Corporate Control, Foreign Ownership Regulation and Technology Transfer*

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Abstract

It is observed that in order to undertake foreign direct investment (FDI), multinationals are often required to form joint ventures (JVs) with local firms. This paper examines the effects of technology transfer to JVs in the presence of foreign ownership regulation. We specifically consider technology spillover from JVs to local firms, and its relation with corporate control. It is shown that foreign ownership regulation may facilitate both technology transfer and spillover when the multinational has corporate control. Under corporate control by the local partner firm, however, such regulation may hamper technology transfer.

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1 Introduction

Even before the current trend of “globalization”, many developing countries have started to adopt systematic policies to attract foreign direct investment (FDI), such as lower corporate taxes, duty free zones, export subsidies, etc. The goal of such policies is not only to attract foreign capital and increase domestic employment, but also to attract superior foreign technology which comes with FDI. With respect to the latter purpose, joint venture (JV) with local firms is often required. For example, the Chinese government does not allow foreign auto makers to have their own subsidiaries. Thus, all world-leading automakers form JVs with Chinese automakers. To manufacture a national car in Malaysia, Proton was established as a JV with Mitsubishi and Mitsubishi Motors in 1983.

The existing theoretical literature argues that foreign technology transferred in this way has two effects: i) It can raise the productivity of firms that are partially owned by foreign firms; ii) It can raise the productivity of firms that are 100 percent domestically owned, through technology spillovers from the partially foreign owned firms. Papers in this tradition include for instance Horstmann and Markusen (1989) and Markusen and Venables (1998). And Vishwasrao and Bosshardt (2001), Griffith et al. (2002) and Javorcik (2004) find empirical evidence supporting this view for various countries.

However, using Venezuelan data, Aitken and Harrison (1999) found a third effect of FDI, namely, productivity in domestically owned plants declines when FDI increases, because their markets may be stolen by the partially foreign owned firms, forcing local firms to cut output over the same level of fixed costs. Other empirical plant-level studies have also questioned the findings that 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).

These empirical findings motivate us to build a theoretical model that complements

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1 The upper limit of foreign ownership is currently 50%.
2 JV is observed even without foreign ownership regulation. For example, GM and Toyota established a JV called NUMMI in California in 1984.
3 Moreover, Markusen and Venables (1999) even show that the domestic firms may grow to the point where local production overtakes and forces out FDI plants.
the existing literature. We believe that there are two central issues. One is technology spillover 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 neglected so far. 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 that affect the firm. In a sole proprietorship, a single individual has the right to 100 percent of the profit of the firm. The same individual also has complete control over the company, making the decisions about levels of prices, outputs, investments and where to purchase inputs and locate plants, etc. 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 making 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 start with the simplest case: 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 which has superior technology always determines the investment in technology. All costs and profits, however, are shared between the parents according to their financial interests. The technology developed with the investment is partially spilled over.

\footnote{Elsewhere we deal with corporate control through FDI and examine the effects of commercial policies (Ishikawa et al., 2004).}
to the local partner firm.

We consider two settings. In the first one, the foreign firm has corporate control. We find that regulations on foreign ownership facilitate such technology transfer/spillover. This arises because an increase in the foreign ownership share reduces the output of the JV, lowering the incentive for the foreign firm to invest in technology.

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. The foreign firm has incentives to invest in technology if spillover is low. That is, given that technology spillover is small, deregulation on foreign ownership induces more investment in technology and consequently its spillover to the local partner.

There are a few recent papers on foreign ownership and technology transfer that are also related to ours. Lee and Shy (1982) examine the relationship between ownership regulation and technology transfer in a monopoly model. Marjit and Mukherjee (1998) discuss various types of contractual arrangements between a multinational and a local firm, and show that whenever there is a difference between the perceived payoffs from the project, an equity participation is needed. In Sinha (2001), a JV is formed in response to government restriction on foreign ownership just like ours. However, he focuses on the possibility that the JV becomes unstable in a subsequent period when the government removes the restriction. Glass and Saggi (2002) analyze the host-country government’s incentives to attract FDI when FDI bring positive technology spillover. Under conditions that FDI is particularly attractive to the multinational, the government may discourage FDI. Kabiraj and Marjit (2003) focus on the optimal tariff, adding technology transfer to the traditional story. They find that a tariff induces technology transfer, which may benefit consumers rather than hurt them. As such, the optimal tariff is lower under technology transfer. Lin and Saggi (2004) study a JV between a local and a foreign firm who provide complementary inputs. They show that the local firm’s profits may be maximized by assigning a majority share to the foreign firm, because minimization of double moral hazard requires that the firm with the more productive input obtain majority ownership.

As mentioned earlier, these studies abstract from analyzing corporate control. In the present paper, taking corporate control into account and using an oligopolistic framework,
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 gives rise to insights that could match the findings in the empirical literature.

The rest of the paper is organized as follows. Sections 2 sets up the basic model. Section 3 examines technology transfer and regulation on foreign ownership under foreign corporate control. Section 4 analyzes corporate control by the local partner firm. Section 5 investigates corner solutions. And finally, section 4 concludes the paper.

