Corporate Control, Foreign Ownership Regulations and Technology Transfer*

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October, 2008

Abstract

Multinationals are often required to form joint ventures (JVs) with local firms when entering the host country market. Explicitly taking corporate control into account, we explore the relationship between technology transfer and foreign ownership regulation in the presence of technology spillovers from JVs to local firms. It is shown that foreign ownership regulations may facilitate both technology transfer and spillovers when the multinational has corporate control. Under corporate control by the local partner firm, however, such regulations may hamper technology transfer.

JEL Classification Numbers: F12, F13, F23

Keywords: FDI, joint ventures, ownership regulations, corporate control, technology transfer

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*We thank two anonymous referees, K. Miyagiwa, C. Syropoulos, seminar participants at City University of Hong Kong, Hitotsubashi University, University of Hawaii at Manoa, University of New South Wales, University of Strathclyde and University of Sydney, and attendents at the IEFS Japan Meeting 2004 and the ETSG Conference 2005 for their valuable comments. Any remaining errors are our own responsibility. Jota Ishikawa acknowledges financial support from the MEXT of Japan under the COE Projects, the Japan Economic Research Foundation, the Nomura Research Foundation, and the Japan Securities Scholarship Foundation.

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I Introduction

Regardless of whether it is optimal or not, regulation on foreign ownership is widely observed. Some developed countries impose such regulations in the service industries such as aviation, post and telecommunications, etc. In many developing countries, regulations are also found in manufacturing. Even though the current trend of ' globalization' may help to bring them down to a certain degree, some developing countries require foreign multinational enterprises (MNEs) to form joint ventures (JVs) with local firms, the main goal of which is to learn superior foreign technology.[1]

The existing *theoretical* literature argues that foreign technology transferred in this way can raise the productivity of local firms through technology spillovers from the (partially) foreign owned firms.[2] However, *empirical* plant-level studies have questioned the findings that foreign direct investment (FDI) has a positive impact on the productivity of local firms (see for instance, Haddad and Harrison, 1993; Djankov and Hoekman, 2000; and Saggi, 2002). In particular, using Venezuelan data, Aitken and Harrison (1999) found that an increase in FDI may raise the market share of the partially foreign owned firms, forcing local firms to cut output over the same level of fixed costs.

These empirical findings motivate us to build a theoretical model that may help to explain for the contrasting arguments in the existing literature, and hopefully provide guidance for developing-country governments in designing policies to attract FDI and foreign technology. We wish to analyze how foreign ownership regulation affects corporate control, technology transfer and competition with local independent and partner firms.

We believe that there are two central issues that have not been examined in detail. One is technology spillovers from the (partially) foreign-owned branch to local firms. Such spillovers reduce the multinational's incentives to invest in technology used in the partially owned branch. We examine the interactions in the home market of a domestic incumbent firm with a given inferior technology and a potential foreign entrant with a superior technology. Due to government regulations on foreign ownership, the foreign firm must form a JV with a local firm in order to enter the home market. The JV incurs a setup cost which determines the degree of technology transfer. This new JV technology can further be spilled over to the domestic partner firm.

The other is corporate control, which the existing literature has largely neglected.[3] To be more specific, the existing literature has focused almost exclusively on financial interest, i.e., how profits are shared among joint owners. Corporate control depends on financial interest, but plays markedly different roles. It refers to the right to make the decisions on prices, outputs, investments and where to purchase inputs and locate plants. In a sole proprietorship, a single individual has the right to 100 percent of the firm's profit. The same individual also has complete control over the company. In the case of a partial ownership, nobody has 100 percent ownership. However, a principal shareholder may have 100 percent corporate control and the others have none.

Once corporate control is introduced, it is not hard to see that if the local partner firm does not have a high financial interest, then it may not have much say in the daily decision makings of the jointly owned firm. A direct consequence could be that the foreign technology transferred is at low levels or outdated. The present paper is built along these lines. We consider the simplest case under the following assumptions: the partner with the higher financial interest has 100 percent control of the JV and it thus decides on how much final output to produce. Regardless of who has corporate control, the foreign firm which has superior technology always determines the level of investment in technology. All costs and profits, however, are shared between the parent firms according to their financial interests. The technology developed with the investment is partially spilled over to the local partner firm through the JV.

Specifically, we investigate two settings. In the first one, the foreign firm has corporate control. We find that regulations on foreign ownership facilitate such technology transfer/spillovers. It arises because an increase in the foreign ownership makes the local partner firm more aggressive and the scale of the JV smaller, lowering the incentive for the foreign firm to invest in technology. These imply that given that the foreign firm has majority ownership and corporate control, regulation on foreign ownership may be effective in inducing more investment in technology and in facilitating technology transfer. On the other hand, there are cases where the independent local rival firm benefits from such regulations due to production substitution, which is in line with empirical studies such as Haddad and Harrison (1993), Aitken and Harrison (1999), Djankov and Hoekman (2000) and Saggi (2002), who find that increases in FDI may not necessarily benefit local firms. Since there does not exist any empirical study that simultaneously investigates corporate control, foreign ownership regulation and technology transfer altogether as in the present model, our results might provide pointers for future empirical research.

In the second setting, we allow the local partner firm to have corporate control, and find that regulation on foreign ownership can hamper technology transfer. This is because local corporate control can induce the foreign firm to invest more in technology if spillovers are low. Thus deregulation on foreign ownership encourages more investment in technology and consequently higher spillovers to the local partner. In some cases a lower bound may be desirable. If spillovers are too high, on the other hand, the foreign firm loses interest in technology investment. These findings are supported by empirical evidence. For instance, using data of foreign multinationals in Japan, Nakamura and Xie (1998) find that foreign ownership and transfer of intangible assets are positively related. Mansfield (1994) and Lee and Mansfield (1996) find that in the chemical and other industries, it is often unlikely for U.S. firms to transfer advanced technology to foreign affiliates in which they have a partial interest.[4] In addition, Bai, Tao and Wu (2004) document that Chinese local governments actually design the tax system so as to put a lower bound on foreign ownership in JVs, hoping to attract both capital and technology.

Finally we also investigate the shift of control rights. If the extent of technology spillovers is not too large (resp. sufficiently large), we find that a shift from local to foreign corporate control of the JV results in a discrete drop (resp. rise) of investment in technology and hence spillovers. Thus governments in developing countries must take precaution when designing policies to attract foreign technology. Opposite policies may have to be taken depending on who has control and how large technology spillovers are.

There are a number of papers on foreign ownership and technology transfer that are related to ours.[5] As mentioned earlier, however, the existing studies abstract from analyzing corporate control. For example, Müller and Schnitzer (2006) study JVs and technology transfers, but using a setup of the host-country government and a multinational enterprise. In the present paper, taking corporate control into account and using an oligopolistic framework of three firms, we are able to analyze cases of technology transfer to a local partner firm, regulations on foreign ownership and their impacts on independent rival firms, which give rise to insights that match the findings in the empirical literature.

