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Asymmetric Information and Global Sourcing

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Abstract: This paper aims to study the choice of offshoring modes made by multinationals in the presence of asymmetric information. We focus on two types of asymmetric information, namely hidden characteristics and hidden action. The former creates adverse selection problem, and the later leads to moral hazard problem, both of which incur non-trivial costs to multinationals. We show that different offshoring modes, including greenfield foreign direct investment, joint venture, and outsourcing, can serve as a means to overcome or mitigate the problem of information asymmetry. We study the conditions under which one particular type of offshore modes dominates the others. The model generates implications consistent with the patterns of the prevalence of various offshoring models over time, and across industries and countries.

JEL Classification: F21; F23.

Keywords: Asymmetric Information, Global Sourcing, Foreign Direct Investment, Joint Venture, Outsourcing

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1 Introduction

One of the most publicized potential disadvantages to offshore production is poor quality control. Cases in point are fire-hazard batteries, lead-paint toys, melamine-laced pet food crisis and melamine-tainted milk incidence uncovered in recent years. In addition to the threat to consumers' safety, the costs of recalling all the the defective products from the market followed by the incidences and the damage caused to the business reputation and image have eroded a huge chunk of the benefits by locating production activity in low-wage countries.

The reason for why it is so difficult to ensure product quality in the face of global operation may attribute to problem of information asymmetry.

This paper aims to study firm's optimal choice of global production modes in the presence of asymmetric information. In particular, we focus on two types of asymmetric information, namely hidden characteristics and hidden actions. The former creates adverse selection problem and the later leads to moral hazard problem, which potentially incur non-trivial costs to multinationals. We argue that multinationals's choice of different global production modes, including greenfield foreign direct investment, joint venture, and offshore outsourcing, can serve as a means to overcome or mitigate the costs arising from certain or both types of asymmetric information.

In particular, greenfield FDI keeps the production within firm's boundary and thus avoids adverse selection problem. However, the moral hazard problem still prevails. In contrast, through offshore joint venture, a foreign firm teams up with a local firm to produce the product and shares the profits with local joint venture partner. The business mode helps to enhance the interest alignment between two entities such that the moral hazard problem can be mitigated. On the other hand, with the mode of offshore outsourcing, the foreign firm subcontracts the production process to a third party, whose type and effort level is unobservable and non-verifiable. Even though the foreign firm can design a contract to induce truthful-telling and to deter shirking behavior, the costs may be very expensive as when the problem of adverse selection is serious.

We study the conditions under which one particular type of offshore production modes is likely to emerge. The implications generated by the model also help explain the trend and variation of the prevalence of different global business models across industries and countries, and over time.

In particular, we show that in a particular industry, the mode of free-field FDI prevails in the host county with low developmental levels while outsourcing mode prevails in the countries which are relatively more developed. Joint venture modes prevails in the countries with moderate developmental level. As the industry become more competitive, outsourcing eventually become the most profitable way of offshoring. The implications are consistent with the findings by Hummels, Rapoport and Yi (1998), Hummels, Ishii and Yi (2001), Feenstra and Hanson (2003), Borga and Zeile (2002), Yeats (2001), Hanson et al. (2001, 2003), among others.

Empirical Motivation

In Figure (1), we utilize use the data from United Nations Conference on Trade and Development (UNCTAD) FDI/TNC Database and show the trend and variation of cross-border merger and acquisition (CMA) investments as a percentage of FDI inflows to the host countries over time and across countries. According to the definition given in the World Investment Report issued by UNCTAD, FDI inflow equals the sum of greenfield FDI and cross-border merger acquisition, and CMA refers to that a foreign firm acquires or merges with an existing local firm, which entails a change in the control of the merged or acquired firm and involves share-holding in a business entity.

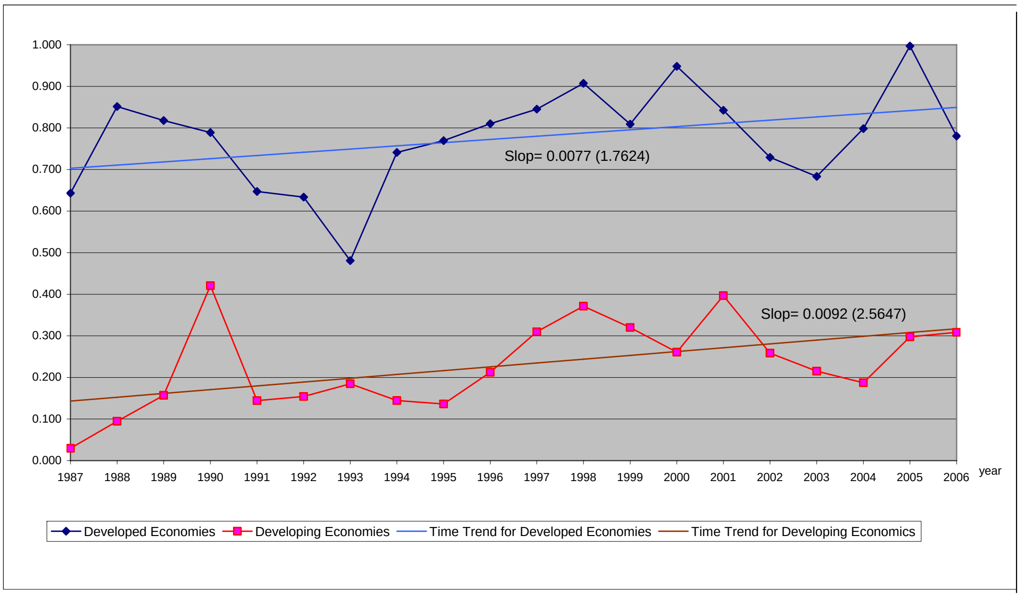
As show in Figure (1), the importance of CMA is higher in the developed countries than that in developing countries. Moreover, there exhibits a increasing trend over the past two decades between 1987 and 2006.[1]

With regard to the question as which operation model to adopt when offshoring, the responses of the CEO's or top managers from the world's largest 1000 companies vary across industries based on the 2005 FDI Confidence Index, an annual survey conducted by the A.T.Kearney, Inc. since 1998. As shown in Figure (2), the business models for moving corporate functions offshore include captive (greenfield FDI) and joint venture, as well as third-party outsourcing and other non-FDI options.

