{n}_f$ on I_d : $\frac{\partial G^d}{\partial \bar{n}_f}$

The partial effect of $\bar{n}_f$ on I_d is given by

$$\frac{\partial G^d}{\partial \bar{n}_f} = n_d \frac{\partial k_d}{\partial \bar{n}_f} + k_d \frac{\partial n_d}{\partial \bar{n}_f}, \quad (\text{B3.3})$$

where
$$\frac{\partial k_d}{\partial \bar{n}_f} = -\frac{a_{kd}}{A_d} \frac{g'(\bar{n}_f)}{g(\bar{n}_f)} \left(\frac{F_d}{b}\right)^{1/2}. \quad (\text{B3.4})$$

The change in the number of domestic firms with respect to the number of foreign firms is given by

$$\frac{\partial n_d}{\partial \bar{n}_f} = \frac{\left[\frac{c_d g'(\bar{n}_f)}{b g(\bar{n}_f)} - \left\{ \left(\left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right) - \left(\bar{n}_f \frac{c_d g'(\bar{n}_f)}{b g(\bar{n}_f)} \right) \right\} \right]}{\left(\frac{F_d}{b} \right)^{1/2}} \quad (\text{B3.5})$$

The first term in the numerator is an increase in market demand. The middle term is an output of the new foreign firm while the third term (with the negative sign) is the reduction in outputs of the existing $\bar{n}_f$ foreign firms. Taken together, the numerator measures the net change in market demand that would be supplied by domestic firms.

The net change in the number of domestic firms increases with (absolute value of) the price elasticity of demand, and/or with a decreasing technology gap. By implication, the number of domestic firms is more likely to increase with the number of foreign firms in the industry with relatively high price elasticity of demand (low b) and/or with lower technological gap (low $c_d - c_f$).

Using (B3.4)-(B3.6), the partial effect of $\bar{n}_f$ on I_d is given by

$$\frac{\partial G^d}{\partial \bar{n}_f} = \left[\frac{c_d g'(\bar{n}_f)}{b g(\bar{n}_f)} - \left\{ \left(\left(\frac{F_d}{b} \right)^{1/2} - \left(\frac{c_d - c_f}{b} \right) - \bar{n}_f \frac{c_d}{b} \frac{g'(\bar{n}_f)}{g(\bar{n}_f)} \right) \right\} \right] - \left[\frac{g'(\bar{n}_f)}{g(\bar{n}_f)} \left\{ \left(\left(\frac{a - c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right) - \bar{n}_f \left(\left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right) \right\} \right]. \quad (\text{B3.6})$$

C. Partial Effect of Other Variables on Domestic Investment

Partial effect of the market size : π_a

This partial effect is given by

$$\frac{\partial G^d}{\partial a} = \delta_d \left(n_d \frac{\partial k_d}{\partial a} + k_d \frac{\partial n_d}{\partial a} \right), \quad (C3.1)$$

where $\frac{\partial k_d}{\partial a} = 0$, and $\frac{\partial n_d}{\partial a} = \frac{1}{(bF_d)^{1/2}}$. Because $\frac{\partial n_d}{\partial a}$ is positive, the partial effect of the market size is positive. The partial effect of the market size on domestic investment is greater in industry with high price elasticity compared to that with low price elasticity. The opposite is true for the fixed cost.

Partial Effect of the Real Wages : π_{w_l}

This partial effect is measured by

$$\pi_{w_l} = \frac{\partial G^d}{\partial w_l} - \frac{\partial G^f}{\partial w_l} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f}, \quad (C3.2)$$

where $\frac{\partial G^d}{\partial w_l} = n_d \frac{\partial k_d}{\partial w_l} + k_d \frac{\partial n_d}{\partial w_l}$ and $\frac{\partial G^f}{\partial w_l} = \bar{n}_f \frac{\partial k_f}{\partial w_l}$. Because $\frac{\partial k_d}{\partial w_l} > 0$ and

$\frac{\partial n_d}{\partial w_l} \left(= -1 / \left(\frac{F_d}{b} \right)^{1/2} \frac{\partial c_d}{\partial w_l} \right) < 0$, $\frac{\partial G^d}{\partial w_l}$ is ambiguous. It is likely to be positive when the

price elasticity of demand is relatively high and/or the product is relatively more

capital-intensive. Since $\frac{\partial k_f}{\partial w_l}$ is positive,¹⁰⁴ $\frac{\partial G^f}{\partial w_l}$ is positive. Hence, π_{w_l} is ambiguous regardless of any spillover effect.

But it is likely to be positive in the industry with high capital intensity and/or high price elasticity of demand. If foreign and domestic firms are identical, then the long-run effect of the real wage on investment reduces to $\frac{\partial G^d}{\partial w_l} + \frac{\partial G^f}{\partial w_l}$ which is more likely to be positive.

Partial Effect of the Real User Cost of Capital : π_{w_k}

This partial effect is given by

$$\pi_{w_k} = \frac{\partial G^d}{\partial w_k} - \frac{\partial G^f}{\partial w_k} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f}, \quad (C3.3)$$

where $\frac{\partial G^d}{\partial w_k} = n_d \frac{\partial k_d}{\partial w_k} + k_d \frac{\partial n_d}{\partial w_k}$, and $\frac{\partial G^f}{\partial w_k} = \bar{n}_f \frac{\partial k_f}{\partial w_k}$. Since $\frac{\partial k_d}{\partial w_k} < 0$, and

$\frac{\partial n_d}{\partial w_k} \left(= -1 / \left(\frac{F_d}{b} \right)^{1/2} \frac{\partial c_d}{\partial w_k} \right) < 0$, $\frac{\partial G^d}{\partial w_k} < 0$. Also because $\frac{\partial k_f}{\partial w_k} < 0$, $\frac{\partial G^f}{\partial w_k} < 0$. The partial

¹⁰⁴ Note that, we do not begin our analysis in this study by assuming that the first choice a multinational producer must face is whether or not to undertake FDI, in which case the choice of an output level in host and home countries would be involved. The relevant variable should have been the relative (Thai vis-à-vis foreign) unit labour cost which is in principle negatively related to FDI flows unless a strong substitution effect between labour and capital were in operation. If there is no strong substitution effect, the effect would be reversed.

effect (π_{w_k}) is, therefore, expected to be negative if there is no spillover effect in the model. With spillover effect, however, the effect becomes ambiguous.

D. Some Extensions of the Basic Model ¹⁰⁵

D.1. An alternative functional form of the spillover effect

If the technological spillover is generated by the combined output of foreign firms (Q_f), the technology of a local firm can be expressed as

$$A_d = g(Q_f)A_f = g(q_f(\bar{n}_f), \bar{n}_f) A_f \quad (D3.1)$$

where $g(\cdot)$ is concave in the number of foreign firms ($\bar{n}_f$) and the output of each foreign firm (q_f). As in chapter 2, $0 < g(\cdot) < 1$. The effect of $\bar{n}_f$ on the spillover effect is now given by

$$\frac{\partial g}{\partial \bar{n}_f} = \frac{\partial g}{\partial \bar{n}_f} + \frac{\partial g}{\partial q_f} \frac{\partial q_f}{\partial \bar{n}_f} \quad (D3.2)$$

The number of foreign firms can affect the magnitude of the technological spillover through two channels: (1) directly via function g , and (2) indirectly, via its effect on equilibrium output of the foreign firm. Since the effect of $\bar{n}_f$ on q_f is negative, this

¹⁰⁵ The notations used in this appendix are the same as those used throughout the text.

specification does not guarantee that the spillover effect increases with an increasing number of foreign firms, i.e., $\frac{\partial g}{\partial \bar{n}_f}$ is ambiguous.