Dasgupta and Sengupta (1995) also tackle the control problem, using a mechanism-design approach and focusing on transfer pricing. They assume a ‘ control gain’ , the amount of which is private information of the MNE. The host-country government then chooses the optimal regulation of the MNE by maximizing tax revenue, which involves restricting the MNE's ownership and also setting a ceiling on the transfer price of an input that the MNE provides. Bai, Tao and Wu (2004) analyze JV organization and control rights problems under private information and incomplete contractibility, but without technology transfer or spillovers.

The rest of the paper is organized as follows. Section 2 sets up the basic model. Section 3 examines technology transfer and regulation on foreign ownership. And finally, Section 4 concludes the paper.

II The Model

(i) Basic Structure

We consider three firms F, X and Y, interacting in the home market. Firm F is a foreign firm, which can only enter the home market through FDI. However, due to foreign ownership regulations imposed by the home government, it has to form a JV with a local partner X. Firm X may be willing to do so because firm F posses superior technology, which is used in the JV and can potentially be spilled over to firm X. There is also an independent local firm Y, which competes with firm X and the JV.[6] We wish to use this structure to analyze how foreign ownership regulation affects control, technology transfer and competition with local independent and partner firms.

Assume that the JV formed is a completely new plant Z, which produces output z. Firm F owns a share k of the JV, and the other share $(1-k)$ goes to firm X. For simplicity, k is assumed to be exogenously given. With its superior technology, firm F would always choose to go alone (choosing $k = 1$) if allowed. However, we are more interested in how the home government can impose ownership regulation to attract foreign technology, and thus we assume k to be set by the home government.[7] A new investment f is required when setting up the JV.

The inverse demands for the imperfectly substitutable goods are respectively

$$\begin{aligned} p_z &= a_z - z - \gamma(x + y), \\ p_q &= a_q - (x + y) - \gamma z, \end{aligned}$$

where z is the output of plant Z (i.e., the JV), and x and y are those of firms X and Y respectively, with $q = x + y$, and $\gamma \in (0, 1)$ is a parameter indicating the degree of substitutability between the output of the JV and those of the local firms, and a_z and a_q are parameters. Product differentiation can be justified on the grounds that the JV uses superior foreign technology, which potentially leads to products that meet consumer demands better than local ones.

The setup investment f required when building the JV reduces the marginal cost of production. As a result, the total cost of the JV can be written as

$$TC_Z = c(f)z + f,$$

where $c'(f) < 0$, $c(0) = c_X$, $c''(f) > 0$. The variable f can also be called an investment in technology, capacity or R&D. It can only be conducted by firm F, which has superior technology. Then, only firm F can determine how much f to invest. However, the financial interests are arranged such that both partner firms share all costs and profits according to the shares they respectively hold. Thus, firms F and X pay the investment costs kf and $(1-k)f$, respectively.

If the JV is formed successfully, its technology is spilled over to the local partner-firm X, such that:

$$\tilde{c}_X = c_X - g(c_X - c(f)) = c_X - \tau(f), \tag{1}$$

where $g \in (0,1)$ is a parameter and $\tau(f) \equiv g(c_X - c(f))$. However, the technology of the local independent firm Y is not affected.[8]

We focus only on the home market. If the JV is not formed, the foreign firm F cannot enter because of trade costs or host government regulations.[9] Since we are interested in technology transfer, we assume that without foreign entry, the domestic firm cannot invest on its own to improve technology. If the JV is formed, then there are three plants X, Y and Z in the home market.[10] The profit of the JV can be written as:

$$\pi_Z \equiv (p_z - c(f))z - f.$$

Thus, the profits of firms F, X and Y become respectively,

$$\begin{aligned} \pi_F &\equiv k\pi_Z, \\ \pi_X &\equiv \pi_{XX} + (1-k)\pi_Z, \\ \pi_Y &\equiv (p_q - c_Y)y. \end{aligned}$$

where $\pi_{XX} \equiv (p_q - \tilde{c}_X)x$ is the profit from the local plant for partner firm X, which also obtains a share $(1-k)$ of the JV profit.

The following sections examine the effects of ownership regulation on technology transfer, by explicitly taking corporate control into account. We model financial interests and corporate control in a simple way. The partner with the higher financial interest takes total control of the JV; that is, it determines the JV's output. Since there are two cases $k \geq 1/2$ and $k < 1/2$ (if $k = 1/2$, we assume firm F has corporate control since it possesses better technology), we shall investigate them sequentially, given that firm F determines f.

The game has two stages. In the first stage, taking the foreign ownership k as given, firm F chooses the amount of investment on technology. In the second stage, firms compete in a Cournot fashion. The game is solved by backward induction.

(ii) Output Competition Stage

There are three plants X, Y and Z. Firms X and Y determine the outputs of their own plants, x and y, respectively. And the firm holding corporate control determines the output of the JV, i.e., it is firm X if $k < 1/2$ and firm F if $k \geq 1/2$.

Profit maximization with respect to its own output by firms X and Y results in the following first order conditions (FOCs) respectively,

$$p_q - (1-g)c_X - gc(f) - x - (1-k)\gamma z = 0, \tag{2a}$$

$$p_q - c_Y - y = 0. \tag{2b}$$

For the JV, the FOCs for output z are

$$\frac{\partial \pi_X}{\partial z} = (1-k)\left(p_z - c(f) - z\right) - \gamma x = 0, \quad \text{if } k < 1/2; \tag{3a}$$

$$\frac{\partial \pi_F}{\partial z} = k\left(p_z - c(f) - z\right) = 0, \quad \text{if } k \geq 1/2. \tag{3b}$$

The second order condition (SOC) for firm X is satisfied for all k if foreign and local made products are at least slightly differentiated, $\gamma < \sqrt{8/9}$ to be specific. We assume this condition holds throughout this paper. Intuitively, without product differentiation, $\gamma = 1$, then firm X would choose to shut down either plant X or plant Z when it has control over the JV.

Let us introduce an index variable η, which expresses *the control ratio of firm X* to its ownership,

$$\eta = \begin{cases} \frac{1}{1-k} & \text{if} \quad k < 1/2 \\ 0 & \text{if} \quad k \geq 1/2 \end{cases} \tag{4}$$

Using the above, we can express the two FOCs (3a) and (3b) in one equation

$$R - \gamma\eta x = 0, \tag{5}$$

where $R(\equiv p_z - c(f) - z)$ is the marginal profit of output z.

Condition (5) implies that firm X's control ratio, η, and firm X's production scale matter for the determination of output z. In fact, we have the following lemma.

Lemma 1 *When $k < 1/2$ and $\gamma > 0$, an increase in ηx leads the JV to restrict its output.*

The reason is that when $k < 1/2$, firm X has control rights and determines both outputs x and z to maximize its total profits from the JV share and its own plant. When x is large, firm X has an incentive to lower z to reduce its intra-marginal losses. Moreover, when η is large enough, firm X wants to restrict the JV output to raise the profit from plant X.