Offshoring is not a simple site-provider selection process, particularly when it comes to sophisticated and sensitive functions. The concerns over quality control in some business processes, including R&D, knowledge management and analytic functions, result in the choice of offshoring operation primarily through greenfield or joint ventures. Nearly 70 percent of future R&D offshoring will be through FDI, while less than 20 percent of offshore R&D activity will occur through outsourcing. When sending information technology, call centers, distribution and logistics offshore, CEOs prefer to rely on third-party outsourcing contacts. For example, about 55 percent of global investors plan to work with an outside provider when offshoring their IT functions. Despite the rapidly growing business process outsourcing (BPO) market, only 28 percent of global investors ex-

[1] Source: UNCTAD. The simple OLS estimations of the coefficients of the time trends for the groups of developed and developing countries are positive and significant. The numbers shown in the parentheses are the t-statistics.

Figure 1: Mergers and Acquisitions as a Percentage of FDI Inflow to Host Countries

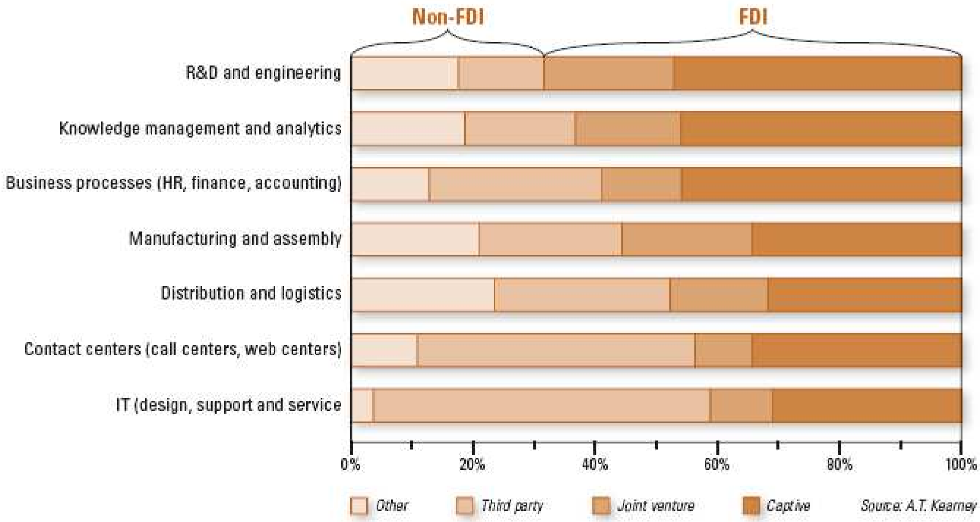


pect to turn to outside service providers to handle functions such as human resources, and finance and accounting. Nearly 60 percent of investors favor using a captive or joint-venture business model to handle BPO functions.

2 The Model

We consider a two-country model, in which the North(foreign country) is assumed to have higher labor cost than the South(domestic country). In an attempt to exploit lower production cost in the South, a foreign firm with an exclusive blueprint chooses one of the three potential production modes to produce a given number of final good in the South, which is normalized to be one. Three possible offshore production modes are: greenfield foreign direct investment, denoted by (F), offshore outsourcing, denoted by (O), and joint venture, denoted by (J). In the case of F, the foreign firm will start up a subsidiary in the domestic country and keeps the production activity in house. In the case of O, the foreign firm will subcontract the production process to a local firm.

Figure 2: CEO's Choice of Operation Models when Offshoring



In the case of J, the foreign firm will form a joint venture with a local firm. Production will be carried out by the new entity, and then two parties will share the profit based on the pre-agreed profit-sharing rule.

Different offshore production modes encounter different types of asymmetric information as summarized in the table shown below and to be elaborated shortly:

	Green Field FDI (F)	Outsourcing (O)	Joint Venture (J)
Hidden Characteristic	No	Yes	Yes
Hidden Action	Yes	Yes	Yes

2.1 Hidden Characteristics

Domestic firm can be either efficient or inefficient. Suppose that the efficient type has low marginal production cost, denoted by c_0, and inefficient type has high marginal production cost, denoted by c_1, where $0 \leq c_0 < c_1$, and $\Delta c \equiv c_1 - c_0 > 0$. Moreover, the likelihood of randomly meeting an efficient type equals τ, where $0 \leq \tau \leq 1$, and an inefficient type is $1 - \tau$, i.e. $Pr(c = c_0) = \tau$, and $Pr(c = c_1) = (1 - \tau)$. Domestic firm's true type is private information and is not observable by the foreign firm. Foreign firm only knows the distribution of the efficiency level of the domestic firm regardless of either O or J. In the case of F, foreign firm will transplant its own technology to the subsidiary located in the South. The marginal production cost of local subsidiary is denoted c_F, and by assumption, $c_0 \leq c_F < c_1$.

2.2 Hidden Actions

All type of production modes encounter the problem of hidden information as the foreign firm can not correctly verify the effort level, denoted by e, exerted by the manager. The manager can choose the two effort levels, say being diligent, denoted by d or shirking, denoted by s, which consequently affect the likelihood of producing/delivering high-quality output. Specifically, let $q \in \{H, L\}$ denote the quality of the output, where H and l denote high-and low-quality, respectively. Further more, let γ_e denote the probability of producing high-quality good given the manager's effort level e, where $Pr(q = H \mid e = d) = \gamma_d$, $Pr(q = L \mid e = d) = (1 - \gamma_d)$, $Pr(q = H \mid e = s) = \gamma_s$, $Pr(q = L \mid e = s) = (1 - \gamma_s)$, $0 < \gamma_s < \gamma_d < 1$, $\Delta\gamma \equiv \gamma_d - \gamma_s > 0$. Exerting effort incurs cost; in particular, $\psi^i(e = s) = 0$, $\psi^i(e = d) = \psi^i$, where $i \in \{F, O, J\}$. We assume that $\psi^F \leq \psi^O = \psi^J \equiv \psi$.

Consumer's willingness to pay to high- and low-quality good is different. For a high quality good, the value to a consumer is a_H, and a low-quality good is a_L, $a_L < a_H$, where $a_H > a_L$, i.e. $\Delta a \equiv a_H - a_L > 0$. Finally, we assume that both foreign and domestic firms are risk neutral.

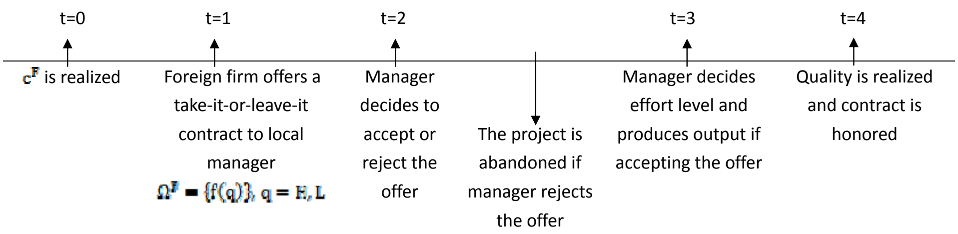
Assumption 1 $c_0 < c_1 < A_s < A_d$, and $\psi < A$, where $A_d \equiv \gamma_d a_H + (1 - \gamma_d) a_L$, $A_s \equiv \gamma_s a_H + (1 - \gamma_s) a_L$, and $A \equiv A_d - A_s$.

