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Endogenous Transportation Costs in Firm's Organization Choice*

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Abstract We analyze the endogenous firms' choice of organization form in the presence of endogenous freight rates, port fees with the public (or asymmetric) port ownership. We found that regardless of port ownership, one firm provides corporate incentives (i.e., U-form), and other firm provides divisional incentives (i.e., M-form). Thus, choosing U-form (resp. M-form) in the asymmetric organization for firm and producer surplus is profitable (resp. unprofitable), but for the government and consumer surplus is socially undesirable (resp. desirable). Furthermore, we present some extensions to check the robustness of the obtained results.

Keywords Port fee, port ownership, M-form, U-form.

JEL Classification D43, F12, F13, L13, M16.

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1. INTRODUCTION

The issue of organizational form is closely related to the debate on the choice of organizational form dating back to Williamson (1975) and Chandler (1969) who articulated the strategic nature of the oligopoly theory. Firms differ substantially in their internal organizational structures, such as the unitary form (U-form) and the multidivisional form (M-form) affects its competitive position in the market, especially when the market is in an oligopolistic environment (Amatori, F. and A. Colli, 2007). There are previous studies (e.g., Harstad, 2007; Guadalupe and Wulf, 2010; Marin and Verdier, 2008; Li and Zhou, 2021; Bai, 2021) in economics that explicitly consider global factors linking international trade flows to firms' internal organization. There are primary empirical studies that international trade affects the organizational form of firms. Marin and Verdier (2008) examined empirically how changes in the trade environment have affected firms' choices of organization in Germany and Austria. As for multi-country studies, Bloom, Sadun, and van Reenen (2010) and Bloom, Sadun, and van Reenen (2012) analyzed management practices or the degree of delegation within firms of organization. By explicitly incorporating endogenous transport costs and port ownership structures into the analysis of internal organization, this paper provides new insights into how international trade conditions shape firms' internal design and welfare outcomes.

Several policy changes for international trade have affected the structure of port ownership(e.g., privatization or public ownership Matsushima and Takauchi, 2014; Choi and Lim, 2023), as well as the effects of trade policies on the transport sector, given endogenous transport costs (Ishikawa and Tarui, 2018, 2021). Specifically, Matsushima and Takauchi (2014) investigated the effects of port privatization on transport cost, port usage fees, and welfare, where the model consists of an international duopoly with two ports and two markets. It is well known that trade barriers, such as transport costs and tariffs via competition among ports affect firms' strategies, organizational forms and so on[1]. Even though transport costs are recognized in the trade literature, their analyses have been unsatisfactory until recently[2]. For example, the prospect of having to travel without cargo (termed "ballast") after offloading at the destination leads to higher freight rates on the round trip. In the transportation economics literature this is-

[1]For industrialized countries, transport cost is at least as large a barrier as policy barriers. According to Anderson and Van Wincoop (2004), the ad valorem tax equivalent of transport cost is 10.7%, and that of tariff and non tariff barriers is 7%.

[2]In this regard, Hummels (2007) states: "As tariffs become a less important barrier to trade, the contribution of transportation to total trade costs – shipping plus tariffs – is rising."

sue is referred to as the backhaul problem, which is mainly dealt with in the domestic trucking industry operating on fixed round-trip routes.

Despite the contribution of above studies in understanding the interaction between managerial delegation and trade policies, it lacks two perspectives. First, there is little formal examination that explicitly considers the firms' organizational form and transport costs in the analysis of managerial delegation in international trade[3]. The organizational form might be chosen strategically by firms' owners taking into account the structure of port ownership including transport cost in the global market. Second, more importantly, the above studies on managerial delegation have paid little attention to the role of transport costs with using ports. In the previous studies, division in the M-form is a product unit responsible for its own operations and profits, whereas in our model, division is a market (i.e., geographic) unit such as domestic sales and overseas sales.

