Sequential Hold-up, Input Control, and Outsourcing

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Abstract

We investigate individual firms’ strategic choice of organization form when outsourcing their intermediate products. First, based on Hart (1995) property rights theory model, we show that sequential investment alleviates the underinvestment of hold-up problem as a result of the encouragement effect of sequential complementary investments. Then we construct a sequential outsourcing model to study the export processing in China. We show that the emergence of the divided ownership and control is to balance the ex post bargaining power of the parties involved, which is partially due to the encouragement effect of sequential complementary investments, instead of merely improving incentive of the party with the weaker bargaining position as in Feenstra and Hanson (2005).

JEL classification: D21, F1, L14, L22
Keywords: Sequential Hold-up, Input Control, Outsourcing

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1 Introduction

We live in a world of globalization. International trade and foreign direct investment (FDI) are among the fastest growing economic activities. In 2006, world merchandise exports are close to 12 trillion dollars and world exports of commercial services are close to 2.7 trillion dollars; in 2005, world FDI inflows are close to 916 billion dollars (UNCTAD 2007). Among the fast expansion of merchandise trade, there has been a rapid growth of trade in intermediate products.

According to Athukorala and Yamashita (2006), world trade in parts and components increases from about 440 billion dollars in 1992 to nearly 1 trillion dollars in 2003. Whereas, during this period of time, world merchandise exports increase from about 3.76 trillion dollars to about 7.53 trillion dollars and world exports of commercial services increase from about 1 trillion dollars to about 1.88 trillion dollars (UNCTAD 2007). Clearly, the expansion of trade in parts and components is much faster than the growth of trade in other merchandise and services.

This phenomenon, closely related to the growing fragmentation of production, has been investigated by many studies, such as “international vertical specialization” (Yi 2003), “international production sharing” (Yeats 2001), and “outsourcing” (Helpman 2006; Spencer 2005). According to Borga and Zeile (2004), the share of intermediate goods shipped by U.S. parent companies to their foreign affiliates for assembly or processing in total U.S. exports of goods increases from 8.5 percent in 1966 to 14.7 percent in 1999; and the share of these exports in total exports of goods by U.S. parents to their foreign affiliates increases from 39.3 percent in 1966 to 64.7 percent in 1999. These shares are large in electronics and transportation equipment, and small in chemical, petroleum, and metal industries.

Moreover, Helpman (2006) points out that “the growth of input trade has taken place both within and across the boundaries of the firm, i.e., as intrafirm and arms-length trade.” The natural question arising is organization form choices of individual firms: integration or outsourcing.\(^2\)

We follow the framework of property rights theory from Grossman and Hart (1986) and Hart and Moore (1990). Under incomplete contract, which arises due to unforeseen contingencies, inability of enforcement, etc., relationship-specific investments are distorted by the hold-up problem and thus underinvested. In their models, relationship-specific investments are simultaneously invested. In contrast,

\(^1\)Feenstra (1998), citing Tempest (1996), describes the production of the Barbie doll. Mattel obtains the molds and additional paints used in decorating from the United States, raw materials (plastic and hair) from Taiwan and Japan, cotton cloth used for dresses in China, and conducts assembly in Indonesia, Malaysia, and China.

\(^2\)Helpman (2006), “...outsourcing means the acquisition of an intermediate input or service from an unaffiliated supplier, while integration means production of the intermediate input or service within the boundary of the firm.”
we study a sequential hold-up model, in which relationship-specific investments are sequentially invested, to investigate individual firms’ strategic choice of organization form when outsourcing their intermediate products.\(^3\)

To illustrate, when a final good producer initiates the proposal of outsourcing its intermediate products to some supplier, it often involves some relationship-specific pre-investments from both sides. The final good producer chooses the optimal organization form, which depends on the contractual environments and specific characteristics of the intermediate products. The supplier and the final good producer have to rely on bargaining to divide the surplus of investment through the ex post renegotiation, since ex ante contracts are incomplete. With sequential investment, the final good producer may have incentive to invest more to elicit more investment from the supplier. Based on Hart (1995), we show that sequential investment alleviates the underinvestment of hold-up problem as a result of the encouragement effect of sequential complementary investments.\(^4\)

In export processing in China, the story is a little different. Usually, there is a foreign final good producer and a Chinese supplier. When the foreign final good producer initiates the proposal of outsourcing of its intermediate products to the Chinese supplier, they will establish a new processing plant. The owner of the processing plant could be either the foreign final good producer or the Chinese supplier. In addition, who controls the supply of the primary inputs is also important.

According to Feenstra and Hanson (2003, 2005), in export processing in China, all processing plants, regardless of ownership, operate under the following two regimes: Pure-assembly and Import-and-assembly. In the pure-assembly regime, the foreign final good producer supplies the primary inputs and retains ownership over the primary inputs; while in the import-and-assembly regime, the processing plant in China imports the primary inputs of its own accord. The major difference between these two regime is that who controls the input purchasing. Thus, there are four types of ownership and input control as describe in table 1.

In contrast, we find that if the foreign final good producer is the owner of the processing plant in China, pure-assembly regime is equivalent to import-and-assembly regime: the foreign final good producer, who is also the owner of the processing plant, supplies the primary inputs and retains ownership over the primary inputs. That is, type I is equivalent to type III.

Feenstra and Hanson (2005) build a model of international outsourcing model to investigate the export processing in China. In their model, the ex post surplus

\(^3\)Nöldeke and Schmidt (1998) construct a sequential investment model and show that the options to own ownership structure achieves the first-best under some specific assumptions. But they do not proceed upon the possible alleviation of underinvestment if investments are sequentially invested.

\(^4\)In Hart (1995), the ex post surplus function is separable in specific investments, which implies specific investments are independent. Hence, sequential investment will be equivalent to simultaneous investment. See footnote 19 on page 42 of Hart (1995) for details.
Table 1: Ownership and Input Control

<table>
<thead>
<tr>
<th>Input Control Regime</th>
<th>Pure-assemble</th>
<th>Import-and-assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership</td>
<td>Foreign</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Chinese</td>
<td>III</td>
</tr>
</tbody>
</table>

function is separable in specific investments and the specific investments are simultaneously invested. They argue that the rational of divided ownership and control is to improve incentive of the party with the weaker bargaining position. In particular, when it is particularly important to obtain good effort investments from the Chinese supplier, to ameliorate the hold-up problem when the foreign final good producer owns the processing plant, the Chinese supplier should be given control over primary input sourcing.\(^5\)

On the contrary, we believe that the party with the stronger bargaining position should be given more control, because the party with the stronger bargaining position has higher incentive to invest. Thus, concentrated ownership and control must be the dominant choice in the organization form if the bargaining position is not balanced. Otherwise, if the bargaining position of the parties involved is relative even, there is room for the divided ownership and control.

In our sequential “outsourcing” model, we show that the emergence of the divided ownership and input control (type II) is to balance the ex post bargaining power of the parties involved, which is partially due to the encouragement effect of sequential complementary investments, instead of merely improving incentive of the party with the weaker bargaining position. In particular, when input control is important and the encouragement effect of sequential complementary investments is high, it might be better for the foreign final good producer to control over primary input sourcing. And hence, divided ownership and input control (type II) is more likely to be optimal.

Our model is related to Antràs (2003), which investigate the pattern of trade and boundaries of firm in a general equilibrium setting. In his model, there is no spot market. Therefore, the outside option is zero. He also assumes there exist fixed cost and free entry to obtain an industry equilibrium to explain why intrafirm trade as a fraction of total trade is positively correlated with capital-labor ratio. Other related literature includes monopolistic competition with heterogenous firms.

\(^5\)From table II on page 740 in Feenstra and Hanson (2005), it seems that when the foreign firms own the processing plant, if the Chinese supplier is given control over primary input sourcing (type I to type III; upper-left cell to lower-left cell), his effort level on producing is decreasing, instead of increasing. In addition, type IV ownership structure (lower-right cell) is dominating type II ownership structure (upper-right cell). According to their model, it seems that type II ownership structure will never happen.
in a general equilibrium setting in international trade, such as Melitz (2003), which studies within-sectoral heterogeneity. Antràs and Helpman (2004) extend the model to incorporate incomplete contract.

The rest of the paper is organized as follows. Section 2 provides the setup of a modified Hart (1995) property rights theory model and shows that sequential investment alleviates the underinvestment of the hold-up problem. Section 3 provides the setup of a sequential “outsourcing” model to study the export processing in China. Then we characterize the optimal organization form choice of individual firms and present our main results. Section 4 concludes.