2 The Model

2.1 Basic structure

Consider three firms F, X and Z, 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 joint venture (JV) with a local partner firm Z. Firm Z 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 Z. There is also an independent local firm X, which competes with firms F and Z.

Assume that the JV formed is a completely new plant Y, which produces output y. Firm F owns a share k of the JV, and the other share \((1-k)\) goes to firm Z. A new investment f is required when setting up the JV.

The inverse demands for the imperfectly substitutable goods Y and Z are given respectively as

\[ p_y = a_y - y - \gamma(z+x), \]  
\[ p_q = a_q - (z+x) - \gamma y, \]

where y is the output of plant Y (i.e., the JV), z and x are those of firms Z and X respectively, with \( q = z+x \), and \( \gamma \in (0,1) \) is a parameter indicating the degree of substitutability between the output of the JV and those of local firms, and \( a_y \) 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 required when building the JV reduces the marginal cost of production. As a result, the total cost of the JV can be written as

$$TC_Y = c(f)y + f,$$

where $c'(f) < 0$, $c(0) = c_Z$, $c''(f) > 0$. 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 to invest in $f$. 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 Z 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 Z, such that:

$$\bar{c}_Z = c_Z - g(c_Z - c(f)),$$

where $0 < g < 1$, is a parameter. However, the technology of the local independent firm X is not affected.

We focus only on the home market. If the JV is not formed, the foreign firm F cannot enter. 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 Y, Z and X in the home market. The profits of the JV can be written as:

$$\pi_Y \equiv \{p_y - c(f)\}y.$$

Thus, the profit functions of firms F, Z and X become respectively,

$$\pi_F = k(\pi_Y - f),$$
$$\pi_Z = \pi_ZZ + (1-k)(\pi_Y - f),$$
$$\pi_X \equiv (p_q - c_X)x.$$

where $\pi_ZZ \equiv (p_q - \bar{c}_Z)z$ is the profit from the local plant for partner firm Z, which also obtains a share $(1-k)$ of the JV profit.

We model financial interests and corporate control in a simple way. The foreign ownership share of the JV $k$ is determined through bargaining between the parent firms.
F and Z, such that the partner with the higher financial interest takes total control of the JV; that is, it determines the JV 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 $f$.

### 2.2 Timing

The timing of the game can be written as follows:

1. Taking the upper limit on foreign ownership, $k$, as given, firm F offers the ownership ratio $(1 - k)$ to firm Z, to form the JV.

2. If firm Z rejects the offer, the JV is not formed; there is no technology spillover, and firm F does not enter the home market but receives a reservation payoff $u(\equiv 0)$.

3. If the JV is formed, the investment in technology $f$ is chosen by firm F, and firms F and Z respectively pay the costs $kf$ and $(1 - k)f$.

4. The partner with corporate control chooses output $y$ for the JV, and simultaneously firms F and Z choose $x$ and $z$ with Cournot conjectures.

The game is solved by backward induction, by going from output competition to technology investment and spillover, and finally to the determination of ownership shares. For convenience, we start with the benchmark case without the JV. Due to government regulations on foreign ownership, if either firm X or firm Z does not agree to form the JV, firm F cannot enter and firms X and Z become duopolists in the home market. Their outputs and profits are respectively

$$x_0 = \frac{a_q - cX + cZ}{3}, \quad \pi_{X0} = x_0^2; \quad (7)$$

$$z_0 = \frac{a_q - cZ + cX}{3}, \quad \pi_{Z0} = z_0^2. \quad (8)$$

This serves as the threat point at the bargaining stage.
3 Corporate Control by the Foreign Firm F: $k \geq 1/2$

If both partners agree to form the JV, then there are three plants X, Y and Z, competing against each other. We first look at the case in which firm F holds majority shares (i.e., $k \geq 1/2$) and hence has total corporate control of the JV.

3.1 Output competition stage

With corporate control, the foreign firm determines the output of the JV, $y$, as well as the setup cost, $f$. And firms X and Z determine the outputs of their own plants, $x$ and $z$.

Profit maximization results in the following first order conditions (FOCs) respectively,

$$p_q - c_X - x = 0, \quad (9)$$
$$p_y - c(f) - y = 0, \quad (10)$$
$$p_q - (1 - g)c_Z - gc(f) - z - (1 - k)y\gamma = 0. \quad (11)$$

It is useful to rewrite the profits of respective firms by using the FOCs:

$$\pi_X = \{p_q - c(f)\}x = x^2, \quad (12)$$
$$\pi_Y = \{p_y - c(f)\}y = y^2, \quad (13)$$
$$\pi_{ZZ} = (p_q - \tilde{c}_Z)z = z^2 + (1 - k)\gamma yz. \quad (14)$$

Further, total differentiation results in the profit change of firm Z as follows:

$$d\pi_Z = -z\{dy + gc'(f)df\} - (\pi_Y - f)dk - (1 - k)\{yc'(f) + 1\}df. \quad (15)$$

