Abstract: We construct a unified framework to study under what conditions one of the three frequently observed organizational structure of international middle-product production may arise in equilibrium: (i) separation of upstream and downstream firms with middle-product trade, (ii) vertical integration of upstream and downstream firms, (iii) global sourcing with upstream firms outsource the final good production to subcontractors. While skilled workers are required for designing and marketing both upstream and downstream products as well as for manufacturing high-tech middle products, unskilled workers are only used for the low-tech manufacturing components of the production of the middle product and the consumable. Under the outsourcing configuration, the source firm still keeps full control of the designing component of the production of the consumable. We solve final output supply, middle-product demand and pricing under each of the three organizational structures and the optimal contract under outsourcing. We show that when subcontractor’s product-defection rate and bargaining strength are sufficiently low, the labor diversification loss is moderate and the communication and search cost is significant, outsourcing is the most preferred whereas separation is the least. We also show that the potential availability of one organizational structure can change the trade-off of the other two structures, thereby granting simple pairwise comparison invalid. Moreover, we find that an equilibrium organizational structure may be suboptimal, as a result of conflicting effects on firm payoffs and consumer surplus. Furthermore, we calibrate various economies and illustrate why different organizational structures may be more frequently observed in different economic environments.

JEL Classification: F20, F21, F23.

Keywords: Middle-Product Trade, Vertical Mergers, Global Sourcing.

Acknowledgment: We are grateful for valuable comments and suggestions from Pol Antràs, Marcus Berliant, Michele Boldrin, Rick Bond, Ron Jones, Bruce Petersen, Ray Riezman, Jacques Thisse and seminar participants at Washington University in St. Louis and Midwest Economic Theory and International Trade Meetings. Financial support from Academia Sinica, the City University of Hong Kong, the National Science Council (NSC 98-2911-H-001-001) and the Weidenbaum Center on the Economy, Government, and Public Policy to enable this international collaboration is gratefully acknowledged.

Correspondence: Ping Wang, Department of Economics, Washington University in St. Louis, Campus Box 1208, One Brookings Drive, St. Louis, MO 63130, U.S.A.; Tel: 314-935-5632; Fax: 314-935-4156; E-mail: pingwang@wustl.edu.
1 Introduction

There has been decades of rising globalization in trade, as it is evident from the on-going increase in the ratios of the average of imports and exports to GDP in major advanced countries over the past five decades (see the Appendix). During the post WWII period, it has also been observed that trade integration is accompanied by production disintegration or fragmentation (see Hummels, Ishii and Yi 2001, particularly the VS index of imported input content of exportables). To promote better understanding of these trends, more attention has been paid, in modern international economics, to the organizational theory of trade, based primarily on the Simon-Williamson transactions-cost approach.

The study of the organization of trade is important not only for production efficiency but also for welfare considerations. For example, the now-classic paper by Vernon and Graham (1971) concludes that when middle products are substitutes in final good production, the upstream monopolist has incentive to monopolize the downstream and vertical mergers can lead to lower welfare. But is it generally true from the production efficiency point of view that vertical integration is more preferable than middle product trade? Using the 1976 Federal Trade Commission line-of-business database, D’Aveni and Ravenscraft (1994) find that vertical integration economizes on headquarter and R&D expenses but raise production costs, thus resulting only marginal efficiency gain. As documented by McLaren (2000), Japanese industry is much less vertically integrated than U.S. and other major developed countries and Taiwanese industry is far less integrated than Korea. The performance of those less-integrated economies, however, need not be worse than the more integrated.

In the present paper, we develop a unified framework based on which we can identify necessary and sufficient conditions for the emergence of a particular organizational structure – separation with middle-product trade, vertical integration or global sourcing. It is important to develop such a unified framework to allow for the possibility of all three organizational structures. This is because that the potential availability of one organizational structure can change the trade-off of the other two structures, thereby granting simple pairwise comparison in previous studies invalid. Moreover, we consider both conventional comparative advantage arguments and an array of organizational costs and show their different but complementary roles in determining the organization of production and trade jointly.

More specifically, we focus on a single final consumable that is produced by a downstream firm using the intermediate good produced by an upstream firm as an input. To our specific interest, one may imagine that upstream production and the design of the downstream production are both high-tech whereas the manufacturing component of downstream production is low-tech. In the context of international trade, one may therefore think that the upstream firms locate in a domestic advanced economy, or the North, with the downstream firms possibly residing in a foreign, less developed country (LDC), or the South. We assume complete production specialization in the sense that the
domestic manufacturers own the entire high-tech technology (inclusive of both the production of the intermediate good and the design of the downstream production) whereas the foreign producers own the low-tech technology (the manufacturing component the downstream production). Producers face a given, downward-sloping world demand for the final consumption good. We consider three organizational structures to manufacture the consumable.

- **Separation (S)**: The representative domestic manufacturer produces the upstream good and exports this middle product to the LDC, where the representative foreign firm manufactures the downstream consumable.

- **Integration (I)**: The representative domestic manufacturer becomes a multinational with complete ownership of the entire production line: itself produces the upstream good, which is provided to the LDC downstream firms to manufacture the final consumable.

- **Outsourcing (O)**: The representative domestic manufacturer is a multinational who owns the upstream firm and produces the intermediate good, offering the output of the middle product, the blue print of the production of the consumable, and a mixed contract to the LDC subcontracting firm. The subcontractor in turn produces the downstream manufacturing component, using the design provided by the upstream outsourcer together with the middle product. The final outputs of the consumable are then shipped to the world market, where the marketing management is operated by the domestic firm.

For illustrative purposes, we shall call the organizational structure in the latter two cases (integration and outsourcing) as *multinational*, as compared to the separated organizational structure that features the conventional *middle product trade* without any international merger or subcontracting arrangements. In contrast to the recent literature of outsourcing, we consider that the upstream firm keep full control of product designs and marketing, only offshoring the manufacturing component of the downstream product. Thus, the outsourcing regime in this recent literature can be viewed as to fall in between our separation and outsourcing regimes: while there is a contractual arrangement as in our outsourcing case, what is outsourced is the entire line of production rather than just the manufacturing part. The Outsourcing Configuration considered in our paper characterizes the scenario of profitable spinoff (downstream manufacturing) following a cross-border merger (integration of designing and marketing) such that integration and spinoff can *coexist* within one firm’s boundary. This largely ignored organizational structure is particularly relevant because the local economy under our consideration is less developed, thereby needing the blueprint from the advanced source economy.¹

¹For example, when Jeep off-shored to China (Beijing) and Intel Corporation to Costa Rica in the 1990s, they only outsourced the manufacturing part of the production.
There are two types of workers: the skilled labor and the unskilled labor. Skilled workers are required for designing and marketing both upstream and downstream products as well as for manufacturing high-tech middle products. In contrast, unskilled workers are only used for the low-tech manufacturing components of the production of the middle product and the consumable. We take into account both conventional production and trade costs and organization costs emphasized in the more recent literature. We explicitly discuss the role of the product-defection risk arising from outsourcing and argue that its importance is nonnegligible. The outsourcing configuration considered here maintains the technology difference between the source and the local countries. We solve final good and middle-product output as well as optimized profits under each of the three organizational structures. In the case of separation, we pin down the middle product price; in the case of outsourcing, we determine the optimal contract. We establish necessary and sufficient conditions under which each configuration arises in equilibrium. Furthermore, we characterize how equilibrium configuration changes in response to shift in technologies and discuss the consequent welfare implications.

Our main findings are summarized as follows. First, When subcontractor’s product-defection rate and bargaining strength are sufficiently low, the labor diversification loss is moderate and the communication and search cost is significant, outsourcing is the most preferred whereas separation is the least. Additionally, if offshore cost-saving is sizable, then outsourcing will take form internationally. Second, any change in the organization cost incurred under Separation would not affect the trade-off between Integration and Outsourcing. On the contrary, a change in the organization cost incurred under Outsourcing would create a “spillover effect” that influences the trade-off between Separation and Integration configuration. Third, while an increase in middle-product skill intensity raises the likelihood for outsourcing to arise in equilibrium, its generates ambiguous effects on the likelihood of Separation and Integration. Fourth, as a result of conflicting effects on firm payoffs and consumer surplus, an equilibrium organizational structure need not be optimal. Finally, we calibrate various economies and illustrate why outsourcing is more frequently observed in the U.S., Japan and Korea are more vertically integrated, and Taiwan features separation structure more often.

Related Literature

There have been various interesting lines of research on vertical mergers since almost four decades ago and on product outsourcing since the turn of the century.

For example, Salinger (1988) identifies three main effects of vertical mergers on merging firm’s output, middle-product demand and middle-product pricing, whereas Helpman (1984) allows firms

---

2Recent examples of outsourced product defection include Nestle products using poissoned milk containing melamine, Matell dolls manufactured using leaded paints, and several leading notebook computers including Dell, Sony and Toshiba assembled with explosive batteries.