Thus, our central objective in this paper is to examine the impacts of *endogenous* freight rates on the endogenously determined firms'organizational form (i.e., delegation structure) and social welfare in reciprocal trade[4]. The key mechanism is that a firm's organizational form determines its manager's aggressiveness in both domestic and export markets, which interacts with transport costs and port-fee decisions. Our main result shows that firms endogenously choose asymmetric organizational forms—one firm adopts the U-form and the other the M-form—even when both ports are publicly owned. The logic is that a U-form manager, who considers both domestic and export markets jointly, behaves defensively compared to M-form because expanding output in one market intensifies competition in the other. In contrast, an M-form manager, responsible for separate divisions, acts more aggressively in each market. Hence, given the rival's M-form (U-form), a firm finds it optimal to choose U-form (M-form) to soften competition (commit to a stronger position). This mutual best-response yields an asymmetric equilibrium.

In summary, when a rival adopts M-form, switching to U-form becomes profitable. This is because selecting the U-form results in higher total costs compared to the M-form. Consequently, the firm reduces its output, which in turn leads to an increase in profit. Conversely, if the rival adopts the U-form, choosing the M-form is profitable as it allows the firm to commit to greater output expansion and exploit the rival's restrained production. This mutual best-

[3]There is ample evidence that many multidivisional firms are run in delegation.

[4]The contributions by Pal and White (1998) combine privatization and the presence of public firms and the presence of strategic trade policies within an international mixed oligopoly. Facing trade policies between tariff regime and free trade, Choi and Lim (2023) analyzed the endogenous firms' choice of organization form based on the absence of endogenous transport costs.

response pattern leads to the asymmetric equilibrium. Furthermore, the M-form firm benefits from a "strong-position" effect—producing more for export and compelling the rival government to lower its port fee—while the U-form firm profits from softer domestic competition. Together, these strategic interactions render the asymmetric organizational form stable in equilibrium.

Given the firm's optimal choice of organization, we consider conflicts with the socially optimal one. When the rival adopts the M-form, choosing the U-form maximizes the firm's profit because it softens competition and reduces transport-related costs. However, from a social welfare perspective—including both consumer surplus and producer surplus—the M-form is preferable. The M-form leads to higher total output, greater consumer surplus, and higher social welfare, even though it yields lower firm profit. Thus, while each firm individually prefers the U-form for profitability, governments and consumers benefit more when firms adopt the M-form. In equilibrium, this divergence between private and social incentives generates an asymmetric outcome where one firm's optimal choice of U-form is socially undesirable, and the other's socially preferred choice of M-form is privately less profitable.

2. RELATED LITERATURE

In a globalized world, the effects of such freight rates using ports among countries and tariffs have become more difficult to measure. For this, Matsushima and Takauchi (2014) considered the problem of port privatization[5]. However, they ignored the difficulty in measuring the effects of freight rates with different organizational form (e.g., the type of delegation). We partly borrow the market structure of Matsushima and Takauchi (2014) to investigate the exporting firms' organizational forms with delegation when freight rates including port usage is a major trade barrier with endogenous choice variables.

One of the most important reasons for this directional imbalance in freight rates is the bilateral trade imbalance on a given round trip. An important point is that the usual transportation service between pairs of countries is provided under conditions of joint production (fronthaul and backhaul) and fixed schedules. Therefore, a bilateral trade imbalance implies an underutilization of the available capacity that carriers have allocated for the bilateral transport markets. The difference in capacity utilization of the vessel across the two bilateral

[5]In the literature, port competition is also discussed on mixed oligopoly context, in which a public firm competes with private one in the market. Czerny, Hoffler, and Mun (2014) used a Hotelling spatial competition model to investigate the effect of port privatization.

transport markets causes a gap between the associated transport costs. Various analyses in the international trade to treat transport costs as endogenous or exogenous have recently resulted in theoretical and empirical findings, providing insights on international trade (Hummels and Skiba, 2004; Behrens and Picard, 2011; Takahashi, 2011; Irarrazabal, Moxnes, and Opromolla, 2015; Ishikawa and Tarui, 2018; Brancaccio, Kalouptsidi, and Papageorgiou, 2020; Hayakawa, K., J. Ishikawa, and N. Tarui , 2020). In particular, Ishikawa and Tarui (2021) incorporated the international transport into a trade model and examined import tariffs.