2 Sequential Hold-up

We follow the setup of Hart (1995). There is a final good producer $M_1$ and a supplier $M_2$. There are two physical assets, $a_1$ and $a_2$, which are associated to $M_1$ and $M_2$ respectively. At date $t = 1$, they agree on the ownership structure, that is, who owns the firm. No further contractual arrangement is possible at this stage. Then, at date $t = 1.1$, $M_1$ invests the relationship-specific investment $i$; at date $t = 1.2$, $M_2$ invests the relationship-specific investment $e$. $C_i(i)$ and $C_e(e)$ represent the cost of the investments. Finally, at date $t = 2$, $M_1$ and $M_2$ renegotiate. If there is an agreement on the price of the intermediate products, intermediate products are produced and payment and transfer are proceeded. Otherwise, if the renegotiation breaks down, they will stay with their own outside options. The timing of the model is illustrated in Figure 1.

Let $A$ represent the assets $M_1$ owns and $B$ represent the assets $M_2$ owns. Thus, $(A, B)$ represents the ownership structure, where $A \cap B = \emptyset$ and $A \cup B = \{a_1, a_2\}$. The ownership structure could be one of the following:

- Non-integration: $M_1$ owns $a_1$ and $M_2$ owns $a_2$, $(A, B) = (\{a_1\}, \{a_2\})$
- Type 1 integration: $M_1$ owns $a_1$ and $a_2$, $(A, B) = (\{a_1, a_2\}, \emptyset)$
• Type 2 integration: \( M2 \) owns \( a1 \) and \( a2 \), \((A, B) = (\emptyset, \{a1, a2\})\)

If trade occurs, the ex post surplus is \( R(i, e) \). If trade does not occur, the outside options for \( M1 \) and \( M2 \) are \( r1(i; A) \) and \( r2(e; B) \) respectively. We make the following assumptions for all ownership structure \((A, B)\) and investments \( i, e \).

**Assumption 1** \( R(i, e), r1(i; A), \) and \( r2(e; B) \) are strictly concave; \( C_i(i) \) and \( C_e(e) \) are strictly convex.

**Assumption 2** \( R(i, e) \geq r1(i; A) + r2(e; B) \)

**Assumption 3**
\[
\begin{align*}
\frac{\partial R(i, e)}{\partial i} &\geq \frac{dr1(i; \{a1, a2\})}{di} \\
\frac{\partial R(i, e)}{\partial e} &\geq \frac{dr2(e; \{a1, a2\})}{de} \\
\end{align*}
\]

Assumption 4
\[
\frac{\partial^2 R(i, e)}{\partial i \partial e} \geq 0
\]

Assumption 1 is the usual assumption of the surplus functions and cost functions. Assumption 2 captures the idea that \( i \) and \( e \) are relationship-specific investments. Assumption 3 says that relationship-specificity also applies in a marginal sense, which is similar to Hart (1995). Assumption 4 says that investments are complementary at the margin.

Let \( \alpha \) represent the ex post bargaining weight of \( M1 \). The ex post payoff of \( M1 \) and \( M2 \) are
\[
\begin{align*}
\pi_1(i, e; A, B) &= r1(i; A) + \alpha[R(i, e) - (r1(i; A) + r2(e; B))] \\
\pi_2(i, e; A, B) &= r2(e; B) + (1 - \alpha)[R(i, e) - (r1(i; A) + r2(e; B))] \\
\end{align*}
\]

\(2.1 \) The First-Best Solution

In the first-best, \( M1 \) and \( M2 \) maximize the date 1 present value of their trading relationship:
\[
\max_{i, e} R(i, e) - C_i(i) - C_e(e)
\]
The first order conditions are
\[
\begin{align*}
\frac{\partial R(i,e)}{\partial i} &= C'_i(i) \\
\frac{\partial R(i,e)}{\partial e} &= C'_e(e)
\end{align*}
\]

Let \((i^*, e^*)\) denote the solution of the above maximization problem.

### 2.2 Simultaneous Investment (Un-observable Investment)

In the case that \(M_2\) cannot observe the investment \(i\) from \(M_1\) before his investment \(e\), the solution is equivalent to that under simultaneous investment. Given the ownership structure \((A, B)\) agreed at date 1, \(M_1\) and \(M_2\) choose \(i\) and \(e\) non-cooperatively at date 1.1 and 1.2. By equation 1, they maximize their own payoffs, net of investment costs.

\[
\begin{align*}
\max_i \pi_1(i, e; A, B) - C_i(i) &= r_1(i; A) + \alpha[R(i, e) - (r_1(i; A) + r_2(e; B))] - C_i(i) \\
\max_e \pi_2(i, e; A, B) - C_e(e) &= r_2(e; B) + (1 - \alpha)[R(i, e) - (r_1(i; A) + r_2(e; B))] - C_e(e)
\end{align*}
\]

The first order conditions are
\[
\begin{align*}
\frac{\alpha}{(1 - \alpha)} \frac{\partial R(i,e)}{\partial i} + (1 - \alpha) \frac{\partial r_1(i;A)}{\partial i} &= C'_i(i) \\
\frac{\alpha}{(1 - \alpha)} \frac{\partial R(i,e)}{\partial e} + \alpha \frac{\partial r_2(e;B)}{\partial e} &= C'_e(e)
\end{align*}
\]

Suppose \((i(A, B), e(A, B))\) satisfy the above first order conditions under ownership structure \((A, B)\).

The following proposition shows that under simultaneous investment, there is underinvestment in relationship-specific investments due to the hold-up problem, which is similar to the result of the property rights theory from Grossman and Hart (1986) and Hart and Moore (1990).

**Proposition 1** Under simultaneous investment, \(i(A, B) \leq i^*\) and \(e(A, B) \leq e^*\), \(\forall (A, B)\).

**Proof.** See the Appendix.

### 2.3 Sequential Investment

Suppose \(M_2\) can observe the investment \(i\) from \(M_1\) before his investment. Given the ownership structure \((A, B)\) agreed at date 1, \(M_1\) chooses \(i\) at date 1.1. After observing \(M_1\’s\) investment, \(M_2\) chooses \(e\) at date 1.2. From equation 1, they maximize their own payoffs, net of investment costs.
By backward induction, at date 1.2, $M_2$ chooses $e$ given the $M_1$’s choice $i$ at date 1.1.

$$\max_e \pi_2(i, e; A, B) - C_e(e) = r_2(e; B) + (1 - \alpha)[R(i, e) - (r_1(i; A) + r_2(e; B))] - C_e(e)$$

s.t.  $i$ is some given constant

The first order condition is

$$(1 - \alpha) \frac{\partial R(i, e)}{\partial e} + \alpha \frac{dr_2(e; B)}{de} = C'_e(e) \quad (2)$$

From the above first order condition, we get the reaction function of $M_2$ under ownership structure $(A, B)$.

$$e = e(i; A, B)$$

At date 1.1, $M_1$ chooses $i$ given the above reaction function of $M_2$.

$$\max_i \pi_1(i, e; A, B) - C_i(i) = r_1(i; A) + \alpha[R(i, e) - (r_1(i; A) + r_2(e; B))] - C_i(i)$$

s.t.  $e = e(i; A, B)$

The first order condition is

$$\alpha \frac{\partial R(i, e)}{\partial i} + (1 - \alpha) \frac{dr_1(i; A)}{di} + \alpha \left[ \frac{\partial R(i, e)}{\partial e} - \frac{dr_2(e; B)}{de} \right] \frac{de}{di} = C'_i(i) \quad (3)$$

Suppose $(\bar{i}(A, B), \bar{e}(A, B))$ satisfy the above first order condition and the reaction function $e(i; A, B)$ of $M_2$ under ownership structure $(A, B)$.

The following proposition shows that under sequential investment, $\frac{de(i; A, B)}{di} \geq 0$, i.e. $M_1$’s investment $i$ encourages $M_2$’s investment $e$, underinvestment of the relationship-specific investment is alleviated. The intuition behind is that since relationship-specific investments are complementary, the first mover has incentive to invest more to encourage the follower catching up.

**Proposition 2** Sequential investment alleviates the underinvestment of hold-up problem, i.e. $\bar{i}(A, B) \geq \bar{i}(A, B)$ and $\bar{e}(A, B) \geq \bar{e}(A, B)$, $\forall (A, B)$.

**Proof.** See the Appendix. ■

### 2.4 Welfare Analysis

In proposition 2, we show that there will be more investments under sequential investment given any ownership structure $(A, B)$. The further question is whether more
investments are better. In other words, if the ex ante surplus $R(i, e) - C_i(i) - C_e(e)$ is increasing with larger $i$ and $e$ under sequential investment.

First, we define conditionally underinvestment. For $M_1$, if $\frac{\partial R(i, e)}{\partial i} > C_i'(i)$, we say $i$ is **conditionally underinvested** given $e$. For $M_2$, if $\frac{\partial R(i, e)}{\partial e} > C_e'(e)$, we say $e$ is conditionally underinvested given $i$. From the first order conditions under simultaneous investment in section 2.2 and the first order conditions under sequential investment in section 2.3, we know that $e$ is always conditionally underinvested given $i$ for any ownership structure $(A, B)$.