Total differentiation of the above FOCs, we obtain the following matrix:

$$\begin{pmatrix}
-2 & -\gamma & -1 \\
-\gamma & -2 & -\gamma \\
-1 & -(2 - k)\gamma & -2
\end{pmatrix}
\begin{pmatrix}
dx \\
dy \\
dz
\end{pmatrix}
= \begin{pmatrix}
0 \\
0 \\
-\gamma y
\end{pmatrix}
dk + c'(\cdot)
\begin{pmatrix}
0 \\
1
\end{pmatrix}
df,
$$

$$\begin{pmatrix}
dx \\
dy \\
dz
\end{pmatrix}
= \frac{1}{H}
\begin{pmatrix}
(k - 2)\gamma^2 + 4 & -\gamma k & \gamma^2 - 2 \\
-\gamma & 3 & \gamma \\
(2 - k)\gamma^2 - 2 & -(3 - 2k)\gamma & 4 - \gamma^2
\end{pmatrix}
\begin{pmatrix}
0 \\
0 \\
-\gamma y
\end{pmatrix}
dk + c'(\cdot)
\begin{pmatrix}
0 \\
1
\end{pmatrix}
df.$$
The Hessian is \[ H = -6 + (3 - k)\gamma^2 < 0 \text{ if } k \geq 1/2. \]

Straightforward calculations give,

\[
\frac{dx}{dk} = \frac{(2 - \gamma^2)y\gamma}{H} < 0, \tag{16}
\]
\[
\frac{dy}{dk} = \frac{y\gamma^2}{H} < 0, \tag{17}
\]
\[
\frac{dz}{dk} = \frac{-(4 - \gamma^2)y\gamma}{H} > 0, \tag{18}
\]
\[
\frac{d(y + z)}{dk} = \frac{-(4 - \gamma - \gamma^2)y\gamma}{H} > 0, \tag{19}
\]
\[
\frac{d(x + z)}{dk} = \frac{-2y\gamma}{H} > 0, \tag{20}
\]
\[
\frac{d(x + y + z)}{dk} = \frac{-y\gamma(2 - \gamma)}{H} > 0. \tag{21}
\]

When foreign ownership share \( k \) rises, only firm Z’s FOC (11) is affected. Given \( y \), the reaction curve of firm Z shifts upwards on the \( x-z \) plane. That is, other things being equal, an increase in \( k \) lowers the profits of firm \( z \) and hence firm \( z \) becomes more aggressive. This increases \( z \) and decreases \( x \) because of strategic substitutes, but the increase in \( z \) outweighs the decrease in \( x \) and hence \( (x + z) \) rises, which in turn lowers \( y \).

These effects can be summarized in Lemma 1.

**Lemma 1** Under foreign corporate control of the JV, an increase in foreign ownership with given setup investment reduces the output of the independent local firm and that of the JV, but raises that of the local partner firm, the sum of the outputs of all local firms and that of the total industry.

Next, the impact of technology investment is derived as,
\[
\frac{dx}{df} = \frac{-k\gamma - (2 - \gamma^2)g}{H} c'(\cdot) < 0, \quad (22)
\]
\[
\frac{dy}{df} = \frac{3 - \gamma g}{H} c'(\cdot) > 0, \quad (23)
\]
\[
\frac{dz}{df} = \frac{(4 - \gamma^2)g - (3 - 2k)\gamma}{H} c'(\cdot) > 0 \Leftrightarrow g > g_1 \equiv \frac{(3 - 2k)\gamma}{(4 - \gamma^2)}, \quad (24)
\]
\[
\frac{d(y + z)}{df} = \frac{(4 - \gamma^2 - \gamma)g + 3(1 - \gamma) + 2k\gamma}{H} c'(\cdot) > 0, \quad (25)
\]
\[
\frac{d(x + z)}{df} = \frac{2g - (3 - k)\gamma}{H} c'(\cdot), \quad (26)
\]
\[
\frac{d(x + y + z)}{df} = \frac{(2 - \gamma)g + 3(1 - \gamma) + k\gamma}{H} c'(\cdot) > 0. \quad (27)
\]

It is straightforward that an increase in \( f \) raises \( y \), which in turn lowers \( z \) (a substitution effect). However, given \( k \geq 1/2 \), it can be shown that \( dz/df > 0 \) if \( g > g_1 \). Here, \( g \) is the parameter representing technology transfer (spillover) from the JV to firm Z. An increase in \( f \) also leads to more technology transfer for any given \( g \). This effect works against the substitution effect by the increase in \( y \). If \( g \) is high enough, then the increase in \( z \) due to technology transfer outweighs the reduction due to substitution. In any case, the sum of effects on outputs \((y + z)\) and on that of the total industry \((x + y + z)\) are always positive.

Nevertheless, the independent local firm’s output is squeezed out by foreign technology investment. The impact on the total output of local firms \((x + z)\) is ambiguous. Again, as enough technology is transferred to firm Z, specifically, if \( g > 5\gamma/4 \) given \( k \geq 1/2 \), then we find \( d(x + z)/df > 0 \).