The above discussion suggests that the trade model should include endogenous transport costs in an explicit manner with the underlying transport sector. In much of the literature, however, the treatment of transport costs is ad hoc. The standard way is to apply the 'iceberg' specification introduced by Samuelson (1954) (e.g., Krugman, 1980; Eaton and Kortum, 2002; Melitz, 2003): a fraction of the traded goods' value is lost in the transportation, where the fraction is given exogenously.

Previous works potentially make some interesting contributions to the urban port development literature. Ducruet, Juhasz, Nagy, and Steinwender (2020) looked at the local costs of port development, which is related to the socially undesirable result in the main findings of this paper. On the other hand, Brooks, Gendron-Carrier, and Rua (2021) found that countries near containerized ports grew much faster than ones further away. This paper also makes interesting contributions to the endogenous transport costs literature. Wong, W. F., (2022) empirically identified the round trip effect, which notes as the joint production of fronthaul and backhaul, and quantifies the importance of the round trip effect for trade policy. Ardelean and Ardelean and Lugovskyy (2023) showed that freight rates are not uniform within routes.

In the domestic oligopoly of industrial organization, the theoretical studies on organizational form and multiproduct firms use either the unitary form (U-form) or the multidivisional form (M-form). Reflecting the growing interests in optimal organizational design, the literature on firms' organization structure has become richer and more diverse by introducing various factors influencing market outcomes, including firms' strategic incentive regarding internal organization (Baye, Crocker, and Ju, 1996; González-Maestree, 2000); managerial delegation within firm (Barcena-Ruiz and Espinosa, 1999) using Vickers (1985), Fershtman and Judd (1987) and Sklivas (1987) model as we call this VFJS model. Using survey data on manufacturing firms across a dozen countries, Bloom, Sadun, and van Reenen (2010) revealed that greater product market competition increases

decentralization. Bloom, Sadun, and van Reenen (2012) used survey data they collected from several countries to show that firms headquartered in high trust regions are more likely to decentralize. Recent advances in international trade theory emphasize strategic incentive of managerial delegation and its implications for trade policies (Das, 1997; Moner-Colonques, 1997; Miller and Pazgal, 2005; Wang, Wang, and Zhao, 2009; Choi and Lee, 2022). In particular, Das (1997) and Moner-Colonques (1997) examined the interaction between managerial incentive and trade policy. Moreover, taking into account that managers compete in domestic and abroad markets, Moner-Colonques (1997) analyzed delegation problem with subsidy and tariff policies assuming firms give incentives according to both domestic and the foreign market in the sense of U-form.

To the best of the author's knowledge, this study is related to Barcena-Ruiz and Espinosa (1999) and Zhou (2005) in the context of analyzing the firms' choice of an optimal organizational form in an oligopolistic market. Barcena-Ruiz and Espinosa (1999), using the multiproduct oligopoly model, show that firms provide corporate incentives (i.e., U-form organization) irrespective of competition modes when goods are substitutes, while Zhou (2005), which examines the determinants of a firm's organizational form in the context of an imperfectly competitive industry, shows that the advantage of being an M-form firm increases with the number of firms in an oligopolistic market as far as the ratio of firms' organizational form is unchanged. However, Barcena-Ruiz and Espinosa (1999) and Zhou (2005) ignored the international trade in measuring the effects of freight rates under port ownership, which focused on the domestic industries.

Together, these strands highlight the novelty of our paper: we integrate organizational-form choice, transport-sector behavior, and port ownership into a model of reciprocal trade.

3. THE RECIPROCAL MARKET MODEL

We consider a two-way oligopolistic trade model. There are two countries, home (country 1) and foreign (country 2) country. There is a single manufacturing firm in each country (firm $i; i = 1,2$ i.e., D_1 and D_2) and a single transport firm T[6]. When two firms export goods to the importing country, they must use the two ports with payments and incur per unit transport costs for its transport

[6]Firm T may locate in country 1 or country 2 or in the third country. The location becomes crucial when analyzing welfare, but we assume for the simplification of the analysis that firm T is located in a third country.