Although foreign ownership share affects firm X's control ratio, the relationship between

k and η is not monotonic:

$$\frac{d\eta}{dk} = \eta^2 = \begin{cases} \frac{1}{(1-k)^2} & \text{if} \quad k < 1/2 \\ 0 & \text{if} \quad k > 1/2 \end{cases}. \tag{6}$$

Figure 1 illustrates this relationship. When firm X has control ($k < 1/2$), a small increase in foreign ownership leads to a higher control ratio. If the foreign firm holds the control right ($k \geq 1/2$), the control ratio falls to zero and is not affected by any small change in the ownership share. This non-monotonicity of η simply reflects the fact that a 1% increase in ownership does not necessarily entail a 1% increase in the control right.

(iii) Technology Choice Stage

In this stage, given k, firm F decides the level of investment in technology f, i.e.,

$$\max_f \pi_F = k\pi_Z.$$

Using the envelope theorem and (5), the FOC is obtained as

$$\frac{\partial \pi_F}{\partial f} = k\left[-z\left(\gamma\frac{\partial(x+y)}{\partial f} + c'(f)\right) + R\frac{\partial z}{\partial f} - 1\right] = 0. \tag{7}$$

A large $c''(f)$ assures the second order condition.

By the implicit function theorem and (7), we obtain the effect of foreign ownership on investment,

$$\frac{df}{dk} = -\frac{\partial^2 \pi_F/\partial f\partial k}{\partial^2 \pi_F/\partial f^2}. \tag{8}$$

Thus, the sign of $\partial^2 \pi_F/\partial f \partial k$ determines whether an increase in foreign ownership facilitates investment in technology. This is investigated in the next section in detail.

III Technology Transfer

(i) Comparative Statics

Let us derive some expressions that will become handy to determine the sign of $\partial^2\pi_F/\partial f\partial k$. The FOCs (2a), (2b), and (5) determine the outputs $x(f,k)$, $y(f,k)$, $z(f,k)$ as functions of investment and the ownership ratio. Total differentiation gives rise to:

$$\begin{pmatrix} 2 & 1 & \gamma(2-k) \\ 1 & 2 & \gamma \\ \gamma(1+\eta) & \gamma & 2 \end{pmatrix} \begin{pmatrix} dx \\ dy \\ dz \end{pmatrix} = -c'(f) \begin{pmatrix} g \\ 0 \\ 1 \end{pmatrix} df + \begin{pmatrix} \gamma z \\ 0 \\ -\eta R \end{pmatrix} dk \qquad (9)$$

The Hessian is positive, i.e., $\Delta \equiv 6-\gamma^2(3-k)-\gamma^2\eta(3-2k)>0$ from the assumption that $\gamma<\sqrt{8/9}$. By defining a threshold $k_1 \equiv 2\left(1-\gamma^2\right)/\left(2-\gamma^2\right)$, we establish the following lemma, on how the ownership ratio affects outputs.

Lemma 2 *An increase in foreign ownership with a given setup investment, (i) reduces the output of the JV, but raises that of the local partner firm and the sum of the outputs of all local firms; (ii) increases the output of firm Y when $k_1 \leq k < 1/2$ but decreases it when $k \geq 1/2$.*

Proof. In the Appendix. ■

The intuition for Lemma 2 is straightforward from FOCs (2a) and (5). Under foreign corporate control (i.e., $k \geq 1/2$), an increase in foreign ownership lowers firm X's earnings from the JV. Hence, firm X becomes more aggressive and increases its output, which forces other firms to lower their outputs. On the other hand, under local corporate control (i.e., $k < 1/2$), an increase in foreign ownership has an additional effect through an increase in η. From Lemma 1, an increase in η leads to a reduction of z and expansions of x and y. Therefore, the net effect on x is positive, while that on y is generally ambiguous.

The impacts of technology investment on outputs with a given foreign ownership depend on the levels of foreign ownership and the degree of technology transfer. Define four areas A, B, C, and D in Figure 2, each of which expresses a combination of parameters (k, g). Areas A and B are defined for all k : area A is the area where $g < g_x \equiv \gamma(3-2k) / \left(4-\gamma^2\right)$; area B is where $g_z \equiv 3(1-k) / \{\gamma(3-k)\} > g > g_x$ for $k < 1/2$ and $g > g_x$ for $k \geq 1/2$. Areas C and D are defined only for $k < 1/2$: area C is where $g_z < g < g_y \equiv \gamma k(1-k) / \{\gamma^2(2-k) - 2(1-k)\}$; area D is where $g > g_y$.[11] Then, we can summarize the effects of investment on each output in terms of the areas.

Lemma 3

(i) If (k, g) belongs to area A, *then* $\partial x/\partial f < 0$, $\partial y/\partial f < 0$, *and* $\partial z/\partial f > 0$;

(ii) if (k, g) belongs to area B, *then* $\partial x/\partial f > 0$, $\partial y/\partial f < 0$, *and* $\partial z/\partial f > 0$;

(iii) if (k, g) belongs to area C, *then* $\partial x/\partial f > 0$, $\partial y/\partial f < 0$, *and* $\partial z/\partial f < 0$;

(iv) if (k, g) belongs to area D, *then* $\partial x/\partial f > 0$, $\partial y/\partial f > 0$, *and* $\partial z/\partial f < 0$.

Proof. In the Appendix. ■

In the case of foreign corporate control (i.e., $k \geq 1/2$ and $\eta = 0$), two cases (i) and (ii) in Lemma 3 are applied depending on whether or not g is larger than g_x. Since investment improves technologies of the JV and firm X through technology transfer/spillover, it is straightforward that it increases the JV's output and decreases that of the independent local firm. The net change of firm X's output depends on the degree of the technology transfer/spillovers, which offsets the substitution effect due to the expansion of the JV. The threshold g_x falls as foreign ownership rises, because an increase in k makes firm X more aggressive to expand its output.

In the case of local corporate control ($k < 1/2$), the effects of technology investment on outputs are more complicated. The first two cases (i) and (ii) in Lemma 3 are the same as under foreign corporate control. However, cases (iii) and (iv) are not straightforward and arise only under local corporate control. Quite surprisingly, more technology investment may reduce the JV output. The intuition follows from Lemma 1. Under local control, firm X restricts the JV's output to secure its own profit. Since the extent of restriction is increasing in the scale of firm X, large technology spillovers (i.e., $g > g_z$) lead firm X to shift more production from the JV to its own plant, and hence resulting in $\partial z/\partial f < 0$. If the spillovers become sufficiently large (i.e., $g > g_y$), then the JV output is reduced by so much that firm Y can also increase its output, yielding $\partial y/\partial f > 0$. This effect is the most counter-intuitive, since the 100%-locally-owned firm increases its output even when the technology of the other two firms is improved.

Finally, we should mention that the counter intuitive cases (iii) and (iv) hold under low product differentiation (i.e., high γ). In fact, in Figure 2, area C emerges iff $\gamma > \sqrt{2/3} \simeq 0.81$, and area D appears iff $\gamma > \left(1+\sqrt{97}\right)/12 \simeq 0.90$. We draw the cases of intermediate product differentiation ($\gamma = 0.85$) and high product differentiation ($\gamma = 0.5$) in Figures 3 and 4, respectively.