We summarize the above as:

**Lemma 2** Under foreign corporate control, an increase in foreign technology investment with given ownership share raises the output of the JV, the sum of the outputs of the JV and the local partner, and the industry’s total output. But it reduces the output of the independent local firm. The output of the local partner and the sum of the outputs of all local firms increase only if enough foreign technology is transferred.
3.2 Technology Transfer Stage

Let us derive some expressions that will become handy soon. Total differentiation yields the changes of profit functions as follows:

\[
d\pi_Y = -\gamma y(dx + dz) - yc'(f)df, \quad (28)
\]

\[
d\pi_{ZZ} = \gamma y(1 - k)dz - z(dx + \gamma dy) - gzc'(f)df, \quad (29)
\]

\[
d\pi_F = -k\gamma y(dx + dz) - k\{yc'(f) + 1\}df + (\pi_Y - f)dk, \quad (30)
\]

\[
d\pi_Z = -\gamma zd y - [z + (1 - k)\gamma y]dx
\]

\[-\{(1 - k)y + gz\} c'(f) + (1 - k)\}df - (\pi_Y - f)dk. \quad (31)
\]

In the technology transfer stage, given \(k\), firm F decides the level of investment in technology \(f\), i.e.,

\[
\max_f \pi_F = k(\pi_Y - f).
\]

Using the envelope theorem, the FOC and second order condition (SOC) are respectively given by

\[
\frac{d\pi_F}{df} = -k \left( \gamma y \frac{d(x + z)}{df} + yc'(f) + 1 \right)
\]

\[
= k \left( \frac{yc'(f)(6 - 2\gamma g)}{H} - 1 \right) = 0,
\]

\[
\frac{d^2\pi_F}{df^2} = \frac{k(6 - 2\gamma g)}{H} \left( yc'' + \frac{dy}{df} c'(f) \right) < 0, \text{ if } c'' \text{ is large enough.}
\]

By the implicit function theorem, we also obtain

\[
\frac{df}{dk} = -\frac{\partial^2\pi_F / \partial f \partial k}{\partial^2\pi_F / \partial f^2},
\]

where

\[
\frac{\partial^2\pi_F}{\partial f \partial k} = \frac{1}{k} \frac{d\pi_F}{df} + k \left[ \frac{c'(f)(6 - 2\gamma g)}{H} \frac{dy}{dk} - \frac{yc'(f)(6 - 2\gamma g)}{(H)^2} \frac{dH}{dk} \right]
\]

\[
= \frac{2k\gamma^2 yc'(f)(6 - 2\gamma g)}{H^2} < 0. \quad (33)
\]

That is, \(df/dk < 0\). An increase in the foreign ownership share raises the setup costs but reduces the output and profits of the JV, lowering firm F’s incentives to invest in technology.
From (3), we can define technology spilled over from the JV to the domestic partner firm as

\[ \tau = g(c_Z - c(f)). \]

Differentiation yields

\[ \frac{d\tau}{dk} = -gc'(c) \frac{df}{dk} < 0. \]  

Therefore, we can formally state:

**Proposition 1** An increase in the foreign ownership share decreases the parents’ investment in technology, eventually resulting in less technology spillover from the JV to the local partner firm.

Moreover, in view of Lemmas 1 and 2 and Proposition 1, the following proposition can be obtained:

**Proposition 2** An increase in the foreign ownership share increases the output of the local partner firm if \( g < g_1 \) and decreases that of the JV. The effect on the output of the independent local firm is ambiguous.

We find that when the foreign firm has majority ownership and corporate control, regulation on foreign ownership may be effective in facilitating technology transfer. In view of (12), the profits of firm X rise if and only if its output rises. Thus, we have

**Corollary 1** An increase in the foreign ownership share may benefit the independent local firm.

### 3.3 Ownership Stage

Finally we come to the ownership stage, in which firm F gives firm Z a "take-it-or-leave-it" offer of the foreign ownership share \( k \), which must be less than the legal limit \( k \). Firm Z accepts the offer if and only if \( \pi_Z \geq \pi_Z^0 \). Thus, firm F solves the following problem:

\[
\begin{align*}
\max_k \pi_F &= k(\pi_Y - f), \\
\text{s.t. } \pi_Z &\geq \pi_Z^0 \text{ and } 0 < k \leq \overline{k}.
\end{align*}
\]
Ignore the constraints for the moment. Using the envelop theorem, we obtain

\[ \frac{d\pi_F}{dk} = (\pi_Y - f) + k \frac{\partial\pi_Y}{\partial k} = 0. \]  

Let \( \hat{k} \) denote the value of \( k \) that satisfies the above equation. If \( \hat{k} < \bar{k} \) and \( \pi_Z \geq \pi_{Z0} \) at \( k = \hat{k} \), the foreign ownership regulation is not binding. Since this case is not very interesting to analyze, we focus on the case where \( \hat{k} > \bar{k} \) and \( \pi_Z > \pi_{Z0} \) at \( k = \bar{k} \); that is, the foreign ownership regulation is binding and firm Z accepts the offer. When \( \pi_Z > \pi_{Z0} \) at \( k = \bar{k} \), the inequality remains to hold even if \( \bar{k} \) increases as long as the increase is small enough. In fact, it is unlikely that firm F makes \( \pi_Z = \pi_{Z0} \) hold by choosing only \( k \) in the presence of the constraint \( 0 < k \leq \bar{k} \).