Over two decades ago, Ethier (1986) shows that arm’s length contracting (such as outsourcing) emerge when information exchanges between the principal and the agent are simple. Based on theory of firm, Grossman and Helpman (2002, 2005) find that product outsourcing is more likely to emerge as the equilibrium configuration if search and communication costs are low and in-house shirking problems are more severe. Moreover, the equilibrium outcome is more likely to feature product offshoring when outsourcers’ bargaining strength is enhanced (Antràs and Helpman 2004) or when outsourcers’ ability in monitoring subcontractors’ shirking problem is higher (Grossman and Helpman 2004). In Riezman and Wang (2008), the outsourcing regime arises if it facilitates better matching with local preferences and if local country’s capital is not too scarce. Finally, Grossman and Rossi-Hansberg (2008) emphasizes trade in tasks rather than complete goods, where tasks offshoring occurs when its trade and communication costs are lower.

For brevity, we refer the reader to two recent and comprehensive surveys, Helpman (2006) and Antràs and Rossi-Hansberg (2008), for critical discussion of the literature in these research lines.

To the end, we would like to summarize several important features in our paper that contrast with the previous studies mentioned above. First, our model incorporates both the conventional production and trade cost and the organization cost emphasized in the more recent literature. Second, we take into account product-defection risk incurred by subcontractors. Third, we characterize an interesting outsourcing configuration in that only is the manufacturing component of the downstream product offshored. Fourth and perhaps most importantly, we allow for three possible organizational structure to illustrate how the potential availability of one organizational structure can change the trade-off of the other structures.
2 The Model

There are three theaters of economic activities: up-stream production (denoted by superscript $U$), down-stream production (denoted by superscript $D$), and subcontracting (in the case of outsourcing). There are two types of workers: the skilled labor ($H$) and the unskilled labor ($L$). We explicitly differentiate the designing/marketing and manufacturing components, denoting them by $A$ and $X$, respectively.

Depending on the organizational structure ($i = S, I, O$), we may have different sets of decision-makers ($j = U, D, C$) under the consideration. Specifically,

- Configuration $S$: the set of decision-makers include $U$ and $D$.
- Configuration $I$: $U$ is the only decision-maker, who owns both the upstream and the down-stream production lines.
- Configuration $O$: there are two separate decision-makers, $U$ and $C$.

In the following chart, we present the game tree that summarizes the decision making at every stage and the resulting equilibrium configurations in parentheses:

$$
\begin{align*}
\text{Separation} & \quad q, X \quad (S) \\
\text{Vertical Merger} & \\
\text{Integration} & \quad X \quad (I) \\
\text{Outsourcing} & \quad X, V (c_0, c_1) \quad \begin{cases} 
C \text{ rejects} \quad (I) \\
C \text{ accepts} \quad (O)
\end{cases}
\end{align*}
$$

where $q$ and $X$ denote middle product price and output, respectively, and $V (c_0, c_1)$ represents the outsourcing contract to be elaborated later.

2.1 Production Technology

We begin by specifying the most important setup of the model, namely, the production technologies facing the upstream and the downstream firms. We assume throughout that there are no substitution between the designing/marketing component and the manufacturing component in both middle product and final consumable production processes. This assumption is not too far from reality while simplifying the analysis greatly.

Denote $H_A^U$ and $H_X^U$, respectively, as skilled labor devoted to the designing/marketing component and the manufacturing component of the middle product. Further denote $L^U$ as unskilled labor devoted to the manufacturing component of the middle product. The design/marketing ($A^U$) and the output ($X^U$) of the middle product are specified as:

$$
\begin{align*}
A^U &= A_0^U \left[ (1 - \sigma i) H_A^U \right]^\frac{1}{\theta} \\
X^U &= \min \{ A^U, \theta H_X^U, L^U \}
\end{align*}
$$
where $\theta > 0$ indicates skill intensity in intermediate good production and $\sigma^i$ measures the organization cost incurred under organizational structure $i$ from communication and search (in units of labor), as well as captures the typical trade cost such as the transport cost and tariff. In the case of full integration, no such costs incur (i.e., $\sigma^I = 0$). When the organizational structure features middle product trade, such costs are greatest (i.e., $0 \leq \sigma^O < \sigma^S < 1$).

Denote $H^D_A$ as skilled labor devoted to the designing/marketing component of the consumable. Let $\gamma X^U$: measure the effective input of the middle product used in downstream production and $\gamma (1 - \nu)L^D$ the effective labor input devoted to the manufacturing component of the consumable, where $\nu \in [0, 1)$ measures the efficiency loss resulting from labor diversification. Then the design/marketing ($A^D$) and the output ($X^D$) of the consumable can be specified as:

$$A^D = A^D_0 (H^D_A)^{1/2}$$

$$X^D = \min \{ A^D, \gamma X^U, \gamma (1 - \nu)L^D \}$$

where $A^U_0 > A^D_0$, indicating that the production of the upstream middle product is relatively more high-tech than the production of the downstream final consumable. In either separated or outsourcing organizational structure, the downstream unskilled workers are completely specializing in the production of the consumable – that is, in the cases of $S$ and $O$, $\nu = 0$. In contrast, under the integrated multinational configuration, unskilled workers are used to produce both upstream and downstream products, thereby facing an efficiency loss and so $\nu \in (0, 1)$ for the case of $I$.

In the case of outsourcing, international monitoring or law enforcement becomes difficult. As a consequence, LDC firms may manufacture the final products that turns out to be defected. We assume that defected products may be returned for full refunds. Denote the (exogenous) probability for LDC firms to produce nondefected products as $(1 - \delta)$. The revenue obtained by the multinational in the source country is therefore $P^O X^O$ in the case of success and 0 otherwise. For convenience, we shall refer the state with no returned products as the high state (denoted $h$) and that with returned defected products as the low state (denoted $l$).

To the end, we summarize the main features associated with each of the three organizational structures as follows.

- **Separation (Configuration $S$)**
  - Upstream firms ($U$) incur communication, search and trade costs ($0 < \sigma^S < 1$) and face a holdup problem, but bear no risk of bad quality control in the final assembling process.
  - Downstream firms ($D$) also face a holdup problem, but have labor specialization gains ($\nu = 0$) over the case of integrated multinationals.
  - Compared to the case of integration, the South saves labor costs by hiring unskilled labor at a lower wage rate $(1 - \zeta^S)w_L$, where $w_L$ denotes the unskilled wage under full
integration and $\zeta^S \geq 0$.

- $U$ makes a take-it-or-leave-it offer to $D$, which pins down the price and quantity of the middle product $q$ and $M$, respectively.

**• Integration (Configuration I)**

- Upstream firms save communication, search and trade costs ($\sigma^I = 0$), bear no risk of LDC firms’ bad quality control, and suffer no holdup problem.
- Downstream firms have less labor specialization ($0 < \nu < 1$), but are free from the holdup problem.
- $U$ makes a take-it-or-leave-it offer to $D$, which determines the payment $S^I$ for acquiring the right of operating $D$.

**• Outsourcing the manufacturing component of consumable production to foreign subcontractors (Configuration O)**

- Upstream firms save communication, search and trade costs relative to the separation configuration ($0 \leq \sigma^O < \sigma^S$), have no holdup problem, but suffer the risk of LDC firms’ bad quality control.
- Downstream subcontractors restore labor specialization in assembling ($\nu = 0$) and have no holdup problem, but produce defected products with probability $\delta$ that, in the absence of effective monitoring or law enforcement, lowers the gross revenue.
- $U$ pays $S^O$ to acquire the right of operating $D$ and then outsources the manufacturing component of final consumable good production to a subcontractor $C$.
- $U$ makes a take-it-or-leave-it offer to $C$ with a mixed contract $c_0 + c_1 P^O X^O$, where $c_0$ represents the lump-sum upfront payment and $c_1 P^O X^O$ measures the performance-based revenue-sharing payment.
- The subcontractor located in the South hires unskilled workers to produce the manufacturing component at a wage rate lower than that under separation, given by $(1 - \zeta^O) w_L$, where $\zeta^S < \zeta^O < 1$.
- Uncertainty realizes after sales.

To the end, it is informative to summarize the main advantages and disadvantages under each organizational structure in our paper in the following table and to compare with setups in previous

---

3 This is because that, in the absence of a readily provided production design, separated downstream producers encounter greater difficulties in lowering the labor cost per efficiency units, compared to subcontractors.
studies. Specifically, in Jones (2000), only production costs and conventional trade cost related to comparative advantage are considered (i.e., $\delta = \sigma^O = \zeta^S = 0$ and $\sigma^S$ only captures the transport cost and tariff), whereas in Grossman and Helpman (2002, 2005), only organization costs are highlighted in which $\nu = \delta = \zeta^S = \zeta^O = 0$, and an additional in-house labor shirking cost is introduced. While Grossman and Helpman (2004) also consider organization costs such as $\sigma^S$, they focus on the consequences of subcontractor’s shirking. Notably, our considerations of the search, communication and trade costs are particularly relevant in the context of international trade because communication and search across countries can be very costly.

