Information, incentives and multinational firms

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A B S T R A C T

I present a model that explains a multinational firm’s choice of organizational form. If a firm in the developed country outsources the production of its intermediate goods to a supplier in the developing country, it faces an adverse selection problem. If it chooses to produce the intermediate goods in its own subsidiary in the developing country, it faces an inefficient monitoring problem. My analysis of this tradeoff provides a new explanation for the observation that FDI is concentrated in capital intensive industries and yields two empirical hypotheses: more firms should adopt outsourcing instead of FDI after trade liberalization; the share of intra-firm trade in total trade should be increasing in the degree of productivity dispersion across intermediate goods suppliers in the developing country.

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1. Introduction

Recent years have witnessed rapid growth of Foreign Direct Investment (FDI).1 With the rapid growth of FDI, intra-firm trade has become an important feature of international trade.2 FDI and intra-firm trade are conducted by Multinational Enterprises (MNEs) which play a key role in the international economy today.3 Other than FDI, MNEs can outsource production by buying intermediate goods from independent suppliers in the developing country. Outsourcing has expanded dramatically in the past two decades, especially in the form of international trade of intermediate goods.4

5 This is an interesting phenomenon which some trade economists have tried to explain. In the seminal work of Antrás (2003b), he uses the incomplete contract theory5 to explain this empirical finding.6 Because of the incompleteness of contracts between the MNE in the developed country and the intermediate goods supplier in the developing country, the hold-up problem appears. Consequently, both sides underinvest. In capital-intensive industries, the investment of the MNE’s input becomes more important compared with the intermediate goods suppliers. Thus, the MNE wants to integrate the intermediate goods supplier to increase its incentive to invest. As a result, the loss of efficiency will be alleviated in the capital-intensive industry, if the MNE integrates the intermediate goods supplier in the developing country.

Although the work of Antrás (2003b) sheds important light on the problem of MNEs’ organizational choice, there are other relevant factors that have not been studied very much in the previous literature. Among these is the asymmetric information problem concerning the southern suppliers’ products. In 2007, it was reported that toys contaminated with toxic levels of lead were found among exports from China to the U.S.7 At the beginning of 2008, dumplings exported to Japan from the Chinese food corporation Tianyang were

7 Similar approaches applied to international trade theory can be found in Antrás (2005), Grossman and Helpman (2002, 2003, 2005) and McLaren (2000).
8 For details, see [URL].
found to be poisonous. The most recent and serious case is the melamine-tainted milk-powder crisis in September 2008. Sanlu and other related firms included melamine which is cheaper than other components of the milk-powder into their products and sold them at high prices. All above cases point out one important issue in international trade, which is the asymmetric information problem regarding the quality of products exported from developing countries.

It is also natural to think that all these quality problems are due to the desire to push down the products' real cost. Interestingly, the New Zealand dairy conglomerate Fonterra that had already held a 43% stake in Sanlu before the crisis was reportedly trying to buy the whole stake of Sanlu after the crisis. This information reveals that the best way to eliminate the asymmetric information problem about the transaction partners’ products (e.g., production cost, productivity, quality) is to integrate them. Other than the cases mentioned above, there is a famous example concerning different organizational choices among giant MNEs. Nike outsourced the whole production of making shoes to companies in developing countries. On the other hand, Intel set up its own subsidiaries in China and Costa Rica to assemble and test computer chips. Therefore, a natural question arises: Why do these two famous MNEs behave so differently? In what follows, I will give an explanation for this phenomenon, and it turns out that the key factor is the asymmetric information concerning the southern suppliers’ productivity.

In this paper, I use contract theory to explain the economic forces behind multinational firms’ choice of organizational form. I focus on comparing two types of production: outsourcing in the developing country and FDI. My model links information asymmetry with the outsourcing decision as follows. Suppose that a potential supplier has private information on his firm’s productivity, and furthermore that his workers must be monitored to prevent shirking. An MNE can either outsource to this supplier or acquire his firm through FDI. Outsourcing requires that the MNE pays an information rent, since the supplier must be induced to reveal his productivity. Though FDI would reveal this productivity directly, it has the disadvantage that the monitoring incentives weaken, since the supplier would no longer enjoy the ownership. Obviously, the MNE is not a real MNE in the outsourcing case, as it does not own foreign affiliates. For convenience, I call the final goods makers in the developed country that undertake outsourcing in the developing country the MNEs also.

My model rationalizes empirical findings that FDI is heavily concentrated in capital-intensive industries from the information frictions perspective. The intuition behind this result is that although the adverse selection problem is not related to the capital intensity of production, the inefficient monitoring problem and its importance in the FDI case are significantly affected by the capital intensity. At first glance, it seems that the increase of capital intensity decreases the marginal product of labor and accordingly southern managers’ incentive to monitor. Nevertheless, a higher capital intensity incentivizes substitution away from labor, and subsequently reduces monitoring costs. Moreover, it also increases the benefits of monitoring through an increase in the capital–labor ratio. In total, an increase in the capital intensity alleviates the inefficient monitoring problem in the FDI case by inducing the manager of the MNE’s subsidiary to choose a higher monitoring intensity. Therefore, the advantage of outsourcing over FDI is less pronounced in capital-intensive industries, and FDI is heavily concentrated in capital-intensive industries. Following this argument, it is straightforward to see that while the main results of this paper are the same as those of Antrás (2003b, 2005), the economic intuition contrasts markedly. Another interesting result is that after trade liberalization, more firms should use outsourcing to produce intermediate goods, since the reduction in the heterogeneity in productivity of the suppliers following trade liberalization reduces the information rent the MNE has to pay which makes outsourcing more attractive. Additionally, my model predicts that the share of intra-firm trade (i.e., FDI) in total trade should be increasing in the degree of productivity dispersion across intermediate goods suppliers in the developing country. The reason is that the increased dispersion of the suppliers’ productivity increases the information rent that the MNE has to pay, and consequently makes the choice of FDI more attractive than outsourcing.

The adverse selection problem in the outsourcing case and the foreign managers’ lack of incentive to work in the FDI case are serious problems in practice, although they have been more or less overlooked by trade economists for many years. Admittedly, there is one important exception in the trade literature that considers the asymmetric information problem. Horstmann and Markusen (1996) presents an interesting model in which the MNE has to choose between making a contract with a foreign agent and setting up her own affiliate in order to sell the products. In their model, the MNE is faced with an asymmetric information problem when contracting with a stand-alone agent in the foreign country. Although the MNE can overcome this problem by setting up her affiliate, it is assumed that in the FDI case, the MNE has to pay a fixed cost (e.g., the set-up cost) which is not incurred in the outsourcing case. In this paper, I will give a more explicit explanation about the disadvantage of FDI by introducing the inefficient monitoring problem. Interestingly, in international management literature, some researchers think about the information and incentive issues surrounding MNEs seriously. This paper will shed light on these important issues in international trade theory.