4 Corporate Control by the Local Partner: \( k < 1/2 \)

In this section, we consider local corporate control. The local partner firm Z holds majority share of the JV, and has corporate control, which enables it to determine the level of the JV output \( y \), as well as that of its own \( z \). However, the investment in technology, \( f \), is still determined by the superior technology provider, firm F. And firm X independently chooses \( x \).

4.1 Output Competition Stage

The FOCs for choosing outputs can be written as

\[ p_q - cx - x = 0, \]  

\[ (1 - k)[p_y - c(f) - y] - yz = 0, \]  

\[ p_q - (1 - g)cz - gc(f) - z - (1 - k)y\gamma = 0. \]

It is useful to rewrite the profits of respective firms by using the FOCs:
\[
\pi_X = (p_y - c(f))x = x^2, \\
\pi_Y = (p_y - c(f))y = y^2 + \frac{\gamma y z}{1-k}, \\
\pi_{ZZ} = (p_y - \tilde{c}_Z)z = z^2 + (1-k)\gamma y z.
\]

Total differentiation of the above FOCs, we obtain the following matrix:

\[
\begin{pmatrix}
-2 & -\gamma & -1 \\
-\gamma(1-k) & -2(1-k) & -\gamma(2-k) \\
-1 & -(2-k)\gamma & -2
\end{pmatrix}
\begin{pmatrix}
dx \\
dy \\
dz
\end{pmatrix}
= \begin{pmatrix}
0 \\
R_y \\
-\gamma y
\end{pmatrix}
dk + c'(\cdot)
\begin{pmatrix}
0 \\
(1-k) \\
g
\end{pmatrix}
df,
\]

where \[R_y = p_y - c(f) - y > 0\] is the marginal profit of the JV.

\[
\begin{pmatrix}
dx \\
dy \\
dz
\end{pmatrix}
= \frac{1}{\Delta}
\begin{pmatrix}
4(1-k)(1-\gamma^2) - k^2\gamma^2 & -\gamma k & -[2(1-k) - (2-k)\gamma^2] \\
\gamma k & 3 & -\gamma(3-k) \\
(k-1)(k\gamma^2 - 2\gamma^2 + 2) & \gamma(2k-3) & (4-\gamma^2)(1-k)
\end{pmatrix}
\begin{pmatrix}
0 \\
R_y \\
-\gamma y
\end{pmatrix}
dk + c'(\cdot)
\begin{pmatrix}
0 \\
(1-k) \\
g
\end{pmatrix}
df,
\]

where we assume \[\Delta \equiv 6k + 6\gamma^2 - 6k\gamma^2 + k^2\gamma^2 - 6 < 0\]. Since \[d\Delta/dk < 0\], for any \[k \leq 1/2\], we have \[\Delta < 0\] if \[\gamma^2 < 12/13\].

Note that \[\Delta_{yz} = \begin{vmatrix}
-2(1-k) & -(2-k)\gamma \\
-(2-k)\gamma & -2
\end{vmatrix} = 4(1-k) - (2-k)^2\gamma^2 > 0\] is a necessary condition for profit maximization. This condition is generally satisfied because for any \[k \leq 1/2\], we obtain \[\Delta_{yz} > 0\] if \[\gamma^2 < 8/9\].

Straightforward calculations give,
\[
\begin{align*}
\frac{dx}{dk} &= -\gamma k R_y - \gamma y A(k) \frac{\Delta}{\Delta} < 0 \text{ if } A(k) < 0, \quad (44) \\
\frac{dy}{dk} &= 3R_y + (3 - k) \gamma^2 y \frac{\Delta}{\Delta} < 0, \quad (45) \\
\frac{dz}{dk} &= -(3 - 2k) \gamma R_y + (4 - \gamma^2) (1 - k) \gamma y \frac{\Delta}{\Delta} > 0, \quad (46) \\
\frac{d(x + z)}{dk} &= -(3 - k) \gamma R_y + \gamma y (\gamma^2 - 2k + 2) \frac{\Delta}{\Delta}. \quad (47)
\end{align*}
\]

Note that in (44), we obtain \( A(k) \equiv 2(1 - k) - (2 - k)\gamma^2 < 0 \) if and only if \( k_1(\equiv 2(1 - \gamma^2)/(2 - \gamma^2)) < k < 1/2 \). Since \( k_1 - 1/2 = (2 - 3\gamma^2)/(2 - \gamma^2) \), we have

**Lemma 3**  
(i) \( A(k) < 0 \) if \( k_1 < k < 1/2 \). (ii) \( A(k) > 0 \) for all \( k < 1/2 \) if \( \gamma^2 < 2/3 \).