<table>
<thead>
<tr>
<th>Case</th>
<th>Upstream</th>
<th>Downstream</th>
<th>Subcontractor</th>
<th>Offshore</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Search</td>
<td>Incomplete</td>
<td>Production</td>
<td>Labor</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
<td>Specialization</td>
<td>Defect</td>
<td>Cost</td>
</tr>
<tr>
<td>or Trade Cost</td>
<td>Cost</td>
<td>Cost</td>
<td>Saving</td>
<td></td>
</tr>
<tr>
<td>$S$</td>
<td>$\sigma^S &gt; 0$</td>
<td>0</td>
<td>0</td>
<td>$\zeta^S \in [0, \zeta^O)$</td>
</tr>
<tr>
<td>$I$</td>
<td>0</td>
<td>$\nu &gt; 0$</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$O$</td>
<td>$\sigma^O \in [0, \sigma^S)$</td>
<td>0</td>
<td>$\delta &gt; 0$</td>
<td>$\zeta^O &gt; 0$</td>
</tr>
</tbody>
</table>

2.2 Profit Functions

Under separated organizational structure ($S$), the profits obtained by the upstream producer and the downstream producer are $\Pi^U$ and $\Pi^D$, respectively. In the two cases with multinationals, it is only necessary to compute the profits of the upstream firm, denoted by $\Pi^I$ and $\Pi^O$, respectively, under Configurations $I$ and $O$. The amount of final consumable is denoted by $X$ which in general is of different optimal level under different organizational structures. In the case of outsourcing, we denote the profit obtained by the representative upstream producer in the high state as $\Pi^O_h$ and in the low state as $\Pi^O_l$; moreover, the second superscript appearing in the factor input variable ($H$ and $L$) is used to denote configurations $I$ and $O$; the similarly, we denote the profit obtained by the representative subcontractor in the high and the low state as $\Pi^C_h$ and $\Pi^C_l$, respectively.

Normalize $w_H = 1$ and denote the relative wage under full integration as $\omega = \frac{w_L}{w_H} < 1$. Further define $\kappa^U \equiv \left(\frac{1}{\gamma a_U^S}\right)^2$, $\kappa^D \equiv \left(\frac{1}{\gamma a_D^S}\right)^2$, $a^i = \frac{1}{1-\sigma^i} \kappa^U + \kappa^D$, and $b^i = \frac{1}{\gamma} \left[\frac{1}{b} + (1 - \zeta^i) \omega\right]$ where $\sigma^I = \zeta^I = 0$. It is noted that while $\kappa^U$ and $\kappa^D$ are pure production costs, $a^i$ and $b^i$ include both production and organization costs. We can now write out the profit functions under the respective organizational structure:

$$\Pi^U = q \frac{X}{\gamma} - \left[(a^S - \kappa^D) X^2 + b^S X + F^U\right]$$

$$\Pi^D = p X - \left\{\kappa^D X^2 + \frac{1}{\gamma} \left[q + (1 - \zeta^S) \omega\right] X + F^D\right\}$$
\[ \Pi' = PX - \left\{ a'X^2 + \left[ b' + \frac{\omega}{\gamma(1-\nu)} \right] X + FU + FD \right\} \]  
\[ \Pi^O = -c_0 - \left[ a^OX^2 + b^OX + FU \right] \]  
\[ \Pi^C = c_0 - \left( \frac{(1-c^O)\omega}{\gamma} X + FD \right) \]  
\[ \Pi^O_h = (1-c_1)PX + \Pi^O \]  
\[ \Pi^C_h = c_1 PX + \Pi^C \]

2.3 Demand

The world demand for the consumable takes a constant elasticity form. The inverse demand function is given by,

\[ P = \left( \frac{X}{D_0} \right)^{\frac{1}{\epsilon}} \]

where \( D_0 > 0 \) represents the strength of the world market and \( \epsilon > 1 \) measures the price elasticity. As shown in Section 3 below, the assumption of \( \epsilon > 1 \) is crucial for guaranteeing an interior solution to upstream firm’s optimization. Under this constant elasticity demand function, the marginal revenue of producing the final consumption good can be computed as \( (1 - \frac{1}{\epsilon}) P \).

3 Optimization

We solve the optimization problem backward. We begin with the third stage: assuming that the upstream and downstream firms merge and that outsourcing arises in equilibrium, we determine the optimal terms of contract \( V(c_0, c_1) \) at a contracted output quantity \( X \), \( \{V(c_0, c_1), X\} \). We then solve the second stage optimization problem: given the optimal contract solved in the third stage, we determine whether a merged firm will manufacture both upstream and downstream products or outsource the downstream product to an outside subcontractor. Finally, we solve the first stage: given the organizational outcome determined in stage 2, we determine whether the upstream and downstream firms will merge.

3.1 Stage 3: Optimal Outsourcing Contract

In our setup, the activities undertaken by upstream outsourcers \( O \), namely designing the manufacturing the middle product and designing the final good, can be viewed as high-tech compared to final-good manufacturing undertaken by subcontractors \( C \). High-tech and inventive tasks are commonly viewed as more vulnerable to risk and uncertainty. It is therefore important to consider outsourcers’ risk-averse behavior and the consequences on their subcontracting decisions. For analytical convenience, we ignore the less essential risk attitude of subcontractors, assuming that they are risk-neutral. We further assume that the outsourcers’ utility takes an absolute risk aversion
The risk-neutral subcontractor’s expected utility is specified as:

$$U^C = (1 - \delta)\Pi^C_h + \delta \Pi^C_l$$

where $\Pi^C_h$ and $\Pi^C_l$ are given by (8). Facing an outside option of $\Pi^0_0 = 0$, $C$ would accept $O$’s contract $\{V(c_0, c_1), X\}$ if and only if the participation constraint, $U^C - \Pi^C_0 \geq 0$, is met, which is equivalent to,

$$c_0 \geq \frac{(1 - \zeta^O)\omega}{\gamma}X - (1 - \delta)c_1 PX + (F^D + \Pi^C_0)$$  \hspace{1cm} (10)

The risk-averse outsourcer determines $\{c_0, c_1, X\}$ to maximize the expected utility,

$$U^O = (1 - \delta)\left(1 - e^{-\alpha\Pi^O_h}\right) + \delta \left(1 - e^{-\alpha\Pi^O_l}\right)$$

subjective to the final good demand schedule and the subcontractor’s participation constraint, (9) and (10), where $\Pi^O_h$ and $\Pi^O_l$ are given by (8). From the first-order condition with respect to $X$, we have

$$(1 - \delta) \left[(1 - \delta c_1) \left(1 - \frac{1}{\epsilon}\right) P - \left(\frac{(1 - \zeta^O)\omega}{\gamma} + b^O\right) - 2a^O X\right] e^{-\alpha\Pi^O_h}$$

\begin{equation}
+ \delta \left[(1 - \delta) c_1 \left(1 - \frac{1}{\epsilon}\right) P - \left(\frac{(1 - \zeta^O)\omega}{\gamma} + b^O\right) - 2a^O X\right] e^{-\alpha\Pi^O_l} = 0, \tag{11}
\end{equation}

where the expression inside both square parentheses must equal zero whenever $X^O > 0$. This is possible only if $1 - \delta c_1 = (1 - \delta)c_1$, implying:

$$c_1 = 1. \tag{12}$$

It is not difficult to verify that, for all $c_1 \in [0, 1)$, $\frac{\partial U^O}{\partial c_1} > 0$. Thus, the solution for $c_1$ must be corner, at the upper bound, 1.

From (8), we can see that

$$\Pi^O_h = \Pi^O_l \equiv \Pi^O$$  \hspace{1cm} (13)

Substituting (12) and (13) into (11), we obtain a fixed point mapping determining the solution $X^O$:

$$X^O = R^O(X^O) \equiv \frac{(1 - \delta) \left(\frac{X^O}{\omega} - \beta - \left(b^O + \frac{(1 - \zeta^O)\omega}{\gamma}\right)\right)}{2a^O}, \tag{14}$$

As shown in the Appendix, the assumption on the demand elasticity, $\epsilon > 1$, guarantees this fixed point mapping is downward-sloping, which is sufficient to ensure the existence of a nondegenerate solution, $X^O > 0$ (see Figure 1).

\[\text{footnote}{By similar arguments, both upstream and downstream firms under Separation and the integrated firm are all involved in the designing components. We therefore assume that all of them are risk averse. Thus, subcontractors are the only agents in our economy with risk-neutral preferences.}\]
Lemma 1: Under $\epsilon > 1$, a nondegenerate solution to upstream output $X^O$ exists.

Because $U^O$ is monotone increasing, (10) must be binding, which implies:

$$c_0 = Q^O(X^O) \equiv \frac{(1 - \xi)^{\omega}}{\gamma} X^O - (1 - \delta) D_0 \left( X^O \right)^{1 - \frac{1}{\epsilon}} + (F^D + \Pi_0^C)$$ (15)

The upfront payment schedule $Q^O(X)$ is U-shaped, where the fixed point solution to $X^O$ is at the downward-sloping portion of $Q^O(X)$ before it reaches the minimum (see Figure 1). It is not difficult to prove that the solution to $c_0$ must be negative – since $c_1 = 1$, the subcontractor gets the entirety of the revenue and must therefore make an upfront payment to the upstream firm in order for the outsourcing contract to be mutually beneficial to both parties. This is because the outsourcer is risk averse. By receiving an upfront payment while giving the maximum share of revenue to the subcontractor, the outsourcer’s risk is minimized.