The following proposition shows that if the encouragement effect is large enough, more investments are better under sequential investment given any ownership structure $(A, B)$. In particular, if both $i$ and $e$ are conditionally underinvested, then the ex ante surplus is increasing with larger $i$ and $e$ regardless of the encouragement effect and ownership structure.

**Proposition 3** Given any ownership structure $(A, B)$, if $\frac{de}{di}$ is large, the ex ante surplus $R(i, e) - C_i(i) - C_e(e)$ is increasing with larger $i$ and $e$ under sequential investment.

In particular, if both $i$ and $e$ are conditionally underinvested, then the ex ante surplus is increasing with larger $i$ and $e$ under sequential investment, regardless of $\frac{de}{di}$ and ownership structure $(A, B)$.

**Proof.** See the Appendix. ■

The intuition behind is that if encouragement effect is large, then $M_1$ does not need to overinvest too much to encourage $M_2$ to catch up. As a result, the ex ante surplus is increasing with larger $i$ and $e$. In particular, if both $i$ and $e$ are conditionally underinvested, there is still room to achieve higher ex ante surplus by increasing $i$ and $e$. Thus, regardless of the encouragement effect and ownership structure, more investments are better under sequential investment.

### 2.5 Optimal Ownership Structure

The results of optimal ownership structure from Hart (1995) still apply in our modified model. The logic is that at date 1, before investing the relationship investments, $M_1$ and $M_2$ negotiate the ownership structure. They will choose the one maximizing the ex ante surplus $R(i, e) - C_i(i) - C_e(e)$ given the lump-sum transfer are possible at date 1.

From the first order conditions in section 2.2 and 2.3, we know that under simultaneous investment $i$ and $e$ are both conditionally underinvested; under sequential investment, $e$ is conditionally underinvested, while $i$ could be conditionally overin-
vested. From proposition 3, if the encouragement effect is large enough, the ownership structure with the largest amount of investments will be optimal. In particular, if both $i$ and $e$ are conditionally underinvested, the optimal ownership structure will be the one with the largest amount of investments regardless of the encouragement effect.

3 Outsourcing

3.1 Basic Setup

Suppose there is a foreign final good producer $M_1$ and a Chinese supplier $M_2$. When $M_1$ initiates the proposal of outsourcing of its intermediate products to $M_2$, they will establish a new processing plant. The owner of the processing plant could be either $M_1$ or $M_2$. We say that to be the owner of the processing plant one has to acquire some physical asset $k$, which may include equipments, machines, buildings, etc. Since the Chinese supplier $M_2$ has the advantage to organize/hire the labor, we assume $M_2$ make the investment $e$ to organize/hire the labor. In addition, to control the primary input purchasing, one has to make the investment $s$ to search for the primary input. We assume there is no comparative advantage for $M_1$ or $M_2$ in searching for the primary input. Let $C_k(k)$, $C_s(s)$, and $C_e(e)$ represent the cost of the investments $k$, $s$, and $e$ respectively.

At date $t = 1$, they agree on the ownership and input control, that is, who owns the firm and who controls the primary inputs. No further contractual arrangement is possible at this stage. From table 1, we have four possible types of ownership and input control. Since type I is equivalent to type III, we have three possible cases.

- type I/III (foreign ownership and control) – $k$, $s$ from $M_1$; $e$ from $M_2$
- type II (divided ownership and control) – $s$ from $M_1$; $k$, $e$ from $M_2$
- type IV (Chinese ownership and control) – $k$, $s$, $e$ from $M_2$

Then, at date $t = 1.1$, $M_1$ makes the relationship-specific investments; at date $t = 1.2$, $M_2$ invests the relationship-specific investments. Finally, at date $t = 2$, $M_1$ and $M_2$ renegotiate. If there is an agreement on the price of the intermediate products, intermediate products are produced and payment/transfer are proceeded. Otherwise, if the renegotiation breaks down, they will stay with their own outside options. The timing of the model is the same as the timing of the model in section 2 illustrated in Figure 1. The exception is that at date $t = 1$, the foreign firm $M_1$ and the Chinese supplier $M_2$ agree on not only who owns the firm, but also who controls the primary input.
If trade occurs, the ex post surplus is $R(k, s, e)$. If trade does not occur, the outside options for $M1$ and $M2$ will depend on the ownership and input control agreed on date 1. Let $\alpha$ represent the ex post bargaining weight of $M1$.

For type I/III ownership and control – foreign ownership and control, $M1$ is the owner and controls the primary input ($k$, $s$ from $M1$; $e$ from $M2$). If renegotiation breaks down, $M1$ with the relationship-specific pre-investments ($k$, $s$) goes to the spot market to seek another potential Chinese supplier with $e$. $M2$ with the relationship-specific pre-investments $e$ goes to the spot market to seek another potential foreign final good producer with ($k$, $s$). We assume the outside options for $M1$ and $M2$ are as follows.

$$\begin{cases}
    r_1(k, s, e; I/III) = \alpha \eta R(k, s, e) \\
    r_2(k, s, e; I/III) = (1 - \alpha)(1 - \psi)\lambda R(k, s, e)
\end{cases}$$

where $\psi$ represents the specificity of intermediate product produced, i.e. if the Chinese supplier sells the product produced on the spot market, he can only get $1 - \psi$ share of the surplus due to the relationship-specific investment. $\eta$ represents the competitiveness/thickness in $M2$ market with $e$. If $\eta$ is large, it is easier for $M1$ to find another Chinese supplier with $e$. $\lambda$ represents the competitiveness/thickness in $M1$ market with ($k$, $s$). If $\lambda$ is large, it is easier for $M2$ to find another foreign final good producer with ($k$, $s$).

For type II ownership and control – divided ownership and control, $M2$ is the owner and $M1$ controls the primary input ($s$ from $M1$; $k$, $e$ from $M2$). If renegotiation breaks down, $M1$ with the relationship-specific pre-investments $s$ goes to the spot market to seek another potential Chinese supplier with ($k$, $e$). $M2$ with the relationship-specific pre-investments ($k$, $e$) goes to the spot market to seek another potential foreign final good producer with $s$. We assume the outside options for $M1$ and $M2$ are as follows.

$$\begin{cases}
    r_1(k, s, e; II) = \alpha(1 - \mu)\gamma R(k, s, e) \\
    r_2(k, s, e; II) = (1 - \alpha)(1 - \mu)(1 - \psi)\theta R(k, s, e)
\end{cases}$$

where $\mu$ represents the specificity of physical asset $k$, i.e. if $M2$ provides $k$ and to be the owner of the processing plant, the total output will be only $1 - \mu$ of total output if $M1$ provides $k$ and to be the owner of the processing plant. This is to capture the idea that $k$ is associated with $M1$. $\gamma$ represents the competitiveness/thickness in $M2$ market with ($k$, $e$). If $\gamma$ is large, it is easier for $M1$ to find another Chinese supplier with ($k$, $e$). $\theta$ represents the competitiveness/thickness in $M1$ market with $s$. If $\theta$ is large, it is easier for $M2$ to find another foreign final good producer with $s$.

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8For simplicity, we assume if $M1$ and $M2$ agree on some type of ownership structure at date 1, they have to stick with this ownership structure if renegotiation breaks down at date 2. That is to say, no further investment can be made if renegotiation breaks down at date 2.

9We assume the ex post bargaining weight between the potential foreign final good producers and the Chinese suppliers remains constant.
For type IV ownership and control – Chinese ownership and control, $M_2$ is the owner and controls the primary input ($k, s, e$ from $M_2$). If renegotiation breaks down, $M_1$ without relationship-specific pre-investments goes to the spot market to seek another potential Chinese supplier with ($k, s, e$). $M_2$ with relationship-specific pre-investments ($k, s, e$) goes to the spot market to seek another potential foreign final good producer without pre-investments. We assume the outside options for $M_1$ and $M_2$ are as follows.

$$
\begin{align*}
    r_1(k, s, e; IV) &= \alpha(1 - \mu)\phi R(k, s, e) \\
    r_2(k, s, e; IV) &= (1 - \alpha)(1 - \mu)(1 - \psi)R(k, s, e)
\end{align*}
$$

where $\phi$ represents the competitiveness/thickness in $M_2$ market with ($k, s, e$). If $\phi$ is large, it is easier for $M_1$ to find another Chinese supplier with ($k, s, e$).

We assume $\eta > \gamma > \phi$ to capture the idea that the competitiveness/thickness in $M_2$ market is decreasing as the investment requirement of $M_2$ is broader; $\lambda < \theta$ to capture the idea that competitiveness/thickness in $M_1$ market is decreasing as the investment requirement of $M_1$ is broader.

In addition, we make the following assumptions similar to assumption 1 and assumption 4 in section 2. Let $O \in \{I/III, II, IV\}$ represent the ownership structure agreed at date 1.