(ii) Control by the Foreign Firm: $k > 1/2$

We are now ready to determine the sign of $\partial^2 \pi_F / \partial f \partial k$. We first look at the case in which firm F holds majority share and hence has corporate control of the JV. From (7), (A1c) in the Appendix, and $R = 0$, we obtain

$$\frac{1}{k}\frac{\partial^2 \pi_F}{\partial f \partial k} = -\frac{\partial z}{\partial k}\left(\gamma \frac{\partial (x+y)}{\partial f} + c'(f)\right) - \gamma z \frac{\partial^2 (x+y)}{\partial f \partial k} = \frac{1}{z}\frac{\partial z}{\partial k} - \gamma z \frac{\partial^2 (x+y)}{\partial f \partial k} < 0, \tag{10}$$

where the inequality holds because (A1d) and (A2c) in the Appendix yield

$$\frac{\partial^2 (x+y)}{\partial f \partial k} = \frac{2\gamma}{\Delta}\frac{\partial z}{\partial f} > 0.$$

Thus,

$$\frac{df}{dk} = -\frac{\partial^2 \pi_F / \partial f \partial k}{\partial^2 \pi_F / \partial f^2} < 0. \tag{11}$$

That is, when the foreign firm has control, an increase in foreign ownership lowers its investment in technology. This arises because given that $k > 1/2$, the foreign firm is already obtaining a majority share of the JV profit. The marginal profit of investment in technology falls with an increase in its ownership share as shown in (10).

Finally, differentiating the technology transfer variable τ with respect to k, we obtain

$$\frac{d\tau}{dk} = -gc'(\cdot)\frac{df}{dk} < 0.$$

Therefore, we can formally state:

Proposition 1 *Under $k > 1/2$, an increase in the foreign ownership share decreases the investment in technology, resulting in less technology spillovers from the JV to the local partner firm.*

In view of Lemma 2, an increase in k raises x and reduces z. When the JV scale shrinks, the technology investment by firm F falls. It arises because keeping the same level of investment becomes costly due to the convexity of the cost function. These results imply that when the foreign firm has majority ownership and hence corporate control, regulation on foreign ownership may be effective in inducing the foreign firm to invest more in technology and in facilitating technology transfer. On the other hand, there are cases where the independent local rival firm benefits from such regulations due to production substitution, which is in line with empirical findings such as those in Haddad and Harrison (1993), Aitken and Harrison (1999), Djankov and Hoekman (2000) and Saggi (2002).

In view of Lemma 2, Lemma 3, and Proposition 1, we can establish the following proposition, on the net effects of foreign ownership on each firm's output.

Proposition 2 *Under $k > 1/2$, an increase in the foreign ownership share raises the output of the local partner firm if $g < g_x$ [i.e. (k, g) belongs to area A in Figure 2], but decreases that of the JV. The effect on the output of the independent local firm is ambiguous.*

Under foreign control, an increase in the foreign ownership share induces firm X to become more aggressive as well as discourages technology investment by firm F. When the extent of technology transfer is small, both effects lead to a rise in the output of firm X and a fall in that of the JV. Since these output changes work in opposite directions, the net effect on the output of the local independent firm Y is ambiguous.

(iii) Control by the Local Partner: $k < 1/2$

When the local partner holds control of the JV, an increase in foreign ownership brings an additional effect on the marginal profit of investment f. Since the marginal profit of the JV, R, is non-zero, the cross partial derivative of firm F's profit is

$$\frac{1}{k}\frac{\partial^2 \pi_F}{\partial f \partial k} = -\frac{\partial z}{\partial k}\left(\gamma \frac{\partial (x+y)}{\partial f} + c'(f)\right) - \gamma z \frac{\partial^2 (x+y)}{\partial f \partial k} + \frac{\partial \left(R\frac{\partial z}{\partial f}\right)}{\partial k}. \quad (12)$$

The first two terms appeared in (10) and it is straightforward to confirm that they remain negative. Regarding the last term, noting $R = \gamma\eta x$, we obtain

$$\begin{aligned} \frac{\partial \left(R\frac{\partial z}{\partial f}\right)}{\partial k} &= \gamma\eta \frac{\partial x}{\partial k}\frac{\partial z}{\partial f} + \gamma\eta x \frac{\partial^2 z}{\partial f \partial k} + \gamma\eta^2 x \frac{\partial z}{\partial f} \\ &= \gamma\eta \left(\frac{R\left(6 - 2\gamma^2 (3-k)\right) + \gamma z \left(4 - \gamma^2\right)}{\Delta}\right)\frac{\partial z}{\partial f} - \frac{3\gamma\eta^2 R}{\Delta}\frac{\partial x}{\partial f}. \end{aligned} \quad (13)$$

When g is large, i.e., both $\partial z/\partial f < 0$ and $\partial x/\partial f > 0$ hold from Lemma 3, the term $\partial\left(R\frac{\partial z}{\partial f}\right)/\partial k$ becomes negative and Proposition 1 continues to hold: foreign ownership discourages investment and technology transfer. However, similarly from Lemma 3, the term $\partial\left(R\frac{\partial z}{\partial f}\right)/\partial k$ becomes positive when g is small that $\partial z/\partial f > 0$ and $\partial x/\partial f < 0$ hold. If g is sufficiently low, the effect of positive $\partial\left(R\frac{\partial z}{\partial f}\right)/\partial k$ outweighs the other negative terms in (12), and then foreign ownership facilitates technology investment and transfer. Defining two thresholds $g_a \equiv 3\gamma k(2-k)/[12\left(1-\gamma^2\right) + k\gamma^2(6-k)]$ and $g_b \equiv [\gamma^2\left(3 + k^2 - 3k\right) - 3(1-k)^2]/\gamma(3-k)\left(k - \gamma^2 + 1\right)$, where $g_a > g_b$, we can formally state:

Proposition 3 *Under $k < 1/2$, (i) When $g \leq g_b$, an increase in the foreign ownership share raises the investment in technology, resulting in more technology spillovers from the JV to the local partner firm. (ii) When $g \geq g_a$, exactly the opposite arises.*

Proof. See the Appendix. ■

In contrast to Proposition 2, Proposition 3 (i) shows foreign ownership facilitates technology investment when the local partner owns control and the technology spillovers are small. In this case, as Lemma 1 states, the output of the JV is set lower than the profit-maximizing level. Thus, if firm F's further investment increases the JV output, it creates a first order positive effect on the JV profit. Lemma 1 says that this marginal profit of investment increases as $R = \eta x$ rises. From Lemma 2, an increase in foreign ownership raises both η and x for a given f, which makes technology investment more appealing. Intuitively, under local control, firm F has added incentive to invest more in order to reduce the local partner's tendency to restrict the JV output. Of course, this argument crucially depends on how much firm F's investment can increase the JV output. Since technology spillovers to firm X weaken this effect, i.e., $\partial^2 z/\partial f \partial g < 0$, we find that foreign ownership increases technology investment only when technology transfer/spillover is sufficiently low.