firm. For simplicity, the domestic transportation is not incorporated into the model. To understand the reasons for our setup, trade costs involve both per unit freight rate and port charge. The utility function of the representative consumer in country i is given by $U_i = a(q_{ii} + q_{ji}) - \frac{q_{ii}^2 + q_{ji}^2 + 2q_{ii}q_{ji}}{2} + m;\ i, j = 1,2, i \neq j$, where a is market size and m is the consumption of the outside good; q_{ii} (resp. q_{ji}) represents the quantity of firm i's (resp. j's) products demanded in country i. Given the utility function of the representative consumer mentioned above, the indirect demand function for good i can be written as follows[7]: for $i, j = 1,2$, such that $i \neq j$,

$$p_{ii} = a - q_{ii} - q_{ji}, \quad p_{ij} = a - q_{jj} - q_{ij},$$

where $p_{ii}(p_{ij})$ is the domestic (export) price.

Moreover, we assume that τ_{ij} is the per unit shipping fee (i.e., freight rate) on the good shipped from country i to j, and f_i is the per unit charge for port usage in port i. Thus, the exporting firm needs to pay charges to both ports: the total per unit cost of export is $\tau_{ij} + f_i + f_j$. The profit of firm i is the sum of profits in the two markets,

$$\Pi_i = \pi_{ii} + \pi_{ij} = p_{ii}q_{ii} + (p_{ij} - \tau_{ij} - f_i - f_j)q_{ij},$$

where π_{ii} (resp. π_{ij}) represents the profits of firm i in the market of country i (resp. country j).

Borrowing the framework of Ishikawa and Tarui (2018, 2021), we assume that the freight rate is linear and additive. Firm T sets freight rates and makes a take-it-or-leave-it offer to firms. If they accept the offer, the two firms engage in Cournot competition in each country. Firm T's costs, C_T, are $C_T = F + \gamma k$ where F, γ, and k are, respectively, the fixed cost, the marginal cost (MC) of operating a means of transport such as vessels, and the capacity (i.e., $[\max q_{ij}, q_{ji}] = k$). Assuming $F = 0$, firm T maximizes its profit:

$$\Pi_T = \tau_{ij}q_{ij} + \tau_{ji}q_{ji} - \gamma k.$$

As in Ishikawa and Tarui (2018, 2021), we assume that firm T adjusts its freight rates to carry a full load in both directions[8]. Obviously, $q_{ij} = q_{ji}$ in equilibrium arises if the two markets as well as the two firms are identical[9]. Figure 1 summarizes the trading structure in the reciprocal trade.

[7] The demand function dates back to Singh and Vives (1984).

[8] This backhaul problem of logistic issue may cause imbalance of shipping volume in outgoing and incoming routes. Transport firms have an incentive to avoid the backhaul problem.

[9] In either $q_{ij} > q_{ji}$ or $q_{ij} < q_{ji}$ in each equilibrium, a full load is not realized for shipping from country j to i or from i to j when firm T maximizes its profit.

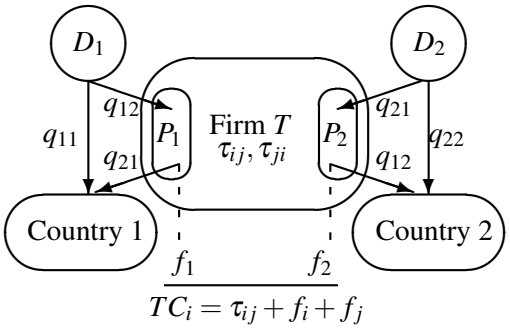

Figure 1: THE MARKET STRUCTURE. $P_i(i = 1,2)$ is the port of country i, $D_i(i = 1,2)$ is the manufacturing firm of country i, and TC_i is total cost of exporting firm in country i. Firm T sets freight rates and makes a take-it-or-leave-it offer to firms D_i.

The owner of manufacturing firm hires a manager (or managers) and delegates the strategic decision to the manager(s). Since each manufacturing firm is selling its products in both countries, firm's owner needs to make a decision whether to organize the firm in two independent divisions, so that each division is in charge of decisions of relevant market, or to concentrate all decisions on both markets in a single decision center. In M-form (multidivisional form), manager of each division receives incentives on the basis of divisional performances while in the U-form (unitary form), compensation is based on corporate performances[10].