Assumption 1 implies that the expected value of the final output is sufficient high such that with complete information (or in the case of first best), the foreign firm(principle) prefers production to shutdown, and prefers diligence to shirking.

3 Greenfield Foreign Direct Investment

We first explain the time line of case when the foreign firm chooses F. As shown shown in Figure (3), at $t = 0$, the foreign firm learns its marginal production cost c^F, and offers a take-it-or-leave-it contract denoted by Ω^F to a local manager manager. The manager then decides whether to accept or reject the offer. The project is abandoned if manager rejects the offer; otherwise, manager decides effort level and produces the agreed amount of output. At the time $t = 4$, the output is delivered and the quality of the output is realized. Finally, the pre-agreed contract is honored. As discussed earlier, foreign firm encounters only the problem of hidden action. To overcome the problem, the foreign firm designs and offers a contract contingent on the quality outcome of the product. In particular, we use $\Omega^F = \{f(q),\ q \in \{H, L\}\}$ to denote the contract. If the delivered output is of of high-quality, the manager receives $f(H)$; otherwise $f(L)$.

Figure 3: The Timeline of Greenfield FDI



Quality-contingent Contract: $\Omega^F = \{f(q),\ q = \{H, L\},\}$

For simplicity, we assume that greenfield FDI does not incur fixed costs. We proceed to solve the optimal contract. Under Assumption 1, we know that the foreign firm aims to induce manager to be diligent. The profit optimization problem is presented below:

$$\max_{\{f(q)\}} \Pi^F = \gamma_d(a_H - f(H)) + (1-\gamma_d)(a_L - f(L))$$

$$s.t.$$

$$IC^M: \ \gamma_d f(H) + (1-\gamma_d) f(L) - c^F - \psi^F \geq \gamma_s f(H) + (1-\gamma_s) f(L) - c^F \tag{1}$$

$$IR: \quad \gamma_d f(H) + (1-\gamma_d) f(L) - c^F - \psi^F \geq 0 \tag{2}$$

where, Π^F denotes the foreign firm's expected profit under the mode of F, IC^M denotes the incentive compatibility constraint, which ensures that the manager weakly prefers diligence to shirking, and IR denotes the individual rationality constraint, which ensures the participation of the manager

(manager has no incentive to reject the offer). We solve the optimal contract as shown as follows:

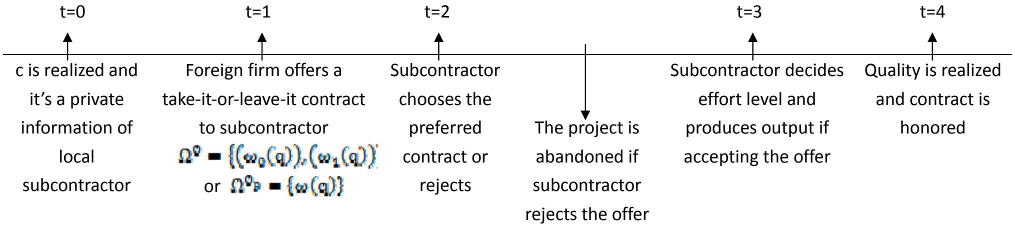
$$\begin{aligned}
&f(H) = c^F + \frac{(1-\gamma_s)\psi^F}{\gamma_d - \gamma_s} = c^F + \frac{(1-\gamma_s)\psi^F}{\Delta\gamma},\\
&f(L) = c^F - \frac{\gamma_s\psi^F}{\gamma_d - \gamma_s} = c^F - \frac{\gamma_s\psi^F}{\Delta\gamma},\\
&\text{optimal } \Pi^F = [\gamma_d a_H + (1-\gamma_d)a_L] - [c^F + \psi^F] = A_d - [c^F + \psi^F],
\end{aligned} \tag{3}$$

where $A_d = \gamma_d a_H + (1-\gamma_d)a_L$ and $\Delta\gamma = \gamma_d - \gamma_s$. The detailed proof is provided in the Appendices.

4 Outsourcing

In the case of O, the foreign firms faces both hidden characteristics problem as well we hidden action problem. The timeline of the case of O is summarized in Figure (4). At time $t = 0$, Domestic firms' type is realized based on the deterministic distribution function. The information of each domestic firm's type c is private information. Foreign firm offers a take-it-or-leave-it contract denoted by Ω^O to a randomly met subcontractor. The subcontractor decides whether or not to accept the offer made by the foreign firm, and chooses a preferred contract in the case when not rejecting. The project is abandoned if subcontractor rejects the offer; otherwise, the subcontractor decides effort level and produces output. The output is delivered and the quality of the product is realized, upon which the pre-agreed contract is honored. The foreign firm can offer a manu of contract to induce the local subcontract to reveal his true type by choosing a particular contract. This manu of contract is called the "separating contract," which is denoted by $\Omega^O = \{(\omega_0(q),\ q = \{H, L\}), (\omega_1(q),\ q = \{H, L\})\}$. In particular, the efficient-type with $c = c_0$ will choose $(\omega_0(q),\ q = \{H, L\})$, while the inefficient-type with $c = c_1$ will prefer $(\omega_1(q),\ q = \{H, L\})$. In the case of offering a separating contract, we also discuss two possible outcomes–one is separating without shutdown, and the other is with shutdown. In the case of shutdown, the individual rationality constraint for the inefficient type is not satisfied such that only the efficient type accept the offer. It is possible that the foreign prefers offering a pooling contract if it is too costly to differentiate efficient type from inefficient type. We use the Ω^{O_p} to denote pooling contract. In particular, $\Omega^{O_p} = \{\omega(q),\ q = \{H, L\}\}$.