We should note that for this new effect to dominate the other effects, the degree of product differentiation must be low enough, i.e., γ to be higher than a certain level. For instance, if the JV and firm X do not compete, i.e. $\gamma = 0$, the JV output is chosen to maximize the JV profit even under local control. Figures 4 and 5 draw respectively the cases of high and low product differentiation ($\gamma = 0.5$ and $\gamma = 0.85$). When (k, g) belongs to areas I and II in Figure 5, an increase in foreign ownership reduces investment in technology (Proposition 1 and Proposition 3 (ii)). Area IV represents the range of parameters under which an increase in foreign ownership increases investment (Proposition 3 (i)), while area III represents the range of parameters where the effect is ambiguous. Therefore, $df/dk > 0$ in Area IV requires a low degree of product differentiation, specifically $\gamma > \sqrt{3/7} \simeq 0.65$. This area appears in Figure 5, but not in Figure 4.

Proposition 3 says that both corporate control and technology spillovers are important in determining whether local firms gain or lose from FDI, as explained in the introduction of the paper. Under local corporate control, when technology spillovers are low, the foreign firm has both incentive and necessity to invest in technology, eventually leading to more technology transfer. If technology spillovers are high, such an incentive disappears. These results may help to explain the contrasting findings in the empirical literature.

However, the net effects of an increase in foreign ownership on outputs are generally ambiguous, because both the effects of investment on outputs (Lemma 3) and that of ownership on investment (Proposition 3) vary according to the extent of technology transfer. The following proposition summarizes the cases in which we have clear-cut results in view of Lemma 2, Lemma 3, and Proposition 3.

Proposition 4 *Suppose $k < 1/2$ and $k_1 < 1/2$. An increase in the foreign ownership share, (i) increases the output of the independent local firm if $g_a \leq g < g_y$ and $k > k_1$ hold; (ii) increases the output of the local partner firm if $g_a \leq g \leq g_x$; (iii) and decreases the output of the JV if $g_a \leq g \leq g_z$.*

This proposition says that when spillovers are relatively low and the local firm has corporate control, relaxing foreign ownership regulation may induce more investment in technology and higher spillovers, eventually benefiting local firms by increasing their outputs. These are supported by empirical studies such as Mansfield (1994) and Lee and Mansfield (1996), Nakamura and Xie (1998), and Bai, Tao and Wu (2004), who find that multinationals are more willing to transfer technology with higher control and lower spillovers.

(iv) Discrete Jump: $k = 1/2$

In the previous subsections, we have focused only on small changes of the foreign ownership without transferring corporate control. To complete the analysis of ownership change, we now examine the effect of a shift in control rights at the threshold $k = 1/2$. As seen in Figure 1, the control-ownership ratio η of firm X drops in discrete amount at $k = 1/2$. To focus on this discrete effect, we consider an increase in η while keeping k constant, and examine its effect on technology investment, i.e., $\partial f(k, \eta)/\partial\eta$.

We rewrite variables as functions of (k, f, η) with a tilde. Then, total differentiation of the FOCs in the output competition stage yields

$$\frac{\partial \tilde{x}(k,f,\eta)}{\partial \eta} = \frac{\gamma^2 x(3-2k)}{\Delta} > 0, \frac{\partial \tilde{y}(k,f,\eta)}{\partial \eta} = \frac{k\gamma^2 x}{\Delta} > 0, \text{ and } \frac{\partial \tilde{z}(k,f,\eta)}{\partial \eta} = \frac{-3\gamma x}{\Delta} < 0. \quad (14)$$

The intuition follows from Lemma 1. An increase in η reduces the JV output, which leads to increases in other firms' outputs. It can also be confirmed that the effects of investment remain the same as in the previous section; that is, $\partial\tilde{x}(k, f, \eta)/\partial f = \partial x(f, k)/\partial f$, $\partial\tilde{y}(k, f, \eta)/\partial f = \partial y(f, k)/\partial f$ and $\partial\tilde{z}(k, f, \eta)/\partial f = \partial z(f, k)/\partial f$.

The implicit function theorem yields the sign of $\partial f(k, \eta)/\partial\eta$ as identical to that of $\partial^2\tilde{\pi}_Z(k, f, \eta)/\partial f\partial\eta$. Analogous to (12), the cross derivative is expressed as

$$\frac{\partial^2 \tilde{\pi}_Z(k,f,\eta)}{\partial f \partial \eta} = -\frac{\partial \tilde{z}}{\partial \eta}\left(\gamma \frac{\partial (x+y)}{\partial f} + c'(f)\right) - \gamma z \frac{\partial^2 (\tilde{x}+\tilde{y})}{\partial f \partial \eta} + \frac{\partial\left(R\frac{\partial z}{\partial f}\right)}{\partial \eta}. \quad (15)$$

From Lemma 3 and (14), the first two terms in (15) are negative and the last term is positive when g is small. The following lemma shows that the net effect depends on the size of g.

Lemma 4 *(i)* $\partial f(k, \eta)/\partial\eta > 0$ *if* $g < g_a$, *(ii)* $\partial f(k, \eta)/\partial\eta < 0$ *if* $g > g_x$.

Proof. See the Appendix. ■

Similar to Proposition 3, an increase in η causes two opposite effects on investment. On the one hand, as seen in (14), an increase in η leads firm X to lower the scale of the JV, which tends to decrease the level of technology investment because of the convex cost function $c(f)$. This effect is expressed as the first two terms in (15). On the other hand, the opposite effect is drawn from Lemma 1. An increase in η and x raises the JV's marginal profit $R = \gamma\eta x$, which in turn increases the return from the JV's additional output. Therefore, this effect leads the foreign firm to invest more. Lemma 4 also shows the former effect dominates the latter one when technology spillovers are large, since such spillovers reduce firm F's technology-investment incentive by weakening its effect on the JV output.

From Lemma 4, we can obtain the effects of a discrete change in ownership on the level of investment.

Proposition 5 *There exists a small number $\varepsilon > 0$ such that (i) when $g < g_a$, an increase in the foreign ownership from $k = 1/2 - \varepsilon$ to $k = 1/2 + \varepsilon$ entails a discrete drop of the investment in technology; and (ii) when $g > g_x$, an increase in the foreign ownership from $k = 1/2 - \varepsilon$ to $k = 1/2 + \varepsilon$ entails a discrete rise of technology investment.*

Proposition 5 underlines the importance of taking into account the shift of control rights, when examining the effects of foreign ownership on technology investment. For example, when technology transfer is large such that $g > g_x$, an increase in foreign ownership reduces technology investment within regimes $k \in [0, 1/2)$ and $k \in (1/2, 1]$, but a shift of control rights from the local firm to the foreign firm at $k = 1/2$ improves technology investment. Therefore, empirical analysis that does not consider the shift of control rights may potentially not detect any strong effects of ownership shares on technology investment. More importantly, if developing countries want to attract foreign technology, sometimes it might help to allow higher foreign ownership rather than impose stricter regulations, since such policies might improve the incentives for the foreign firm to invest more in technology, as supported by the empirical evidence cited in the introduction section.