As it is frequently used when analyzing the efficiency of delegation, we employ the standard VFJS model to examine the organizational form. A firm in U-form is defined here as follows. The owner provides a linear incentive scheme to a manager, who is responsible for decisions concerning both home and foreign markets: for ; $i, j = 1,2$ such that $i \neq j$,

$$\begin{aligned} O_i =& \Pi_i + \theta_i(q_{ii} + q_{ij}) \\ =& p_{ii}q_{ii} + (p_{ij} - \tau_{ij} - f_i - f_j)q_{ij} + \theta_i(q_{ii} + q_{ij}), \end{aligned}$$

where O_i is the objective function of the manager in firm i and θ_i is the incentive parameter that is designed by firm i's owner and may be either positive or negative. If $\theta_i = 0$, firm i's manager is pure profit maximizer while if $\theta_i \neq 0$, then he/she is a more ($\theta_i > 0$) or less ($\theta_i < 0$) aggressive seller in the market.

[10] As in Barcena-Ruiz and Espinosa (1999), we assume that "managing a U-form firm entails a higher degree of responsibility than managing only one division of a firm and, therefore, the managers in charge of U-form firms also have higher opportunity costs."

In an M-form consisting of domestic sales division and export sales division, however, the owner provides different linear incentive schemes for the manager of domestic sales (q_{ii}) and the manager of export sales (q_{ij}). That is, for $i, j = 1,2$, such that $i \neq j$,

$$O_{ii} = \pi_{ii} + \beta_{ii} q_{ii} = p_{ii} q_{ii} + \beta_{ii} q_{ii},$$
$$O_{ij} = \pi_{ij} + \beta_{ij} q_{ij} = (p_{ij} - \tau_{ij} - f_i - f_j) q_{ij} + \beta_{ij} q_{ij},$$

where O_{ii} (resp. O_{ij}) is the objective function of the manager who is responsible for domestic (resp. export) sales division; and β_{ii} (resp. β_{ij}) is the incentive parameter set by the owner with respect to the compensation scheme for the manager of the domestic (resp. export) sales.

We assume that there is no operation cost for each port. The port earns profits from import and export from country i to country j. Accordingly, the port profits of the exporting country and the importing country are given by

$$R_i = f_i(q_{ij} + q_{ji}).$$

There are two scenarios relating to the objective of each port owner. In the first scenario, each port maximizes its domestic surplus (i.e., both ports are nationalized); in the second, port j in country j maximizes its own profit and port i in country i maximizes domestic surplus. The former scenario represents a nationalized port and the latter represents that only the port in j is privatized (say asymmetric port ownership). When the port in country j is privatized, it maximizes R_j. When the port in country i is nationalized, it maximizes social welfare SW_i

$$SW_i = \Pi_i + R_i + CS_i,$$

where $CS_i = \frac{(q_{ij}+q_{ji})^2}{2}$ is consumer surplus and $PS_i \equiv \Pi_i + R_i$ is producer surplus.

Consequently, we can consider the following three cases: (1) Both ports are nationalized or (2) privatized, (3) Only the port in j is privatized. For the simplicity, we ignore the cases of (2) and (3). In the case of (2), this is because we believe that even though the port privatization improves efficiency and increases port trade volume, all countries do not adopt port privatization according to their market circumstances (e.g., the policy of country and large fixed cost for privatization)[11]. We also ignore the case (3) since the same results occur as with the case (1) in the endogenous organizational forms.

[11] In real world, many emerging countries have different preferences between port privatization and nationalization according to their market circumstances. If we consider case (3), asymmetric port ownership, our main results remain same as with the case (1) in the endogenous choice of organizational form with similar intuition. The detailed computations are available from the author upon request.

The timing of the game is as follow. At stage 1, owner of each firm selects firm's organizational form (i.e., the U-form or the M-form). At stage 2, both port and transport firm simultaneously set the port charge and freight rates respectively to maximize its objective[12]. At stage 3, each owner writes his or her manager's incentive contract θ_i or β_{ii} with β_{ij}, in which the manager's objective function is specified[13]. At final stage, each firm of manager simultaneously chooses its quantity to maximize its own objective function. The solution concept used is the subgame perfect Nash equilibrium (SPNE).