**Assumption 5** $R(k, s, e)$ is strictly concave; $C_k(k)$, $C_s(s)$, and $C_e(e)$ are strictly convex.

**Assumption 6**

$$
\begin{align*}
    \frac{\partial^2 R(k, s, e)}{\partial k \partial s} &\geq 0 \\
    \frac{\partial^2 R(k, s, e)}{\partial k \partial e} &\geq 0 \\
    \frac{\partial^2 R(k, s, e)}{\partial s \partial e} &\geq 0
\end{align*}
$$

Assumption 5 is the usual assumption for the surplus functions and cost functions. Automatically, we have $R(k, s, e) \geq r_1(k, s, e; O) + r_2(k, s, e; O)$ from the outside options we assumed, which captures the idea that $k, s, e$ are relationship-specific investments. Assumption 6 says that investments are complementary at the margin.

The ex post payoff of $M_1$ and $M_2$ are

$$
\begin{align*}
    \pi_1(k, s, e; O) &= r_1(k, s, e; O) + \alpha[R(k, s, e) - (r_1(k, s, e; O) + r_2(k, s, e; O))] \\
    \pi_2(k, s, e; O) &= r_2(k, s, e; O) + (1 - \alpha)[R(k, s, e) - (r_1(k, s, e; O) + r_2(k, s, e; O))]
\end{align*}
$$

(4)

### 3.2 The First-Best Solution

In the first-best, $M_1$ and $M_2$ maximize the date 1 present value of their trading relationship:

$$
\max_{k, s, e} R(k, s, e) - C_k(k) - C_s(s) - C_e(e)
$$
The first order conditions are

\[
\begin{align*}
\frac{\partial R(k, s, e)}{\partial k} &= C'_k(k) \\
\frac{\partial R(k, s, e)}{\partial s} &= C'_s(s) \\
\frac{\partial R(k, s, e)}{\partial e} &= C'_e(e)
\end{align*}
\]  

(5)

Let \((k^*, s^*, e^*)\) denote the solution of the above maximization problem.

### 3.3 Outsourcing – Sequential Investment

Suppose the Chinese supplier \(M_2\) can observe the investments from the foreign firm \(M_1\) before his own investments. Given the ownership and input control agreed at date 1, \(M_1\) invests at date 1.1. After observing \(M_1\)'s investments, \(M_2\) invests at date 1.2. From equation 4, they maximize their own payoffs, net of investment costs.

#### 3.3.1 Type I/III ownership and control

By backward induction, at date 1.2, the Chinese supplier \(M_2\) chooses \(e\) given the the foreign firm \(M_1\)'s choice \((k, s)\) at date 1.1.

\[
\max_{e} \pi_2(k, s, e; \text{I/III}) - C_e(e) \\
\text{s.t. } k, s \text{ are some given constants}
\]

where

\[
\pi_2(k, s, e; \text{I/III}) = (1 - \alpha)[1 - \alpha(\eta - (1 - \psi)\lambda)]R(k, s, e) = A_{\text{I/III}}R(k, s, e)
\]

The first order condition is

\[
A_{\text{I/III}} \frac{\partial R(k, s, e)}{\partial e} = C'_e(e)
\]  

(6)

From the above first order condition, we get the reaction function of \(M_2\) under ownership structure I/III.

\[
e = e(k, s; \text{I/III})
\]

At date 1.1, \(M_1\) chooses \((k, s)\) given the above reaction function of \(M_2\).

\[
\max_{k, s} \pi_1(k, s, e; \text{I/III}) - C_k(k) - C_s(s) \\
\text{s.t. } e = e(k, s; \text{I/III})
\]
where
\[
\pi_1(k, s, e; I/III) = \alpha[1 + (1 - \alpha)(\eta - (1 - \psi)\lambda)]R(k, s, e) = (1 - A_{I/III})R(k, s, e)
\]
The first order conditions are
\[
\begin{align*}
(1 - A_{I/III}) \left\{ \frac{\partial R(k, s, e)}{\partial k} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial k}{\partial k} \right\} &= C_k'(k) \\
(1 - A_{I/III}) \left\{ \frac{\partial R(k, s, e)}{\partial s} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial s}{\partial e} \right\} &= C_s'(s)
\end{align*}
\] (7)
Let \((\bar{k}(I/III), \bar{\pi}(I/III), \bar{e}(I/III))\) denote the solution of the above maximization problem.

### 3.3.2 Type II ownership and control

By backward induction, at date 1.2, the Chinese supplier \(M_2\) chooses \((k, e)\) given the foreign firm \(M_1\)'s choice \(s\) at date 1.1.
\[
\max_{k, e} \pi_2(k, s, e; II) - C_e(e) - C_k(k)
\]
\[
\text{s.t. } k, s \text{ are some given constants}
\]
where
\[
\pi_2(k, s, e; II) = (1 - \alpha)(1 - \mu)[1 - \alpha(\gamma - (1 - \psi)\theta)]R(k, s, e) = A_{II}R(k, s, e)
\]
The first order conditions are
\[
\begin{align*}
A_{II} \frac{\partial R(k, s, e)}{\partial e} &= C'_e(e) \\
A_{II} \frac{\partial R(k, s, e)}{\partial k} &= C'_k(k)
\end{align*}
\] (8)
From the above first order conditions, we get the reaction functions of \(M_2\) under ownership structure II.
\[
\begin{align*}
e &= e(s; II) \\
k &= k(s; II)
\end{align*}
\]
At date 1.1, \(M_1\) chooses \(s\) given the above reaction functions of \(M_2\).
\[
\max_s \pi_1(k, s, e; II) - C_s(s)
\]
\[
\text{s.t. } e = e(s; II) \text{ and } k = k(s; II)
\]
where
\[
\pi_1(k, s, e; II) = \alpha(1 - \mu)[1 + (1 - \alpha)(\gamma - (1 - \psi)\theta)]R(k, s, e) = (1 - \mu - A_{II})R(k, s, e)
\]
The first order condition is
\[
(1 - \mu - A_{II}) \left\{ \frac{\partial R(k, s, e)}{\partial s} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial s}{\partial e} + \frac{\partial R(k, s, e)}{\partial k} \frac{\partial k}{\partial s} \right\} = C'_s(s)
\] (9)
Let \((\bar{k}(II), \bar{\pi}(II), \bar{e}(II))\) denote the solution of the above maximization problem.
3.3.3 Type IV ownership and control

At date 1.2, the Chinese supplier $M_2$ chooses $(k, s, e)$.

$$\max_{k,s,e} \pi_2(k, s, e; IV) - C_e(e) - C_k(k) - C_s(s)$$

where

$$\pi_2(k, s, e; IV) = (1 - \alpha)(1 - \mu)(1 - \alpha(\phi - (1 - \psi)))]R(k, s, e) = A_{IV} R(k, s, e)$$

The first order conditions are

$$\begin{cases} 
A_{IV} \frac{\partial R(k, s, e)}{\partial k} = C'_k(k) \\
A_{IV} \frac{\partial R(k, s, e)}{\partial s} = C'_s(s) \\
A_{IV} \frac{\partial R(k, s, e)}{\partial e} = C'_e(e) 
\end{cases} \quad (10)$$

Let $(\bar{k}(IV), \bar{s}(IV), \bar{e}(IV))$ denote the solution of the above maximization problem.

3.4 Optimal Ownership and Control

Now, we turn to the question which type of ownership structure will be agreed by $M_1$ and $M_2$ at date 1. That is, which one is the optimal ownership and control?

First, we introduce the benchmark under simultaneous investment. In the case that $M_2$ cannot observe the investments from $M_1$ before his investments, the solution is equivalent to that under simultaneous investment. Let $(\bar{k}(O), \bar{s}(O), \bar{e}(O))$ denote the solution under simultaneous investment with ownership structure $O$.

The following lemma shows that $\forall O \in \{I/III, II, IV\}$ there exists underinvestment with simultaneous investment; the encouragement effect of sequential complementary investments will alleviate the hold-up problem; if the encouragement effect is large enough, more investments are better; in particular, if all investments are conditionally underinvested, then the ex ante surplus is increasing with larger $k$, $s$, and $e$, regardless of the encouragement effect and ownership structure.