IV Concluding Remarks

We have examined the effects of technology transfer from a foreign firm to a JV and technology spillovers from the JV to the local partner firm in the presence of foreign ownership regulation. We find that both corporate control and technology spillover play key roles, which can help to explain for the contrasting findings in the empirical literature, albeit having been largely neglected. When the multinational has corporate control, it is shown that foreign ownership regulation may facilitate both technology transfer and spillovers, as confirmed in the empirical studies of Haddad and Harrison (1993), Aitken and Harrison (1999), Djankov and Hoekman (2000) and Saggi (2002), who find that increases in FDI may not necessarily benefit local firms. Under corporate control by the local partner firm, however, such regulation may hamper technology transfer. Moreover, it may not benefit the local independent firm either. These findings are supported by empirical studies such as Mansfield (1994) and Lee and Mansfield (1996), Nakamura and Xie (1998), and Bai, Tao and Wu (2004), who find that multinationals are more willing to transfer technology with higher control and lower spillovers.

In concluding this paper, several final remarks are in order. First, we have assumed that firm X and firm F form a JV. It would be interesting to analyze how the foreign firm chooses its partner by introducing competition among local firms. Second, technology spillovers can exist in other forms and in a different direction, such as spillovers of market knowledge from the local partner firm to the foreign firm. Third, control rights may be jointly determined by the two parties, which is more likely to be the case under a fifty-fifty share arrangement. Forth, the welfare effects are ambiguous mainly because the effects on outputs are generally ambiguous. Even if the output effects could be determined, the welfare effects still depend on other factors such as firm productivity. Lastly, the optimal level of regulation when foreign ownership is endogenously determined is also interesting. These remain fruitful avenues for further research.

Appendix

Proof of Lemma 2. Straightforward calculations from (9) give

$$\frac{\partial x}{\partial k} = \frac{\gamma z \left(4-\gamma^2\right) + \gamma \eta R (3-2k)}{\Delta} > 0, \tag{A1a}$$

$$\frac{\partial y}{\partial k} = \frac{\gamma k \eta R - \gamma z \{2-\gamma^2 (1+\eta)\}}{\Delta}, \tag{A1b}$$

$$\frac{\partial z}{\partial k} = -\frac{3\eta R + \gamma^2 z (2\eta+1)}{\Delta} < 0, \tag{A1c}$$

$$\frac{\partial (x+y)}{\partial k} = \frac{\gamma z \left(2+\gamma^2 \eta\right) + \gamma \eta R (3-k)}{\Delta} > 0. \tag{A1d}$$

Lemma 2 is obtained from the fact that $2-\gamma^2(1+\eta) < 0$ in (A1b) holds if and only if $k_1 < k < 1/2$. ■

Proof of Lemma 3. Straightforward calculations from (9) give

$$\frac{\partial x}{\partial f} = \frac{-c'(f)\{g\left(4-\gamma^2\right) - \gamma (3-2k)\}}{\Delta}, \tag{A2a}$$

$$\frac{\partial y}{\partial f} = \frac{c'(f)\left[\gamma k + g\{2-\gamma^2(1+\eta)\}\right]}{\Delta}, \tag{A2b}$$

$$\frac{\partial z}{\partial f} = \frac{-c'(f)\{3-\gamma g(2\eta+1)\}}{\Delta}. \tag{A2c}$$

Under foreign corporate control (i.e., $k \geq 1/2$ and $\eta = 0$), they become

$$\frac{\partial x}{\partial f} = \frac{-c'(f)\{g\left(4-\gamma^2\right) - \gamma (3-2k)\}}{\Delta} > 0, \quad \text{iff } g > g_x,$$

$$\frac{\partial y}{\partial f} = \frac{c'(f)\{\gamma k + g\left(2-\gamma^2\right)\}}{\Delta} < 0,$$

$$\frac{\partial z}{\partial f} = \frac{-c'(f)(3-\gamma g)}{\Delta} > 0.$$

Under local corporate control ($k < 1/2$), by substituting $\eta = (1-k)^{-1}$ into (A2a), (A2b) and (A2c), we obtain

$$\begin{aligned}\frac{\partial x}{\partial f} &= \frac{-c'(f)\{g\left(4-\gamma^2\right)-\gamma\left(3-2k\right)\}}{\Delta} > 0, \quad \text{iff } g > g_x,\\ \frac{\partial y}{\partial f} &= \frac{c'(f)\left[\gamma k\left(1-k\right)-g\{\gamma^2\left(2-k\right)-2\left(1-k\right)\}\right]}{\Delta\left(1-k\right)} < 0, \quad \text{iff } g < g_y,\\ \frac{\partial z}{\partial f} &= \frac{-c'(f)\{3\left(1-k\right)-\gamma g\left(3-k\right)\}}{\Delta\left(1-k\right)} > 0, \quad \text{iff } g < g_z.\end{aligned}$$

By using the fact that $g_y > g_z > g_x > 0$ when $g_y > 0$, we can summarize the effects of investment on each output in terms of parameters (k, g) in Figure 2. ■

Plant X continues to oprerate after the formation of the JV. We show that when the JV is formed, for any investment f, firm X is always willing to continue to produce. This remains true even if we allow transfer payment between firms F and X conditioned on whether firm X continues to operate. ■

We first solve the output and profit of the JV for given x and f from the FOCs. The JV output is

$$z\left(x,f\right) = z\left(0,f\right) - \varepsilon_z x,$$

where

$$\varepsilon_z \equiv \frac{\gamma\left(2\eta-1\right)}{4-\gamma^2} \in (-1,1) \text{ and } z\left(0,f\right) = \frac{2\left(a_z - c\left(f\right)\right) - \gamma\left(a_q - c_Y\right)}{4-\gamma^2}. \quad \text{(A3)}$$

The profit of the JV is decomposed as

$$\begin{aligned}\pi_Z\left(x,f\right) &= \left(p_z - c\left(f\right)\right) z\left(x,f\right) - f\\ &= \left(z\left(x,f\right) + \gamma\eta x\right) z\left(x,f\right) - f \quad \text{(from FOC)}\\ &= \left[z\left(0,f\right)^2 - f\right] + \rho x z\left(x,f\right) - \left(\varepsilon_z x\right)^2\\ &= \pi_Z\left(0,f\right) + \rho x z\left(x,f\right) - \left(\varepsilon_z x\right)^2,\end{aligned}$$

where

$$\rho = (\gamma\eta - 2\varepsilon_z) = \gamma\left(\frac{2-\gamma^2\eta}{4-\gamma^2}\right) > 0.$$

Let x^* be the equilibrium output of firm X when it produces. From the first order condition, the profit from plant X is expressed as

$$\begin{aligned} \pi_{XX}(x^*, f) &= (x^* + \gamma(1-k)\, z(x^*, f))\, x^* \quad \text{(A4)} \\ &> (\varepsilon_z x^*)^2 \ \ \text{(from (A3))}. \end{aligned}$$

Noting $\pi_{XX}(0, f) = 0$, (A3), and (A4), we find that firm X keeps plant X active, because its profit can be increased by doing so:

$$\begin{aligned} &(1-k)\,\pi_Z(x^*, f) + \pi_{XX}(x^*, f) - (1-k)\,\pi_Z(0, f) - \pi_{XX}(0, f) \\ =\ &(1-k)\,\rho x z(x, f) + \pi_{XX}(x^*, f) - (1-k)(\varepsilon_z x^*)^2 > 0. \end{aligned}$$

So far we did not allow any transfer payment between firms F and X. Even if it is allowed, both firms want to maintain firm X's production since their joint profits become higher:

$$\begin{aligned} &\pi_Z(x^*, f) + \pi_{XX}(x^*, f) - \pi_Z(0, f) - \pi_{XX}(0, f) \\ =\ &\rho x z(x, f) + \pi_{XX}(x^*, f) - (\varepsilon_z x^*)^2 > 0. \end{aligned}$$

Therefore, for any investment level f, firm X continues to operate.