It is important to stress that ports charge the same to the home market customers and to customers from the third region. Article 5 of the General Agreement on Tariffs and Trade (GATT) 1994 requires non-discriminatory treatment between agents in the home and foreign countries. Since the ability of each port to commit to port fee has been shown to affect strategic delegation decisions, we consider the scenarios that firm credibly cannot commits to incentive contract. This assumption is formalized by assuming that the firm sets the incentive contract after observing the terms of port fee offered by each port in each country. This might be the case if incentive contract is easy and costless to change and communicate to its country. In this case, firm adjusts its incentive contract in response to observed changes in the behavior of ports. Specifically, in this paper, the timing of the game is motivated by the fact that the port fee is often pursued in a setting in long-run decisions[14]. Our timing framework of game is reasonable because ports fee decisions are relatively long run, at same time, incentive contracts are usually negotiated between managers and firms.

Moreover, we can consider that with the determination of managerial contracts at stage 3, following the choice of the freight rates set by transport firm T at stage 4. This opens the way to an obvious problem of time inconsistency

[12]We need to understand about how sensitive the results in this paper are to model timing. Even if we assume that f_i (i.e., port usage fee) is relatively long-run decision compared to τ_{ij} (i.e., shipping fee), we have the same results as in this paper (the detailed computations are available upon request from the author). Hence, we assume that the internal organization of the firm is a long-run decision (i.e., M-form or U-form), followed by the decision concerning port charges, freight rates, incentive schemes and finally production levels are decided in the short run. What is essential for this game order is that firms have superior commitment ability relative to port fees and freight rates. .

[13]When the output decision is taken to maximize profits (instead of a linear combination of sales), we have the same equilibrium of organizational form. See Proposition 2 in Section 4 for this discussion.

[14]Firm organizational structures are set for a variety of reasons, some of which is in response to freight rates and port fees, but some of which might be due to domestic market conditions or their headquarter decisions.

as the transport firm T might want to modify the freight rates ex post, i.e., once the delegation contracts have become public domain. We will show later that the transport firm will not want to do so. This sequence of choices in the game will mention later in Section 5.

4. MARKET EQUILIBRIUM

At final stage, given the port charges freight rates f_i and τ_{ij}, each exporting firm simultaneously sets its output in the two markets. Since each manufacturing firm has two choices with respect to organizational form, there are three possible combinations of organizational forms based on manufacturing firms' decisions: one firm is an M-form and the other has a U-form, or both are M-form, or both are organized in U-form.

We first solve the last stage, the maximization problem of each manager can be written as follows: if firm i adopts M-from,

$$\max_{q_{ii}} p_{ii}q_{ii} + \beta_{ii}q_{ii} \quad \text{and} \quad \max_{q_{ij}} (p_{ij} - \tau_{ij} - f_i - f_j)q_{ij} + \beta_{ij}q_{ij};$$

if firm i adopts U-form,

$$\max_{q_{ii},q_{ij}} p_{ii}q_{ii} + (p_{ij} - \tau_{ij} - f_i - f_j)q_{ij} + \theta_i(q_{ii} + q_{ij}).$$

By solving the system of the firms' quantify-reaction functions in the market of country i, we obtain equilibrium quantities as follows:

$$q_{ii}(\Theta_i;\mathbf{f}) = \frac{a + \tau_{ji} + f_i + f_j + 2\Theta_{ii} - \Theta_{ji}}{3},$$

$$q_{ji}(\Theta_i;\mathbf{f}) = \frac{a + 2(\Theta_{ji} - \tau_{ji} - f_i - f_j) - \Theta_{ii}}{3},$$

where $\Theta_i = (\Theta_{ii}, \Theta_{ji})$, $\Theta_j = (\Theta_{jj}, \Theta_{ij})$ and $\mathbf{f} = (f_i, f_j)$. In addition, $\Theta_{ii} = \beta_{ii}$ and $\Theta_{ji} = \beta_{ji}$ if firm $i (i, j = 1, 2, i \neq j)$ adopts M-form while $\Theta_{ii} = \theta_i, \Theta_{ji} = \theta_j$ if it is organized in U-form. It holds that $\frac{\partial q_{ii}}{\partial \Theta_{ii}} = \frac{\partial q_{ji}}{\partial \Theta_{ji}} > 0$ and $\frac{\partial q_{ii}}{\partial \Theta_{ji}} = \frac{\partial q_{ji}}{\partial \Theta_{ii}} < 0$, implying that an increase in sales incentives of own firm raises output but that of the rival firm reduces output.