The monitoring issue discussed in this paper is related to a literature in organizational economics, which argues that firms with more hierarchical levels allocate less time and resources to monitoring and lose more control on their workers. In this paper, an independent intermediate goods supplier has two layers (i.e., hierarchical levels): the domestic manager who owns the firm and the workers. The MNE’s foreign affiliate has an extra layer—the owner in the developed country. Due to the separation of ownership and control in the FDI case, the MNE’s subsidiary loses more control of his workers; i.e., the monitoring is less efficient. Subsequent work in this literature derives a hypothesis that workers’ wage rate should be higher in firms with more hierarchical levels, as a higher wage rate raises the cost to workers of shirking and accordingly mitigates the loss of control on workers. This hypothesis is consistent with the result of this paper that a higher wage rate in the FDI case is needed to prevent workers from shirking. Interestingly, Grossman and Helpman (2004) also consider the monitoring issue to be an important factor when comparing outsourcing to FDI. Their stance is that the owner in the developed country can monitor the manager in the developing country more effectively under integration than under outsourcing, which may seem contrary to my assumption that monitoring is less efficient under integration. However, their focus is the owner’s monitoring of the manager, not the manager’s monitoring of the workers. Both papers focus on monitoring asymmetry from different aspects, and different types of inefficient monitoring may be present at the same time.

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9 For details, see http://www.reuters.com/article/LatestCrisis/idUSL1900036.

10 Dunning (1993) writes, “such cognitive deficiencies give rise to bounded rationality, opportunism, adverse selection, moral hazard. This kind of market failure is particularly likely to be associated with cross-border transaction” (p.78). Rugman (1981) also writes, “there are presumably more imperfections and greater transactions costs in international than in domestic markets” (p.42).

11 Pioneering work in this literature includes Williamson (1967), Calvo and Wellisz (1978), etc.

12 Indeed, Williamson (1967) writes, “if, in addition, goals differ between hierarchical levels, the loss in control can be more extensive” (p.135).

13 For details, see Mellow (1982), Oi (1983), Brown and Medoff (1988), and Troske (1999).

14 Although nominal wage rates are the same in both cases, the wage per effective labor unit is higher in the FDI case, as monitoring intensity and workers’ effort levels are lower in this case.
The rest of this paper is organized as follows. Section 2 develops the model and calculates the expected profit in both the outsourcing case and the FDI case. Section 3 compares these two choices of organizational form and describes the production patterns in equilibrium. Section 4 concludes. The proofs of the main results are relegated to the Appendices.

2. The model

When going to the developing country for the production of intermediate goods, the MNE has two options: outsourcing and FDI. Here I use Section 2.1 to describe the model environment. In Section 2.2, I characterize the decision to outsource, while Section 2.3 considers the decision to undertake FDI.

2.1. Environment

2.1.1. Technology

There are two countries called the North (i.e., the developed country) and the South (i.e., the developing country). There are two factors—labor and capital. Consumers’ preferences are such that a producer of final goods in industry \( j \) faces the following iso-elastic demand function\(^{15}\):

\[
y = \lambda_j p^{-1/(1-\alpha)}; 0 < \alpha < 1
\]

where \( p \) is the price of the good and \( \lambda_j \) is a constant term that the producer takes as given. The production technology for the intermediate goods supplier in the South is Cobb–Douglas type:

\[
x = \theta \left( \frac{K}{L} \right)^\beta / \left( \frac{eL}{1-\beta} \right)^{1-\beta}; 0 < \beta < 1
\]

where \( \theta \) indicates the intermediate goods supplier’s productivity which is assumed to be uniformly distributed on \([\theta^0, 1] \) \((0 < \theta^0 < 1)\), and \( e \) is the effort level chosen by each worker. Workers are assumed to be homogeneous, so the optimal effort levels are the same across workers. The key element in this setup is that the information about the productivity is each intermediate goods supplier’s private information when the supplier is not owned by the MNE. For convenience, I assume the production of the final goods from the intermediate goods requires no further costs:

\[
y = x.
\]

2.1.2. Monitoring and the wage contract

The wage schedule considered in this model takes the form of a pair \( \{e, w\} \), which indicates the effort that the workers are expected to expend and the wage rate that applies unless the manager catches them shirking. Workers of the intermediate goods supplier choose their effort levels subject to the following private cost: \( C(e) = e^2 \) and \( e \geq 0 \). In order to induce workers to exert effort, the northern manager monitors every worker with intensity \( q \). Monitoring intensity \( q \) means that if the worker chooses an effort level less than the one specified in the wage contract, he will be caught shirking and fired with probability \( q \). Workers who are fired at this stage can obtain a reservation wage rate \( w_0 > 0 \) by working elsewhere. I assume that workers’ behavior and production outcomes are not contractible, but can be verified by the manager. The manager of the supplier cannot fire workers without demonstrated shirking, even when workers are shirking.\(^{16}\) Thus, the wage rate that induces workers to choose effort level \( e \) must satisfy\(^ {17}\):

\[
w - e^2 \geq (1 - q) w + qw_0,
\]

\[
w > w_0.
\]

The left-hand side of the first inequality is the net benefit of exerting effort \( e \) specified in the wage contract, and the right-hand side is the net benefit of shirking. The relationship between \( q \) and \( \{e, w\} \) is:

\[
q = \frac{e^2}{w-w_0}.
\]

In order to monitor workers, the manager has to incur the monitoring cost:

\[
M(q) = \eta q^2,
\]

where \( \eta > 0 \) measures the monitoring difficulty. Monitoring is assumed to be verifiable. Accordingly, agents cannot make contracts based on it.

2.2. Asymmetric information and outsourcing in the South

In the outsourcing case, it is assumed that the manager of the supplier owns the firm. The timing of events in this case is defined as follows. At period 1, the manager of the supplier decides his monitoring intensity and the wage schedule for the workers. At period 2, the MNE and the supplier make a contract on the production plan and the transfer price. At period 3, workers of the supplier choose their effort level; the production occurs. At period 4, workers of the supplier obtain their wages, and the supplier gets his monetary transfer from the MNE. Meanwhile, the MNE receives the intermediate goods, and the manager of the intermediate goods supplier gets his income. The wage contract and the monitoring intensity decided at period 1 determines the unit efficient labor cost (i.e., the average cost of inducing one worker to pay one unit effort) in the outsourcing case which includes both the wage payment and the cost of monitoring. This cost is denoted by \( \bar{w}_s \) henceforth. I use backward induction to solve the model.