Proposition 1: (Outsourcing Contract) Under $\epsilon > 1$, the outsourcing contract features an upfront payment by the risk-neutral subcontractor to the risk-averse outsourcer with the subcontractor getting the entire share of revenue.

Using (9), (12), (14) and (15), we can obtain outsourcer’s optimized profit under outsourcing:

$$\Pi^O(X^O) = (1 - \delta) \left( \frac{1}{\epsilon} \right) \left( \frac{D_0}{X^O} \right)^{\frac{1}{\epsilon}} X^O + a^O \left( X^O \right)^2 - \Pi_0^C - F^U - F^D$$ (16)

Thus, when final good demand is more elastic, the upstream firm’s monopoly rent and hence its optimized profit are lower. We then turn to the determination of the acquisition payment $S^O$ when $U$ makes a take-it-or-leave-it offer to $D$ to acquire the downstream firm, which is simply:

$$S^O = \Pi^D$$ (17)

3.2 Stage 2: Integration Versus Outsourcing

We are now prepared to derive the optimized output and profit under integration. The multinational’s optimization problem is given by,

$$\max_X \Pi^I = \left( \frac{X}{D_0} \right)^{-\frac{1}{\epsilon}} X - a^I(X)^2 - \left[ b^I + \frac{\omega}{\gamma(1 - \nu)} \right] X - (F^U + F^D)$$

The first-order condition can be manipulated to yield the fixed point mapping that determines the solution $X^I$,

$$X^I = R^I(X^I) \equiv \frac{(1 - \frac{1}{\epsilon}) X^I}{2a^I} - \left[ b^I + \frac{\omega}{\gamma(1 - \nu)} \right]$$ (18)

where $R^I(X^I)$ is downward-sloping. By similar arguments, we can prove:

Lemma 2: Under $\epsilon > 1$, a nondegenerate solution to upstream output $X^I$ exists.
Substituting (9) and (18) into (7) results in the optimized profit under integration:

$$\Pi^I(X^I) = \frac{1}{\epsilon} \left( \frac{D_0}{X^I} \right)^{\frac{1}{\epsilon}} X^I + a^I (X^I)^2 - F^U - F^D \tag{19}$$

Similar to the Outsourcing configuration, when final good demand is more elastic, the integrated firm’s monopoly rent is lower, as is its optimized profit. Because $U$ makes a take-it-or-leave-it offer to $D$ to acquire the downstream firm, the acquisition payment $S^I$ must be pinned down at:

$$S^I = \Pi^D \tag{20}$$

### 3.3 Stage 1: Merge Versus Separation

In the case of separation, the downstream firm chooses an optimal quantity of final good output such that profits are maximized given the price of intermediate input $q$:

$$\max_{X^S} \Pi^D = \left( \frac{X^S}{D_0} \right)^{-\frac{1}{\epsilon}} X^S - \left\{ \kappa^D (X^S)^2 + \frac{1}{\gamma} [q + (1 - \zeta^S) \omega] X^S + F^D \right\}$$

The first-order condition is given by,

$$\left( 1 - \frac{1}{\epsilon} \right) \left( \frac{X^S}{D_0} \right)^{-\frac{1}{\epsilon}} - 2\kappa^D X^S - \frac{1}{\gamma} [q + (1 - \zeta^S) \omega] = 0 \tag{21}$$

which yields a downward sloping middle-product demand relationship in forms of the final product $X^S = K(q)$.

The upstream firm takes the downstream firm’s middle-product demand curve as given and then chooses optimal pricing to maximize her profits:

$$\max_{q} \Pi^U = q K(q) \frac{K^U}{\gamma} - \left\{ \frac{\kappa^U}{1 - \sigma^S} [K(q)]^2 + b^S K(q) + F^U \right\}$$

As shown in the Appendix, the first-order condition can be combined with (21) to yield a downward-sloping fixed point mapping of middle product output and an upward-sloping middle product supply curve,

$$q = \frac{\epsilon}{\epsilon - 1} b^S \gamma + \frac{(1 - \zeta^S) \omega}{\epsilon - 1} + 2\gamma \left( \frac{1}{\epsilon - 1} a^S + \frac{1}{\epsilon - 1} \kappa^D \right) X^S \tag{22}$$

$$X^S = R^S(X^S) \equiv \frac{(1 - \frac{1}{\epsilon} \gamma)^2 \left( \frac{X^S}{D_0} \right)^{-\frac{1}{\epsilon}} - \left[ b^S + \frac{(1 - \zeta^S) \omega}{\gamma} \right]}{2 (a^S + \kappa^D)} \tag{23}$$

where an interior fixed point of $X^S > 0$ in (23) always exists.

**Lemma 3:** Under $\epsilon > 1$, a nondegenerate solution to middle product output $X^S$ exists.
It is easily seen from (21) and (22) that the more elastic final good demand is, the less elastic middle product demand and the more elastic middle product supply will be. Moreover, we can characterize middle-product market equilibrium using both the demand and the supply schedules given by (21) and (22), respectively. The downward-sloping demand and upward-sloping supply schedules are plotted in Figure 2. When the communication, search and trade cost incurred under Separation is higher, middle good supply shifts left while middle product demand remains unchanged. As a result, middle product output decreases and its price rises. When labor-cost saving under Separation is greater, both middle product demand and supply shift rightward. While middle product output increases, the net effect on the middle product price is ambiguous.

**Proposition 2:** (Middle-Product Market Equilibrium) A higher communication, search and trade cost lowers middle product output but raises its price. Greater labor-cost saving raises middle product output but has an ambiguous effect on the price.

These relationships can then be substituted into (5) and (6) to derive the total surplus accrued from middle-product trade between the downstream and upstream firms (see the Appendix):

\[
\Pi^U(X^S) + \Pi^D(X^S) = \left(2 - \frac{1}{\epsilon}\right) \frac{1}{\epsilon} \left(\frac{D_0}{X}\right)^{\frac{1}{2}} X + (a^S + 2\kappa^D) X^2 - F^U - F^D
\]  

(24)

Similar to Outsourcing and Integration configurations, the elasticity of final good demand has a negative effect on monopoly rent (see the \(\frac{1}{\epsilon}\) term in the expression above). However, its net effect on optimized profit \((2 - \frac{1}{\epsilon}) \frac{X}{\epsilon}\) is lower under Separation compared to the other two configurations. There are two dampening factors of this negative effect. First, since the upstream firm does not face final good consumers directly, it is partially insulated from this monopoly rent squeeze. Second, in response to this change, the upstream firm will set the middle product price lower. As a result, the downstream firm’s demand for middle products does not reduce by as much. Since higher middle product output leads to larger profits, the profit reduction caused by a more elastic final good demand is smaller. This finding is summarized as follows.

**Proposition 3:** (Final Good Demand Elasticity and Producer Profits) An increase in the demand elasticity of the final good lowers producer profits under any configuration. Such a negative effect is larger under Outsourcing and Integration than under Separation.

Imagine the presence of many final goods. When a particular final good has many competing substitutes, it can be regarded as to have more elastic demand. To produce such a good, the organizational structure is therefore more likely to be in forms of middle product trade (separation), rather than multinational arrangements (integration or outsourcing).
4 Equilibrium Organizational Structures

Based on the 3-stage decision process, we now proceed to establish necessary and sufficient conditions under which each of the three organizational structures arises in equilibrium.

- The structure of Separation emerges in equilibrium if and only if:
  \[ \Pi^U(X^S) > \max\{\Pi^I(X^I) - S^I, \Pi^O(X^O) - S^O\} \quad \text{or} \quad \Pi^D(X^S) > \max\{S^I, S^O\} \]

  The condition implies that either the upstream firm or the downstream firm strictly prefers the status quo that is Separation to merger. In other words, it must be the case that either the upstream firm is reluctant to become a multinational or the downstream firm rejects the upstream firm’s offer to merge with her. As a result, the case of Separation emerges.

- The structure of Integrate emerges in equilibrium if and only if
  \[ \Pi^I(X^I) - S^I > \max\{\Pi^U(X^S), \Pi^O(X^O) - S^O\} \quad \text{and} \quad \Pi^D(X^S) \leq S^I \]

  The condition implies that the upstream firm strictly prefers Integration to any other structures, and the downstream firm is weakly better off in the case of Integration than in the case of Separation. As a result, the case of Integration arises.

- The structure of Outsourcing emerges in equilibrium if and only if
  \[ \Pi^O(X^O) - S^O > \max\{\Pi^U(X^S), \Pi^I(X^I) - S^I\}, \Pi^D(X^S) \leq S^O \quad \text{and} \quad \Pi^C(X^O) \geq \Pi^C_0 \]

  Under the condition, the upstream firm strictly prefers Outsourcing than any other kind of structures, and the downstream firm and the subcontractor are both weakly better off in the case of Outsourcing than in the status quo such that Outsourcing arises in equilibrium.