**Lemma 1** i) $\forall O \in \{I/III, II, IV\}, k(O) \leq k^*, s(O) \leq s^*, e(O) \leq e^*$.  
ii) $\forall O \in \{I/III, II, IV\}, \bar{k}(O) \geq k(O), \bar{s}(O) \geq s(O), \bar{e}(O) \geq e(O)$. In particular, for type IV ownership structure, $\bar{k}(IV) = k(IV) \leq k^*, \bar{s}(IV) = s(IV) \leq s^*, \bar{e}(IV) = e(IV) \leq e^*$.  
iii) If the encouragement effect is large enough, more investments are better under sequential investment given any ownership structure $O \in \{I/III, II, IV\}$. In particular, if $k$, $s$, and $e$ all are conditionally underinvested, then $R(k, s, e) - C_k(k) - C_s(s) - C_e(e)$ is increasing with larger $k$, $s$, and $e$, regardless of the encouragement effect and ownership structure.
The following proposition shows that if the specificity of physical asset $k$ is high, then the optimal ownership structure will be foreign ownership and control (type I/III); if the encouragement effect of sequential complementary investments is large, type I/III and type II ownership structure will more likely be optimal; if the ex post relative bargaining power of $M_1$ is large, then the optimal ownership structure will be foreign ownership and control (type I/III); if the ex post relative bargaining power of $M_2$ is large, then the optimal ownership structure are more likely Chinese ownership and control (type IV); if the ex post relative bargaining power of $M_1$ and $M_2$ are close and if the encouragement effect of sequential complementary investments is large, then divided ownership and control (type II) is more likely to be optimal.

**Proposition 4**

i) If $\mu$ is large, the optimal ownership structure will be foreign ownership and control (type I/III).

ii) If the encouragement effect of sequential complementary investments is large, type I/III and type II ownership structure will more likely be optimal.

iii) If $A_{I/III}$, $A_{II}$, and $A_{IV}$ are close to zero, then the optimal ownership structure will be type I/III; if $A_{I/III}$, $A_{II}$, and $A_{IV}$ are close to one, then type IV ownership structure will more likely be optimal; if $A_{I/III}$, $A_{II}$, and $A_{IV}$ are in the mid-range between zero and one, and if the term $\frac{\partial R(k,s,e)}{\partial e} \frac{\partial e(s;II)}{\partial s} + \frac{\partial R(k,s,e)}{\partial k} \frac{\partial k(s;II)}{\partial s}$ in equation 9 is large, then divided ownership and control (type II) is more likely to be optimal.

**Proof.** See the Appendix. ■

Intuitively, the above proposition says that the party with the stronger bargaining position should be given more control, because the party with the stronger bargaining position has higher incentive to invest. Thus, concentrated ownership and control must be the dominant choice in the organization form if the bargaining position is not balanced. Otherwise, if the bargaining position of the parties involved is relative even, there is room for the divided ownership and control. The emergence of the divided ownership and input control (type II) is to balance the ex post bargaining power of the parties involved, which is partially due to the encouragement effect of sequential complementary investments.

Similar to Hart (1995), we say that $k$ becomes relatively unproductive if $R(k,s,e) - C_k(k) - C_s(s) - C_e(e)$ is replaced by $\beta[R(k,s,e) - C_k(k) - C_s(s) - C_e(e)] + R(k,s,e)|_{k=0} - C_s(s) - C_e(e)$, where $\beta > 0$ is small. This implies

$$\frac{R(k,s,e)|_{k=0} - C_s(s) - C_e(e)}{R(k,s,e) - C_k(k) - C_s(s) - C_e(e)} = (1 - \beta) \to 1$$
That is to say, $k$ becomes unimportant relative to $s$ and $e$. Similarly, we define relatively unproductive for $s$ and $e$. The following lemma shows that when some investments are relative unproductive, what the optimal ownership structure is.

**Lemma 2**

i) *If both $s$ and $e$ are relatively unproductive, type II ownership structure will never be optimal. In addition, if ex post relative bargaining power of $M1$ is large, the optimal ownership structure will be type I/III; otherwise, the optimal ownership structure will be type IV.*

ii) *If both $k$ and $e$ are relatively unproductive, type II ownership structure will never be optimal. In addition, if ex post relative bargaining power of $M1$ is large, the optimal ownership structure will be type I/III; otherwise, the optimal ownership structure will be type IV.*

iii) *If both $k$ and $s$ are relatively unproductive, type II ownership structure will never be optimal. The optimal ownership structure will be type IV, except for the case of large $\mu$, in which the optimal ownership structure will be type I/III.*

iv) *If only $s$ is relatively unproductive, type II ownership structure will never be optimal. In addition, if ex post relative bargaining power of $M1$ and the encouragement effect are large, the optimal ownership structure will be type I/III; otherwise, the optimal ownership structure will be type IV.*

v) *If only $e$ is relatively unproductive, type II ownership structure will be optimal, only if $\frac{\partial R(k,s,e)}{\partial k} \frac{\partial k(s;II)}{\partial s}$ in equation 9 is large. Otherwise, the optimal ownership structure will be either type I/III or type IV: if ex post relative bargaining power of $M1$ is large, the optimal ownership structure will be type I/III; if ex post relative bargaining power of $M2$ is large, the optimal ownership structure will be type IV.*

**Proof.** See the Appendix.

The following proposition summarizes the results of the above lemma.

**Proposition 5** *Only if $s$ is important (not relatively unproductive), be divided ownership and control (type II) optimal. Further, if only $e$ is relatively unproductive, divided ownership and control (type II) will be optimal only if the encouragement effect of complimentary investments is large.*

### 3.4.1 Optimal Ownership and Control – Export Processing in China

In this section, we apply the results of proposition 4 and 5 to investigate the export processing in China. First, we make some assumptions:
Region In southern coastal provinces, the competitiveness/thickness in $M_2$ market is higher. That is to say, $\eta > \gamma > \phi$ is larger than those in the interior and northern provinces. It is easier for $M_1$ to find another Chinese supplier in southern coastal provinces.\footnote{Southern coastal provinces include Shanghai, Zhejiang, Fujian, Guangdong, and Hainan.}

Further, in southern coastal provinces, the wage rate is higher.

Industry In the high value-added industry, such as office machines, the specificity of physical asset $k$ is higher. That is to say, $\mu$ is larger than that in the low value-added industry, such as apparel. This is to capture the idea that high value-added industry is associated with higher demand of technology.

Further, in the high value-added industry, such as office machines, the specificity of intermediate product produced is higher. That is to say, $\psi$ is larger than that in the low value-added industry, such as apparel. This is to capture the idea that high value-added industry is associated with higher specificity of intermediate product produced.

In addition, the high value-added industry is capital intensive, while the low value-added industry is labor intensive.

SEZ (Special Economic Zone) In addition to the high competitiveness/thickness in $M_2$ market and high wage rate in the southern coastal provinces, inside SEZ, ex post bargaining weight $\alpha$ of $M_1$ is higher than that outside of SEZ. This is to capture the idea that SEZ usually has stronger commercial institutions.

Hong Kong Re-exports If the trade is re-exported through Hong Kong, the competitiveness/thickness in $M_1$ market is higher. That is to say, $\lambda < \theta$ is higher than those of direct exports from China. It is easier for $M_2$ to find another foreign final good producer. This is to capture the idea that trades from Hong Kong have better networks and information of the global market.\footnote{Here, we assume that traders from Hong Kong serve the role of middleman or experts. See Feenstra and Hanson (2004) for detailed analysis.}

Based on the above assumptions, the following corollary derives the results from our theoretical model.

Corollary 1 Region In southern coastal provinces, foreign ownership and control (type I/III) will be more common. In addition, the capital intensive industry is more likely in the export processing in southern coastal provinces.

Industry In the high value-added industry, foreign ownership and control (type I/III) will be more common.
SEZ (Special Economic Zone) Inside SEZ, foreign ownership and control (type I/III) will be more common.

Hong Kong Re-exports If the trade is re-exported through Hong Kong, Chinese ownership and control (type IV) is more common.

Proof. See the Appendix. ■

3.4.2 Empirical Evidence – Export Processing in China

Now we turn to the empirical evidence of export processing in China to test our theoretical findings. Table 2 reproduces the mean shares of Chinese processing exports by ownership and regime from Feenstra and Hanson (2003).\(^\text{12}\)

We have the following empirical evidence. First, foreign ownership and input control (type I/III) is the majority.\(^\text{13}\) Second, divided ownership and control (type II) is more likely in southern coastal provinces. Third, in the high value-added industry, such as office machines, foreign ownership and input control (type I/III) captures more than 70%; while in the low value-added industry, such as apparel, Chinese ownership is more likely. Fourth, inside SEZs (Special Economic Zones), foreign ownership and input control (type I/III) captures more than 80%; while outside SEZs, divided ownership and control (type II) is dominant. Fifth, divided ownership and control (type II) is more common in the trade of re-exported through Hong Kong, compared to the trade of direct exports from China.

The empirical evidence supports our corollary that foreign ownership and input control (type I/III) is more common in high value-added industry and inside SEZ, but confronts our corollary that in the interior and northern provinces, foreign ownership and control (type I/III) captures even higher proportion and if the trade is re-exported through Hong Kong, Chinese ownership and control (type IV) is not more common.

The possible reason is that in Feenstra and Hanson (2003), if the owner of the processing plant is from Hong Kong, they count it as foreign ownership (type I/III). Instead, if we assume that traders from Hong Kong serve the role of middleman or experts, then it might be better to classify them as the second layer of supplier of intermediate products. Thus, if the owner of the processing plant is from Hong Kong, they count it as Chinese ownership (type II or type IV). More empirical work needs to be done to test our theoretical results.