Figure 4: The Timeline of Outsourcing



4.1 Separating Contract without Shutdown: $\Omega^O = \{(\omega_0(q),\ q = \{H, L\}), (\omega_1(q),\ q = \{H, L\})\}$

$$\max_{\{(\omega_0(q)),(\omega_1(q))\}} \Pi^O = \tau[\gamma_d(a_H - \omega_0(H)) + (1-\gamma_d)(a_L - \omega_0(L))] + (1-\tau)[\gamma_d(a_H - \omega_1(H)) + (1-\gamma_d)(a_L - \omega_1(L))]$$

$s.t.$

$$IC_0^A: \max_{i\in\{d,s\}} \gamma_i\omega_0(H) + (1-\gamma_i)\omega_0(L) - c_0 - \psi_i \geq \max_{i\in\{d,s\}} \gamma_i\omega_1(H) + (1-\gamma_i)\omega_1(L) - c_0 - \psi_i \tag{4}$$

$$IC_1^A: \max_{i\in\{d,s\}} \gamma_i\omega_1(H) + (1-\gamma_i)\omega_1(L) - c_1 - \psi_i \geq \max_{i\in\{d,s\}} \gamma_i\omega_0(H) + (1-\gamma_i)\omega_0(L) - c_1 - \psi_i \tag{5}$$

$$IR_0: \max_{i\in\{d,s\}} \gamma_i\omega_0(H) + (1-\gamma_i)\omega_0(L) - c_0 - \psi_i \geq 0 \tag{6}$$

$$IR_1: \max_{i\in\{d,s\}} \gamma_i\omega_1(H) + (1-\gamma_i)\omega_1(L) - c_1 - \psi_i \geq 0 \tag{7}$$

$$IC_0^M: \gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) - c_0 - \psi \geq \gamma_s\omega_0(H) + (1-\gamma_s)\omega_0(L) - c_0 \tag{8}$$

$$IC_1^M: \gamma_d\omega_1(H) + (1-\gamma_d)\omega_1(L) - c_1 - \psi \geq \gamma_s\omega_1(H) + (1-\gamma_s)\omega_1(L) - c_1 \tag{9}$$

where, Π^O denotes the foreign firm's expected profit under the mode of O, $IC_i^A,\ i \in \{0, 1\}$ denote the incentive compatibility constraints for both efficient type and inefficient type to reveal his true type, IC^M denotes the incentive compatibility constraint, which ensures that the manager weakly prefers diligence to shirking, and IR denotes the individual rationality constraint, which ensures the participation of the manager (manager has no incentive to reject the offer) of both types. We solve the optimal contract as shown as follows:

$$\omega_0(H) = \omega_1(H) = c_1 + \frac{(1-\gamma_s)\psi}{\Delta\gamma}$$
$$\omega_0(L) = \omega_1(L) = c_1 - \frac{\gamma_s\psi}{\Delta\gamma}$$
$$\text{optimal } \Pi^O = [\gamma_d a_H + (1-\gamma_d)a_L] - [c_1 + \psi] = A_d - [c_1 + \psi] \tag{10}$$

The results suggest that separating contract without shutdown does not exist and degenerates to the pooling contract. The detailed proof is provided in the Appendices.

4.2 Separating Contract with Shutdown: $\Omega^O = \{(\omega_0(q),\ q = \{H, L\}), (\omega_1(q),\ q = \{H, L\})\}$

$$\max_{\{(\omega_0(q)),(\omega_1(q))\}} \Pi^O = \tau[\gamma_d(a_H - \omega_0(H)) + (1-\gamma_d)(a_L - \omega_0(L))] + (1-\tau)[0]$$
$$s.t.$$
$$IC_0^A: \max_{i\in\{d,s\}} \gamma_i\omega_0(H) + (1-\gamma_i)\omega_0(L) - c_0 - \psi_i \geq \max_{i\in\{d,s\}} \gamma_i\omega_1(H) + (1-\gamma_i)\omega_1(L) - c_0 - \psi_i \tag{11}$$
$$IC_1^A: \max_{i\in\{d,s\}} \gamma_i\omega_1(H) + (1-\gamma_i)\omega_1(L) - c_1 - \psi_i \geq \max_{i\in\{d,s\}} \gamma_i\omega_0(H) + (1-\gamma_i)\omega_0(L) - c_1 - \psi_i \tag{12}$$
$$IR_0: \max_{i\in\{d,s\}} \gamma_i\omega_0(H) + (1-\gamma_i)\omega_0(L) - c_0 - \psi_i \geq 0 \tag{13}$$
$$IR_1: \max_{i\in\{d,s\}} \gamma_i\omega_1(H) + (1-\gamma_i)\omega_1(L) - c_1 - \psi_i \leq 0 \tag{14}$$
$$IC_0^M: \gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) - c_0 - \psi \geq \gamma_s\omega_0(H) + (1-\gamma_s)\omega_0(L) - c_0 \tag{15}$$

The optimization problem is identical to the case of separating contract without shutdown, except, (1) IR_1 does not hold, and (2) IC_1^M is irrelevant. We then solve the optimal contract and the optimized expected profit as follows:

$$\omega_0(H) = c_0 + \frac{(1-\gamma_s)\psi}{\Delta\gamma}$$
$$\omega_0(L) = c_0 - \frac{\gamma_s\psi}{\Delta\gamma}$$
$$\omega_1(H) = \omega_1(L) = 0$$
$$\text{optimal } \Pi^O = \tau\{[\gamma_d a_H + (1-\gamma_d)a_L] - [c_0 + \psi]\} = \tau[A_d - (c_0 + \psi)] \tag{16}$$

The solution implies that only the efficient subcontractor will accept the offer and choose the contract $(\omega_0(H), \omega_0(L))$, and exerts good effort. The detailed proof is provided in the Appendices.

4.3 Pooling Contract: $\Omega^{O_p} = \{\omega(q),\ q = \{H, L\}\}$

Here, we show that the pooling contract is identical to the separating contract without shutdown:

$$\max_{\{\omega(q)\}} \Pi^O = \gamma_d(a_H - \omega(H)) + (1-\gamma_d)(a_L - \omega(L))$$

$$s.t.$$

$$IC_0^M:\ \gamma_d\omega(H) + (1-\gamma_d)\omega(L) - c_0 - \psi \geq$$

$$\gamma_s\omega(H) + (1-\gamma_s)\omega(L) - c_0 \tag{17}$$

$$IC_1^M:\ \gamma_d\omega(H) + (1-\gamma_d)\omega(L) - c_1 - \psi \geq$$

$$\gamma_s\omega(H) + (1-\gamma_s)\omega(L) - c_1 \tag{18}$$

$$IR_0:\ \gamma_d\omega(H) + (1-\gamma_d)\omega(L) - c_0 - \psi \geq 0 \tag{19}$$

$$IR_1:\ \gamma_d\omega(H) + (1-\gamma_d)\omega(L) - c_1 - \psi \geq 0 \tag{20}$$

where we need only check IC_i^M and IR_i, where $i \in \{0, 1\}$.

$$\omega(H) = c_1 + \frac{(1-\gamma_s)\psi}{\Delta\gamma}$$

$$\omega(L) = c_1 - \frac{\gamma_s\psi}{\Delta\gamma}$$

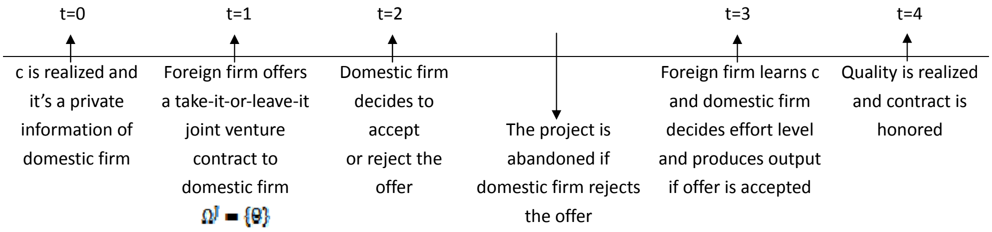
$$\text{optimal } \Pi^{O_p} = [\gamma_d a_H + (1-\gamma_d)a_L] - [c_1 + \psi] = A_d - [c_1 + \psi] = \Pi^O \tag{21}$$

The detailed proof is provided in the Appendices.