As shown in (17) and (20), we know that \( \Pi^D(X^S) = S^I = S^O \). The necessary and sufficient conditions for each configuration to arise in equilibrium are therefore reduced to:

<table>
<thead>
<tr>
<th>Equilibrium Configuration</th>
<th>Necessary and Sufficient Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S )</td>
<td>( \Pi^U(X^S) + \Pi^D(X^S) &gt; \max{\Pi^I(X^I), \Pi^O(X^O)} )</td>
</tr>
<tr>
<td>( I )</td>
<td>( \Pi^I(X^I) &gt; \max{\Pi^U(X^S) + \Pi^D(X^S), \Pi^O(X^O)} )</td>
</tr>
<tr>
<td>( O )</td>
<td>( \Pi^O(X^O) &gt; \max{\Pi^U(X^S) + \Pi^D(X^S), \Pi^I(X^I)} )</td>
</tr>
</tbody>
</table>
We illustrate how the upstream firm’s propensity in favor of one particular type of organizational structure varies with three key parameters, say $\sigma$, $\nu$, and $(1 - \delta)$, graphically. It is useful to compare the general form of the profit function under each of three organizational structures (recall (16), (19) and (24)):

\[
\begin{align*}
\Pi^O(X) &= (1 - \delta) \left( \frac{1}{\epsilon} \right) \left( \frac{D_0}{X} \right) \frac{1}{2} X + a^O X^2 - \Pi^C_0 - F^U - F^D \\
\Pi^I(X) &= \frac{1}{\epsilon} \left( \frac{D_0}{X} \right) \frac{1}{2} X + a^I X^2 - F^U - F^D \\
\Pi^U(X) + \Pi^D(X) &= \left( 2 - \frac{1}{\epsilon} \right) \frac{1}{\epsilon} \left( \frac{D_0}{X} \right) \frac{1}{2} X + (a^S + 2\kappa^D) X^2 - F^U - F^D
\end{align*}
\]

As shown in the Appendix, for every $X > 0$, $\Pi^U(X) + \Pi^D(X) > \Pi^I(X) > \Pi^O(X)$. Moreover, $\Pi^O(X)$, $\Pi^I(X)$ and $\Pi^U(X) + \Pi^D(X)$ are all strictly increasing in $X$. As $X \to 0$, they all become negative; as $X \to \infty$, they all go to infinity. Furthermore, for small $X$, they are all concave. These profit functions are plotted in Figure 3.

We are now prepared to pin down the solution of consumable under each of the three organizational structures by the intersection of $R^i(X)$ and the 45°-line (see the bottom panel of Figure 3). These solutions can then be mapped into the corresponding profit functions to yield optimized profits. In general, there is no definite ordering of the three optimized profits. For illustrative purposes, Figure 3 is drawn with outsourcing yielding the highest profits and separation the lowest.

Since $R^O(X)$ shifts to the right and $\Pi^O(X)$ shifts upward as the yield rate of the production performed by the subcontractor, $(1 - \delta)$, increases, we know that $X^O$ and the optimized profit under outsourcing ($\Pi^O(X^O)$) also rise which make outsourcing more profitable. In response to an increase in the organization cost incurred from communication and search ($\sigma^S$), $R^S(X)$ shifts to the left and $\Pi^U(X) + \Pi^D(X)$ shifts downward. As a result, $X^S$ and the optimized aggregate profit under separation ($\Pi^U(X^S) + \Pi^D(X^S)$) decreases, granting the separation structure disadvantageous. Further, when the efficiency loss resulting from labor diversification ($\nu$) increases, $R^I(X)$ shifts to the left, thus lowering $X^I$ and the corresponding optimized profit $\Pi^I(X^I)$. This makes integration less favorable. Finally, an increase in the subcontractor’s outside option ($\Pi^C_0$) lowers the vertical intercept of $\Pi^O$ and hence the optimized profit $\Pi^O(X^O)$, which reduces the profitability to outsource. In the case where subcontractor’s product-defection risk and outside option are sufficiently low, the labor diversification loss is moderate and the communication and search cost is sufficiently high, outsourcing is the most preferred whereas separation is the least – the case shown in Figure 3.

**Proposition 4:** (Optimized Profits)

(i) Under Separation, the optimized profit increases with lower communication, search and trade costs or greater labor-cost saving.
(ii) Under Integration, the optimized profit increases with a reduced efficiency loss from labor diversification.

(iii) Under Outsourcing, the optimized profit increases with a higher subcontractor’s yield rate, lower subcontractor’s outside option, lower communication, search and trade costs, or greater labor-cost saving.

To gain further insights, we focus on the subcontractor yield-rate and the labor diversification loss parameters and partition the parameter space \(((1 - \delta), \nu)\) into three different regions correspondent to the respective organization structures \(S\) (separation), \(I\) (integration) and \(O\) (outsourcing). To begin, consider the indifference boundary between organizational structures \(I\) and \(O\) under \(\Pi^C_0 = 0\), denoted by \(\hat{AB}\), a curve connecting point \(A\) and point \(B\), as illustrated in the upper panel of Figure 4. It is clear that outsourcing more likely to arise when \((1 - \delta)\) is high and \(\nu\) is low. Moreover, as \((1 - \delta)\) reduces, the cost of outsourcing is higher, which requires \(\nu\) (cost of integration) to increase in order to maintain indifferent between organizational structures \(I\) and \(O\). This outline the downward-sloping indifference boundary between \(I\) and \(O\). As \(\Pi^C_0\), \((1 - \zeta^O)\), or \(\gamma\) (design intensity) rises, this indifference boundary shifts outward. Next, we examine the indifference boundary between organizational structures \(I\) and \(S\), denoted by \(\overline{CD}\), a line connecting point \(C\) and point \(D\) as illustrated in the middle panel of Figure 4. This indifference boundary does not depend on \((1 - \delta)\), and hence is horizontal in \(((1 - \delta), \nu)\) space. There is in general a critical value of \(\nu\) given a particular value of \(\sigma^S\) such that integration and separation are equally profitable. As \(\sigma^S\) or \(\gamma\) increases, this indifference boundary shifts upward. Now, we turn to the indifference boundary between organizational structures \(S\) and \(O\), denoted by \(\overline{EF}\) as illustrated in the bottom panel of Figure 4. Since \(\nu\) represents the cost of labor diversification, which arises only when upstream and downstream firms are integrated, the indifference boundary between \(S\) and \(O\) does not depend on \(\nu\), and thus is a vertical line. In response to an increase in \(\sigma^S\), \(\zeta^O\) or \(\gamma\), this indifference boundary shifts leftward. Finally, it is easily seen that at the intersection of \(\overline{CD}\) and \(\overline{EF}\), organizational structures \(I\) and \(S\) must be indifferent and \(S\) and \(O\) must also be indifferent. Thus, at this intersection, organizational structures \(I\) and \(O\) must also be indifferent too, implying that the indifference boundary between \(I\) and \(O\) (\(\hat{AB}\)) must pass through the same point \(G\) as depicted in the upper left panel of Figure 5. In summary,

**Lemma 4:** The indifference boundary between Separation and Integration projected onto \(((1 - \delta), \nu)\) space is independent of subcontractor’s yield rate, whereas the indifference boundary between Separation and Outsourcing is independent of the efficiency loss from labor diversification. The indifference boundary between Integration and Outsourcing is downward-sloping.

In the benchmark case, we choose point \(G\) to be interior (see in the upper left panel of Figure 5). In this scenario, all three organizational structures may arise within the domain of parameters.
((1 − δ), ν) ∈ [0, 1] × [0, 1]. When \(CD\) falls below the horizontal axis (see panel (1) of Figure 5), only may organizational structures \(S\) and \(O\) emerge in equilibrium; when \(EF\) is on the right of \(1 − δ = 1\), only can \(I\) and \(S\) arise (see panel (2) of Figure 5); when \(EF\) is on the left of \(1 − δ = 0\) or \(CD\) is above \(ν = 1\), the only possible equilibrium structures are \(I\) and \(O\) (see panels (3a) and (3b) of Figure 5, respectively). It is also possible that only one organizational structure can emerge under some extreme cases (as depicted in panels (4a-c) of Figure 5).

**Theorem:** (Equilibrium Configuration) Under \(\epsilon > 1\), one of the three configurations with nondegenerate production will emerge in equilibrium.

(i) When the communication, search and trade cost is sufficiently low, the labor diversification loss is not too low, and subcontractor’s product-defection rate and bargaining strength are not too low, separation arises in equilibrium.

(ii) When the labor diversification loss is sufficiently low, the communication, search and trade cost is significant, and subcontractor’s product-defection rate and bargaining strength are not too low, integration arises in equilibrium.

(iii) When subcontractor’s product-defection rate and bargaining strength are sufficiently low, labor-cost saving is sufficiently large, the labor diversification loss is not too low and the communication, search and trade cost is significant, outsourcing arises in equilibrium.

### 5 Equilibrium Characterization and Welfare Analysis

We now turn to characterize the equilibrium organization of production and trade and examine the welfare properties. In addition to an analytic study, we also conduct calibration analysis to gain further insights.