Optimal Capital Stock and Equilibrium Investment

Most long-run equilibrium solutions of this modified model remain the same as those in chapter 2 (i.e., in Appendix I.A). However, now the marginal cost of domestic firm is given by

$$c_d(w_{kd}, w_l) = \frac{B(w_{kd}, w_l)}{g(q(\bar{n}_f), \bar{n}_f) A_f} \quad (\text{D3.3})$$

The partial effect of I_f on $I_d : \pi_{I_f}$

We can still write I_d and I_f generally as

$$I_d = G^d(\alpha, w_{kd}, w_l, \bar{n}_f), \text{ and} \quad (\text{D3.5})$$

$$I_f = G^f(w_{kd}, w_l, \bar{n}_f). \quad (\text{D3.6})$$

Differentiating (D3.5) and (D3.6) totally, eliminating $d\bar{n}_f$, and rearranging, one obtains

$$dI_d = \pi_a da + \pi_{w_{kd}} dw_{kd} + \pi_{w_l} dw_l + \pi_{I_f} dI_f, \quad (\text{D3.7})$$

where $\pi_a = \frac{\partial G^d}{\partial a}$, $\pi_{w_{kd}} = \left(\frac{\partial G^d}{\partial w_{kd}} - \frac{\partial G^f}{\partial w_{kd}} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right)$, $\pi_{w_l} = \left(\frac{\partial G^d}{\partial w_l} - \frac{\partial G^f}{\partial w_l} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right)$, and $\pi_{I_f} = \left(\frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right)$.

As discussed in chapter 3, the partial effect of I_f on I_d depends on $\frac{\partial G^d}{\partial \bar{n}_f}$ and

$\frac{\partial G^f}{\partial \bar{n}_f}$. Recalling that $I_d = \delta_d n_d k_d$ and $I_f = \delta_f \bar{n}_f k_f$, we have

$$\frac{\partial G^f}{\partial \bar{n}_f} = \delta_f \left(\bar{n}_f \frac{\partial k_f}{\partial \bar{n}_f} + k_f \right) \quad (\text{D3.8})$$

$$\frac{\partial G^d}{\partial \bar{n}_f} = \delta_d \left(n_d \frac{\partial k_d}{\partial \bar{n}_f} + k_d \frac{\partial n_d}{\partial \bar{n}_f} \right), \quad (\text{D3.9})$$

Considering first the partial effect of $\bar{n}_f$ on I_f (i.e., $\frac{\partial G^f}{\partial \bar{n}_f}$). In this modified version,

the effect of $\bar{n}_f$ on k_f is

$$\frac{\partial k_f}{\partial \bar{n}_f} = -\frac{a_{kf}}{A_f g(Q_f)} \frac{c_d}{b} \left(\frac{\partial g}{\partial \bar{n}_f} + \frac{\partial g}{\partial q_f} \frac{\partial q_f}{\partial \bar{n}_f} \right). \quad (\text{D3.10})$$

Since $\frac{\partial g}{\partial \bar{n}_f} > 0$, $\frac{\partial g}{\partial q_f} > 0$, and $\frac{\partial q_f}{\partial \bar{n}_f} < 0$, the effect of $\bar{n}_f$ on k_f is ambiguous

(i.e., $\frac{\partial k_f}{\partial \bar{n}_f} \lessgtr 0$). It follows that $\frac{\partial G^f}{\partial \bar{n}_f}$ is ambiguous.

The partial effect of $\bar{n}_f$ on I_d is considered next. We have,

$$\frac{\partial k_d}{\partial \bar{n}_f} = -\frac{a_{kd}}{A_d g(Q_f)} \left(\frac{F_d}{b} \right)^{1/2} \left(\frac{\partial g}{\partial \bar{n}_f} + \frac{\partial g}{\partial q_f} \frac{\partial q_f}{\partial \bar{n}_f} \right). \quad (\text{D3.11})$$

Since $\frac{\partial g}{\partial \bar{n}_f} > 0$, $\frac{\partial g}{\partial q_f} > 0$, and $\frac{\partial q_f}{\partial \bar{n}_f} < 0$, the effect of the number of foreign firms on

demand for capital of a domestic firm is ambiguous, i.e., $\frac{\partial k_d}{\partial \bar{n}_f} \lessgtr 0$.

The effect of the number of foreign firms on the number of domestic firms is given by

$$\frac{\partial n_d}{\partial \bar{n}_f} = \frac{\left[\frac{c_d}{b g(Q_f)} \left(\frac{\partial g}{\partial \bar{n}_f} + \frac{\partial g}{\partial q_f} \frac{\partial q_f}{\partial \bar{n}_f} \right) \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) + \bar{n}_f \frac{c_d}{b g(Q_f)} \left(\frac{\partial g}{\partial \bar{n}_f} + \frac{\partial g}{\partial q_f} \frac{\partial q_f}{\partial \bar{n}_f} \right) \right\} \right]}{\left(\frac{F_d}{b} \right)^{1/2}} \quad (\text{D3.12})$$

Since the effect of the number of foreign firms on spillover is ambiguous, the effect on the unit cost of production of a domestic firm is ambiguous. It follows that the effect on market price and market demand is ambiguous. Thus, $\frac{\partial n_d}{\partial \bar{n}_f} \lessgtr 0$.

It thus follows from the above analysis that, with the technological spillover, the long-run effect of foreign on domestic investment is ambiguous. If, however, the superior technology of the foreign firms does not benefit the domestic firms via spillover, the effect of $\bar{n}_f$ on I_f in (D3.8), reduces to

$$\frac{\partial G^f}{\partial \bar{n}_f} = \delta_f \frac{a_{kf}(w_{kf}, w_l)}{A_f} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}. \quad (\text{D3.13})$$

The effect of $\bar{n}_f$ on I_d in (D3.9), is reduces to

$$\frac{\partial G^d}{\partial \bar{n}_f} = -\delta_d \frac{a_{kd}(w_{kd}, w_l)}{A_d} \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}. \quad (\text{D3.14})$$

The partial effect of I_f on I_d is then given by

$$\frac{\partial G^d}{\partial G^f} = -\frac{\delta_d}{\delta_f} \frac{a_{kd}(w_{kd}, w_l)}{a_{kf}(w_{kf}, w_l)} \frac{A_f}{A_d}, \quad (\text{D3.15})$$

which is negative. Thus, without the technological spillover, the foreign investment would crowd out the domestic investment as derived in chapter 3. It also follows that

if foreign and domestic firms are identical, the crowding out effect would be complete, i.e.,

$$\frac{\partial G^d}{\partial G^f} = -1 \quad (\text{D3.16})$$

D.2. Traded-goods Sector

The analysis in chapter 3 can be modified to apply to a traded sector. For this purpose, the linear inverse demand function (2.4) can be re-written as

$$p = z + b \bar{Q}, \quad p'(\bar{Q}) < 0, \quad (\text{D3.17})$$

where p is the domestic currency price of the product; b is the absolute value of the slope of the industry demand curve, and the intercept term z is the saturation level of consumption for the good if it were free, and $\bar{Q}$ is the aggregate demand by both the domestic and foreign residents. The variables $\bar{Q}$ may be written as

$$\bar{Q} = Q^d + Q^f, \quad (\text{D3.18})$$

where Q^d is the demand by the domestic residents, and is given by

$$Q^d = a - b' , \quad (D3.19)$$

where a is the domestic market size parameter, b' is the absolute value of the demand curve of the domestic residents, and e is the price of domestic currency in terms of foreign currency.