2.2.1. The optimal production contract

It is assumed that the southern suppliers’ market is not competitive. Thus, the northern MNEs cannot extract southern suppliers’ positive profit through ex ante transfers.\(^ {18}\) In this case, the independent supplier owns the capital and therefore bears the rental cost of capital which is denoted by \( r \); the northern firm provides the technological blueprint for production to the southern supplier. The intermediate goods supplier’s profit in the outsourcing case is:

\[
U = T(y) - \frac{\bar{w}_s}{\theta} y^{1-\beta - r}.
\]

where \( T(y) \) is the monetary transfer the MNE pays to buy the intermediate goods, and \( \bar{w}_s y^{1-\beta - r} / \theta \) is the production cost.\(^ {19}\)

As the stand-alone supplier holds some private information (i.e., the value of \( \theta \)), the adverse selection problem occurs when the MNE negotiates with the independent supplier. The MNE has to design an incentive compatible contract that makes the intermediate goods

\(^{15}\) This demand function is derived from the CES utility function [see Dixit and Stiglitz, 1977] such that \( 1/(1-\alpha) \) is the elasticity of substitution between varieties. The term \( \lambda_j \) depends on the total expenditure on industry \( j \) and prices of all commodities sold in industry \( j \).

\(^{16}\) For the justification of these assumptions, see Calvo and Wellisz (1978).

\(^{17}\) Note that if the worker decides to shirk, choosing zero effort level will always be optimal. In addition, I assume that \( w = w_0 \) when solving the optimization problem and then verify that this constraint is not binding in equilibrium.

\(^{18}\) If I allowed for ex ante transfers in the outsourcing case, the MNE could extract all the information rent that the supplier can earn ex post in advance. Readers should interpret the analysis here as a partial equilibrium analysis.

\(^{19}\) As the manager enjoys the ownership of the intermediate goods supplier in the outsourcing case, he fully internalizes the monitoring cost.
supplier reports his productivity truthfully. Thus, the objective function for the MNE is:

\[
\Pi_0 = \max_y \int_y^{\int_{\theta'} \left[ \lambda^{1-\alpha} y - T(y') \right] \frac{dy'}{1-\theta'} + \int_{\theta'}^{y_0} \left( \int_{\theta}^{y} \left[ \lambda^{1-\alpha} y - T(y') \right] \frac{dy'}{1-\theta'} - \frac{W_{s}^{1-\beta} y}{\theta} \right] \frac{dy}{1-\theta'}} - U(y) \right] \frac{dy}{1-\theta'},
\]

s.t. \( T(y') - \frac{W_{s}^{1-\beta} y}{\theta} \geq 0, \quad \forall \theta' \)

where \( y(\theta) \) is the production contract based on the productivity the supplier reports. The MNE makes the decision of \( y(\theta) \), and the intermediate goods supplier takes it as given when deciding his strategy. The first constraint above is the incentive compatibility constraint that in equilibrium, the supplier that has the productivity level \( \theta \) has incentive to report his productivity truthfully. The second constraint above is the individual rationality constraint that a supplier which has any possible productivity level can earn non-negative profit in equilibrium. Following the standard steps, the above problem can be reduced to the following:

\[
\Pi_0 = \max_y \int_y^{\int_{\theta'} \left[ \lambda^{1-\alpha} y - \frac{W_{s}^{1-\beta} y}{\theta} \right] \frac{dy'}{1-\theta'} - \frac{W_{s}^{1-\beta} y}{\theta^2} (1-\theta') - U(y') \right] \frac{dy}{1-\theta'},
\]

s.t. \( U(y') \geq 0, \quad y'(\theta) > 0. \)

The term \( \lambda^{1-\alpha} y - \frac{W_{s}^{1-\beta} y}{\theta} \) is the total surplus created by the MNE and the supplier; the term \( \frac{W_{s}^{1-\beta} y}{\theta^2} \) is the information rent the MNE has to pay while maximizing the total surplus.

When the intermediate goods supplier’s productivity is \( \theta \), he gets the information rent which equals \( \int_{\theta'}^{y_0} \left( \frac{W_{s}^{1-\beta} y}{\theta^2} \right) \frac{dy'}{\nu^2} \). Therefore, the expected information rent the MNE pays is equal to:

\[
\int_{\theta'}^{\int_{\theta'}^{y_0} \left( \frac{W_{s}^{1-\beta} y}{\theta^2} \right) \frac{dy'}{\nu^2} \right] \frac{dy}{1-\theta'},
\]

which verifies the third term in the bracket of the above objective function. The MNE takes into account the information rent she has to pay while maximizing the total surplus.

Solving the problem, I obtain the optimal transfer price and the optimal production plan in the outsourcing case:

\[
T_s(y_s', \theta') = \int_{\theta'}^{y_0} \left( \frac{W_{s}^{1-\beta} y_s'}{\theta} \right) \frac{dy'}{1-\theta'} + \int_{\theta'}^{y_0} \left( \frac{W_{s}^{1-\beta} y_s'}{\theta^2} \right) \frac{dy}{1-\theta'},
\]

\[
y_s'(\theta) = \lambda_{y_s}(\alpha \theta / W_{s}^{1-\beta} \nu^2)^{1/(1-\alpha)}.
\]

From Eq. (5), it is easy to see that as long as the supplier is not the most productive (i.e., \( \theta < 1 \)), the optimal output level is always less than the first best level (i.e., \( y^B(\theta) = \lambda_{y_s}(\alpha \theta / W_{s}^{1-\beta} \nu^2)^{1/(1-\alpha)} \)) which would maximize the total profit in the absence of the adverse selection problem. In other words, the MNE makes less productive suppliers produce less in order to reduce the information rent she has to pay to the more productive supplier. From Eq. (4), it is easy to see that the more productive a supplier is, the higher profit he can get from the MNE, as the first term in the right-hand side of Eq. (4) is nothing but his production cost.

Finally, substituting Eq. (5) into the objective function, I derive the expected profit in the outsourcing case as:

\[
\Pi_0 = \left(1 - \alpha \right) \lambda_{y_s} \left( \frac{\alpha \nu}{W_{s}^{1-\beta} \nu^2} \right) \frac{\nu^2(1-\alpha)}{(1+\alpha)(1-\theta')}. \tag{6}
\]

2.2.2. The optimal wage contract

From Eq. (3), it is clear that the southern manager’s objective of choosing the optimal wage contract (i.e., (\( w, \nu \)) at period 1 is to minimize the unit efficient labor cost which equals:

\[
\tilde{w} = |M(q) + w| / e, \tag{7}
\]

where the relationship between workers' effort level and the wage contract is characterized by Eq. (1). Substituting Eqs. (1) and (2) into Eq. (7) gives us an expression of the unit efficient labor cost determined by \( e \) and \( w \) as below:

\[
\tilde{w} = \frac{\eta (e^2)}{w=w_0} + w = \frac{\eta e^2}{(w-w_0)^2} + \frac{w}{e}. \tag{8}
\]

For any given wage rate \( w \), the manager wants to minimize the unit efficient labor cost by making workers choose the optimal effort level:

\[
e^*_s(w) = \left( |w-w_0|^2 / 3 \eta \right)^{1/2}. \tag{9}
\]

After substituting Eq. (9) into Eq. (8), I rewrite the problem of minimizing the unit efficient labor cost as follows:

\[
\min_{w} \left[ \frac{w^3}{27 (w-w_0)^2} \right]^{1/2}. \tag{10}
\]

Solving this problem, I obtain the following results:

\[
w^*_s = 3w_0, \tag{11}
\]

\[
e^*_s = \left( \frac{4w_0}{\eta} \right)^{1/2}, \tag{12}
\]

\[
q^*_s = \frac{e^*_s}{w^*_s - w_0} = \left( \frac{w_0}{\eta} \right)^{3/2}. \tag{13}
\]

To insure an interior solution of \( q^*_s \) (i.e., \( 0 < q^*_s < 1 \)), I assume that \( w_0 < \eta \). Under this assumption, the optimal wage schedule in the outsourcing case is defined as \( (e^*_s, w^*_s) = (|4w_0^2 / \eta|^{1/4}, 3w_0) \). As the

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20 The problem here is a mechanism design problem under asymmetric information. For details, see Appendix A1.