#### 5.1 Comparative Statics

We begin by conducting comparative-static exercises. In particular, we focus on effects of changes in (i) three organization cost parameters, search/communication/trade cost (\(σ^S\) and \(σ^O\)) and subcontractor’s outside option (\(Π^C_0\)), and (ii) three production cost parameters, labor cost-saving (\(ζ^S\) and \(ζ^O\)) and middle-product skill intensity (\(θ\)). Depending on the status-quo equilibrium, the results of each comparative static analysis may not be the same qualitatively. For the sake of brevity, however, we restrict our analysis only to the benchmark case.

Let us first look at the exercise of increasing \(σ^S\) or decreasing \(ζ^S\), both granting the separation structure disadvantageous. An increase in \(σ^S\) or a reduction in \(ζ^S\) shifts \(CD\) upward, and \(EF\) to the left, but leaves \(AB\) unchanged (see Figure 6(a)). The new intersection point is \(G'\). As a
consequence, the region of $S$ unambiguously shrinks, accompanied by an expansion of regions $I$ and $O$. In words, an increase in search, communication and trade costs or a decrease in labor cost-saving makes the separated configuration less likely to arise in equilibrium and vertical integration and global sourcing more likely to become the equilibrium outcome.

In response to an increase in $\Pi_0^C$ or $\sigma^O$ or a reduction in $\zeta^O$, $AB$ shifts outward whereas $EF$ shifts to the right (see Figure 6(b)), with $CD$ remaining unaffected. Thus, the region of $O$ shrinks while the regions of $I$ and $S$ expand. That is, an increase in search, communication and trade costs or a decrease in offshoring labor cost-saving makes outsourcing less likely to arise in equilibrium and grant both separation and vertical integration more advantageous. To gain further insight, we decompose the net effects into three and use Figure 6(b) to demonstrate the details. In stage 2 along the decision tree, a multi-national determines whether to integrate the upstream and downstream or whether to outsource. Thus, an increase in these organization costs of outsourcing creates a direct effect where the region of Outsourcing shrinks from $O = \bigcup_{i=1}^5 O_i$ to $O' = O_1 \cup O_2$ and the region of Integration expands from $I$ to $I' = I \cup O_3 \cup O_4 \cup O_5$. The region of Separation remains unchanged in this stage. Back to stage 1, the winner of Integration and Outsourcing configurations is then compared with the Separation configuration. When the winner is Outsourcing, an increase in these organization costs of outsourcing yields an indirect effect such that the region of Outsourcing shrinks from $O' = O_1 \cup O_2$ to $O'' = O_1$ whereas the region of Separation expands from $S$ to $S' = S \cup O_2$. When the winner turns out to be Integration, however, such an organization cost increase generates a spillover effect. Specifically, because the outside option of Integration, namely Outsourcing, is less attractive, the comparative advantage of Integration is also weakened. As a consequence, the region of Integration shrinks from $I' = I \cup O_3 \cup O_4 \cup O_5$ to $I'' = I \cup O_4 \cup O_5$ while the region of Separation expands further from $S' = S \cup O_2$ to $S'' = S \cup O_2 \cup O_3$. That is, changes in a pure outsourcing-related organization cost can change the trade-off between Integration and Separation. This spillover effect is a result of the fact that the potential availability of one organizational structure can influence the comparative advantage of the other two structures. Thus, an analysis based on simple pairwise comparison may be biased or even invalid.

With regard to an increase in $\theta$, $AB$ shifts inward whereas $EF$ shifts leftward (see Figure 6(c)). However, its effect on $CD$ is ambiguous, which can be seen by comparing (18) and (23). On the one hand, higher skill intensity in manufacturing the middle product grants separation less advantageous than integration as the former structure features a lower upstream markup. On the other hand, separation become more advantageous than integration because of labor cost-saving under separation and incomplete-specialization cost under integration. When the markup effect dominates the organizational cost effect, $CD$ shifts downward (referred to as Case 1 in Figure 6(c)); otherwise, it shifts upward (referred to as Case 2). In either case, an increase in middle-product skill intensity makes outsourcing more likely to arise. In Case 1, an increase in middle-product
Proposition 5: (Equilibrium Characterization)

(i) **While a change in the organization cost incurred under Separation does not affect the trade-off between Integration and Outsourcing, a change in the organization cost incurred under Outsourcing creates a spillover effect influencing the trade-off between Separation and Integration.**

(ii) **While an increase in middle-product skill intensity raises the likelihood for outsourcing to arise in equilibrium, its effects on the likelihood of Separation and Integration are ambiguous.**

To the end, we would like to document that the effects of changes in $\omega$ and $\gamma$ are even more complicated than shifts in $\theta$. Specifically, changes in $\omega$ and $\gamma$ both create additional effects through the middle-product price and the upfront payment of the outsourcing contract. As a consequence, one cannot obtain any unambiguous comparative-static results analytically.

5.2 Welfare Implications

We next turn to basic welfare analysis. Notice that as a result of the risk averting behavior of upstream and downstream firms, inclusion of the risk-neutral subcontractor’s payoff would generate great complication even under a simple equally weighted social welfare function. Thus, we focus primarily on the case where $\Pi^C_0 = 0$. In this case, to measure world welfare, we only need to take into account of upstream/downstream firm payoffs and consumer surplus. Given the downward-sloping final good demand, consumer surplus is positively related to the output of the final product. These arguments indicate that Figure 3 alone is sufficient for conducting welfare analysis.

In the case as drawn (Figure 3), outsourcing leads to both higher firm payoffs and higher output, thus higher consumer surplus. In this case, outsourcing arises in equilibrium and achieves highest welfare. In general, however, equilibrium configuration need not be optimal. Consider for example the case where search/communication/trade cost is sufficiently high to cause a downward shift in the $\Pi^O$ curve so that vertical integration becomes the equilibrium organizational structure. Meanwhile, labor cost-saving from global sourcing is sufficiently high to offset this previous effect and leave the $R^O$ locus unchanged. Under this circumstance, equilibrium output of middle and final products are still the highest under outsourcing. Thus, while global sourcing generates less firm payoffs than integration, it continues to yield highest consumer surplus. Should the latter benefit outweighs the former, vertical integration becomes a suboptimal equilibrium structure of organization.

Proposition 6: (Welfare) **An organizational structure may generate conflicting effects on firm payoffs and consumer surplus and an equilibrium configuration need not be optimal.**
6 Calibrated Equilibrium Regimes

We are now prepared to illustrate based on special features of various economies to explain why different equilibrium configurations have been more frequently observed in different economic environments. In particular, why does Japanese industry outsource much less than the U.S. and why Taiwanese industry is far less integrated than Korea.

We begin by calibrating the model based on the trade of the U.S. (the North) with its two largest LDCs partners, China and India (the South).

It is well-documented that total trade cost in unit values is in the order of 10 to 30% and that labor saving in the South is of comparable scales. Thus, we set \( \sigma^S = 0.2, \zeta^S = 0.25, \sigma^O = 0.1, \) and \( \zeta^O = \frac{1}{3}. \) It is also well-documented that price elasticities of demands for manufacturing goods falls in the range of 1 to 3. We therefore take \( \epsilon = 2 \) as the benchmark value. Based on the estimates by D’Aveni and Ravenscraft (1994), integration cost in production due to incomplete specialization is about 12\%, which implies: \( \nu = 0.12. \) Based on the non-production/production wage differential of 1.6 (cf. Machin and van Reenen 1998), we set \( \omega = 1/1.6 = 0.625. \)

Without loss of generality, we normalize the final output in the South and the mass of unskilled workers in the North as one: \( X^D = L^U = 1. \) It is reasonable to assume the defect rate at 5\%: \( \delta = 0.05. \) In the benchmark case, we take fixed costs and subcontractor’s outside option at proper values such that per capita profits are reasonable: \( F^U = 20, F^D = 10 \) and \( \Pi_0^C = 5. \) Moreover, we set the ratio of designing labor in the North to the South as 5, which yields a ratio of total workers in the North to the South about 12.5. Concerning other population allocations, we compute their values based on two observations in the U.S. manufacturing sector: (i) non-production employment share is about \( \rho = 30\% \) in 1990 (cf. Machin and van Reenen 1998) and (ii) the percentage of high-skilled workers is about \( s = 48\% \) (cf. Sachs and Shatz 1996). Thus, we can compute: \( H_X^U = \frac{1-\rho}{1-s} - 1 = 0.346 \) and \( H_A^U = \frac{\rho}{1-s} = 0.577. \) Thus, \( H_A^D = \frac{H_X^D}{5} = 0.115. \) Finally, the value of intermediate goods exported to the South is about 45 (computed from Yi 2003), from which we can obtain: \( q = \frac{45}{X^U}. \)

By using (1)-(4) and the definitions of \( \kappa^U, \kappa^D, a^i \) and \( b^i, \) we can (i) write \( A^D = X^D = 1, \) \( A_0^D = \frac{A^D}{(H_X^D)^{1/2}} = 2.944 \) and \( \kappa^D = (A_0^D)^{-2} = 0.115 \) and (ii) express \( \theta, \gamma, A^U, A_0^U, L^D, \kappa^U, a^i \) and \( b^i \) as functions of \( X^U. \) We then combine (23) and (22) to solve jointly \( X^U = 24.334 \) and \( D_0 = 12767. \) We can further substitute the value of \( X^U \) into the functions mentioned above to (i) calibrate \( \theta = 70.298, \gamma = 0.0411, A_0^U = 35.819 \) and \( \kappa^U = 0.462, \) and (ii) compute \( A^U = 24.334 \) and \( L^D = 27.652. \)

The benchmark case for the U.S. is depicted in the upper left panel of Figure 7. Given \( ((1 - \delta), \nu) = (0.95, 0.12), \) we can see that one can expect, on average, outsourcing to emerge as the efficient equilibrium outcome (see point AUS that falls in the outsourcing region). Around this benchmark equilibrium, an increase in the unskilled wage rate or a decrease in the design intensity
is found to shift $CD$ downward and $EF$ leftward, thereby expanding the regions of outsourcing and separation and shrinking the region of integration.