We assume the following sufficient condition, which requires that shipping fee, γ be sufficiently small to ensure that the quantity supplied by each firm is positive.

Assumption 1. *$\gamma \in (0, \gamma^A)$, where $\gamma^A \equiv a/9$.*

This assumption ensures that exporting firms produce under either privatized or public port ownership. Taking into account their influence on the production levels of the ensuing stage, linear incentive schemes are decided, The owner of firm 1 (M-form) decides β_{11} and β_{12} so as to $\max_{\beta_{11},\beta_{12}} \Pi_1^{MU} (\equiv \pi_{11}^{MU}(\beta_{11},\theta_2;\mathbf{f}) + \pi_{12}^{MU}(\beta_{12},\theta_2;\mathbf{f}))$ where the superscript 'MU' denotes that firm i chooses the M-form and the firm j chooses the U-form. Similarly, the owner of firm 2 (U-form) decides θ_2 to $\max_{\theta_2} \Pi_2^{MU}$. Differentiating Π_1^{MU} with respect to β_{11} and β_{12}, and applying the envelope theorem, we obtain

$$\frac{\partial \Pi_1^{MU}}{\partial \beta_{11}} = \underbrace{-\beta_{11}\frac{\partial p_{11}}{\partial q_{11}}\frac{\partial q_{11}}{\partial \beta_{11}}}_{\text{competition effects}} + \underbrace{P'(Q)q_{11}\frac{\partial q_{21}}{\partial \beta_{11}}}_{(-)}, \tag{1}$$

$$\frac{\partial \Pi_1^{MU}}{\partial \beta_{12}} = \underbrace{-\beta_{12}\frac{\partial p_{12}}{\partial q_{12}}\frac{\partial q_{12}}{\partial \beta_{12}}}_{\text{competition effects}} + \underbrace{P^{*\prime}(Q^*)q_{12}\frac{\partial q_{22}}{\partial \beta_{12}}}_{(-)}, \tag{2}$$

where $P'(Q)$ and $P^{*\prime}(Q^*)$ are domestic and exporting prices in country 1 and 2. The first term on the right-hand side (RHS) of equations (1) and (2) represents the profit loss caused by output increase in the corresponding market (i.e., competition effects), while the second term the strategic rent shifts from firm 1 to firm 2 via the rival firm's price change in the corresponding market (i.e., rent-shifting effects). Thus, by solving $\frac{\partial \Pi_i^{MM}}{\partial \beta_{ii}} = 0$, $\frac{\partial \Pi_i^{MM}}{\partial \beta_{ij}} = 0$ and $\frac{\partial \Pi_i^{UU}}{\partial \theta_i} = 0$, we can obtain the equilibrium values in incentive parameters β_{ii}^{MM}, β_{ij}^{MM} and θ_i^{UU} as a function of f_i and τ_{ij} (note that the superscript 'MM (UU)' denotes that both firms choose the M(U)-form).

$$\beta_{ii}^{MM} = \frac{a+2(f_i+f_j+\tau_{ji})}{5}, \quad \beta_{ij}^{MM} = \frac{a-3(f_i+f_j+\tau_{ij})}{5},$$

$$\theta_i^{UU} = \frac{2a-f_i-f_j-3\tau_{ij}+2\tau_{ji}}{10}.$$

Similarly, the derivative of the each firm's maximal profit with respect to θ_2 is obtained as follows (if x_{ji}^{MU}, the first letter always corresponds to firm j's choice, and the second letter to firm i's choice. On the other, if x_{ij}^{MU}, the first letter always corresponds to firm i's choice, and the second letter to firm j's choice):