21 See Eq. (4) below.

22 Here, I use Fubini’s theorem.

23 Due to the relationship between \( q \) and \( (w, q) \) characterized by Eq. (1), the problem of deriving the optimal \( (w, q) \) is equivalent to the problem of deriving the optimal \( (w, w) \).

24 The superscript “*” indicates the optimal value and the subscript “s” indicates the outsourcing case.
manager minimizes the unit efficient labor cost in the outsourcing case, monitoring in this case is efficient.

2.3. Inefficient monitoring and the foreign direct investment

The timing of events in the FDI case is defined as follows. At period 1, the southern manager of the supplier decides his monitoring intensity and the wage schedule for workers. At period 2, the MNE decides the output and input levels. At period 3, workers of the supplier choose their effort levels; the production occurs. At period 4, workers of the supplier get their wage. Meanwhile, the southern manager’s compensation and the MNE’s profit are determined by the bargaining process. There are two differences here compared with the outsourcing case. First, I assume that if the MNE integrates the supplier, the information of the supplier’s productivity becomes clear for the MNE, because after integration, the northern headquarters can get access to the core information concerning the productivity. Furthermore, I assume a bargaining process that determines the payoffs for the southern manager and the MNE. This is because the owner and the manager of the southern supplier differ in this case, and monitoring itself is not verifiable. The southern manager and the northern owner bargain over the profit that is generated by the production, because the production cost and sales revenue are assumed to be verifiable.

It is assumed that the MNE can confiscate all of the products and fire the southern manager, while the southern manager gets nothing when the bargaining breaks down. Furthermore, I assume that the northern owner can only get $\mu$ fraction of the final profit if the negotiation collapses. This is because without the southern manager’s cooperation, the value that can be extracted from the intermediate goods in the subsequent production process shrinks. In other words, southern managers’ human capital (e.g., their knowledge about the quality of the intermediate goods and personal experience regarding how to use the intermediate goods efficiently) affects the value of intermediate goods. Additionally, I assume a symmetric Nash bargaining for convenience. As in the outsourcing case, I adopt a symmetric assumption that the MNE cannot extract the southern manager’s positive profit through ex ante transfers, and solve the model using backward induction.

2.3.1. The wage rate

The determination of the wage rate is similar to that in the outsourcing case, except that in the FDI case the private monitoring cost is not included into the labor cost, because the southern manager does not own the firm and monitoring is not verifiable. Eq. (1) shows the relationship between $q$ and $(e, w)$, so the worker’s effort level is determined as:

$$e(q, w) = \sqrt{q(w-w_0)}.$$  \hspace{1cm} (14)

From Eq. (14), I derive the unit labor cost that does not include the monitoring cost in the FDI case as:

$$\bar{w}_n(q, w) = w / e(q, w) = \frac{w}{q(w-w_0)}.$$  \hspace{1cm} (15)

2.3.2. The production plan

As the MNE can only obtain $\mu$ fraction of the final profit if the ex post negotiation collapses, the MNE’s objective function can be written as:

$$\max_y \frac{(1+\mu)}{2} \left[ \frac{1}{\eta} - \bar{w}_n(q, w)^{1-\beta} \right].$$  \hspace{1cm} (16)

where $\bar{w}_n$ is the unit labor cost in the FDI case. Solving this problem, I get:

$$y^*_c(\theta) = \frac{\alpha \theta}{\bar{w}_n(q, w)^{1-\beta}} \left( \frac{1}{\eta} \right)^{\frac{1-\alpha}{\alpha}}.$$  \hspace{1cm} (17)

2.3.3. The monitoring intensity

As the result of bargaining, the southern manager gets $(1-\mu)/2$ fraction of the final profit, and chooses $(q, w)$ to maximize his payoff. Thus, the southern manager’s optimization problem is:

$$\max_{q, w} \frac{(1-\mu)}{2} \left[ \frac{1}{\eta} - \bar{w}_n(q, w)^{1-\beta} \right].$$  \hspace{1cm} (18)

where $\theta$ is the productivity of the supplier and $L^*_o(q, w)$ is the number of workers employed in the production process.

I use the following four steps to rewrite the above objective function as a function of the model’s primitives and $(q, w)$. First, I substitute the optimal production plan decided at period 2 (i.e., Eq. (17)) into Eq. (18) to rewrite the southern manager’s optimization problem as:

$$\max_{q, w} \frac{(1-\mu)}{2} \left[ \frac{1}{\eta} - \frac{\alpha \theta}{\bar{w}_n(q, w)^{1-\beta}} \right].$$  \hspace{1cm} (19)

Second, from the property of the Cobb–Douglas production function, we know that the MNE should choose the inputs according to the following rule:

$$\bar{w}_n(q, w) e^*_c(q, w) L^*_o(q, w) = \frac{1}{\beta}.$$  \hspace{1cm} (20)

and the optimal production plan can be rewritten as:

$$y^*_c(\theta) = \frac{\alpha \theta}{\bar{w}_n(q, w)^{1-\beta}} \left( \frac{\bar{w}_n(q, w)}{r} \right)^{\frac{1}{\beta}}.$$  \hspace{1cm} (21)
Third, by comparing Eq. (21) to Eq. (17), I obtain the optimal level of labor input as:

\[
L^*_n(q, w) = \frac{\lambda_n(1-\beta)}{\theta_n(w_n(q, w))} \left( \frac{r}{w_n(q, w)} \right)^\mu \left( \frac{\alpha \theta_n(q, w)}{\theta_n(w_n(q, w))} \right)^{\frac{1}{\gamma-1}}. \tag{22}
\]

Fourth, after substituting Eqs. (14), (15) and (22) into Eq. (19), I rewrite the optimal monitoring intensity and the optimal wage rate as the solutions to the following problem:

\[
\max_{q, w} \left( \frac{1-\mu}{2} A \left( \frac{w-w_0}{w^2} \right)^{q(\beta)} - \beta_b \left( \frac{w-w_0}{w^2} \right)^{q(\beta)} - q^2 + \eta(\theta) \right), \tag{23}
\]

where

\[
t(\beta) = \frac{\alpha(1-\beta)}{2(1-\alpha)},
\]

\[
A = (1-\alpha) \lambda_n \left( \frac{\alpha \theta_n}{\theta_n} \right)^{\frac{1}{\gamma-1}},
\]

and

\[
B = \lambda_n(1-\beta) \left( \frac{\theta}{\theta_n} \right)^{\frac{1}{\gamma-1}}.
\]