The demand by foreign residents (Q^f) is given by

$$Q^f = a^* - b' pe , \quad (D3.20)$$

where a^* is the foreign market size parameter, and b' is the absolute value of the demand curve of the foreign residents.

Hence, intercept term in (D3.17) is

$$z = \frac{(a + a^*)}{b' \left(1 + \frac{1}{e}\right)} . \quad (D3.21)$$

As can be seen from (D3.21), z now depends on the domestic market size (a), the foreign market size (a^*), and the host country's exchange rate ($1/e$). The absolute value of the slope of the demand curve is¹⁰⁶

¹⁰⁶ Note that Thailand had implemented fixed-exchange rate policy until July 2, 1997. Hence $1/e$ is a constant.

$$b = \frac{1}{b' \left(1 + \frac{1}{e}\right)} . \quad (\text{D3.22})$$

Optimal capital stock and equilibrium investment

The long-run equilibrium solutions derived from this modified model are the same as those derived in chapter 2 except for the number of domestic firms. In this case, the number of domestic firms in the long-run equilibrium is given by

$$n_d = \frac{\left\{ \left(\frac{z - c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right\} - \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\}}{\left(\frac{F_d}{b} \right)^{1/2}} \quad (\text{D3.23})$$

The partial effect of I_f on I_d : π_{I_f}

The equilibrium domestic and foreign investments can thus be written generally as

$$I_d = G^d(a, a^*, e, w_l, w_{kd}, \bar{n}_f) . \quad (\text{D3.24})$$

The foreign investment in the long-run equilibrium is still the same as (3.2).

Differentiating (D3.24) and (3.2) totally, and eliminating $d\bar{n}_f$, we obtain

$$dI_d = \pi_a da + \pi_{a^*} da^* + \pi_e de + \pi_{w_{kd}} dw_{kd} + \pi_{w_l} dw_l + \pi_{I_f} dI_f \quad (D3.25)$$

$$\text{where } \pi_a = \frac{\partial G^d}{\partial a}, \quad \pi_{a^*} = \frac{\partial G^d}{\partial a^*}, \quad \pi_e = \frac{\partial G^d}{\partial e}, \quad \pi_{w_{kd}} = \left(\frac{\partial G^d}{\partial w_{kd}} \frac{\partial G^f}{\partial w_{kd}} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right),$$

$$\pi_{w_l} = \left(\frac{\partial G^d}{\partial w_l} - \frac{\partial G^f}{\partial w_l} \frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right), \quad \text{and } \pi_{I_f} = \left(\frac{\partial G^d / \partial \bar{n}_f}{\partial G^f / \partial \bar{n}_f} \right).$$

As can be seen from (D2.23), the long-run effect of foreign on domestic investment now depends also on the foreign market size (a^*), and the host country's exchange rate ($1/e$), among others. However, it still holds that the long-run relationship between foreign and domestic investment is ambiguous if superior technology of foreign firms spills over to domestic firms. The foreign investment would crowd out the domestic investment if there is no spillover effect. The crowding out effect would be complete if foreign and domestic firms are identical.

D.3. Product Differentiation

If product of the foreign and domestic firms are differentiated, the inverse demand functions of the two types of firms are given by

$$P_m = a_m - b(Q_m + \theta Q_j), \quad m, j = d, f \quad (D3.26)$$

where p_d is price; b is the absolute value of the slope of the demand curve faced by domestic firms; Q_d is the total output of all domestic firms, and the intercept term a_d

is the saturation level of consumption for the product of domestic firms if it were free, while p_f , b , Q_f and a_f are the corresponding variables for a foreign firms. The parameter θ measures the degree of product differentiation ($0 \leq \theta \leq 1$).¹⁰⁷ If $\theta = 0$, products produced by the foreign and the domestic firms are completely differentiated. If $\theta = 1$, the products are homogenous.

Optimal capital stock and equilibrium investment

With product differentiation, the optimal capital stock of a domestic firm remains the same as that in chapter 2 because there is free entry for domestic firms in the long-run and the unit cost is constant (i.e., does not depend on the level of output). The number of domestic firms, however, now depends also on the degree of product differentiation. More specifically,

$$n_d = \frac{\left\{ \left(\frac{1 + (1 - \theta)\bar{n}_f}{1 + (1 - \theta^2)\bar{n}_f} \right) \left(\frac{a - c_d}{b} \right) - \left(\frac{1 + \bar{n}_f}{1 + (1 - \theta^2)\bar{n}_f} \right) \left(\frac{F_d}{b} \right)^{1/2} - \frac{\theta \bar{n}_f}{1 + (1 - \theta^2)\bar{n}_f} \left(\frac{c_d - c_f}{b} \right) \right\}}{\left(\frac{F_d}{b} \right)^{1/2}} \quad (\text{D3.27})$$

For a foreign firm, the long-run equilibrium output now depends as well on the degree of product differentiation, and it is given by

¹⁰⁷ The parameter θ converts products into compatible unit.

$$q_f = \left(\frac{F_d}{b}\right)^{1/2} \left\{ \frac{\left(1 + (1 - \theta)\bar{n}_f\right)\left(\frac{a - c_d}{b}\right) - \theta\bar{n}_f\left(\frac{c_d - c_f}{b}\right)}{\left(1 + (1 - \theta)n_d\right)\left(\frac{a - c_d}{b}\right) + (1 + n_d)\left(\frac{c_d - c_f}{b}\right)} \right\}, \quad (\text{D3.28})$$

where n_d is given in (D3.27).

As can be seen from (D3.28), the difference between the equilibrium output of a foreign and of a domestic firm is due not only to the technology gap but also to the degree of product differentiation. It follows that the effect of the number of foreign firms on the output of a foreign firm is ambiguous. Although the spillover reduces the foreign firms' cost advantage, the effect of the reduction in cost advantage on their output depends as well on the degree of production differentiation. If the their products are very much differentiated from those of the domestic firms, their equilibrium output may not decrease with an entry.

Thus, the effect of the number of foreign firms on capital demand of each foreign firm is ambiguous. It follows the effect of the number of foreign firms on foreign investment is ambiguous.