5 Joint Venture

In the case of joint venture (J), the foreign firm also encounters the problem of hidden characteristics and hidden action. The difference between J and O is the formate of contracts available for and adopted by the foreign firm to overcome the problem. In the case of J, a profit-sharing rule is offered which make the interest of the manager more align with that of the foreign firm, but can not be contingent on the quality of the output. The timeline of the joint venture case is summarized in Figure (5). at time $t = 0$, local firm's type c is realized, and again it's a private information and unobservable by the foreign firm. Foreign firm offers a take-it-or-leave-it joint venture contract, denoted by Ω^J to domestic firm. Domestic firm decides to accept or reject the offer. The project is abandoned if domestic firm rejects the offer; otherwise domestic firm decides effort level and produces output. The output is delivered, quality is realized, and profits are realized, upon which

Figure 5: The Timeline of Joint Venture



and contract is honored and profits are slitted between the foreign firm and local joint venture partner according to the sharing rule.

In the case of J, there does not exits separating equilibrium since both type of local firms will choose the contract granting them greater share of profit. In other words, joint venture can not solve adverse-selection problem. Moreover, to design a optimal profit-sharing rule, the foreign firm faces a trade-off between inducing diligent-behavior, which leads to greater profits, and smaller share of the profits. Depending on the distribution of the domestic firms' type and the disutility of being diligent, the optimal profit sharing rule may not always aim to induce high effort as shown below:

5.1 Profit-sharing Rule (diligence-inducing contract): $\Omega^{J_d} = \{\theta\}$

We first solve the optimal profit sharing rule such that both type of domestic firms exert high effort.

$$\max_{\{\theta\}} \Pi^{J_d} = \tau\theta[\gamma_d a_H + (1-\gamma_d)a_L - c_0] + (1-\tau)\theta[\gamma_d a_H + (1-\gamma_d)a_L - c_1]$$

$$s.t.$$

$$IC_0^M: \ (1-\theta)[\gamma_d a_H + (1-\gamma_d)a_L - c_0] - \psi \geq (1-\theta)[\gamma_s a_H + (1-\gamma_s)a_L - c_0] \tag{22}$$

$$IC_1^M: \ (1-\theta)[\gamma_d a_H + (1-\gamma_d)a_L - c_1] - \psi \geq (1-\theta)[\gamma_s a_H + (1-\gamma_s)a_L - c_1] \tag{23}$$

$$IR_0: \ (1-\theta)[\gamma_d a_H + (1-\gamma_d)a_L - c_0] - \psi \geq 0 \tag{24}$$

$$IR_1: \ (1-\theta)[\gamma_d a_H + (1-\gamma_d)a_L - c_1] - \psi \geq 0 \tag{25}$$

where Π^{J_d} denotes the expected profit if the foreign firm offers a contract Ω^{J_d}, $IC_i^M,\ i \in \{0,1\}$ enure both type exert high effort, and $IR_i,\ i \in \{0,1\}$ ensure both types of firm accept the offer. The optimal profit sharing rule is solved as:

$$\begin{aligned}
\theta_0^d = \theta_1^d &= 1 - \frac{\psi}{[\gamma_d a_H + (1-\gamma_d)a_L] - [\gamma_s a_H + (1-\gamma_s)a_L]} = 1 - \frac{\phi}{A} \\
\text{optimal } \Pi^{J_d} &= \left\{1 - \frac{\psi}{[\gamma_d a_H + (1-\gamma_d)a_L] - [\gamma_s a_H + (1-\gamma_s)a_L]}\right\} \times \\
&\quad \{[\gamma_d a_H + (1-\gamma_d)a_L] - [\tau c_0 + (1-\tau)c_1]\} \\
&= \left(1 - \frac{\psi}{A}\right)\{A_d - [\tau c_0 + (1-\tau)c_1]\}
\end{aligned} \tag{26}$$

The detailed proof is provided in the Appendices. It is clear from the solution that when high effort incurs great disutility to the manager, i.e. ϕ is approaching A, it is very costly to offer sufficient incentive. So the foreign firm may consider an alternative, say shirking-inducing, profit-sharing rule:

5.2 Profit-sharing Rule (shirking-inducing contract): $\Omega^{J_s} = \{\theta\}$

$$\max_{\{\theta\}} \Pi^{J_s} = \tau\theta[\gamma_s a_H + (1-\gamma_s)a_L - c_0] + (1-\tau)\theta[\gamma_s a_H + (1-\gamma_s)a_L - c_1]$$

$$s.t.$$

$$\begin{aligned}
IC_0^M:\ &(1-\theta)[\gamma_s a_H + (1-\gamma_s)a_L - c_0] \geq \\
&(1-\theta)[\gamma_d a_H + (1-\gamma_d)a_L - c_0] - \psi
\end{aligned} \tag{27}$$

$$\begin{aligned}
IC_1^M:\ &(1-\theta)[\gamma_s a_H + (1-\gamma_s)a_L - c_1] \geq \\
&(1-\theta)[\gamma_d a_H + (1-\gamma_d)a_L - c_1] - \psi
\end{aligned} \tag{28}$$

$$IR_0:\ (1-\theta)[\gamma_s a_H + (1-\gamma_s)a_L - c_0] \geq 0 \tag{29}$$

$$IR_1:\ (1-\theta)[\gamma_s a_H + (1-\gamma_s)a_L - c_1] \geq 0 \tag{30}$$

where Π^{J_s} denotes the expected profit when offering a contract Ω^{J_s}, $IC_i^M,\ i \in \{0,1\}$ enure both type exert low effort, and $IR_i,\ i \in \{0,1\}$ ensure both types of firm accept the offer. The optimal profit sharing rule is solved as:

$$\begin{aligned}
&\theta_0^s = \theta_1^s = 1 \\
&\text{optimal } \Pi^{J_s} = [\gamma_s a_H + (1-\gamma_s)a_L] - [\tau c_0 + (1-\tau)c_1] = A_s - [\tau c_0 + (1-\tau)c_1]
\end{aligned} \tag{31}$$

The detailed proof is provided in the Appendices. The solution suggests that the foreign firm will keep the full share of the profit, and the local joint venture partner regardless of efficient type or inefficient type will earn zero profit.