I solve the above optimization problem in two steps. First, for any given wage rate \( w \), the optimal monitoring intensity is:

\[
q(w, \beta) = \left[ \frac{(1-\mu)w}{4\theta(2 + t(\beta))} \right]^\frac{1}{2}. \tag{24}
\]

After substituting Eq. (24) into Eq. (23), I rewrite the maximization problem as:

\[
\max_w \left( \frac{1-\mu}{2} A \left( \frac{w-w_0}{w^2} \right)^{q(\beta)} - \beta_b \left( \frac{w-w_0}{w^2} \right)^{q(\beta)} - q^2 + \eta(\theta) \right) \frac{w}{w^2}. \tag{25}
\]

Solving this problem, I obtain the optimal wage rate, the optimal monitoring intensity and the unit labor cost in the FDI case as follows:\(^{30}\):

\[
w^*_n = 3w_0. \tag{26}
\]

\[
q^*_n(\beta) = \left[ \frac{(1-\mu)3w_0}{4\theta(2 + t(\beta))} \right]^\frac{1}{2}, \tag{27}
\]

\[
\theta^*_n = \left[ \frac{27\theta(2 + t(\beta))w_0}{1-\mu} \right]^\frac{1}{2}. \tag{28}
\]

At this point I pause to highlight three important properties of my solution. First of all, the optimal monitoring intensity is much lower in the FDI case.\(^{31}\) In other words, monitoring in the FDI case is inefficient. There are two reasons why this is the case. First, because of the symmetric Nash bargaining, the southern manager can only get a fraction (precisely, \((1-\mu)/2\)) of the benefit from monitoring and therefore engages in less monitoring. Second, as the owner does not take into account the manager’s monitoring cost when making the production plan, there is excess use of labor input; i.e., \(L^*_n(q)\) is higher than the first best level. Consequently, the marginal product of labor input drops, and the marginal benefit of monitoring decreases. This explains why the monitoring intensity would be still lower in the FDI case, even if \((1-\mu)/2 = 1\).

The solution’s second important property is although nominal wage rates are the same in both cases, the wage per effective labor unit is higher in the FDI case, as the monitoring intensity and workers’ effort levels are lower in this case. This is consistent with the argument discussed in the introduction: workers’ wage rate is higher in firms with more hierarchical levels. In international trade literature, numerous studies show that compared with independent intermediate goods suppliers, there is a wage premium in MNEs’ southern affiliates. Furthermore, even after controlling for workers’ characteristics (e.g., education level), some studies still find an “unexplained” wage premium within the MNEs’ subsidiaries.\(^{32}\) This empirical finding is consistent with my result here, as firms that monitor their workers less (i.e., the MNE’s southern affiliate in my model) set higher wage rates.

The solution’s third important property is that \(q_n(\beta)\) is an increasing function of \(\beta\). At first glance, it seems that the increase of the capital intensity decreases the marginal product of labor and accordingly southern managers’ incentive to monitor. Nevertheless, a higher capital intensity incentivizes substitution away from labor, and subsequently reduces monitoring costs. Moreover, it also increases the benefits of monitoring through an increase in the capital–labor ratio. In total, an increase in the capital intensity alleviates the inefficient monitoring problem in the FDI case by inducing the manager of the MNE’s southern subsidiary to choose a higher monitoring intensity.

2.3.4. The expected profits

By substituting Eq. (17) into Eq. (16), I derive the profit for an MNE with productivity level \(\theta\) as:

\[
\pi_f(\theta) = \frac{(1+\mu)}{2} (1-\alpha) \lambda_n \left( \frac{\alpha \theta_n}{\theta_n} \right)^{\frac{1}{\gamma-1}}. \tag{29}
\]

Integrating \(\theta\) from 0 to 1, I obtain the expected profit for the MNE in the FDI case:

\[
\Pi_f = \frac{(1+\mu)}{2} (1-\alpha)^2 \lambda_n \left( \frac{\alpha \theta_n}{\theta_n} \right)^{\frac{1}{\gamma-1} \left( 1-\theta^\frac{1}{\gamma-1} \right)} \left( 1-\theta^\frac{1}{\gamma-1} \right). \tag{30}
\]

where \((1+\mu)/2\) captures the MNE’s bargaining power. It is useful to derive the southern manager’s expected profit in equilibrium as:

\[
\Pi_M = \frac{1-\mu}{2(1+\mu)} \Pi_f \tag{31}
\]

and the southern manager’s expected profit over the expected total profit as:

\[
\pi(\mu, \beta) = \frac{\Pi_M + \Pi_f}{1-\mu} \tag{31}
\]

which increases with the capital intensity \(\beta\) and decreases with \(\mu\).

\(^{30}\) Alert readers may think that the southern manager might earn negative profit in equilibrium. However, the first order condition with respect to \(q\) ensures that the southern manager always earns strictly positive profit in equilibrium for any possible parameters’ values.

\(^{31}\) See Eq. (27) and Eq. (12).

\(^{32}\) Aitken et al. (1996) and Lipsey and Sriholt (2004) show that even if the effect of southern workers’ education level and southern affiliates’ profit level on wage rates is controlled for in the regression, there still exists a wage premium in MNEs’ southern affiliates. Furthermore, the robustness check in their papers also confirms the wage premium in MNEs’ subsidiaries. In total, the above evidence shows that foreign ownership is strongly correlated with the wage premium.
3. Results

In Section 3.1, I consider the MNE’s choice between outsourcing and FDI, while in Section 3.2, I show some results derived from the comparative statics.

3.1. FDI v.s. outsourcing

It follows from Eq. (6) and Eq. (30) that the ratio of the MNE’s expected profit in the FDI case to that in the outsourcing case is:

\[
\frac{\Pi_f}{\Pi_o} = L(\theta') \left( \frac{1 + \mu}{2} \right)
\]

where

\[
\theta' = \left( \frac{1 + \theta \mu}{2(1 - \alpha)} \right)
\]

and

\[
L(\theta') = \frac{(1 + \alpha)(1 - \theta')}{1 - \theta' + \alpha}
\]

In order to derive the main result of this paper, I adopt the following assumption which is a necessary and sufficient condition for Lemma 1.33

**Assumption 1.**

\[
\mu \geq \frac{5}{32}
\]

Theoretically, this assumption requires that the southern manager’s bargaining power captured by \((1 - \mu)/2\) not be too large. Empirically, this means the southern manager's income relative to the MNE's profit captured by \((1 - \mu)/(1+\mu)\) is not too large. Under **Assumption 1**, I derive the following lemma which links the relative profit in the FDI case to the capital intensity34:

**Lemma 1.**

\[
R'(\beta) > 0 \quad \text{for} \quad \beta \in [0, 1] \quad \text{and} \quad R'(1) \geq 0
\]

**Lemma 1** implies that the relative profit in FDI case is increasing in \(\beta\). There are three economic forces behind this result. The first one is when the capital intensity goes up, the under-investment in monitoring, which arises only in the FDI case, becomes less severe, because workers' effort level and labor input are less important for the final profit. The second one is that when \(\beta\) increases, the manager's monitoring intensity and workers' effort level increase. This effect further mitigates the monitoring problem attending FDI by connecting higher \(\beta\) with greater monitoring intensity as explained in Section 2.3.3, which in turn effects higher effort through Eq. (14). On the other hand, Eq. (31) has the supplier's profit share increasing in \(\beta\) under FDI, leaving the MNE’s expected profit lower ceteris paribus.