One may then wonder why other organizational structures than the outsourcing configuration have been more frequently observed in other countries, such as Japan, Taiwan and Korea, while facing the same South, China and India. We argue that these observations can be readily explained as a result of different technologies, infrastructures, and organizational costs. In the table below, we summarize our selection of such parameters under each regime.

<table>
<thead>
<tr>
<th>Country</th>
<th>Parameter Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>$\sigma^S = 0.2$, $\zeta^S = 0.25$, $\sigma^O = 0.1$, $\zeta^O = \frac{1}{3}$, $\Pi^C_0 = 5$, $\delta = 0.05$, $\nu = 0.12$, $A^U_0 = 35.819$, $A^D_0 = 2.944$, $\theta = 70.298$, $\gamma = 0.0411$, $F^U = 20$, $F^D = 10$, $\omega = 0.625$, $D_0 = 12767$, $\epsilon = 2$</td>
</tr>
<tr>
<td>Japan</td>
<td>$\zeta^S = 0.25 \cdot 0.75$, $\zeta^O = \frac{1}{3} \cdot 0.75$, $\nu = 0.12 \cdot \frac{2}{3}$, others identical to the U.S.</td>
</tr>
<tr>
<td>Taiwan</td>
<td>$\zeta^S = 0.25 \cdot \frac{2}{3}$, $\zeta^O = \frac{1}{3} \cdot \frac{2}{3}$, $\nu = 0.12 \cdot 3$, $\Pi^C_0 = 5 \cdot 1.2$, $\delta = 0.05 \cdot 2.5$, $\theta = 70.298 \cdot 0.75$, others identical to the U.S.</td>
</tr>
<tr>
<td>Korea</td>
<td>$\nu = 0.12$, others identical to Taiwan</td>
</tr>
</tbody>
</table>

Specifically, the user cost of labor in Japan is not as high as in the U.S. We thus adjust the labor cost-saving factors $(\zeta^S, \zeta^O)$ downward by 25% from the benchmark value in the U.S. However, it is also known that the Japanese government has set up the economic system in favor of large, vertically integrated corporations. We thereby lower its associated integration cost ($\nu$) by one-third from the U.S. benchmark. The calibrated Japanese regime is plotted in the upper right panel of Figure 7, where it is expected that, on average, vertical integration will arise in equilibrium (see point $E_{Japan}$ that falls in the integration region).

In Taiwan and Korea, the user cost of labor is even lower. So the labor cost-saving factors $(\zeta^S, \zeta^O)$ are adjusted downward by one-third from the U.S. benchmark. Moreover, both economies lack a complete infrastructure and law institutions to monitor the subcontractors or to protect against subcontractors’ imitation and spin-off. Accordingly, we adjust their product-defection rates higher from 5% to 12.5% and their outside option ($\Pi^C_0$) higher by 20%, compared to the U.S. benchmark case. Further, we recognize that the skill intensity of manufacturing the middle product ($\theta$) in Taiwan and Korea is not as high as in the U.S., which is therefore adjusted downward by 25%. Finally, it is important to stress a major difference between the two economies: while Korea encourages conglomeration of firms (as it is evident by the presence of many chaebols), Taiwan
encourages median and small enterprises (with many large-scale production operated by public enterprises). We thus choose Korea’s integration cost factor to be as low as in the U.S. and Taiwan’s to be three times as large as the U.S.’ benchmark value. We depict the calibrated Taiwanese and Korean regimes in the lower left and lower right panels of Figure 7, respectively. As indicated by points $E_{Taiwan}$ and $E_{Korea}$, it is expect that, on average, separation will be the efficient equilibrium outcome in Taiwan whereas integration will emerge in equilibrium in the Korean economy.

7 Concluding Remarks

We have constructed a unified framework to study trade and organizational choice by vertically connected firms and established necessary and sufficient conditions for separation, vertical integration and global sourcing to arise in equilibrium. We have shown that outsourcing is the most preferred and separation is the least preferred if subcontractor’s product-defection rate and bargaining strength are sufficiently low, the labor diversification loss is moderate and the communication and search cost is significant. We have illustrated how the potential availability of one organizational structure can change the trade-off of the other structures. We have also illustrated that an equilibrium organizational structure may be suboptimal. Furthermore, we have calibrated based on various economies to explain why different equilibrium configurations have been more frequently observed in different economic environments.

In order to produce an array of analytic results, we have simplified the production structure greatly. In particular, we have employed Leontief technologies and considered proportional organization-related costs. Perhaps the most important extension to our paper is to allow for more general production structure. Of course, such a generalization would grant the model unsolvable analytically. Yet, one may still conduct calibration analysis following the lead of Yi (2003), to check the robustness of the responses of organizational choice to various shifts in cost parameters. Additionally, in this more general framework, one may examine quantitatively whether vertical integration or outsourcing leads to higher welfare than middle-product trade, to compare with previous findings established by D’Aveni and Ravenscraft (1994) and Fujita and Thisse (2006).
Appendix

In this Appendix, we provide some supporting data and detailed proofs of the results obtained in the main text.

**Ratios of the average of imports and exports to GDP in respective years**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>14.5</td>
<td>16.5</td>
<td>21.6</td>
<td>24.0</td>
<td>33.5</td>
</tr>
<tr>
<td>Japan</td>
<td>8.8</td>
<td>8.3</td>
<td>11.8</td>
<td>8.4</td>
<td>10.1</td>
</tr>
<tr>
<td>U.K.</td>
<td>15.3</td>
<td>16.5</td>
<td>20.3</td>
<td>20.6</td>
<td>29.0</td>
</tr>
<tr>
<td>U.S.</td>
<td>3.4</td>
<td>4.1</td>
<td>8.8</td>
<td>8.0</td>
<td>13.1</td>
</tr>
</tbody>
</table>

**Characterizing the fixed point mapping of middle product output and the lump-sum upfront payment**

Under the Outsourcing configuration, the fixed point mapping, \( R^O(X) \), satisfies the following boundary conditions: \( R^O(\bar{X}^O) = 0 \) and \( \lim_{X \to 0} R^O(X) = \infty \), where

\[
\bar{X}^O = \left[ \frac{(1 - \delta) \left( \frac{1}{1 - \frac{1}{\epsilon}} \right)}{\epsilon_0 + \frac{\omega(1 - c^O)}{\gamma}} \right]^{\epsilon} D_0 > 0
\]

Moreover, it is strictly decreasing and strictly convex,

\[
\frac{\partial R^O(X)}{\partial X} = -\frac{1}{\epsilon} \left( 1 - \frac{1}{\epsilon} \right) \frac{(1 - \delta) P}{2a^O X} < 0,
\]

\[
\frac{\partial^2 R^O(X)}{\partial X^2} = \frac{1}{\epsilon} \left( 1 - \frac{1}{\epsilon} \right) \left( 1 + \frac{1}{\epsilon} \right) \frac{(1 - \delta) P}{2a^O X^2} > 0.
\]

The existence and uniqueness of the fixed point \( X^O \) is thus guaranteed. Since the shape of the respective fixed point mapping under Integration and under Separation is similar, we will omit any further discussion for brevity.

The schedule \( Q^O(X) \) is U-shaped, reaching the minimum at

\[
\hat{X}^O = D_0 \left[ \frac{(1 - \delta) \left( \frac{1}{1 - \frac{1}{\epsilon}} \right)}{\omega(1 - c^O) \gamma} \right]^{\epsilon} > \bar{X}^O
\]

satisfying:

\[
Q^O(0) = F^D + \Pi^C_0 > 0,
\]

\[
\frac{\partial^2 Q^O(X)}{\partial X^2} = (1 - \delta) \frac{1}{\epsilon} \left( 1 - \frac{1}{\epsilon} \right) \frac{P}{X} > 0
\]

\[
\left. \frac{\partial Q^O(X)}{\partial X} \right|_{X = \hat{X}^O} = -2a^O X^O + b^O < 0.
\]
where the last expression implies $X^O < \hat{X}^O$.