6 The Choices of Global Production Mode

Comparing the optimized expected profits functions facing the foreign firm given optimal contract under different offshore production modes, say equations (3), (16), (21), (26), and (31), we are ready to study the optimal choice of global production mode. In particular, we write the optimized profits as functions of τ, which is the likelihood of encountering a high-type domestic firm.

$$\Pi^F(\tau) = A_d - c^F - \psi^F \tag{32}$$

$$\Pi^{O_p}(\tau) = A_d - c_1 - \psi \tag{33}$$

$$\Pi^O(\tau) = \tau[A_d - c_0 - \psi] \tag{34}$$

$$\Pi^{J_d}(\tau) = (1 - \frac{\psi}{A})[A_d - \tau c_0 - (1-\tau)c_1] \tag{35}$$

$$\Pi^{J_s}(\tau) = A_s - \tau c_0 - (1-\tau)c_1 \tag{36}$$

Notice that in the case of greenfield FDI, these exists no adverse-selection problem, therefore, $\Pi^F(\tau)$ is a horizontal line. In the case of O_p, outsourcing with pooling contract, the foreign firm offers the same deal to both efficient and inefficient types, and thus the expected payment is independent with τ, and thus a horizontal line.

Lemma 1 Under Assumption 1, we know $\Pi^{O_p}(\tau) \leq \Pi^F(\tau)$ $\forall \tau \in [0,1]$.

We thus only need to compare (32), (34), (35), and (36).

Lemma 2 Under Assumption 1,

(i) $\frac{\partial \Pi^F(\tau)}{\partial \tau} < \frac{\partial \Pi^{J_d}(\tau)}{\partial \tau} < \frac{\partial \Pi^{J_s}(\tau)}{\partial \tau} < \frac{\partial \Pi^O(\tau)}{\partial \tau}$, $\forall \tau \in [0,1]$.

(ii) $\Pi^O(0) < \min\{\Pi^{J_d}(0),\ \Pi^{J_s}(0)\} < \max\{\Pi^{J_d}(0),\ \Pi^{J_s}(0)\} < \Pi^F(0)$.

(iii) $\max\{\Pi^{J_d}(1),\ \Pi^{J_s}(1)\} < \Pi^O(1)$. (See Appendices for the Proof)

Definition Define $\tau^F_{J_s}$, $\tau^F_{J_d}$, τ^F_O, $\tau^{J_s}_O$, $\tau^{J_d}_O$, and $\tau^{J_d}_{J_s}$, such that $\Pi^F(\tau^F_{J_s}) = \Pi^{J_s}(\tau^F_{J_s})$, $\Pi^F(\tau^F_{J_d}) = \Pi^{J_d}(\tau^F_{J_d})$, $\Pi^F(\tau^F_O) = \Pi^O(\tau^F_O)$, $\Pi^O(\tau^{J_s}_O) = \Pi^{J_s}(\tau^{J_s}_O)$, $\Pi^O(\tau^{J_d}_O) = \Pi^{J_d}(\tau^{J_d}_O)$, $\Pi^{J_d}(\tau^{J_d}_{J_s}) = \Pi^{J_s}(\tau^{J_d}_{J_s})$. We can solve them as:

$$\begin{aligned}
\tau_{J_s}^F &= \frac{(A-\psi^F)+(c_1-c^F)}{c_1-c_0} \\
\tau_{J_d}^F &= \frac{A(c_1-c^F-\psi^F)+(A_d-c_1)\psi}{(c_1-c_0)(A-\psi)} \\
\tau_O^F &= \frac{A_d-c^F-\psi^F}{A_d-c_0-\psi} \\
\tau_O^{J_s} &= \frac{(A_s-c_1)}{(A_d-c_1-\psi)} \\
\tau_O^{J_d} &= \frac{(A-\psi)(A_d-c_1)}{A(A_d-c_1-\psi)+(c_1-c_0)\psi} \\
\tau_{J_s}^{J_d} &= \frac{A^2-(A_d-c_1)\psi}{(c_1-c_0)\psi}
\end{aligned}$$

Lemma 3 Under Assumption 1, if $c_0+\psi<c^F+\psi^F$, we know $\tau_{J_s}^F<\tau_O^F$.

Proposition 1 Define $\hat{\psi}$ and $\bar{\psi}$, such that:

$$\tau_O^{J_d}(\hat{\psi})=\tau_{J_s}^{J_d}(\hat{\psi}),\ \text{and}\ \tau_{J_d}^F(\bar{\psi})=\tau_{J_s}^F(\bar{\psi}). \tag{37}$$

Given $c_0+\psi<c^F+\psi^F$,

(i) if $\psi<\hat{\psi}$, for $\tau\in[0,\ \tau_{J_d}^F)$, F is the dominant strategy; for $\tau\in[\tau_{J_d}^F,\ \tau_O^{J_d})$, J_d is dominant strategy; and for $\tau\in(\tau_O^{J_d},1]$, O is the dominate strategy, as shown as Case A in Figure (6)

(ii) if $\hat{\psi}<\psi<\bar{\psi}$, for $\tau\in[0,\ \tau_{J_d}^F)$, F is the dominant strategy; for $\tau\in[\tau_{J_d}^F,\ \tau_{J_s}^{J_d})$, J_d is dominant strategy; for $\tau\in[\tau_{J_s}^{J_d},\ \tau_O^{J_s})$, J_s is dominant strategy; and for $\tau\in(\tau_O^{J_s},1]$, O is the dominate strategy as shown as Case B in Figure (6).

(iii) if $\bar{\psi}<\psi$, for $\tau\in[0,\ \tau_{J_s}^F)$, F is the dominant strategy; for $\tau\in[\tau_{J_s}^F,\ \tau_O^{J_s})$, J_s is dominant strategy; and for $\tau\in(\tau_O^{J_s},1]$, O is the dominate strategy as shown as Case C in Figure (6).

Proposition 2(Case D) If $c^F+\psi^F<c_0+\psi$, $\max\{\Pi^{J_d}(\tau),\Pi^{J_s}(\tau),\Pi^O(\tau)\}<\Pi^F(\tau)\ \forall\tau\in[0,1]$. Greenfield FDI is the dominate global production mode for any $\tau\in[0,1]$. (See Appendices for Proof.)