33 For details, see Appendix A.4.
34 For proof, see Appendix A.2.
35 See Eqs. (27) and (14).

**Assumption 1** suffices to ensure that this last effect is dominated by the first two, yielding an overall positive relation between the capital intensity and the attractiveness of FDI. Simple calculation shows that the southern manager’s expected income over the MNE’s expected profit is \((1 - \mu)/(1 + \mu)\). **Assumption 1** requires that this number be smaller than 73%, which is consistent with our conjecture. Alert readers may argue that the minimum \(\mu\) under which **Lemma 1** holds is in general sensitive to the specification of the model (e.g., the production function, the monitoring cost function). However, the key issue **Assumption 1** addresses is that the income of the southern manager is small relative to the MNE’s profit, which is realistic and reasonable. As long as this condition is satisfied, the last effect mentioned above will be dominated by the first two, and the main result of this paper that the relative attractiveness of FDI rises with the capital intensity is valid. It is also straightforward to see that if I allowed for the possibility of ex ante transfers that can be used to extract the southern manager’s profit in the FDI case, the above result would be valid irrespective of the value of \(\mu\), as the third effect, which is the only negative effect on the MNE’s expected profit when \(\beta\) increases, would disappear. Based on Lemma 1, I derive the following proposition:

**Proposition 1.** If \(R(1) > 1 > R(0)\), there exists a cutoff point \(\beta_{OF} = (0, 1)\) between outsourcing and FDI. When \(\beta < \beta_{OF}\), outsourcing is optimal for the MNE; when \(\beta > \beta_{OF}\), FDI is optimal for the MNE. If \(R(1) \geq 1\), FDI dominates outsourcing for any capital intensity. If \(R(1) < 1\), outsourcing dominates FDI for any capital intensity.

Because the case where \(R(0) \geq 1\) and the case where \(R(1) \leq 1\) are out of this paper’s scope, I focus on the case where \(R(1) > 1 > R(0)\) henceforth. In Fig. 1, I plot six possible \(R(\beta)\) for different values of \(\alpha\) and \(\theta\). From the figure, it is easy to see that the cutoff point \(\beta_{OF}\) exists for a wide range of parameters’ values. Based on Proposition 2, I derive the following main result of this paper:

**Corollary 1.** Compared with outsourcing, intra-firm trade (FDI) is heavily concentrated in capital-intensive industries.

Although the adverse selection problem is not related to the capital intensity of production, the importance of inefficient monitoring is significantly affected by the capital intensity. When the capital intensity goes up, the MNE suffers less from the inefficient monitoring problem in the FDI case, as the southern manager has more incentives to monitor workers, and the inefficient monitoring problem itself becomes less important for the final profit. Therefore, FDI becomes more attractive than outsourcing. As a result, MNEs that
use capital-intensive intermediate goods should choose FDI instead of outsourcing.

3.2. The comparative statics

One possible link between this paper and empirical studies is the relationship between the capital intensity \( \theta^* \) and the cutoff point \( \beta_{OF} \). In order to investigate this relationship, I derive the following lemma\(^{38}\):

**Lemma 2.**

\[
L'(\theta^*) > 0
\]

The intuition behind Lemma 2 is that a smaller variance of productivity makes outsourcing more attractive than FDI, as the decreased productivity difference reduces the information rent. From Lemma 2, we know that \( L(\theta^*) \) decreases with \( \theta^* \). As \( S(\beta) \) is an increasing function of \( \beta \), an increase in \( \theta^* \) leads to an increase in \( \beta_{OF} \).

**Proposition 2.** When \( \theta^* \) goes up, the cutoff point between outsourcing and FDI (i.e., \( \beta_{OF} \)) increases.

An increase in \( \theta^* \) is good news for the MNE regardless of her choosing outsourcing or FDI, as the average productivity of suppliers in the South increases. However, it is better news for MNEs that are engaged in outsourcing as the productivity difference narrows, and hence the adverse selection problem is mitigated. Applying Melitz (2003)’s argument, we expect that trade liberalization in the southern intermediate goods suppliers’ industry forces less productive suppliers to exit the market, hence, the productivity difference between suppliers in the South narrows. My result predicts that trade liberalization entails the expansion of outsourcing as opposed to FDI.

Additionally, countries with better business disclosure standards should presumably be less plagued by the asymmetric information problem. My model predicts that more outsourcing relative to FDI should be seen in such countries.

Furthermore, another testable hypothesis of this paper is that the share of intra-firm trade (i.e., FDI) in total trade should be increasing in the degree of productivity dispersion across southern intermediate goods suppliers. In my model, if there is a mean preserving spread in the distribution of southern suppliers’ productivity, FDI should be adopted by more firms relative to outsourcing, as the asymmetric information problem becomes more serious in the South after this change.\(^{39}\) Interestingly, Antrás and Helpman (2004) also investigate the relationship between the share of intra-firm trade in total trade and firm heterogeneity. One

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\(^{38}\) Proof is relegated to Appendix A.3.

\(^{39}\) The range of the productivity dispersion across southern suppliers should be seen as an indicator of the degree of information asymmetry.
of the main results of that paper is the share of intra-firm trade in total trade should be increasing in the degree of productivity dispersion across northern firms (e.g., MNEs in the FDI case). Both papers discuss the impact of firm heterogeneity on the share of intra-firm trade in total trade. These impacts may be present at the same time.

Revisiting the case study from the introduction, it is reasonable to assume that the shoe-making industry is highly competitive. Thus, productivity difference among suppliers should be small. But in the computer chip industry, the production technology has not been standardized and the market is not very competitive, so there is much more uncertainty about MNEs’ transaction partners. My model predicts that Intel should choose FDI and Nike should choose outsourcing. It seems that the number of scandals concerning the quality of products disclosed has multiplied recently. MNEs should believe that there is more uncertainty regarding southern suppliers than before. Hence, FDI is expected to be chosen more frequently as a way to overcome the asymmetric information problem in the future.

4. Final remarks

I have presented a simple model using contract theory to explain the behavior of multinational firms. The main idea is that if the production of intermediate goods is labor-intensive, the MNE should not use integration to overcome the adverse selection problem. This is because the inefficient monitoring problem in the FDI case becomes more serious. Consequently, the MNEs should integrate southern suppliers to produce capital-intensive intermediate goods and source the production of labor-intensive intermediate goods to stand-alone southern suppliers.