\(^\text{12}\)In table 2, we combine the mean shares of type I and type III.
\(^\text{13}\)Also, the interior and northern provinces are more concentrated in the low value-added industries, such as apparel, footwear, and toys.
Table 2: Mean shares of Chinese Processing Exports By Ownership and Regime

<table>
<thead>
<tr>
<th>Regime</th>
<th>By Region</th>
<th>Ownership of factory:</th>
<th>Ownership of factory:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All provinces</td>
<td>Foreign</td>
<td>Chinese</td>
</tr>
<tr>
<td></td>
<td>Ownership of factory:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pure-assembly</td>
<td>0.579</td>
<td>0.271</td>
</tr>
<tr>
<td></td>
<td>import-and-assembly</td>
<td>0.146</td>
<td>0.297</td>
</tr>
<tr>
<td>By Industry</td>
<td>Office Machines</td>
<td>Ownership of factory:</td>
<td>Ownership of factory:</td>
</tr>
<tr>
<td></td>
<td>pure-assembly</td>
<td>0.726</td>
<td>0.211</td>
</tr>
<tr>
<td></td>
<td>import-and-assembly</td>
<td>0.062</td>
<td>0.187</td>
</tr>
<tr>
<td>By Location</td>
<td>Inside SEZs</td>
<td>Ownership of factory:</td>
<td>Ownership of factory:</td>
</tr>
<tr>
<td></td>
<td>pure-assembly</td>
<td>0.826</td>
<td>0.076</td>
</tr>
<tr>
<td></td>
<td>import-and-assembly</td>
<td>0.098</td>
<td>0.157</td>
</tr>
<tr>
<td>By Trade Route</td>
<td>Hong Kong Re-Exports</td>
<td>Ownership of factory:</td>
<td>Ownership of factory:</td>
</tr>
<tr>
<td></td>
<td>pure-assembly</td>
<td>0.514</td>
<td>0.367</td>
</tr>
<tr>
<td></td>
<td>import-and-assembly</td>
<td>0.098</td>
<td>0.119</td>
</tr>
</tbody>
</table>

\(a\)Excluding Shanghai, Zhejiang, Fujian, Guangdong, and Hainan

4 Conclusion

We investigate individual firms’ strategic choice of organization form when outsourcing their intermediate products. Follow the framework of property rights theory from Grossman and Hart (1986) and Hart and Moore (1990). Under incomplete contract, relationship-specific investments are distorted by the hold-up problem and thus underinvested. In their models, relationship-specific investments are simultaneously invested. In contrast, we study a sequential hold-up model, in which relationship-specific investments are sequentially invested. With sequential investment, the final good producer may have incentive to invest more to elicit more investment from the supplier. Based on Hart (1995), we show that sequential investment alleviates the underinvestment of hold-up problem as a result of the encouragement effect of sequential investment.
complementary investments.

Then we construct a sequential outsourcing model to study the export processing in China. When the foreign final good producer initiates the proposal of outsourcing of its intermediate products to the Chinese supplier, they will establish a new processing plant. According to Feenstra and Hanson (2003, 2005), in export processing in China, all processing plants, regardless of ownership, operate under the following two regimes: Pure-assembly and Import-and-assembly. We find that if the foreign final good producer is the owner of the processing plant in China, pure-assembly regime is equivalent to import-and-assembly regime.

Feenstra and Hanson (2005) build a model of international outsourcing model to investigate the export processing in China. They argue that the rational of divided ownership and control is to improve incentive of the party with the weaker bargaining position. On the contrary, we believe that the party with the stronger bargaining position should be given more control, because the party with the stronger bargaining position has higher incentive to invest. Thus, concentrated ownership and control must be the dominant choice in the organization form if the bargaining position is not balanced. Otherwise, if the bargaining position of the parties involved is relative even, there is room for the divided ownership and control.

In our sequential “outsourcing” model, we show that the emergence of the divided ownership and input control (type II) is to balance the ex post bargaining power of the parties involved, which is partially due to the encouragement effect of sequential complementary investments, instead of merely improving incentive of the party with the weaker bargaining position. In particular, when input control is important and the encouragement effect of sequential complementary investments is high, it might be better for the foreign final good producer to control over primary input sourcing. And hence, divided ownership and input control (type II) is more likely to be optimal.

Finally, we turn to the empirical evidence of the export processing in China to test our theoretical model. From the data in Feenstra and Hanson (2003), the empirical evidence supports some of our results, while confronts with others. More empirical work has to be done.

Appendix

Proof of Proposition 1

Let \( x = (i, e) \). Similar to the proof of proposition 1 in Hart and Moore (1990), define \( g(x) = R(i, e) - C_i(i) - C_e(e) \) and \( h(x; A, B) \) such that

\[
\nabla g(x) = \left( \frac{\partial R(i, e)}{\partial i} - C_i'(i) \right) \left( \frac{\partial R(i, e)}{\partial e} - C_e'(e) \right)
\]
\[ \nabla h(x; A, B) = \left( \alpha \frac{\partial R(i,e)}{\partial i} + (1 - \alpha) \frac{\partial R(i,e)}{\partial e} + \alpha \frac{d r_1(i,A)}{d e} - C'_i(i) \right) \]

From the first order conditions in section 2.1 and 2.2, we have

\[ \nabla g(x)|_{x=(i^*, e^*)} = 0 \]
\[ \nabla h(x; A, B)|_{x=(i(A,B), e(A,B))} = 0 \]

By assumption 3, we have \( \nabla g(x) \geq \nabla h(x; A, B) \) for any ownership structure \((A, B)\) and investments \(i, e\). Define \( f(x, \lambda) = \lambda g(x) + (1 - \lambda) h(x; A, B) \). Also define \( x(\lambda) = (i(\lambda), e(\lambda)) \) to solve \( \nabla f(x, \lambda) = 0 \). Total differentiating, we obtain

\[ H(x, \lambda) dx(\lambda) = -[\nabla g(x) - \nabla h(x; A, B)]d\lambda \]

where \( H(x, \lambda) \) is the Hessian of \( f(x, \lambda) \) with respect to \( x \). By assumption 1 and assumption 4, \( H(x, \lambda) \) is negative definite. Also, by assumption 4, the off-diagonal elements of \( H(x, \lambda) \) are non-negative. By Takayama (1985), p.393, theorem 4.D.3 [II\textsuperscript{IV} and IV\textsuperscript{IV}], \( H(x, \lambda)^{-1} \) is nonpositive. Thus, \( dx(\lambda)/d\lambda \geq 0 \), and \( x(1) \geq x(0) \), which implies \( i(A,B) \leq i^* \) and \( e(A,B) \leq e^* \). ■

**Proof of Proposition 2**

By backward induction, at date 1.2, M2 maximizes his own payoffs, net of investment costs, by choosing \( e \) given M1’s choice \( i \) at date 1.1. Total differentiating the first order condition (equation 2), we obtain

\[ (1 - \alpha) \frac{\partial^2 R(i,e)}{\partial e^2} de + (1 - \alpha) \frac{\partial^2 R(i,e)}{\partial e \partial i} di + \alpha \frac{d^2 r_2(e;B)}{d e^2} de = C''_2(e)de \]

Rearranging and by assumption 1 and 4, we have

\[ \frac{de}{di} = \frac{(1 - \alpha) \frac{\partial^2 R(i,e)}{\partial e \partial i}}{C''_2(e) - (1 - \alpha) \frac{\partial^2 R(i,e)}{\partial e^2} - \alpha \frac{d^2 r_2(e;B)}{d e^2}} \geq 0 \]

Similar to the proof of proposition 1, let \( x = (i, e) \). By equation 2 and 3, define \( h(x; A, B) \) and \( l(x; A, B) \) such that

\[ \nabla h(x; A, B) = \left( \alpha \frac{\partial R(i,e)}{\partial i} + (1 - \alpha) \frac{\partial R(i,e)}{\partial e} + \alpha \frac{d r_1(i,A)}{d e} - C'_i(i) \right) \]

\[ \nabla l(x; A, B) = \left( \alpha \frac{\partial R(i,e)}{\partial i} + (1 - \alpha) \frac{d r_1(i,A)}{d e} + \alpha \frac{d r_2(e;B)}{d e} - C'_e(e) \right) \]
From the first order conditions in section 2.2 and 2.3, we have

$$\nabla h(x; A, B)\big|_{x = (\tilde{i}(A, B), \tilde{e}(A, B))} = 0$$
$$\nabla l(x; A, B)\big|_{x = (\tilde{i}(A, B), \tilde{e}(A, B))} = 0$$

By assumption 3 and $\frac{de(i; A, B)}{di} \geq 0$, we have $\nabla l(x; A, B) \geq \nabla h(x; A, B)$ for any ownership structure $(A, B)$ and investments $i, e$. The remaining is same as the proof of proposition 1. We have $\tilde{i}(A, B) \geq \hat{i}(A, B)$ and $\tilde{e}(A, B) \geq \hat{e}(A, B)$. ■

**Proof of Proposition 3**

From proposition 2, given any ownership structure $(A, B)$ there will be more investments under sequential investment. Total differentiating the ex ante surplus $R(i, e) - C_i(i) - C_e(e)$,

$$d[R(i, e) - C_i(i) - C_e(e)] = \left[ \frac{\partial R(i, e)}{\partial i} - C'_i(i) \right] di + \left[ \frac{\partial R(i, e)}{\partial e} - C'_e(e) \right] de$$

Since $e$ is conditionally underinvested, which implies $C'_e(e) < \frac{\partial R(i, e)}{\partial e}$, clearly, if

$$\frac{de}{di} > -\frac{\partial R(i, e)}{\partial i} - C'_i(i)$$

then $R(i, e) - C_i(i) - C_e(e)$ is increasing in $i$ and $e$ under sequential investment.