	$c_0+\psi<c_F+\psi_F$	$c_F+\psi_F<c_0+\psi$
$\psi<\hat{\psi}$	Case A: F and J_d and O	Case D: F
$\hat{\psi}<\psi<\bar{\psi}$	Case B: F, J_d, J_s, and O	Case D: F
$\bar{\psi}<\psi$	Case C: F, J_s, and O	Case D: F

7 Conclusions

The importance of asymmetric information in the decision making of multinational firms deserves more careful study as suggested by recent high profile incidences related to bad quality control arising from offshoring. This paper untangles two distinct aspects of information asymmetry, namely hidden characteristics and hidden actions, and analyzes how different offshoring modes can serve as means to overcome or mitigate the information asymmetry problem. The implications generated by the model are reich enough to reconcile the patterns of the prevalence of offshoring modes across countries, industries, and over time.

Appendices

Optimal Contract under the FDI Arrangement

There exists an optimal contract $\Omega^F = \{f(q)\}, q = H, L$, which maximizes the foreign firm's expected profit and makes the manager's IR and IC^M constraints binding as explained below:

- (2) must be binding. If not, $\gamma_d f(H) + (1-\gamma_d)f(L) - c^F - \psi^F > 0$, the foreign firm (principal) then can reduce $f(L)$ to make it binding without affecting the inequality of (1) since $\gamma_d > \gamma_s$.
- Since (2) is binding, $\Pi^F = A_d - c^F - \phi^F$ which makes the binding condition of (1) irrelevant. For simplicity, we assume (1) binding to solve the optimal contract.

Solving (1) and (2) with equalities, we can obtain $\Omega^F = \{f(q)\}, q = H, L$ as

$$f(H) = c^F + \frac{(1-\gamma_s)\psi^F}{\Delta\gamma}$$
$$f(L) = c^F - \frac{\gamma_s \psi^F}{\Delta\gamma}$$
$$\text{optimal } \Pi^F = A_d - [c^F + \psi^F]$$

Optimal Separating Contract without Shutdown under the Outsourcing Arrangement

There exists an optimal contract $\Omega^O = \{(\omega_0(q)), (\omega_1(q))\}, q \in \{H, L\}$ which maximizes the foreign firm's expected profit and makes the manager's IC_0^A, IC_0^M, IC_1^M and IR_1 constraints binding as explained below:

- Given (8) and (9), we can simplify (4), (5), (6) and (7) as

$$\gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) - c_0 - \psi \geq$$
$$\gamma_d\omega_1(H) + (1-\gamma_d)\omega_1(L) - c_0 - \psi \tag{38}$$
$$\gamma_d\omega_1(H) + (1-\gamma_d)\omega_1(L) - c_1 - \psi \geq$$
$$\gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) - c_1 - \psi \tag{39}$$
$$\gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) - c_0 - \psi \geq 0 \tag{40}$$
$$\gamma_d\omega_1(H) + (1-\gamma_d)\omega_1(L) - c_1 - \psi \geq 0 \tag{41}$$

- (38) and (39) implies that the two conditions should be binding simultaneously and one of which is redundant, say (39).

- (38) and (41) imply (40), hence (40) is redundant.

- we than prove that (41) must be binding. If not, $\gamma_d\omega_1(H) + (1-\gamma_d)\omega_1(L) - c_1 - \psi > 0$, the principal/foreign firm can reduce $\omega_0(L)$ and $\omega_1(L)$ with $\Delta\omega_0(L) = \Delta\omega_1(L)$ to lower rewards/payments to the subcontractor until it is binding but still ensure (38) and (39) hold.

- (38) must be binding since (41) is binding (). If not, $\gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) > (c_1 + \psi)$, then the foreign firm can reduce $\omega_0(L)$ until it is binding without violating the conditions of (41).

- If (12) is binding, no matter whether (6) is binding or not, Π^O would not be affected. Therefore, we can make (6) binding to find out one of the contracts.

- If (38) and (41) are binding, no matter whether (8) and (9) are binding or not, Π^O is determined. For simplicity, we assume them to be binding to solve the optimal contract.

Solving (8), (9), (38), and (41) with equalities, we can obtain $\Omega^O = \{(\omega_0(q)), (\omega_1(q))\}, q = H, L.$ as:

$$\begin{aligned}
&\omega_0(H) = \omega_1(H) = c_1 + \frac{(1-\gamma_s)\psi}{\Delta\gamma} \\
&\omega_0(L) = \omega_1(L) = c_1 - \frac{\gamma_s\psi}{\Delta\gamma} \\
&\text{optimal } \Pi^O = A_d - [c_1 + \psi]
\end{aligned}$$

Optimal Separating Contract with Shutdown under the Outsourcing Arrangement

There exists an optimal contract $\Omega^O = \{(\omega_0(q)), (\omega_1(q) = 0)\}, q \in \{H, L\}$, which maximizes the principal's expected profit and makes the subcontractor's IC_0^A and IC_0^M constraints binding as explained below:

- We can let $\omega_1(q) = 0$ to shutdown the inefficient subcontractor.

- Given $\omega_1(q) = 0$, and (15), (14) is redundant and we can simplify (11), (12), and (13) as:

$$\gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) - c_0 - \psi \geq 0 \tag{42}$$

$$0 \geq \gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) - c_1 - \psi \tag{43}$$

$$\gamma_d\omega_0(H) + (1-\gamma_d)\omega_0(L) - c_0 - \psi \geq 0 \tag{44}$$

- (44) is redundant since (42) and (44) are identical.

- (42) must be binding. If not, $\gamma_d \omega_0(H) + (1-\gamma_d)\omega_0(L) - c_0 - \psi > 0$, the foreign firm can reduce $\omega_0(L)$ to make it binding without violating (15) and (43).

- (43) must be satisfied since (42) is binding and $0 \geq (c_0 - c_1)$. Therefore, (43) is redundant.

- Given (42) is binding, no matter whether (15) is binding or not, Π^O would not be affected. Therefore, for simplicity, we let (15) binding to solve the contracts

Solving (15) and (42) with equalities, we can obtain $\Omega^O = \{(\omega_0(q)), (\omega_1(q) = 0)\}, q \in \{H, L\}$ as:

$$
\begin{aligned}
&\omega_0(H) = c_0 + \frac{(1-\gamma_s)\psi}{\Delta\gamma} \\
&\omega_0(L) = c_0 - \frac{\gamma_s \psi}{\Delta\gamma} \\
&\omega_1(H) = \omega_1(L) = 0 \\
&\text{optimal } \Pi^O = \tau \{A_d - [c_0 + \psi]\}
\end{aligned}
$$

Optimal Pooling Contract under the Outsourcing Arrangement

There exists an optimal contact $\Omega^{O_p} = \{\omega(q)\}, q \in \{= H, L\}$, which maximizes the foreign firm's expected profit and makes the subcontractor's IC_0^M and IR_1 constraints binding as explained below:

- (17) is redundant since (17) and (18) are identical.