Proof of Proposition 3. We drive $\partial^2\pi_Z/\partial f \partial k$ by differentiating $\partial\pi_Z/\partial k$ with respect to

f instead of calculating (12) directly. From FOC (2b), we obtain

$$\begin{aligned}\frac{\partial \pi_Z}{\partial k} &= -\gamma z \frac{\partial (x+y)}{\partial k} + R\frac{\partial z}{\partial k} \\ &= -\gamma^2 \left(\frac{3x^2 + 2\gamma xz(3-k)(1-k) + z^2 (1-k)^2 \left(2(1-k)+\gamma^2\right)}{(1-k)^3 \Delta} \right),\end{aligned}$$

and differentiation yields

$$\frac{\partial^2 \pi_Z}{\partial k \partial f} = \frac{2\gamma^2 x c'(f)}{(1-k)^3 \Delta^2} (xA + zB),$$

where

$$\begin{aligned} A &\equiv \left\{12\left(1-\gamma^2\right) + k\gamma^2 (6-k)\right\}(g-g_a), \qquad \text{(A3)} \\ B &\equiv 2\gamma (1-k)(3-k)\left(1+k-\gamma^2\right)(g-g_b). \end{aligned}$$

Since

$$g_a - g_b = \frac{\Delta^2 (1-k)^2}{\gamma (3-k)(k-\gamma^2+1)\{12(1-\gamma^2) + k\gamma^2 (6-k)\}} > 0,$$

we can conclude that $\partial^2 \pi_Z / \partial f \partial k > 0$, i.e., $df/dk > 0$ when $g \leq g_b$, and $df/dk < 0$ when $g \geq g_a$. ■

Proof of Lemma 4. Similar to the proof of Proposition 3, we obtain the following:

$$\begin{aligned}\frac{\partial \tilde{\pi}_Z(k,f,\eta)}{\partial \eta} &= -\gamma z \frac{\partial (\tilde{x}+\tilde{y})}{\partial \eta} + R\frac{\partial \tilde{z}}{\partial \eta} \\ &= -\frac{\gamma^2}{1-k}\left(\frac{3x^2 + \gamma xz(3-k)(1-k)}{\Delta}\right), \\ \frac{\partial^2 \tilde{\pi}_Z(k,f,\eta)}{\partial \eta \partial f} &= \frac{-\gamma^2}{\Delta}\left[xA + \{3x + \gamma z (3-k)(1-k)\}\frac{\partial x}{\partial f}\right].\end{aligned}$$

Recall $A > 0$ if and only if $g > g_a$ from (A3) and $\partial x / \partial f > 0$ if and only if $g > g_x$ from (A2a).

Since

$$g_x - g_a = \frac{2\gamma\,(3-k)\,(1-k)\,\Delta}{(4-\gamma^2)\,\{12\,(1-\gamma^2) + k\gamma^2\,(6-k)\}} > 0,$$

we have $\partial^2\tilde{\pi}_Z(k, f, \eta)/\partial\eta\partial f > 0$ if $g < g_a$ and $\partial^2\tilde{\pi}_Z(k, f, \eta)/\partial\eta\partial f < 0$ if $g > g_x$. It follows that $df/d\eta > 0$ if $g < g_a$, and $df/d\eta < 0$ if $g > g_z$. And since η drops in a discrete amount at $k = 1/2$, the effect of a change in η outweighs that of a change in k, in the neighborhood of $k = 1/2$. ■

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Notes

[1]For example, in China, the upper limit of foreign ownership is currently 50%. World-leading automakers have been producing in China through JVs with local automakers. Also, in Malaysia, Proton was established as a national car, which is a JV with Mitsubishi Motors.

[2]Papers in this tradition include for instance Horstmann and Markusen (1989), Markusen and Venables (1998) and Ishikawa and Horiuchi (2008). And Vishwasrao and Bosshardt (2001), Dimelis and Louri (2002), Griffith et al. (2002) and Smarzynska Javorcik (2004) find empirical evidence supporting this view for various countries.

[3]Taking corporate control into account explicitly, we examine the effects of trade and industrial policies when exports and FDI coexist elsewhere (Ishikawa et al., 2004).

[4]Mansfield (2000) extends this study to include cases of Germany and Japan, and obtains similar findings.

[5]See Lee and Shy (1992), Marjit and Mukherjee (1998), Mukherjeet and Sengupta (2001), Sinha (2001), Glass and Saggi (2002), Kabiraj and Marjit (2003), Lin and Saggi (2004), and Müller and Schnitzer (2006), among others.

[6]Even if there are more independent local firms, the qualitative nature of our main results remains unchanged.

[7]One could also introduce bargaining to determine the ownership shares. However, this makes the analysis much more complicated. For our purpose, it is sufficient to assume that the foreign ownership share detemined in the bargain is always greater than the upper limit

set by the foreign government.

[8]The presence of spillovers to firm Y would not change the essence of our results as long as the spillovers to firm Y are small.

[9]When firm F has to incur a large fixed cost (say, a beach head cost) to start exports, even a small tariff or transport cost becomes prohibitive.

[10]In the Appendix, we prove that plant X continues to produce even after the formation of the JV.

[11]It follows that $g_y > g_z > g_x > 0$ when $g_y > 0$.