This paper contributes to the theory of multinational firms in the following ways. First, this paper points out one significant concern of the MNEs in reality: southern managers’ work incentive. I believe this paper is one of the few papers addressing this important issue in a formal way. Second, the information problem is treated as the disadvantage of engaging in outsourcing in this paper. This point has been somewhat overlooked by previous research. Third, this paper also explores the inner structure of MNEs, which needs much more research in the future. The new theoretical mechanism based on the information asymmetry proposed in this paper points to the need for more empirical work to clarify the determinants of MNEs’ cross-border organizational choices. For example, one can expect that outsourcing should be commonly seen in developing countries that have better accounting systems, because better accounting systems alleviate the uncertainty surrounding southern suppliers’ productivity. In addition, the degree of southern suppliers’ productivity dispersion is also a significant factor for northern firms to consider when they choose the organizational form of the intermediate goods production.

Undoubtedly, much more research remains to be done. Incorporating the above model into a general equilibrium framework is expected to reveal more implications regarding the output of MNEs’ subsidiaries relative to outsourcing partners and the share of intra-industry trade among others. It is also worth extending this model into a dynamic setup, which possibly can shed light on the resolution of asymmetric information problems in the South. One rough conjecture is that repeated transactions between MNEs and southern suppliers should alleviate the asymmetric information problem and hence favor outsourcing instead of FDI.

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Appendix A

Appendix A.1. The solution to the mechanism design problem

Suppose the supplier’s type (i.e., \( \theta \)) is continuous. The payoffs of the supplier and the MNE can be expressed as:

\[
U(\vartheta', \theta) = u(y(\vartheta'), \theta) + T(y(\vartheta'));
\]

\[
V(\vartheta') = v(y(\vartheta')) - T(y(\vartheta')).
\]

where

\[
u(y(\vartheta'), \theta) = \left(1 - \frac{\beta}{\alpha} \right) \frac{\beta^\alpha}{\theta} (\vartheta')^\alpha.
\]

\[
v(y(\vartheta')) = \frac{1 - \alpha}{\alpha} (\vartheta')^\alpha.
\]

In the above equations, \( \theta \) is the agent’s real type, and \( \vartheta' \) is agent’s reported type. The incentive compatibility constraint requires that:

\[
\frac{dU(\vartheta, \theta)}{d\theta} = u_\theta(y(\theta), \theta).
\]

The above condition states that when \( \vartheta' = \theta \) is the agent’s optimal strategy, the total derivative of \( U(\theta) \) with respect to \( \theta \) equals its partial derivative, or we can say there is no indirect effect from \( \theta \). There is a theorem that describes the sufficient and necessary conditions for the incentive compatible contract as follows:

\[\text{Condition A: } \text{the envelope condition is satisfied. Condition B: the optimal scheme } y'(\theta) \text{ is a monotonically increasing function of } \theta.\]

For convenience, I define \( S(y(\theta), \theta) = U(\theta, \theta) + V(\theta) \). Based on the above two conditions, I rewrite the mechanism design problem as follows:

\[\Pi_0 = \max_{\vartheta \in \vartheta} \int_{\theta} \left[ S(y(\theta), \theta) - U(\theta, \theta) \right] d\theta \]

\[
s.t. \quad U(\vartheta', \vartheta'') \geq 0, \quad y'(\theta) > 0, \quad \frac{dU(\vartheta, \theta)}{d\theta} = u_\theta(y(\theta), \theta).
\]

40 Other papers addressing this issue include Grossman and Helpman (2004) and Antràs, Foley and Desai (2009).

41 This is called the envelope condition.

42 For details, see Fudenberg and Tirole (chapter 7, 1991).

43 This is called the monotonicity condition.
where \( f(\theta) \) is the probability density function of \( \theta \). Using the envelope condition and the technique of integration by parts, I derive:

\[
\int_0^1 U(\theta, \theta) f(\theta) d\theta = \left[ -U(\theta, \theta)(1-F(\theta)) \right]_0^1 + \int_0^1 \frac{dU(\theta, \theta)}{d\theta} \frac{1-F(\theta)}{f(\theta)} d\theta \\
= U(\theta^*, \theta^*) + \int_0^1 u_\alpha(y(\theta), \theta) \left( \frac{1-F(\theta)}{f(\theta)} \right) d\theta.
\]

where \( F(\theta) \) is the cumulative distribution function of \( \theta \). Therefore, the mechanism design problem can be rewritten as:

\[
\Pi_0 = \max \int_0^1 \left[ S(y(\theta), \theta) - u_\alpha(y(\theta), \theta) \right] \left( \frac{1-F(\theta)}{f(\theta)} \right) d\theta - U(\theta^*, \theta^*) \quad \text{s.t.} \ U(\theta^*, \theta^*) \geq 0, \\
y'(\theta) > 0.
\]

For the model in this paper, I have the following results:

\[
u_\alpha(y(\theta), \theta) = \frac{\varphi \theta^{-\alpha} y(\theta)}{\theta^+},
\]

and

\[
1 - \frac{F(\theta)}{f(\theta)} = 1 - \theta.
\]

Therefore, I have obtained the reduced form of the mechanism design problem as specified in the main text. Usually, the monotonicity condition is ignored when we derive the first order condition. After obtaining the optimal scheme \( y(\theta) \), we check whether the monotonicity condition is satisfied. In addition, the second order condition has to be checked. Sufficient conditions that ensure the second order condition is satisfied are:

1. \( \nu_\alpha(y(\theta), \theta) \geq 0, \forall y, \forall \theta \).
2. \( u_\alpha(y(\theta), \theta) \leq 0, \forall y, \forall \theta \).
3. \( \frac{d}{d\theta} \left( \frac{1-F(\theta)}{f(\theta)} \right) / d\theta < 0, \forall \theta, \forall \theta \).

Apparently, all these three conditions are satisfied for the model studied in this paper.

### Appendix A.2. Proof of Lemma 1

Under log transformation, what I have to show becomes:

\[
\frac{d \ln(R(\beta))}{d \beta} = \frac{d \ln(S(\beta))}{d \beta} > 0.
\]

Differentiating \( \ln(S(\beta)) \) with respect to \( \beta \), I obtain:

\[
\frac{d \ln(S(\beta))}{d \beta} = \left[ -\frac{t(\beta)}{2 + t(\beta)} + \ln \frac{64(1-\mu)}{27(2 + t(\beta))} \right] t'(\beta) \left( \frac{h(\beta)}{2} \right). \tag{32}
\]

Simple calculation shows that \( t'(\beta) < 0 \) for \( \beta \in [0, 1] \) and \( t'(\beta) > 0 \) for \( \beta > [0, 1] \). It is also straightforward to show that \( \ln \frac{64(1-\mu)}{27(2 + t(\beta))} \leq 0 \), if \( \mu \geq \frac{5}{32} \). Therefore, \( R'(\beta) > 0 \) for \( \beta \in [0, 1] \). Moreover, it is clear that \( R'(1) > 0 \) if \( \mu > \frac{5}{32} \) and \( R'(1) = 0 \) if \( \mu = \frac{5}{32} \).