For a domestic firm, as in chapter 3, its demand for capital stock decreases with an increasing number of foreign firms. The effect on the number of domestic firms remains ambiguous, but depends as well on the degree of product differentiation. In fact, $\left| \frac{\partial n_d}{\partial \bar{n}_f} \right|$ increases with θ indicating that if for an industry that foreign and domestic

firms produce relatively close substitutes the effect of an increasing number of foreign firms on the number of domestic firms would be relatively strong.

Taken together the partial effect of the number of foreign firms on foreign and domestic investment, we again obtain an ambiguous long-run relationship between foreign and domestic investment.

If there is no technological spillover, the number of domestic firms would decrease with an increasing number of foreign firms, i.e.,

$$\frac{\partial n_d}{\partial \bar{n}_f} = \frac{-\theta}{\left(\frac{F_d}{b}\right)^{1/2} \left(1 + (1 - \theta^2)\bar{n}_f\right)} \left\{ (1 - \theta) \left(\frac{a - c_d}{b}\right) + \theta \left(\frac{F_d}{b}\right)^{1/2} + \left(\frac{c_d - c_f}{b}\right) \right\}$$

(D3.29)

It thus follows that foreign investment would crowd out domestic investment.

E. Numerical Simulation

In this appendix, some concrete examples of the relationship between I_d and I_f are provided using numerical simulation on possible values. The emphasis of the simulation is on the possibility of a positive long-run relationship between I_d and I_f , i.e., $\frac{\partial G^d}{\partial G^f} > 0$. In other words, the emphasis is on the condition of growing investment in the host country, or both $\frac{\partial G^d}{\partial \bar{n}_f}$ and $\frac{\partial G^f}{\partial \bar{n}_f}$ being positive. The case in which positive $\frac{\partial G^d}{\partial G^f}$ is the result of both $\frac{\partial G^d}{\partial \bar{n}_f}$ and $\frac{\partial G^f}{\partial \bar{n}_f}$ being negative can be ignored. The case of positive relationship is chosen to show that, in some market structures, I_f complements I_d . Additionally, the market condition should be such that the domestic firms are able to compete, even if their costs of production are higher than those of the foreign subsidiaries. The last condition implies that at least one domestic firm survives the industrial competition, or $n_d > 0$. The necessary and sufficient conditions under which $n_d > 0$, $\frac{\partial G^d}{\partial \bar{n}_f} > 0$, and $\frac{\partial G^f}{\partial \bar{n}_f} > 0$ simultaneously, are referred to as the conditions for net complementary effect to prevail. Each of these conditions is given below:

- (1) From (B3.2), we have $\frac{\partial G^f}{\partial \bar{n}_f} > 0$ if and only if

$$\left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\} > \bar{n}_f \frac{c_d}{b} \frac{g'(\bar{n}_f)}{g(\bar{n}_f)} \quad (\text{E3.1})$$

The condition (E3.1) states that $\frac{\partial G^f}{\partial \bar{n}_f} > 0$ if and only if the output produced by one

foreign firm is greater than the total reduction in output of the existing $\bar{n}_f$ foreign

firms. $\frac{\partial G^f}{\partial \bar{n}_f} < 0$ otherwise.

(2) From (B3.7), $\frac{\partial G^d}{\partial \bar{n}_f} > 0$ if and only if

$$\left[\left\{ \frac{c_d}{b} \frac{g'(\bar{n}_f)}{g(\bar{n}_f)} - \left\{ \left(\frac{F_d}{b} \right)^{1/2} - \left(\frac{c_d - c_d}{b} \right) - \bar{n}_f \frac{c_d}{b} \frac{g'(\bar{n}_f)}{g(\bar{n}_f)} \right\} \right\} \right] > \left[\frac{g'(\bar{n}_f)}{g(\bar{n}_f)} \left\{ \left\{ \left(\frac{a - c_d}{b} \right) - \left(\frac{F_d}{b} \right)^{1/2} \right\} - \bar{n}_f \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_d}{b} \right) \right\} \right\} \right] \quad (\text{E3.2})$$

(3) Using (2.7), $\frac{\partial n_d}{\partial \bar{n}_f} > 0$ if and only if

$$\frac{c_d}{b} \frac{g'(\bar{n}_f)}{g(\bar{n}_f)} > \left\{ \left(\frac{F_d}{b} \right)^{1/2} + \left(\frac{c_d - c_f}{b} \right) \right\} - \left(\bar{n}_f \frac{c_d}{b} \frac{g'(\bar{n}_f)}{g(\bar{n}_f)} \right) \quad (\text{E3.3})$$

To run a numerical simulation, we first define a specific form of the constant-returns-to scale Cobb-Douglas production function. Outputs of the two type of firms in industry i in period t are thus given by,

$$q_j = A_j l_j^\alpha k_j^{1-\alpha}, \quad j = d, f \quad (\text{E3.4})$$

where q_d , l_d and k_d are, respectively, quantity of output produced, labour employed, and capital stock used by a domestic firm, while q_f , l_f and k_f are the corresponding variables for a foreign subsidiary. The variables A_d and A_f are (Hick-neutral) technology indexes for foreign and domestic firms. The term α is the income share of capital.

The spillover effect on domestic firms is assumed to be exponentially related to the extent of foreign presence. Thus, relative technology of local firms can be written as

$$A_d = g(\beta, \bar{n}_f) A_f = e^{-\frac{\beta}{\beta \bar{n}_f + 1}} A_f, \quad (\text{E3.5})$$

where the spillover parameter β is greater than zero. The partial effect of l_f on l_d is then derived as

$$\frac{\partial G^d}{\partial G^f} = \frac{\delta_d}{\delta_f} \frac{c_d}{c_f} \left(\frac{c_f \left((\beta \bar{n}_f + 1)^2 - \beta \bar{n}_f \right) + (bF_d)^{1/2} \left(\beta (\bar{n}_f + 1) - (\beta \bar{n}_f + 1)^2 \right) + c_d \left(\beta (2 - \beta \bar{n}_f^2) - 1 \right) - \beta a}{-c_f (\beta \bar{n}_f + 1)^2 + (bF_d)^{1/2} (\beta \bar{n}_f + 1)^2 + c_d \left((\beta \bar{n}_f + 1)^2 - \beta \bar{n}_f \right)} \right) \quad (\text{E3.6})$$

where $\frac{c_d}{c_f} = e^{(\frac{1}{\beta \bar{n}_f + 1})}$, and it is assumed for simplicity that $w_{kd} = w_{kf}$. Note that for a given set of market parameters; b , F_d and a , the partial effect can be expressed as a function of $\bar{n}_f$ and β .