Comparing (44)–(47) to (16)–(21), we have

**Corollary 2** If \( k > k_1 \), then Lemma 1 holds even under local corporate control of the JV.

Next, regarding the impact of foreign investment on technology, we derive,

\[
\begin{align*}
\frac{dx}{df} &= -c'(\cdot)[(1 - k)\gamma k + gA(k)] \frac{\Delta}{\Delta} < 0 \text{ if } A(k) > 0, \quad (48) \\
\frac{dy}{df} &= c'(\cdot) [3(1 - k) - (3 - k)g] \frac{\Delta}{\Delta} > 0, \iff g < \frac{3(1 - k)}{(3 - k)\gamma} \equiv g_3, \quad (49) \\
\frac{dz}{df} &= c'(\cdot)(1 - k) [g (4 - \gamma^2) - (3 - 2k)\gamma] \frac{\Delta}{\Delta} > 0, \iff g > g_1 \quad (50)
\end{align*}
\]

Note that when \( A(k) < 0 \), we obtain \( dx/df > 0 \) if and only if \( g > -(1 - k)\gamma k/A \equiv g_3 \). Also, if \( A(k) < 0 \), then

\[
\begin{align*}
g_3 - g_2 &= \frac{(1 - k)\Delta}{(3 - k)A\gamma} > 0, \\
g_2 - g_1 &= \frac{-2\Delta}{(4 - \gamma^2)(3 - k)\gamma} > 0.
\end{align*}
\]

Thus, we have the following cases:
Lemma 4 (i) Suppose $A(k) > 0$ with given $k$. Then,

\begin{align*}
\text{if } g > g_2, & \quad dx/df < 0, \quad dy/df < 0, \quad \text{and } dz/df > 0; \\
\text{if } g_2 > g > g_1, & \quad dx/df < 0, \quad dy/df > 0, \quad \text{and } dz/df > 0; \\
\text{if } g_1 > g, & \quad dx/df < 0, \quad dy/df > 0, \quad \text{and } dz/df < 0. \\
\end{align*}

(51)

(ii) Suppose $A(k) < 0$ with given $k$. Then,

\begin{align*}
\text{if } g > g_3, & \quad dx/df > 0, \quad dy/df < 0, \quad \text{and } dz/df > 0; \\
\text{if } g_3 > g > g_2, & \quad dx/df < 0, \quad dy/df < 0, \quad \text{and } dz/df > 0; \\
\text{if } g_2 > g > g_1, & \quad dx/df < 0, \quad dy/df > 0, \quad \text{and } dz/df > 0; \\
\text{if } g_1 > g, & \quad dx/df < 0, \quad dy/df > 0, \quad \text{and } dz/df < 0. \\
\end{align*}

(52)

Careful comparison of these cases gives rise to the following:

Corollary 3 Under local corporate control of the JV $(k < 1/2)$ and given ownership share, we obtain (i) $dy/df < 0$ if $g > g_2$; (ii) $dz/df < 0$ if $g < g_1$; (iii) $dx/df > 0$ if $g > g_3$; (iv) $dy/df > 0$, $dz/df > 0$ and $dx/df < 0$ for all other cases.

Some intuition follows. Case (iv) is the same as under foreign corporate control. However, the other three cases are just the opposite and counter intuitive. To understand them fully, let us compare the FOCs in the output competition stage for both cases of foreign and local corporate control. Under foreign corporate control, firm F decides on both $y$ and $f$. That is, it can always choose optimal levels of both variables such that $dy/df > 0$. In contrast, under local corporate control, $y$ is determined by firm Z. As is clear from FOCs (10) and (38), for any given $f$, $y$ is always smaller under local corporate control. Thus for low levels of technology spillover (specifically $g < g_2$), we still obtain $dy/df > 0$. However, if technology spillover is high such that $g > g_2$, then further investment in technology improvement cannot increase $y$, since it is determined by the local partner firm Z, resulting in $dy/df < 0$. This generally leads to $d(x + z)/df > 0$ under linear demand, which mostly consists of an increase in $z$ (i.e., $dz/df > 0$).

Furthermore, if sufficiently high levels of technology is spilled over such that $g > g_3$, then $y$ decreases by so much that the local independent firm X’s output is also pushed up, yielding $dx/df > 0$. On the other hand, if there is only limited technology spillover such that $g < g_1$, then investment in technology only raises $y$, while reducing $x$ and $z$ since they are substitutes of $y$. 