From proposition 2, we know $\frac{de}{di} > 0$. Thus, if both $i$ and $e$ are conditionally underinvested,

$$-\frac{\partial R(i, e)}{\partial i} - C'_i(i) < 0$$

Consequently, the ex ante surplus is increasing with larger $i$ and $e$ under sequential investment regardless of $\frac{de}{di}$ and ownership structure. ■

**Proof of Lemma 1**

i) Under simultaneous investment, the first order conditions will be similar to those under sequential investment, except that there will be no encouragement effect. Since $A_{I/III}$, $A_{II}$, and $A_{IV}$ are all smaller than one, under simultaneous investment $k$, $s$, and $e$ are all conditionally underinvested. Similar to the proof of proposition 1 and 2, we have $\forall O \in \{I/III, II, IV\}$, $k(O) \leq k^*$, $s(O) \leq s^*$, $e(O) \leq e^*$. 23
ii) By assumption 5, 6, and the first order conditions under sequential investment, we can show that the encouragement effect of complementary investments is always positive. Similar to the proof of proposition 2, we have $\forall \mathbf{O} \in \{I/III, II, IV\}$, $k(O) \geq k(O), s(O) \geq s(O), e(O) \geq e(O)$.

In particular, for type IV ownership structure, since $M2$ will make all the investments, there will be no encouragement effect of sequential investment. Thus, the result under sequential investment is equivalent to that under simultaneous investment. That is to say, $k(IV) = k(IV) \leq k^*, s(IV) = s(IV) \leq s^*, e(IV) = e(IV) \leq e^*$.

iii) From the proof above, given any ownership structure $\mathbf{O} \in \{I/III, II, IV\}$ there will be more investments under sequential investment. Similar to the proof of proposition 3, total differentiating the ex ante surplus $R(k, s, e) - C_k(k) - C_s(s) - C_e(e)$,

$$d[R(k, s, e) - C_k(k) - C_s(s) - C_e(e)] = \left[\frac{\partial R(k, s, e)}{\partial k} - C'_k(k)\right] dk + \left[\frac{\partial R(k, s, e)}{\partial s} - C'_s(s)\right] ds + \left[\frac{\partial R(k, s, e)}{\partial e} - C'_e(e)\right] de$$

Considering the type I/III ownership structure (foreign ownership and control – $k, s$ from $M1$; $e$ from $M2$), from equation 6, $e$ is conditionally underinvested, which implies $C'_e(e) < \frac{\partial R(k, s, e)}{\partial e}$. Clearly, if

$$de > -\left[\frac{\partial R(k, s, e)}{\partial k} - C'_k(k)\right] dk + \left[\frac{\partial R(k, s, e)}{\partial s} - C'_s(s)\right] ds$$

then $R(k, s, e) - C_k(k) - C_s(s) - C_e(e)$ is increasing in $k, s, e$ under sequential investment.

From the proof above, we know the encouragement effect is always positive, that is $de > 0$. Thus, if $k, s, e$ all are conditionally underinvested,

$$-\left[\frac{\partial R(k, s, e)}{\partial k} - C'_k(i)\right] dk + \left[\frac{\partial R(k, s, e)}{\partial s} - C'_s(s)\right] ds < 0$$

Consequently, the ex ante surplus is increasing with larger $k, s, e$ under sequential investment regardless of the encouragement effect.

Proof of Proposition 4

i) If $\mu$ is large, then $A_{II}, 1 - \mu - A_{II}$, and $A_{IV}$ will go to zero. Consequently, $k, s, e$ will be small under type II and type IV ownership structure. Thus, the optimal ownership structure must be foreign ownership and control (type I/III), if $\mu$ is large enough.
ii) From lemma 1, under type IV ownership structure, \( k, s, \) and \( e \) all are conditionally underinvested and more investments are better. If the encouragement effect of sequential complementary investments is large, there will be more investments. Thus, type II and type IV ownership structure will more likely be optimal.\(^{14}\)

iii) From section 3.1, the ex post relative bargaining power of \( M_1 \) is \( A_{III}, A_{II}, \) and \( A_{IV} \) under type I/III, type II, and type IV ownership structure respectively. Further, \( A_{III}, A_{II}, \) and \( A_{IV} \) are decreasing as the bargaining weight \( \alpha \) increases, the competitiveness/thickness in \( M_1 \) market \( \lambda \) and \( \theta \) decrease, the competitiveness/thickness in \( M_2 \) market \( \eta, \gamma, \) and \( \phi \) increase, and the specificity of intermediate product produced \( \psi \) increases.

If \( A_{III}, A_{II}, \) and \( A_{IV} \) are close to zero, \( k, s, \) and \( e \) will all be too small under type IV ownership structure. Thus, type IV ownership structure will be dominated by type I/III and type II ownership structure. Moreover, \( k \) and \( e \) will be too small under type II ownership structure. Therefore, the encouragement effect must be small under type II ownership structure. Similarly, \( k \) and \( e \) will be too small under type I/III ownership structure. Therefore, the encouragement effect must be small under type I/III ownership structure. Since \( 1 - \mu - A_{II} < 1 - A_{III} \), clearly type II ownership structure will be dominated by type I/III ownership structure.

If \( A_{III}, A_{II}, \) and \( A_{IV} \) are close to one, \( s \) will be too small under type II ownership structure. Since \( A_{II} < A_{IV} \), type II ownership structure will be dominated by type IV ownership structure. Similarly, \( k \) and \( s \) will be too small under type I/III ownership structure. Therefore, type IV ownership structure will more likely be optimal. Only if \( \mu \) is large enough, be type I/III ownership structure optimal.

Since \( A_{II} < A_{IV} \), if the term \( \frac{\partial R(k, s, e)}{\partial e} \frac{\partial e(s; II)}{\partial s} + \frac{\partial R(k, s, e)}{\partial k} \frac{\partial k(s; II)}{\partial s} \) in equation 9 is small and \( A_{II} \) is large (hence \( 1 - \mu - A_{II} < A_{IV} \)), type II ownership structure will be dominated by type IV ownership structure. Thus, if \( A_{III}, A_{II}, \) and \( A_{IV} \) are in the mid-range between zero and one, and if the term \( \frac{\partial R(k, s, e)}{\partial e} \frac{\partial e(s; II)}{\partial s} + \frac{\partial R(k, s, e)}{\partial k} \frac{\partial k(s; II)}{\partial s} \) in equation 9 is large, then divided ownership and control (type II) is more likely to be optimal. ■

\(^{14}\)There is chance for conditionally overinvestment and if overinvestment is so large that less investment is preferred.
Proof of Lemma 2

i) If both $s$ and $e$ are relatively unproductive, from the first order conditions in section 3.3, we end up with comparing

$$\text{type I/III: } (1 - A_{I/III}) \left\{ \frac{\partial R(k, s, e)}{\partial k} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial e(k, s; I/III)}{\partial k} \right\} = C'_k(k)$$

$$\text{type II: } A_{II} \frac{\partial R(k, s, e)}{\partial k} = C'_k(k)$$

$$\text{type IV: } A_{IV} \frac{\partial R(k, s, e)}{\partial k} = C'_k(k)$$

Note, since $e$ is relative unproductive, the term $\frac{\partial R(k,s,e)}{\partial e} \frac{\partial e(k,s;I/III)}{\partial k}$ in the above equation is small. As $1 - A_{I/III}$, $A_{II}$, and $A_{IV}$ are all smaller than one, $k$ is conditionally underinvested. Thus, more investment will be better.