To simulate numerically, the necessary and sufficient conditions under which the long-run positive relationship prevails are considered together. To illustrate graphically the necessary conditions under which the positive relationship occurs, we substitute and rearrange the conditions (E3.1), (E3.2), and (E3.3) and thus obtain the necessary conditions (E3.7)-(E3.10) below. Hence, the relationship would be positive only if the conditions (E3.7)-(E3.10) were satisfied simultaneously. These necessary conditions specify the required relation between the policy variable, $\bar{n}_f$ --which reflects the extent of FDI restriction/liberalization--and the spillover parameter, β , for the relationship to be positive. In other words, we obtain positive $\frac{\partial G^d}{\partial G^f}$ only if the parameters β and $\bar{n}_f$ satisfy all the following four necessary conditions:

$$(1) \beta > 0 \quad (\text{E3.7})$$

$$(2) \exp(\beta \bar{n}_f + 1) < \left(\frac{(\beta \bar{n}_f + 1)^2}{(\beta \bar{n}_f + 1)^2 - \beta(\bar{n}_f + 1)} \right) \quad , \quad (E3.8)$$

(3)

$$1 - \exp(\beta \bar{n}_f + 1) \left(1 - \frac{\beta \bar{n}_f}{(\beta \bar{n}_f + 1)^2} \right) < \frac{\exp\left(\frac{1}{\beta \bar{n}_f + 1}\right) \left\{ \beta(2 - \beta \bar{n}_f) - 1 \right\} + \left\{ (\beta \bar{n}_f + 1)^2 - \beta \bar{n}_f \right\}}{\left\{ (\beta \bar{n}_f + 1)^2 - \beta(\bar{n}_f + 1) \right\}} \quad (E3.9)$$

$$(4) \exp(\beta \bar{n}_f + 1) < \left(\frac{(\beta \bar{n}_f + 1)^2 - \beta \bar{n}_f}{(\beta^2 \bar{n}_f^2 - 2\beta + 1)} \right) \quad (E3.10)$$

The above conditions give upper and lower limits on the number of foreign subsidiaries as functions of the spillover parameter, β . Each of these relations results from at least one of the three necessary and sufficient conditions of net complementary effect or combinations of them. The intersection of the necessary conditions (E3.7)-(E3.10) lies in the innermost of these bounds. Outside of these limits at least one or more of the necessary conditions would be violated, i.e., it would be either that $\frac{\partial G^f}{\partial \bar{n}_f} < 0$, or $\frac{\partial G^d}{\partial \bar{n}_f} < 0$, or $n_d < 0$. The innermost of these bounds is illustrated in Figure E3.1.

As shown in Figure E3.1, I_f crowds out I_d , i.e., $\frac{\partial G^d}{\partial \bar{n}_f} < 0$, when there is no spillover, or $\beta = 0$. When the spillover is relatively small, for instance $\beta < 0.5$, the number of foreign subsidiaries in the industry has to be very large for the complementary effect to outweigh substitution effect. However, this is unlikely in an

oligopolistic industry in which number of firms are small. So, in the context of oligopolistic industry we would conclude that for a very small spillover effect, the necessary conditions are violated, so that the net crowding out effect results. From policy perspective, the host government may choose to implement a restrictive FDI policy if the survival of local firms is a priority.

With a moderate level of spillover, for instance $0.5 < \beta < 0.7$, the positive relationship would prevail only if the number of foreign subsidiaries are larger than the lower bound depicted in Figure E3.1. With a relatively moderate spillover effect, the lower bounds of number of foreign subsidiaries being smaller compared to that of the relatively small spillover. With only few foreign subsidiaries in the industry, the spillover effect on a domestic firm would be big enough to outweigh the substitution effect, when the spillover parameter is relatively big. This specific case thus suggests that the industry in which the magnitude of spillover is relatively small should be liberalized to a larger extent in order to capture big enough complementary effect to offset the substitution effect. This would allow local firms to interact with more foreign investors. Otherwise, the technology gap would be so great that domestic firms were unable to compete, and foreign investment would, to some extent, replace the domestic investment. The industry with relatively large spillover effect, however, could afford relatively restrictive FDI.

In sum, this specific case suggests that in an oligopolistic market with a given level of technological disadvantage of domestic firms, the required minimum number of foreign firms that must be allowed in the market becomes smaller as spillover effect

increases. This is because the spillover effect is defined in such a way that the large positive spillover effect on a local firm could either be generated from large β or large $\bar{n}_f$.

Since the required relationships between the number of foreign firms and the magnitude of spillover effect specified in (E3.7)-(E3.10) are non-linear, there are also upper bounds applied to the number of foreign firms for a given level of spillover effect. However, the upper bounds which could have been applied to the number of foreign firms are so great that they become irrelevant in the context of oligopolistic industry.

Figure E3.1. Lower Bounds of the Number of Foreign Firms

Note that the necessary conditions (E3.7)-(E3.10) specify the relationship between $\bar{n}_f$ and β required for positive relationship between foreign and domestic investment to exist. We have yet to consider the necessary and sufficient conditions

under which the relationship is positive. To do so, we specify the lower and the upper bounds of the market size parameter (a), and fixed-variable cost ratio,¹ beyond which either the condition (E3.11) or (E3.12) is violated. The effect of I_f on I_d would be positive if and only if, at a given β , and $\bar{n}_f$ in the specified range shown in Figure E3.1, the market size (a) is in a certain range, or alternatively, a satisfies the following condition :

$$c_d + b(\bar{n}_f + 1) \left(\frac{F_d}{b} \right)^{1/2} + \bar{n}_f (c_d - c_f) < a$$

$$< \left(\bar{n}_f + 1 + b \left(\frac{F_d}{b} \right)^{1/2} \right) - \frac{bF_d}{\beta} (\beta^2 \bar{n}_f^2 - \beta \bar{n}_f - \beta + 1) - \left(\frac{(\beta \bar{n}_f + 1)^2 - \beta \bar{n}_f}{\beta} \right) (c_d - c_f),$$

(E3.11)

and the fixed-variable cost ratio satisfies the following condition:

$$\frac{1 - \exp \left(\frac{1}{\beta \bar{n}_f + 1} \right) \left(1 - \frac{\beta \bar{n}_f}{(\beta \bar{n}_f + 1)^2} \right)}{(b)^{1/2} \bar{s}} < \frac{(F_d)^{1/2}}{\alpha^{-\alpha} (1 - \alpha)^{\alpha-1} w_l^\alpha w_k^{1-\alpha}} < \frac{1 - \exp \left(\frac{1}{\beta \bar{n}_f + 1} \right) \left(1 - \frac{\beta (\bar{n}_f + 1)}{(\beta \bar{n}_f + 1)^2} \right)}{(b)^{1/2} \bar{s}}$$

(E3.12)

If any of the condition (E3.7)-(E3.12) is violated, I_f would crowd out I_d .

The case in which the necessary conditions (E3.7)-(E3.10) and the necessary and sufficient conditions (E3.11)-(E3.12) are satisfied and yield the positive relationship between foreign and domestic investment are illustrated in Figures E3.2

¹ The fixed-variable cost ratio is given by $\frac{(F_d)^{1/2}}{\alpha^{-\alpha} (1 - \alpha)^{\alpha-1} w_l^\alpha w_k^{1-\alpha}}$.

and E3.3. The two figures illustrate examples of industrial structures in which I_f and I_d are complement. At a given level of spillover parameter (β), the number of foreign subsidiaries ($\bar{n}_f$) used in the numerical simulation for the illustration in Figure E3.2 and Figure E3.3 is in the range specified in Figure E3.1 to ensure that the necessary conditions are satisfied. Moreover, the fixed-variable cost ratio employed in simulating the lower and the upper bounds of the market size in Figure E3.2 is consistent with its upper bounds specified in Figure E3.3, i.e., it is under its upper bounds shown in Figure E3.3.