16
4.2 Technology Transfer Stage

Total differentiation yields the changes of profit functions as:

\[
d\pi_F = k \left[ R_y dy - \gamma y(dx + dz) - y c'(f) df - df \right] + (\pi_Y - f) dk. \tag{53}
\]

Given \(k\), firm F decides the level of investment in technology \(f\).

\[
\max_f \pi_F = k(\pi_Y - f). \tag{54}
\]

The FOC is given by

\[
\frac{d\pi_F}{df} = k \left( \frac{\partial \pi_Y}{\partial f} - 1 \right) = 0.
\]

By the implicit function theorem, we have

\[
\frac{df}{dk} = -\frac{\partial^2 \pi_F / \partial f \partial k}{\partial^2 \pi_F / \partial f^2},
\]

where

\[
\frac{\partial^2 \pi_F}{\partial f \partial k} = \frac{\partial}{\partial f} \left( k \frac{\partial \pi_Y}{\partial k} + \pi_Y - f \right)
\]

\[
= k \frac{\partial^2 \pi_Y}{\partial k \partial f} + \left( \frac{\partial \pi_Y}{\partial f} - 1 \right) = k \frac{\partial^2 \pi_Y}{\partial k \partial f}. \tag{55}
\]

From (53),

\[
\frac{\partial \pi_Y}{\partial k} = R_y \frac{\partial y}{\partial k} - \gamma y \frac{\partial (x + z)}{\partial k}
\]

\[
= \frac{3R_y^2 + 2\gamma^2 (3 - k) y R_y + \gamma^2 y^2 (\gamma^2 - 2k + 2)}{\Delta} < 0, \tag{57}
\]

and since \(R_y = \gamma z / (1 - k)\), we further derive

\[
\frac{\partial^2 \pi_Y}{\partial k \partial f} = \frac{2\gamma R_y}{\Delta (1 - k)} \left[ \frac{3\partial z}{\partial f} + \gamma (3 - k) (1 - k) \frac{\partial y}{\partial f} \right]
\]

\[
+ \frac{2\gamma^2 y}{\Delta (1 - k)} \left[ \gamma (3 - k) \frac{\partial z}{\partial f} + (1 - k) \left( \gamma^2 - 2k + 2 \right) \frac{\partial y}{\partial f} \right], \tag{58}
\]
where

\[
\frac{3\partial z}{\partial f} + \gamma(3-k)(1-k)\frac{\partial y}{\partial f} = \frac{c'(\gamma)(1-k)}{\Delta} \left[ g\{12(1-\gamma^2) + k\gamma^2(6-k)\} - 3\gamma k(2-k) \right] \\
< 0 \iff g < \frac{3\gamma k(2-k)}{12(1-\gamma^2) + k\gamma^2(6-k)} \equiv g_a,
\]  

(59)

and

\[
\gamma(3-k)\frac{\partial z}{\partial f} + (1-k)(\gamma^2 - 2k + 2)\frac{\partial y}{\partial f} = \frac{2c'(\gamma)(1-k)}{\Delta} \left[ \gamma g(3-k)(1-\gamma^2 + k) + 3(1-k)^2 - \gamma^2(k^2 - 3k + 3) \right] \\
< 0 \iff g < \frac{3(1-k)^2 - \gamma^2(k^2 - 3k + 3)}{\gamma(3-k)(1-\gamma^2 + k)} \equiv g_b.
\]  

(60)

When \( g < \min\{g_a, g_b\} \), both (59) and (60) are negative, which leads to a positive sign for (58). Then we obtain \( df/dk > 0 \) and \( d\tau/dk > 0 \), both of which are opposite to the case of \( k > 1/2 \). These are formally stated as:

**Proposition 3** When \( g < \min\{g_a, g_b\} \), an increase in the foreign ownership share raises the investment in technology, resulting in more technology spillover from the JV to the domestic partner firm.

To find out the intuition behind Proposition 3, we first derive the following lemma.

**Lemma 5** \( \min\{g_a, g_b\} < g \) (i.e., Proposition 3) holds only if \( \partial z/\partial f < 0 \).

**Proof.** Since

\[
g_2 - g_b = \frac{(k\gamma^2 - 6k + 6)k}{\gamma(3-k)(1-\gamma^2 + k)} > 0,
\]

\[
g_2 - g_a = \frac{-6\Delta}{(3-k)\gamma\{12(1-\gamma^2) + k\gamma^2(6-k)\}} > 0,
\]

we obtain \( \min\{g_a, g_b\} < g_2 \). Now suppose \( g_1 < \min\{g_a, g_b\} \). Then, when \( g_1 < g < \min\{g_a, g_b\} \), Corollary 2 leads to \( \partial z/\partial f > 0 \) and \( \partial y/\partial f > 0 \), which contradicts with the positive sign of (58).

\[\blacksquare\]
With sufficiently small technology transfer, a higher marginal profit for the JV raises firm F’s incentive to invest in technology, even if an increase in the foreign ownership share decreases the JV’s output. Thus, given that technology spillover is small, deregulation on foreign ownership induces more investment in technology and its spillover to the local partner.

In view of Lemmas 3, 4 and 5 and Proposition 3, we also obtain:

**Proposition 4** Suppose $k_1 < k < 1/2$. An increase in the foreign ownership share lowers the output of the independent local firm if $g < \min\{g_a, g_b\}$ and $A(k) < 0$ hold. The effects on the outputs of the local partner and the JV are generally ambiguous.