Since $A_{II} < A_{IV}$, type II ownership structure will never be optimal. Comparing $1 - A_{I/III}$ and $A_{IV}$, if ex post relative bargaining power of $M1$ is large, the optimal ownership structure will be type I/III; otherwise, the optimal ownership structure will be type IV.

ii) If both $k$ and $e$ are relatively unproductive, from the first order conditions in section 3.3, we end up with comparing

$$\text{type I/III: } (1 - A_{I/III}) \left\{ \frac{\partial R(k, s, e)}{\partial s} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial e(k, s; I/III)}{\partial s} \right\} = C'_s(s)$$

$$\text{type II: } (1 - \mu - A_{II}) \left\{ \frac{\partial R(k, s, e)}{\partial s} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial e(s; II)}{\partial s} + \frac{\partial R(k, s, e)}{\partial k} \frac{\partial k(s; II)}{\partial s} \right\} = C'_s(s)$$

$$\text{type IV: } A_{IV} \frac{\partial R(k, s, e)}{\partial s} = C'_s(s)$$

Note, since both $k$ and $e$ are relative unproductive, the term $\frac{\partial R(k,s,e)}{\partial e} \frac{\partial e(k,s;I/III)}{\partial s}$ in the above equation is small. So is the term $\frac{\partial R(k,s,e)}{\partial e} \frac{\partial e(s;II)}{\partial s} + \frac{\partial R(k,s,e)}{\partial k} \frac{\partial k(s;II)}{\partial s}$. As $1 - A_{I/III}$, $1 - \mu - A_{II}$, and $A_{IV}$ are all smaller than one, $s$ is conditionally underinvested. Thus, more investment will be better.

Since $1 - \mu - A_{II} < 1 - A_{I/III}$, type II ownership structure will never be optimal. Comparing $1 - A_{I/III}$ and $A_{IV}$, if ex post relative bargaining power of $M1$ is large, the optimal ownership structure will be type I/III; otherwise, the optimal ownership structure will be type IV.

iii) If both $k$ and $s$ are relatively unproductive, from the first order conditions in
section 3.3, we end up with comparing

\[
\text{type I/III: } A_{I/III} \frac{\partial R(k, s, e)}{\partial e} = C'_e(e) \\
\text{type II: } A_{II} \frac{\partial R(k, s, e)}{\partial e} = C'_e(e) \\
\text{type IV: } A_{IV} \frac{\partial R(k, s, e)}{\partial e} = C'_e(e)
\]

As \( A_{I/III}, A_{II}, \) and \( A_{IV} \) are all smaller than one, \( e \) is conditionally underinvested. Thus, more investment will be better.

Since \( A_{II} < A_{IV} \), type II ownership structure will never be optimal. Comparing \( A_{I/III} \) and \( A_{IV} \), the optimal ownership structure will be type IV, except for the case of large \( \mu \), in which the optimal ownership structure will be type I/III.

iv) If only \( s \) is relatively unproductive, from the first order conditions in section 3.3, we end up with comparing

\[
\text{type I/III: } \left\{ \begin{array}{l}
(1 - A_{I/III}) \left\{ \frac{\partial R(k, s, e)}{\partial k} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial (k, s; I/III)}{\partial k} \right\} = C'_k(k) \\
A_{I/III} \frac{\partial R(k, s, e)}{\partial e} = C'_e(e)
\end{array} \right.
\]

\[
\text{type II: } \left\{ \begin{array}{l}
A_{II} \frac{\partial R(k, s, e)}{\partial k} = C'_k(k) \\
A_{II} \frac{\partial R(k, s, e)}{\partial e} = C'_e(e)
\end{array} \right.
\]

\[
\text{type IV: } \left\{ \begin{array}{l}
A_{IV} \frac{\partial R(k, s, e)}{\partial k} = C'_k(k) \\
A_{IV} \frac{\partial R(k, s, e)}{\partial s} = C'_s(s)
\end{array} \right.
\]

As \( A_{II} \) and \( A_{IV} \) are both smaller than one, both \( k \) and \( e \) are conditionally underinvested for type II and type IV ownership structure. Thus, more investment will be better. Since \( A_{II} < A_{IV} \), type II ownership structure will never be optimal.

Comparing \( 1 - A_{I/III} \) and \( A_{IV} \), if ex post relative bargaining power of \( M1 \) and the term \( \frac{\partial R(k, s, e)}{\partial e} \frac{\partial (k, s; I/III)}{\partial k} \) are large, the optimal ownership structure will be type I/III; otherwise, the optimal ownership structure will be type IV.

v) If only \( e \) is relatively unproductive, from the first order conditions in section 3.3, we end up with comparing

\[
\text{type I/III: } \left\{ \begin{array}{l}
(1 - A_{I/III}) \left\{ \frac{\partial R(k, s, e)}{\partial k} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial (k, s; I/III)}{\partial k} \right\} = C'_k(k) \\
(1 - A_{I/III}) \left\{ \frac{\partial R(k, s, e)}{\partial s} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial (k, s; I/III)}{\partial s} \right\} = C'_s(s)
\end{array} \right.
\]

\[
\text{type II: } \left\{ \begin{array}{l}
A_{II} \frac{\partial R(k, s, e)}{\partial k} = C'_k(k) \\
(1 - \mu - A_{II}) \left\{ \frac{\partial R(k, s, e)}{\partial s} + \frac{\partial R(k, s, e)}{\partial e} \frac{\partial (s; II)}{\partial s} + \frac{\partial R(k, s, e)}{\partial k} \frac{\partial (k; II)}{\partial s} \right\} = C'_s(s)
\end{array} \right.
\]

\[
\text{type IV: } \left\{ \begin{array}{l}
A_{IV} \frac{\partial R(k, s, e)}{\partial k} = C'_k(k) \\
A_{IV} \frac{\partial R(k, s, e)}{\partial s} = C'_s(s)
\end{array} \right.
\]
Note, since $e$ is relative unproductive, the terms $\frac{\partial R(k,s,e)}{\partial e}, \frac{\partial R(k,s,e)}{\partial s}$ in the above equations are small. The only exception is the term $\frac{\partial R(k,s,e)}{\partial k}$.

As $1 - A_{I/III}$ and $A_{IV}$ are both smaller than one, both $k$ and $s$ are conditionally underinvested for type I/III and type IV ownership structure. Thus, more investment will be better. Suppose the term $\frac{\partial R(k,s,e)}{\partial k}$ is small. Since $1 - \mu - A_{II} < 1 - A_{I/III}$ and $A_{II} < A_{IV}$, if $1 - \mu - A_{II} < A_{IV}$, type II ownership structure will be dominated by type IV. Otherwise, if $1 - \mu - A_{II} > A_{IV}$, which implies $1 - A_{I/III} > 1 - \mu - A_{II} > A_{IV} > A_{II}$, type II ownership structure will be dominated by type I/III. Thus, type II ownership structure will be optimal, only if $\frac{\partial R(k,s,e)}{\partial k}$ in equation 9 is large. Otherwise, the optimal ownership structure will be either type I/III or type IV: if ex post relative bargaining power of $M_1$ is large, the optimal ownership structure will be type I/III; if ex post relative bargaining power of $M_2$ is large, the optimal ownership structure will be type IV.

**Proof of Corollary 1**

**Region** From our assumptions in section 3.4.1, in southern coastal provinces, the competitiveness/thickness in $M_2$ market is higher. That is to say, $\eta > \gamma > \phi$ is larger than those in the interior and northern provinces, which implies $A_{I/III}, A_{II}$, and $A_{IV}$ is decreasing. From proposition 4, if the ex post relative bargaining power of $M_1$ is increasing, foreign ownership and control (type I/III) will be more common.

Further, in southern coastal provinces, the wage rate is higher. The capital intensive industry is more likely in the export processing in southern coastal provinces.

**Industry** From our assumptions in section 3.4.1, in the high value-added industry, the specificity of physical asset $k$ is higher. And so is specificity of intermediate product produced. That is to say, $\mu$ and $\psi$ are both larger than those in the low value-added industry, which implies $A_{I/III}, A_{II}$, and $A_{IV}$ is decreasing. From proposition 4, if the ex post relative bargaining power of $M_1$ is increasing, foreign ownership and control (type I/III) will be more common.

**SEZ (Special Economic Zone)** From our assumptions in section 3.4.1, in addition to the high competitiveness/thickness in $M_2$ market in the southern coastal provinces, inside SEZ, ex post bargaining weight $\alpha$ of $M_1$ is higher than that outside of SEZ. Both of these imply $A_{I/III}, A_{II}$, and $A_{IV}$ is decreasing. From proposition 4, if the ex post relative bargaining power of $M_1$ is increasing, foreign ownership and control (type I/III) will be more common.
Hong Kong Re-exports From our assumptions in section 3.4.1, if the trade is re-exported through Hong Kong, the competitiveness/thickness in M1 market is higher. That is to say, \( \lambda < \theta \) is higher than those of direct exports from China, which implies \( A_{I/III} \), \( A_{II} \), and \( A_{IV} \) is increasing. From proposition 4, if the ex post relative bargaining power of M2 is increasing, Chinese ownership and control (type IV) will be more common.

References