**Deriving middle product price and output under Separation**

Straightforward differentiation of $X^S = K(q)$ based on (21) leads to:

$$
K'(q) = \frac{-X^S}{\gamma \left[ \frac{1}{\varepsilon} \left( 1 - \frac{1}{\varepsilon} \right) \left( \frac{X^S}{D_0} \right)^{\frac{1}{\varepsilon}} + 2\kappa D X^S \right]} < 0
$$

which can be substituted into the upstream firm’s first-order condition with respect to $q$ to obtain:

$$
\frac{K(q)}{\gamma} \left\{ 1 - \frac{q}{\gamma} \frac{2\kappa U K(q)}{1 - \sigma S} - b^S \frac{1}{\varepsilon} \left( \frac{X^S}{D_0} \right)^{\frac{1}{\varepsilon}} + 2\kappa D K(q) \right\} = 0,
$$

With $X^S > 0$, we can manipulate the above expression to write the middle product price as below:

$$
q = b^S \gamma + 2\gamma \left( \frac{\kappa U}{1 - \sigma S} + \kappa D \right) X^S + \frac{\gamma}{\varepsilon} \left( 1 - \frac{1}{\varepsilon} \right) \left( \frac{X^S}{D_0} \right)^{-\frac{1}{\varepsilon}}
$$

Substituting this expression into (21), we obtain:

$$
\left( 1 - \frac{1}{\varepsilon} \right)^2 \left( \frac{X^S}{D_0} \right)^{-\frac{1}{\varepsilon}} = b^S + \frac{1 - \zeta^S}{\gamma} \omega + 2 \left( \frac{\kappa U}{1 - \sigma S} + 2\kappa D \right) X^S
$$

which can be rewritten as the fixed point mapping given by (23). One may easily check that $\frac{dR^S(X)}{dX} < 0$, $\lim_{X \to 0} R^S(X) = \infty$, and $R^S \left( D_0 \left[ \frac{(1-1)^2}{b^S + (1-\zeta^S)\omega} \right]^\varepsilon \right) = 0$. Thus, the existence of a positive fixed point is always assured. We can then substituting (23) into the middle product price expression above to solve (22).

We next substitute (22) into (5) to derive the net profits accrued to the upstream firm:

$$
\Pi^U(X^S) = \frac{\varepsilon + 1}{\varepsilon - 1} \left( a^S + \kappa D \right) (X^S)^2 + \frac{1}{\varepsilon - 1} \left[ b^S + \frac{(1 - \zeta^S) \omega}{\gamma} \right] X^S - F^U
$$

Similarly, we can substitute (23) and (22) into (6) to obtain the net profits accrued to the downstream firm:

$$
\Pi^D(X^S) = \frac{1}{(\varepsilon - 1)^2} \left\{ \left[ 2\varepsilon a^S + (1 + \varepsilon^2) \kappa D \right] (X^S)^2 + \varepsilon \left[ b^S + \frac{(1 - \zeta^S) \omega}{\gamma} \right] X^S \right\} - F^D
$$

The total surplus accrued from middle-product trade between the downstream and upstream firms is then given by,

$$
\Pi^U(X^S) + \Pi^D(X^S) = \frac{X^S}{(\varepsilon - 1)^2} \left\{ \left[ (\varepsilon^2 + 2\varepsilon - 1) a^S + 2\varepsilon^2 \kappa D \right] X^S + (2\varepsilon - 1) \left[ b^S + \frac{(1 - \zeta^S) \omega}{\gamma} \right] \right\} - (F^U + F^D)
$$
which can be simplified to (24) using (23).

**Comparing the profit functions**

Since \(2 - \frac{1}{\epsilon} > 1 > (1 - \delta), \frac{1}{1 - \sigma} > 1, \) and \(\Pi_0^C > 0,\) it is clear from (25) that, for every \(X > 0,\)

\[\Pi^U(X) + \Pi^D(X) > \Pi^I(X) > \Pi^O(X) > 0.\]

We further know that

\[
\lim_{X \to 0} \Pi^O(X) = -F^U - F^D - \Pi_0^C \\
\lim_{X \to 0} \Pi^I(X) = -F^U - F^D \\
\lim_{X \to 0} \Pi^U(X) + \Pi^D(X) = -F^U - F^D \\
\lim_{X \to \infty} \Pi^O(X) = \lim_{X \to \infty} \Pi^I(X) = \lim_{X \to \infty} \Pi^U(X) + \Pi^D(X) = \infty
\]

Moreover, we can compute:

\[
\frac{\partial \Pi^O(X)}{\partial X} = (1 - \delta) \left(1 - \frac{1}{\epsilon}\right) \frac{1}{\epsilon} \left(\frac{D_0}{X}\right)^\frac{1}{\epsilon} + 2a^O X \\
\frac{\partial \Pi^I(X)}{\partial X} = \left(1 - \frac{1}{\epsilon}\right) \frac{1}{\epsilon} \left(\frac{D_0}{X}\right)^\frac{1}{\epsilon} + 2a^I X \\
\frac{\partial (\Pi^U(X) + \Pi^D(X))}{\partial X} = 2 \left(1 - \frac{1}{\epsilon}\right) \left(1 - \frac{1}{\epsilon}\right) \frac{1}{\epsilon} \left(\frac{D_0}{X}\right)^\frac{1}{\epsilon} + 2(a^S + 2\kappa^D) X
\]

which are all positive. Since \((2 - \frac{1}{\epsilon}) > 1 > (1 - \delta)\) and \(\frac{1}{1 - \sigma} > 1,\) we can conclude that, for every \(X > 0,\)

\[
\frac{\partial (\Pi^U(X) + \Pi^D(X))}{\partial X} > \frac{\partial \Pi^I(X)}{\partial X} > \frac{\partial \Pi^O(X)}{\partial X} > 0.
\]

Furthermore, the second derivatives are given by,

\[
\frac{\partial^2 \Pi^O(X)}{\partial X^2} = -(1 - \delta) \left(1 - \frac{1}{\epsilon}\right) \left(\frac{1}{\epsilon}\right) \frac{2}{\epsilon} \left(\frac{D_0}{X}\right)^\frac{1}{\epsilon} \frac{1}{X} + 2a^O \\
\frac{\partial^2 \Pi^I(X)}{\partial X^2} = - \left(1 - \frac{1}{\epsilon}\right) \left(\frac{1}{\epsilon}\right) \frac{2}{\epsilon} \left(\frac{D_0}{X}\right)^\frac{1}{\epsilon} \frac{1}{X} + 2a^I \\
\frac{\partial^2 (\Pi^U(X) + \Pi^D(X))}{\partial X^2} = -2 \left(1 - \frac{1}{\epsilon}\right) \left(1 - \frac{1}{\epsilon}\right) \left(\frac{1}{\epsilon}\right) \frac{2}{\epsilon} \left(\frac{D_0}{X}\right)^\frac{1}{\epsilon} \frac{1}{X} + 2(a^S + 2\kappa^D)
\]

which are all negative for small \(X.\) It is useful to note that

\[
\frac{d}{d\sigma^S} \left(\Pi^U(X^S) + \Pi^D(X^S)\right)
\]

\[
= \left\{ \left(2 - \frac{1}{\epsilon}\right) \left(1 - \frac{1}{\epsilon}\right) \frac{1}{\epsilon} \left(\frac{D_0}{X^S}\right)^\frac{1}{\epsilon} + 2(a^S + 2\kappa^D) X^S \right\} \frac{dX^S}{d\sigma^S} + \frac{\kappa^U}{(1 - \sigma)^2} (X^S)^2 
\]

\[
= \left\{ \left(2 - \frac{1}{\epsilon}\right) - \frac{1}{2} \left(1 - \frac{1}{\epsilon}\right) \right\} \left(1 - \frac{1}{\epsilon}\right) \frac{1}{\epsilon} \left(\frac{D_0}{X^S}\right)^\frac{1}{\epsilon} + (a^S + 3\kappa^D) X^S \right\} \frac{dX^S}{d\sigma^S} < 0
\]
References


Figure 1: The Optimal Outsourcing Contract

Figure 2: Middle-product Market Equilibrium
Figure 3: Profits under Different Organizational Structures
Figure 4: Partition of Each Pair of Organization Structures on \(((1 - \delta), \nu)\) Space
Figure 5: Risk, Efficiency, and the Choice of Organizational Status Quo Parameters

[Diagram showing different scenarios and parameters related to organizational status quo, with labels and equations indicating different cases such as Benchmark, (1), (2), (3a), (3b), (4a), (4b), and (4c).]
Figure 6: Risk, Efficiency, and the Choice of Organizational Structures

Comparative Statics (a) An increase in $\sigma^S$ or a decrease in $\zeta^S$

Comparative Statics (b) An increase in $\Pi^G_0$ or $\sigma^O$, or a decrease in $\zeta^O$

Comparative Statics (c) An increase in $\theta$

Case 1

Case 2
Figure 7: Calibrated Equilibrium Regimes

U.S.

Japan

Taiwan

Korea

$E_{US} = (0.95, 0.12)$

$E_{Japan} = (0.95, 0.08)$

$E_{Taiwan} = (0.875, 0.36)$

$E_{Korea} = (0.875, 0.12)$