### 4.3 Ownership Stage

Finally we come to the ownership stage. However, it is the same with the ownership stage in the case where $k \geq 1/2$. We thus focus on the case where $\tilde{k} > k$ and $\pi_Z > \pi_{Z0}$ at $k = \overline{k}$, that is, the foreign ownership regulation is binding and firm Z accepts the offer. In this case, $\pi_Z > \pi_{Z0}$ remains to hold for a small enough increase in $\overline{k}$.

### 5 Corner Solutions

Our benchmark case is a duopoly without the JV. So far we have assumed that the two local firms remain in the market after the JV is formed. However, it is possible that one of the local firms or both of them exit from the market. In this section, we investigate these cases.

First, we examine the case where the JV becomes the monopolist. In this case, it does not matter which firm has corporate control. Whether the output level is determined by firm F or firm Z, it is unique given $f$:

$$y = \frac{a - c(f)}{2},$$

which is independent of $k$. That is, given the setup investment, a change in $k$ does not affect the output level.
We now consider the level of investment in technology $f$ determined by
\[
\max_f \pi_F = k(\pi_Y - f).
\]
Noting that the profits of the JV are given by (13), the FOC and SOC can then be written respectively as
\[
\frac{d\pi_F}{df} = k(2y\frac{\partial y}{\partial f} - 1) = k(-ye'(f) - 1) = 0,
\]
\[
\frac{d^2\pi_X}{df^2} = -k(\frac{\partial y}{\partial f}e'(f) + ye''(f)) < 0.
\]
The SOC is satisfied if $e''$ is sufficiently high.

We next consider the effect of a change in $k$ on $f$. Since $y$ is independent of $k$, we have
\[
\frac{df}{dk} = -\frac{\partial^2\pi_F/\partial f\partial k}{\partial^2\pi_F/\partial f^2} = 0.
\]
Thus, the optimal $f$ is independent of the ownership share in the case of the monopoly.

At the ownership stage, firm F solves the following problem:
\[
\max_k \pi_F = k(\pi_Y - f),
\text{s.t. } \pi_Z \geq \pi_{Z0} \text{ and } 0 < k \leq \bar{k}.
\]
Since $f$ and $\pi_Y$ are uniquely determined, firm F makes $k$ as high as possible. Suppose that $\pi_Z = \pi_{Z0}$ holds at $k = \bar{k}$, then $k^* = \min\{\bar{k}, \bar{\bar{k}}\}$, where $k^*$ is the optimal level of $k$ for firm F. Thus, we obtain

**Proposition 5** Suppose that the JV becomes the monopolist in the market. Then, $k^* = \min\{\bar{k}, \bar{\bar{k}}\}$. And the parents’ investment in technology is independent of the ownership share.

Next we consider the case where one of the two local firms stops its production. In the case where the local independent firm (firm X) exits from the market, the analysis is similar to that in the previous section. Since firm X does not play any crucial role in the previous section, the essence of the results obtained there remains valid. That is, our
main result on the technology transfer and spillover can be obtained even without the independent local firm. However, the presence of firm X allows us to examine the effects of foreign ownership regulation on firms which have no relationship with foreign firms.

In the case where the local partner firm stops its production, there is no technology spillover from the JV to the local firm. The analysis is similar to that in the monopoly case above.\(^5\)

6 Concluding Remarks

We have examined the effects of technology transfer from a foreign firm to a JV and technology spillover from the JV to the local partner firm in the presence of foreign ownership regulation. It is shown that foreign ownership regulation may facilitate both technology transfer and spillover when the multinational has corporate control. Under corporate control by the local partner firm, however, such regulation may hamper technology transfer. Moreover, foreign ownership regulation may not benefit the local independent firm.

Some remarks are in order. First, we have assumed that firm Z and firm F form a JV. It would be interesting to analyze how the foreign firm chooses its partner. The local firms may compete so as to be selected as the partner. Our assumption of a take-it-or-leave-it offer at the ownership stage may be justified from this point of view.

Second, we have incorporated only one type of spillover generated by the JV: the technology spillover from the foreign firm to the local partner firm. There may exist other types and in a different direction, such as spillovers of market knowledge from the local partner firm to the foreign firm. In the presence of such spillovers, not only the local firm but also the foreign firm may have more incentives to form a JV.

Lastly, we have assumed that the upper limit on foreign ownership is exogenously given. This assumption is made because our focus is on the relationship between the foreign ownership regulation and technology transfer. However, it is worthwhile to analyze the optimal level of the regulation. These remain fruitful avenues for future research.

\(^5\)The outputs of the JV and firm X are, respectively, 
\[y = \frac{2(a_y - c(f)) - \gamma (a_q - c_X)}{(4 - \gamma^2)}\] and 
\[x = \frac{2(a_q - c_X) - \gamma (a_y - c(f))}{(4 - \gamma^2)}.\] Thus, both \(y\) and \(\pi_Y\) are independent of \(k\).
References