### Appendix A.3. Proof of Lemma 2

Differentiating \( L(\theta^*) \) with respect to \( \theta \), I get:

\[
\text{Sign}(L'(\theta^*)) = \text{Sign} \left( (1+\alpha) \theta^* \frac{2^{(1+2\alpha)}}{2^{(\alpha+1)}} - \theta^* \frac{2^{(1+2\alpha)}}{2^{(\alpha+1)}} \right) = \text{Sign} \left( 1+\alpha \theta^* \frac{2^{(1+2\alpha)}}{2^{(\alpha+1)}} - \theta^* \frac{2^{(1+2\alpha)}}{2^{(\alpha+1)}} \right)
\]

Because \( y = \theta^* (0 < \theta^* < 1) \) is a convex function. By Jensen’s inequality, I derive:

\[
\alpha \theta^* \frac{2^{(1+2\alpha)}}{2^{(\alpha+1)}} + \left( 1+\alpha \theta^* \frac{2^{(1+2\alpha)}}{2^{(\alpha+1)}} - \theta^* \frac{2^{(1+2\alpha)}}{2^{(\alpha+1)}} \right)
\]

Therefore,

\[
L'(\theta^*) < 0.
\]

### Appendix A.4. Discussion of assumption 1

First, it has been proved that Assumption 1 is a sufficient condition for Lemma 1. Now, I prove that Assumption 1 is also a necessary condition for Lemma 1. From Appendix A.2, we know that:

\[
\frac{d \ln(R(\beta))}{d \beta} = \left[ -\frac{t(\beta)}{2 + t(\beta)} + \ln \frac{64(1-\mu)}{27(2 + t(\beta))} \right] t'(\beta) \left( \frac{h(\beta)}{2} \right),
\]

where \( t(\beta) = \frac{\alpha(1-\beta)}{2(1-\alpha)} \). Suppose Assumption 1 is not satisfied, then

\[
\frac{d \ln(R(\beta))}{d \beta} \bigg|_{\beta=1} = -\frac{\alpha}{4(1-\alpha)} \ln \frac{64(1-\mu)}{54}.
\]

which is strictly negative when \( \mu < \frac{5}{32} \). Because \( \frac{d \ln(R(\beta))}{d \beta} \) is a continuous function of \( \beta \), \( R'(\beta) < 0 \) when \( \beta \) is close to 1 in the case of \( \mu < \frac{5}{32} \). As a result, Lemma 1 cannot hold. Therefore, Assumption 1 is also a necessary condition for Lemma 1.

Next, I consider the case where Assumption 1 is not satisfied. In order to explore the relationship between \( \beta \) and \( \frac{d \ln(R(\beta))}{d \beta} \) in this case, I rewrite \( \frac{d \ln(R(\beta))}{d \beta} \) as:

\[
\frac{d \ln(R(\beta))}{d \beta} = \frac{\alpha}{4(1-\alpha)} \left[ \frac{t(\beta)}{2 + t(\beta)} + \ln \frac{27(2 + t(\beta))}{64(1-\mu)} \right].
\]

Now, it is straightforward to see that \( \frac{d \ln(R(\beta))}{d \beta} \) decreases with \( \beta \) for \( \alpha \in (0, 1) \) and \( \frac{d \ln(R(\beta))}{d \beta} \bigg|_{\beta=1} < 0 \). The next step is to compare the value of \( \frac{d \ln(R(\beta))}{d \beta} \bigg|_{\beta=0} \) with 0. Simple calculation shows:

\[
\frac{d \ln(R(\beta))}{d \beta} \bigg|_{\beta=0} = \frac{\alpha}{4(1-\alpha)} \left[ \frac{\alpha}{4-3\alpha} + \ln \frac{27(4-3\alpha)}{128(1-\mu)(1-\alpha)} \right] \equiv \frac{\alpha}{4(1-\alpha)} H(\alpha, \mu).
\]
and

\[ H(0, \mu) < 0 \quad \text{and} \quad \lim_{\alpha \to 1} H(\alpha, \mu) = +, \]

as \( \mu \in \left[0, \frac{5}{32}\right] \) now. Therefore, for any \( \mu \in \left[0, \frac{5}{32}\right] \), there always exists a cutoff \( \alpha(\mu) \in (0, 1) \) such that \( H(\alpha(\mu), \mu) = 0 \), and \( \alpha(\mu) \) decreases with \( \mu \). Finally, I obtain the following proposition:

**Proposition 3.** In the case where \( \mu \in \left[0, \frac{5}{32}\right] \), there always exists a cutoff point \( \alpha(\mu) \in (0, 1) \). If \( \alpha \) is bigger than \( \alpha(\mu) \), \( R(\beta) \) increases with \( \beta \) first and decreases with \( \beta \) when \( \beta \) gets close to 1; if \( \alpha \) is smaller than \( \alpha(\mu) \), \( R(\beta) \) decreases with \( \beta \) for all \( \beta \in [0, 1] \). Furthermore, the cutoff point \( \alpha(\mu) \) decreases with \( \mu \).

In total, there are three cases of \( R'(\beta) \):

1. \( 1 > \mu \geq \frac{5}{32} \) and \( 1 > \alpha > 0 \); \( R'(\beta) \geq 0 \).
2. \( 0 < \frac{5}{32} > \mu \geq 0 \) and \( \alpha(\mu) > \alpha > 0 \); \( R'(\beta) < 0 \).
3. \( \frac{5}{32} > \mu \geq 0 \) and \( 1 > \alpha > \alpha(\mu) \); \( R'(\beta) > 0 \) for small \( \beta \) and \( R'(\beta) < 0 \) for big \( \beta \).

Fig. 2 represents the three cases of \( R(\beta) \). First, it is intuitive to see that for a bigger \( \mu \) which means the southern manager gets a smaller share of the total profit for all \( \beta \in [0, 1] \), there should be a smaller range of \( \alpha \) in which the relative profit of FDI (i.e., \( \frac{\Pi_F}{\Pi_O} \)) decreases monotonically with the capital intensity \( \beta \). Second, simple calculation shows that:

\[ |R'(\beta)| = \frac{\alpha}{2(1-\alpha)}. \]

which increases with \( \alpha \). A bigger \( \alpha \) means that the variation of the southern manager’s share in total profit is more sensitive to the change of the capital intensity. Thus, the relative profit in the FDI case increases first and decreases when \( \beta \) gets close to 1, which is summarized in case 3. For a small \( \alpha \), the variation of the southern manager’s share in total profit is not as sensitive to the change of the capital intensity as in case 3. Furthermore, because \( r(\mu, 0) \) is big when \( \alpha \) and \( \mu \) are small, the southern manager already has a big share when the capital intensity is zero. Therefore, the relative profit in the FDI case decreases when \( \beta \) goes up, and there is no reversal of the sign of \( R'(\beta) \). This is summarized in case 2.

### References