Figure E3.2 shows the variation of the upper and lower limits of the market size parameter (a) with the spillover parameter (β), for a given number of foreign subsidiaries ($\bar{n}_f$), a variable-fixed cost ratio, and foreign technology (A_f).

Figure E3.2. Upper and Lower Bounds of Market Size, a

Figure E3.3 shows the upper bounds of fixed- to variable cost ratio as a function of spillover parameter (β) under which the necessary and the sufficient conditions of positive relationship are satisfied, for a given number of foreign firms, and foreign technology. This can be viewed as an upper limit of fixed cost, beyond which the conditions of net complementary effect cannot be realized, regardless of the spillover effect. This upper limit is seen to decrease with increasing $\bar{n}_f$. Therefore, between two industries with the same foreign technology, A_f , and spillover effect, a more restrictive foreign investment policy should be implemented in the industry with higher fixed-cost.

Figure E3.3: Upper Bounds of Fixed-Variable Cost Ratio

Figure E3.4 illustrates the variation of $\frac{\partial G^d}{\partial G^f}$ with respect to the degree of spillover (β). It shows that $\frac{\partial G^d}{\partial G^f}$ decreases with increasing β . This is due to the assumption of diminishing returns in spillover. This figure also shows that the effect of I_f on I_d is stronger in the industry with higher price elasticity.

Figure E3.4: Variation in $\frac{\partial G^d}{\partial G^f}$ with respect to spillover, β

Figure E3.5 shows the variation of $\frac{\partial G^d}{\partial G^f}$ with respect to number of foreign subsidiaries. Among different industries which experience positive relationship between domestic and foreign investment, the coefficient of the relationship in the industry with lower number of foreign subsidiaries (which may be due to relatively restrictive policy towards FDI) is bigger than that in the industry with more foreign subsidiaries. As opposed to the case of positive relationship, among industries which

experience negative $\frac{\partial G^d}{\partial G^f}$, the net substitution effect is larger in the industry with more foreign presence (or the policy towards FDI is more liberal). It is also the case that the effect of foreign investment on domestic investment is stronger in the industry with higher price elasticity of demand.

Figure E3.5: Variation in $\frac{\partial G^d}{\partial G^f}$ with respect to number of foreign subsidiaries

APPENDIX II. THE DATA

A. The Data

Table A4.1 Foreign direct investment at 1988 prices, 1971-1995

M. Baht	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1971	6	635.8	601.3	148.9	101.3	546.2	134.3	49.1
1972	12.1	852.8	653.4	249.4	311.8	712.8	396.1	22.2
1973	11.8	1448.1	841.3	167.5	1305.5	301.4	108.5	34.5
1974	34.5	2344.6	540.2	223.2	3147.2	287.0	1684.2	20.8
1975	4.6	1479.7	1062.5	413.6	2557.4	356.3	138.0	8.8
1976	2.7	1121.7	784.2	586.2	2218.5	309.7	175.4	11.2
1977	3.0	1742.7	552.6	533.1	3548.2	452.4	203.5	28.6
1978	1.9	1373.7	656.0	175.2	3821.9	423.3	166.8	27.3
1979	8.3	1388.2	621.7	232.6	5978.4	504.8	306.1	84.8
1980	357.9	1766.8	1348.8	651.3	6941.8	1285.0	1008.1	358.3
1981	12.1	4212.3	996.8	763.1	3733.3	1874.5	1131.8	350.9
1982	22.9	3697.2	1066.6	385.3	3730.1	1162.6	2325.5	101.4
1983	84.7	3727.0	2356.6	710.6	5788.6	1052.2	4061.6	466.6
1984	97.5	5711.5	2939.9	375.0	5989.2	1378.5	4544.0	156.6
1985	104.9	2480.1	1911.7	721.9	4048.9	1952.3	611.7	383.7
1986	237.7	3290.1	2665.6	824.3	3108.9	1572.4	309.6	472.2
1987	353.4	6140.0	2342.0	832.7	2209.5	1498.6	329.9	578.2
1988	330.4	18251.0	4143.1	1139.3	6024.5	1901.1	477.6	908.7
1989	650.5	23165.6	7304.5	1539.9	6432.6	3458.4	534.2	1514.2
1990	855.3	29336.0	12322.7	1787.1	18624.3	3201.9	1017.4	1548.6
1991	789.0	22184.3	7463.3	1577.4	21956.0	2920.5	1844.8	2583.0
1992	172.4	17011.0	7105.7	1884.9	19960.0	12342.5	2658.7	2595.1
1993	375.8	19854.2	6991.6	1417.7	16845.7	4826.8	2623.7	1379.7
1994	13.9	16817.5	9637.7	1622.0	13014.2	1809.0	1205.0	1242.6
1995	203.1	21017.8	12257.5	2164.5	16386.9	795.3	1019.5	1606.8

Source: Nominal FDI data are obtained from the Balance of Payment Division, The Bank of Thailand.

The non-residential fixed capital formation deflator are obtained from the National Economic and Social Development Board.

(1) Agriculture, (2) Manufacture, (3) Trade, (4) Transportation and communication, (5) Banking, insurance, and real estate, (6) Construction, (7) Mining and quarrying, (8) Services

Table A4.2 Private domestic investment at 1988 prices, 1971-1995

M. Baht	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1971	23077	13085.2	12319.7	30087.1	5496.7	7293.8	1348.7	1365.9
1972	21404.9	14948.2	12770.6	28390.6	7347.2	9850.0	452.2	1668.9
1973	22367.2	20199.9	18345.7	30375.5	3550.0	10402.0	907.0	1229.5
1974	42035.5	4622.4	16892.8	30647.8	2700.0	10382.0	1055.0	163.8
1975	24231.4	20275.3	17346.5	30630.5	5582.0	11098.0	1301.0	431.0
1976	18017.3	23526.4	19286.8	30133.8	3884.0	11181.0	3925.0	1595.0
1977	20814.0	23533.3	22953.4	37012.9	3378.0	12444.0	1317.0	1832.0
1978	27479.1	22954.3	19577.0	28725.8	1588.0	14721.0	3396.0	1729.0
1979	18075.7	28143.8	20211.9	36314.4	1291.0	15015.0	4610.0	2418.0
1980	16878.1	23549.2	27486.2	35891.7	266.0	22485.0	3348.0	2094.0
1981	19639.9	26390.7	24270.2	35612.9	1860.0	22966.0	3598.0	1411.0
1982	15038.1	20338.8	22007.5	32502.7	2527.0	20060.0	5022.0	9829.0
1983	18542.3	36367.0	20500.4	39244.4	1067.0	21570.0	3153.8	1418.0
1984	13346.5	31715.5	24028.1	31116.0	575.0	26812.0	6401.6	8355.0
1985	19520.1	31860.9	28644.3	20004.1	4350.0	28936.0	3757.0	7712.0
1986	23973.3	37732.9	21116.4	22670.7	3307.0	22658.0	4261.0	1317.0
1987	18459.6	55664.0	30805.0	35957.3	6613.0	25591.0	5967.0	560.1
1988	20021.6	70068.0	38670.9	45753.7	1483.0	63519.0	15769.0	2144.0
1989	20068.5	88481.4	52628.5	70497.1	3311.0	30559.0	11892.0	3827.0
1990	43052.7	137743	75048.3	129590	180.0	77230.0	30351.0	10028.0
1991	86269.0	89257.7	70335.7	85929.7	2748.0	77367.0	11075.0	13204.0
1992	50565.6	125299	77354.3	121078	710.0	86423.0	11415.0	7743.0
1993	62941.2	136878	90145.4	133905	4595.0	90159.0	21158.0	10216.0
1994	84076.1	147375	82557.3	166674	11358.0	89329.0	23397.0	14597.0
1995	83855.9	182361	94436.5	189844	9893.0	87738.0	31507.0	15619.0

Source: The National Economic and Social Development Board.