- Since $c_1 > c_0$, (20) implies (19), hence (19) is redundant.

- (20) must be binding. If not, $\gamma_d \omega(H) + (1-\gamma_d)\omega(L) - c_1 - \psi > 0$, foreign firm can reduce $\omega(H)$ and $\omega(L)$ with $\Delta\omega(H) = \Delta\omega(L)$ to make it binding without affecting the inequality of (17).

- Since (20) is binding, no matter whether (17) is binding or not, Π^O would not be affected. Therefore, for simplicity, we let it be binding to solve the contract.

Solving (20) and (17)(24) with equalities, we can obtain $\Omega^{O_p} = \{\omega(q)\}, q \in \{H, L\}$ as

$$
\begin{aligned}
&\omega^p(H) = c_1 + \frac{(1-\gamma_s)\psi}{\Delta\gamma} \\
&\omega^p(L) = c_1 - \frac{\gamma_s \psi}{\Delta\gamma} \\
&\text{optimal } \Pi^{O_p} = A_d - [c_1 + \psi]
\end{aligned}
$$

Optimal Diligence-inducing, Profit-sharing Contract under the Joint Venture Arrangement

There exists an optimal contract $\Omega^{J_d} = \{(\theta)\}$, which maximizes the principal's expected profit and makes the joint venture partner's IC_0^M constraint binding as explained below:

- (22) and (23) are identical. We let (23) be redundant.
- (25) implies (24), hence (24) is redundant.
- (22) and Assumption 1 imply (25), hence (25) is redundant.
- (22) must be binding. If not, $(1-\theta)[\gamma_d a_H + (1-\gamma_d)a_L - c_0] - \psi > (1-\theta)[\gamma_s a_H + (1-\gamma_s)a_L - c_0]$. The foreign firm can increase θ to make it binding.

Solving (22) with equality, we can obtain $\Omega^{J_d} = \{(\theta)\}$ as:

$$\theta^d = 1 - \frac{\psi}{[\gamma_d a_H + (1-\gamma_d)a_L] - [\gamma_s a_H + (1-\gamma_s)a_L]} = 1 - \frac{\psi}{A}$$

$$\text{optimal } \Pi^{J_d} = \left\{1 - \frac{\psi}{A}\right\}\{A_d - [\tau c_0 + (1-\tau)c_1]\} \tag{45}$$

Optimal Shirking-inducing Profit-sharing Contract under the Joint Venture Arrangement

There exists an optimal contract $\Omega^{J_s} = \{(\theta)\}$, which maximizes the principal's expected profits and makes domestic firm's IR_1 constraint binding as explained below:

- (27) and (28) are identical. We let (28) be redundant.
- Since $c_1 > c_0$, (30) implies (29), and (29) is redundant.
- (30) must be binding. If not $(1-\theta)[\gamma_s a_H + (1-\gamma_s)a_L - c_1] > 0$. The foreign firm can increase θ to make it binding without violating (27).
- Since (30) is binding, $\theta = 1$ and $0 \geq -\psi$ under Assumption 1. Therefore (27) must be satisfied, and is redundant

We can solve optimal Π^{J_s} as:

$$\theta^s = 1$$

$$\text{optimal } \Pi^{J_s} = [\gamma_s a_H + (1-\gamma_s)a_L] - [\tau c_0 + (1-\tau)c_1]$$

$$\theta^s = 1$$

$$\text{optimal } \Pi^{J_s} = A_s - [\tau c_0 + (1-\tau)c_1]$$

Proof of Lemma 2 (i)

$$\begin{aligned}
\frac{\partial \Pi^F(\tau)}{\partial \tau} &= 0 \\
\frac{\partial \Pi^{J_d}(\tau)}{\partial \tau} &= \left(1 - \frac{\phi}{A}\right)(c_1 - c_0) \\
\frac{\partial \Pi^{J_s}(\tau)}{\partial \tau} &= (c_1 - c_0) \\
\frac{\partial \Pi^O(\tau)}{\partial \tau} &= (A_d - c_0 - \phi)
\end{aligned}$$

Proof of Lemma 2 (ii)

$$\begin{aligned}
&\Pi^F(0) = A_d - c_F - \psi > 0 \\
&\Pi^{J_d}(0) = (1 - \frac{\psi}{A})(A_d - c_1) > 0 \\
&\Pi^{J_s}(0) = A_s - c_1 > 0 \\
&\Pi^O(0) = 0 \\
&\Pi^F(0) - \Pi^{J_d}(0) = (c_1 - c_F) + (\frac{A_s - c_1}{A})\psi \geq 0 \\
&\Pi^F(0) - \Pi^{J_s}(0) = (c_1 - c_F) + (A - \psi) \geq 0 \\
&\Pi^{J_d}(0) - \Pi^{J_s}(0) = \frac{\psi}{A}(\frac{A^2}{\psi} - A_d + c_1) \lesseqgtr 0.
\end{aligned}$$

Proof of Lemma 2 (iii)

$$\begin{aligned}
&\Pi^O(1) = A_d - c_0 - \psi > 0 \\
&\Pi^{J_d}(1) = (1 - \frac{\psi}{A})(A_d - c_0) > 0 \\
&\Pi^{J_s}(1) = A_s - c_0 > 0 \\
&\Pi^O(1) - \Pi^{J_d}(1) = \frac{\psi}{A}(A_s - c_0) \geq 0 \\
&\Pi^O(1) - \Pi^{J_s}(1) = A - \psi \geq 0
\end{aligned}$$

Proof of Proposition 2

$$\begin{aligned}
\Pi^F(1) &= A_d - c_F - \psi \\
\Pi^O(1) &= A_d - c_0 - \psi
\end{aligned}$$

Since $c^F + \psi^F < c_0 + \psi$, we know $\Pi^O(1) < \Pi^F(1)$. According to Lemma 2, $\max\{\Pi^{J_d}(1),\ \Pi^{J_s}(1)\} < \Pi^O(1) < \Pi^F(1)$, and $\max\{\Pi^{J_d}(0),\ \Pi^{J_s}(0),\ \Pi^O(0)\} < \Pi^F(0)$. Since $\Pi^{J_d}(1)$, $\Pi^{J_s}(\tau)$, $\Pi^O(\tau)$, and

$\Pi^F(\tau)$ are continues and weakly increasing function, we prove that $\max\{\Pi^{J_d}(\tau), \Pi^{J_s}(\tau), \Pi^O(\tau)\} < \Pi^F(\tau)\ \forall \tau \in [0, 1]$.

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Figure 6: Optimal Global Production Modes