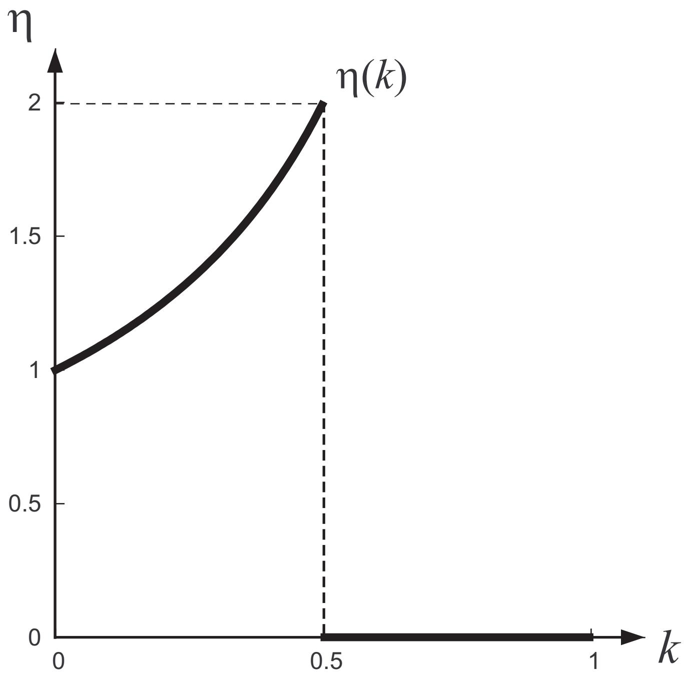

Figure 1: Schedule of the control-ownership ratio

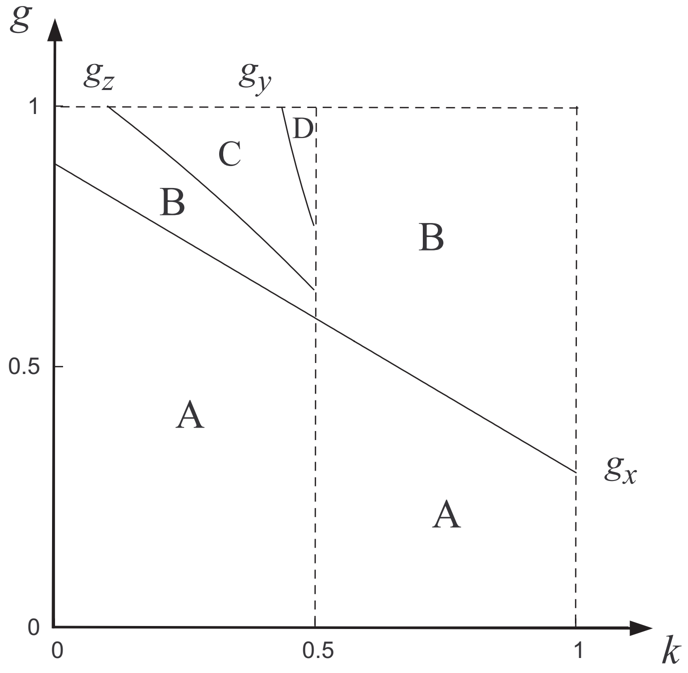

Figure 2: Effect of investment on outputs ($\gamma = 0.93$)

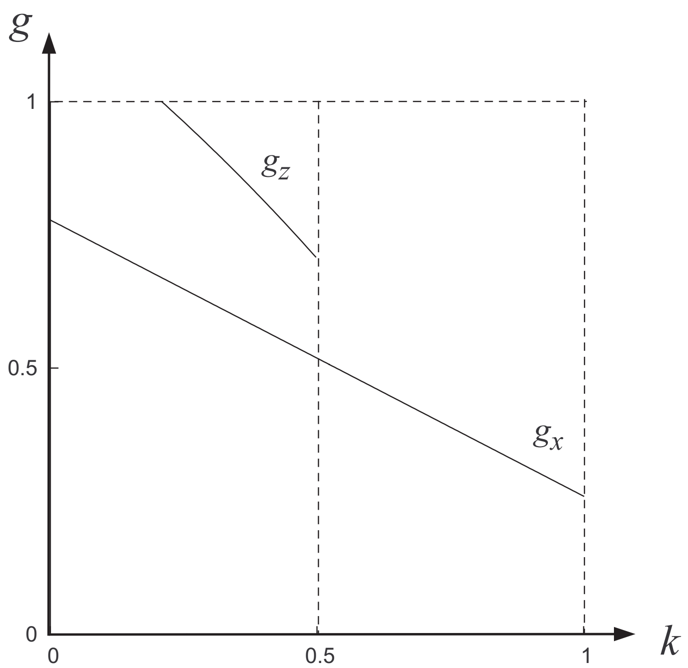

Figure 3: Intermediate product differentiation($\gamma = 0.85$)

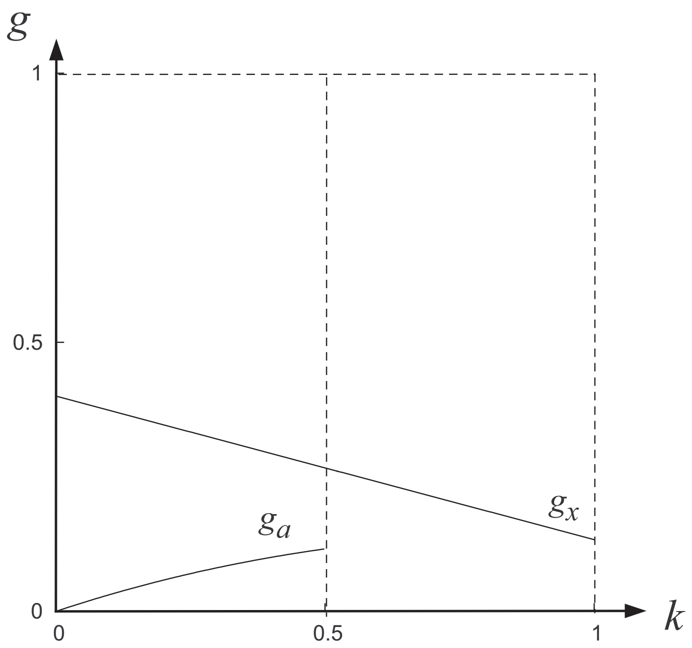

Figure 4: High product differentiation($\gamma = 0.5$)

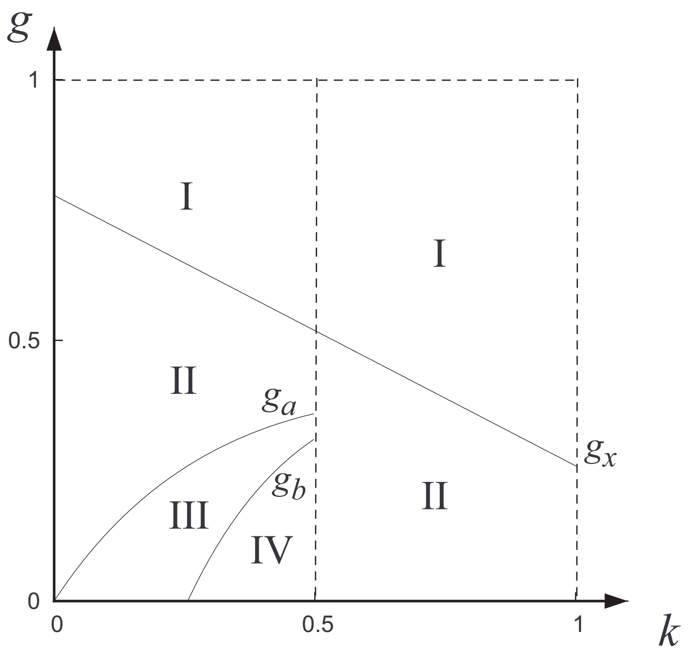

Figure 5: Effect of foreign ownership on investment ($\gamma = 0.85$)