(1) Agriculture, (2) Manufacture, (3) Trade, (4) Transportation and communication, (5) Banking, insurance, and real estate, (6) Construction, (7) Mining and quarrying, (8) Services

Table A4.3 Real Wages, 1971-1995
(Baht/Year)

	(1)	(2)	(3)	(4)	(5)
1971	4149.4	7004.8	7026.6	8029.2	6557.9
1972	4165.6	7032.1	7054.0	8060.6	6583.5
1973	4359.3	7359.1	7382.0	8435.4	6767.5
1974	5037.6	8504.2	8530.7	9747.9	7120.7
1975	6264.8	10575.9	10608.7	12122.5	10431.7
1976	6603.7	11148.0	11182.7	12778.4	10541.4
1977	6878.4	11611.7	11647.9	13309.9	10670.6
1978	7536.6	10831.1	12077.1	13143.0	11014.3
1979	8520.7	12835.6	13403.8	15127.8	12423.6
1980	8920.7	14367.1	14990.1	16540.3	13743.2
1981	9806.7	16267.0	17694.2	20938.9	15759.5
1982	10357.5	18768.4	19842.6	22522.0	17237.0
1983	11777.2	21090.8	22293.2	25164.0	19799.5
1984	13946.5	23494.6	25252.1	26443.0	21847.4
1985	10447.9	25480.7	24697.2	28407.3	21334.9
1986	10626.7	26716.9	26762.8	27990.4	21746.4
1987	11200.1	25122.4	24201.6	28448.7	21707.5
1988	10836.1	30367.0	28915.6	29695.2	23833.6
1989	11474.0	27390.2	25368.6	30534.7	24533.0
1990	12803.7	29720.9	28260.6	38230.3	27799.5
1991	14358.6	31483.3	29936.4	40497.4	29448.0
1992	1633.9	33277.9	31642.8	42805.8	31126.5
1993	18277.3	34632.3	32930.6	44548.0	32393.4
1994	19141.0	35795.9	34037.1	46044.8	33481.8
1995	20292.5	37653.7	35803.6	48434.5	35219.5

Source: Thailand Development Research Institute

(1) Agriculture, (2) Manufacture, (3) Industry, (4) Services (5) Total

Table A4.4 Real User Cost of Capital, 1971-1995

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1971	0.2660	0.2924	0.3324	0.2729	0.3945	0.2765	0.2752	0.2584
1972	0.2598	0.2863	0.3236	0.2639	0.3985	0.2666	0.2755	0.2639
1973	0.2254	0.2569	0.2909	0.2312	0.3315	0.2271	0.2348	0.2371
1974	0.2130	0.2182	0.2616	0.2033	0.2957	0.1973	0.2141	0.2186
1975	0.2035	0.2330	0.2764	0.2238	0.3247	0.2057	0.2097	0.2239
1976	0.2170	0.2175	0.2210	0.1992	0.2831	0.2358	0.2027	0.2197
1977	0.1852	0.2068	0.2762	0.2045	0.2717	0.1863	0.1957	0.2167
1978	0.1894	0.1936	0.2317	0.1764	0.2545	0.1959	0.1876	0.2105
1979	0.1814	0.1860	0.2174	0.1777	0.2460	0.1915	0.1851	0.2025
1980	0.1819	0.2039	0.2328	0.1980	0.2636	0.2012	0.2092	0.2206
1981	0.2032	0.2025	0.2457	0.1729	0.2488	0.2304	0.1867	0.2506
1982	0.1942	0.1826	0.1891	0.2067	0.2163	0.2218	0.2264	0.1871
1983	0.1292	0.1604	0.1989	0.1444	0.2312	0.1617	0.1680	0.1973
1984	0.2496	0.2115	0.2121	0.2148	0.2400	0.2666	0.2284	0.2157
1985	0.1393	0.2244	0.2292	0.1884	0.2595	0.1586	0.2589	0.2331
1986	0.1673	0.0827	0.1546	0.1504	0.1710	0.1571	0.0206	0.1635
1987	0.0748	0.1700	0.1717	0.1697	0.1944	0.0888	0.1761	0.1738
1988	0.2456	0.1793	0.1644	0.1303	0.1664	0.2523	0.1612	0.1698
1989	0.0669	0.1432	0.1426	0.1719	0.1692	0.0687	0.1515	0.1302
1990	0.1581	0.1372	0.1565	0.1914	0.1601	0.1560	0.1174	0.1610
1991	0.2246	0.2049	0.182	0.2544	0.2416	0.1921	0.2345	0.1591
1992	0.1680	0.1434	0.1304	0.1669	0.1593	0.1581	0.1593	0.1189
1993	0.1897	0.1727	0.1757	0.2067	0.1991	0.1752	0.1770	0.1649
1994	0.1597	0.1498	0.1651	0.1751	0.1817	0.1410	0.1550	0.1607
1995	0.1864	0.1717	0.1795	0.1922	0.1988	0.1722	0.1783	0.1717

Note: (1) Agriculture, (2) Manufacture, (3) Trade, (4) Transportation and communication, (5) Banking, insurance, and real estate, (6) Construction, (7) Mining and quarrying, (8) Services

B. Unit Root Tests Using Time Series

Table B4.1 Time Series Properties of Variables (Levels of the Variables)

	ITOT	IAG	IMIN	ICN	IMNU	ITRAD	ITRN	IBNK	ISER
τ_τ	-0.99	-1.20	-2.20	-1.61	-0.83	-0.87	0.35	-1.41	-1.48
τ_μ	1.04	-0.24	-0.74	0.46	1.39	0.97	2.06	0.31	0.56
τ	2.20	0.76	0.30	1.69	2.71	2.32	2.94	1.23	2.03
	FDI	FAG	FMIN	FCN	FMNU	FTRAD	FTRN	FBNK	FSER
τ_τ	-2.10	-1.97	-3.0	-3.38*	-2.46	-2.15	-2.35	-1.41	-2.62
τ_μ	-0.57	-1.70	-2.87*	-2.37	-0.95	-0.08	-2.29	0.31	-1.05
τ	0.48	-1.17	-1.74	-1.66	-0.11	0.79	-0.74	1.23	-0.34
	CT	CAG	CMIN	CCN	CMNU	CTRAD	CTRN	CBNK	CSER
τ_τ	-3.47*	-3.42*	-4.03**	-3.96*	-4.11**	-2.71	-2.79	-2.84	-3.19
τ_μ	-2.52	-3.13*	-3.30**	-2.83*	-2.90*	-2.43	-3.20**	-3.11**	-1.94
τ	-1.68	-1.08	-1.12	-1.21	-1.41	-2.15	-1.22	-2.56**	-1.30
	WT	WAG	WMNU	WIN	WSER	GNPR			
τ_τ	-2.57	-1.51	-2.49	-2.09	-2.05	0.31			
τ_μ	0.93	0.54	0.85	0.46	1.05	1.59			
τ	3.19	2.42	4.19	4.14	3.11	1.94			

Notes: (1) τ_τ , τ_μ , and τ denote the Augmented-Dickey-Fuller statistics with drift and trend, with drift, and without drift (so that without trend), respectively.

(2) *, **, and *** denote significance at the 10%, 5%, and 1% levels respectively.

APPENDIX III. ADDITIONAL ESTIMATION RESULTS

Table A5.1 Case 1: Sector-specific intercepts, common short- and long-run slope coefficients (t-statistic in parentheses), Case 1

Dependent variable : I_d

	DOLS ^c		DOLS ^c		DOLS ^d		DOLS ^e	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
<i>GNPR</i>	0.01 (0.70)	0.02 (0.16)	0.001 (0.10)	0.005 (0.38)	— —	— —	— —	— —
w_{kd}	515,690 (4.73)***	469,510	476,520 (4.13)***	477,090 (4.15)***	469,920 (4.08)***	480,590 (4.32)***	— —	— —
w_l	1.52 (2.86)**	1.65 (2.87)**	1.63 (2.77)**	1.54 (2.58)**	2.34 (3.47)***	2.28 (3.30)***	— —	— —
<i>FDI</i>	1.68	2.24	2.19	1.89	1.93	2.37	3.06	1.89
(t-stat. for $H_0 : \beta_4 = 0$)	(2.29)**		(3.65)***	(2.61)**	(2.54)**	(3.90)***	(4.77)***	(3.04)***
(t-stat. for $H_0 : \beta_4 = -1$)	(2.68)***		(5.31)***	(3.99)***	(3.85)***	(4.58)***	(6.33)***	(4.64)***
Adjusted R^2	0.79	0.80	0.80	0.80	0.78	0.80	0.71	0.82
Std. error of regression	16,739	14,806	15,050	15,168	15,203	15,130	17,822	11,579
F-stat. for all $\alpha_i = \alpha$ ^a	12.33***		11.36***	11.15***	—	—	—	—
<u>Cointegration tests</u>								
Levin and Lin (1992) ^b	-2.50**	-3.06***	-3.17***	-3.07***	-2.63**	-3.46***	-2.87**	-4.83***

Note: ^a The F-test uses the DOLS pooled regression as the restricted regression

^b The critical value at the 10% significance level is -1.44 and at 5% is -1.81 for Levin and Lin (1992). Test statistics that are negative and greater in absolute value than the critical value indicate that the equations are cointegrated.

^c Include sector-specific constants (version 2).

^d This regression includes sector- and time-specific constants (version 3).

^e Include sector- and time-specific constants (version 1). These results can also be obtained from a

specification where GNPR and its leads and lags are included and drop four time dummies.

(i) and (v) include one lag and one lead of the first-difference term of all explanatory variables.

(ii), (vi), and (vii) includes two leads and two lags for FDI but one lead and one lag for others.

(iii) includes two lags and one lead for FDI but one lead and one lag for others.

(iv) includes one lag and two leads for FDI but one lead and one lag for others.

(viii) includes three lags and three leads of the first-difference of FDI and sector- and time-specific constants.

*, **, and *** test statistic is significant at 10%, 5%, and 1% significance level respectively.

Table A5.2 Sector-specific intercepts and short-run coefficients, common long-run coefficients: Case 2, version 2 (t-statistic in parentheses)

Dependent variable : I_d

	DOLS (i)	DOLS (ii)	DOLS (iii)	SUR (iv)	SUR (v)	SUR (vi)
<i>GNPR</i>	0.003 (0.24)	0.019 (1.77)*	0.012 (1.54)	0.020 (4.75)***	0.016 (3.71)***	0.019 (4.92)***
w_{kd}	411,740 (3.88)***	500,120 (4.87)***	281,280 (3.46)***	307,250 (7.79)***	365,540 (9.33)***	233,534 (11.50)***
w_l	1.50 (2.84)***	0.90 (2.07)**	0.52 (1.40)	0.30 (1.07)	0.60 (2.18)**	0.18 (1.49)
<i>FDI</i>	2.29	2.73	2.30	2.43	2.74	2.58
(t-stat. for $H_0 : \beta_4 = 0$)	(4.05)***	(4.95)***	(1.57)	(11.68)**	(15.59)***	(3.23)***
(t-stat. for $H_0 : \beta_4 = -1$)	(5.81)***	(6.76)***	(2.26)**	(16.48)**	(21.29)***	(4.45)***
Adjusted R^2	0.82	0.86	0.95	—	—	—
Std. error of regression	14,026	12,465	7,312	—	—	—
F-stat. for common short-run coefficients	0.98	1.41	1.78	—	—	—
<u>Cointegration tests</u>						
Levin and Lin (1992)	-3.78***	-4.65***	-8.80***	-2.67***	-2.97***	-8.54***

Note: In columns (i) and (iv), different short-run effects of FDI for the first lead and lag while assuming the same dynamic response of investment to the second lead and lag of the first-difference term of FDI. Common short-run effects of w_{kd} and w_l .

In column (ii) and (v), different short-run effects of FDI and common short-run for others.

In column (iii) and (vi), different short-run effects for all explanatory variables.

Table A5.3 Sector-specific intercepts and short-run coefficients, common long-run coefficients: Case 2, version 3 (t-statistic in parentheses)

Dependent variable : I_d	DOLS (i)	DOLS (ii)	SUR (iii)	SUR (iv)
w_{kd}	393,74 (3.76)***	479,970 (4.24)***	354,928 (9.76)***	390,482 (9.99)***
w_l	2.80 (5.28)***	2.81 (4.56)***	1.57 (4.13)***	0.91 (2.61)***
FDI	2.62	2.75	2.07	2.82
(t-stat. for $H_0 : \beta_4 = 0$)	(5.90)***	(5.01)***	(6.08)***	(16.30)***
(t-stat. for $H_0 : \beta_4 = -1$)	(8.16)***	(6.83)***	(9.02)***	(22.09)***
Adjusted R^2	0.82	0.83	—	—
Std. error of regression	14,033	13,596	—	—
F-stat. for common short-run coefficients	1.42	1.86	—	—
<u>Cointegration tests</u>				
Levin and Lin (1992)	-4.50***	-5.09***	-2.65***	-2.91***

Note: We would have obtained the same results if we run regression with GNPR but drop some of time dummies.

In columns (i) and (iii), different short-run effects of FDI for the first lead and lag while assuming the same dynamic response of investment to the second lead and lag of the first-difference term of FDI. Common short-run effects of w_{kd} and w_l .

In columns (ii) and (iv), different short-run effects of FDI and common short-run for others.

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