$$\frac{\partial \Pi_2^{MU}}{\partial \theta_2} = \underbrace{-\theta_2\left(\frac{\partial q_{22}^{MU}}{\partial \theta_2} + \frac{\partial q_{21}^{MU}}{\partial \theta_2}\right)}_{\text{competition effects}} + \underbrace{P^{*\prime}(Q^*)q_{22}^{MU}\frac{\partial q_{12}^{MU}}{\partial \theta_2}}_{(-)} + \underbrace{P'(Q)q_{21}\frac{\partial q_{11}^{MU}}{\partial \theta_2}}_{(-)},$$

where the first term on the RHS represents the profit loss due to the increased competition in the market, the second (resp. last) term, which is negative, strategic rent shifts from firm 2 (U-form) to firm 1 (M-form) in the market of foreign country (resp. home country). Note that the superscript 'MU' in Π_2^{MU} denotes that firm 2 chooses the U-form and the firm 1 chooses the M-form.

By solving $\frac{\partial \Pi_1^{MU}}{\partial \beta_{11}} = 0$, $\frac{\partial \Pi_1^{MU}}{\partial \beta_{12}} = 0$ and $\frac{\partial \Pi_2^{MU}}{\partial \theta_2} = 0$ simultaneously, we can obtain the equilibrium values in incentive parameters β_{11}^{MU}, β_{12}^{MU} and θ_2^{MU} as a function of f_i. Thus, we can obtain the equilibrium values in incentive parameters β_{11}^{MU}, β_{12}^{MU} and θ_2^{MU} as a function of f_i and τ_{ij}.

$$\beta_{ii}^{MU} = \frac{8a + 11(f_i + f_j) - 2\tau_{ij} + 13\tau_{ji}}{40}, \quad \beta_{ij}^{MU} = \frac{8a - 19(f_i + f_j) - 22\tau_{ij} + 3\tau_{ji}}{40},$$

$$\theta_j^{MU} = \frac{2a - f_i - f_j + 2\tau_{ij} - 3\tau_{ji}}{10}.$$

Note that when using subscript j in θ_j^{MU} only with superscript MU, j chooses U-from given i chooses M-form (we denote as x_j^{MU} where θ, q, Π, SW and so on). Moreover, we use subscripts "ii" and "jj" (or 11 and 22) in x_{ii}^{MU}, implying that i chooses M-from given j chooses U-form and x_{jj}^{MU}, implying that j chooses U-from given i chooses M-form when referring to specific countries/firms (e.g., firm 1 in country 1 and firm 2 in country 2).

4.1. ASYMMETRIC ORGANIZATIONAL FORM IN PUBLIC PORT OWNERSHIP

At stage 2, given that ports are in public ownership, we consider that each maximization problem is given by $SW_i = R_i + \Pi_i + CS_i$ and Π_T under public port ownership, which maximizes its profit (note that expressions such as x_{ij}^{MU} (x_{ji}^{MU}): $x = q, \tau$ and so on, now consistently denote the variable related to firm $i(j)$ when firm $i(j)$ adopts M-form and firm $j(i)$ adopts U-form).

$$\max_{\tau_{ij}, \tau_{ji}} \Pi_T = \max[\tau_{ij} q_{ij}^{MU}(\tau_{ij}, \tau_{ji}) + \tau_{ji} q_{ji}^{UM}(\tau_{ij}, \tau_{ji}) - \gamma k)] \text{ s.t. } q_{ij}^{MU} = q_{ji}^{UM},$$

which is equivalent to $\tau_{ij} = \frac{9\tau_{ji} - f_i - f_j}{10}$.

$$\max_{f_i} SW_i^{MU} \quad \text{and} \quad \max_{f_j} SW_j^{UM}.$$

As suggested in Model section, among three types of equilibrium, the firm T adjusts its freight rates to carry a full load in both directions to avoid the back-

$\beta_{ii}^{MU} = \frac{1342a+147\gamma}{4183}$,	$\beta_{ij}^{MU} = \frac{157a-441\gamma}{8366}$
$q_{ii}^{MU} = \frac{2(1342a+147\gamma)}{4183}$,	$q_{jj}^{MU} = \frac{2323a+189\gamma}{4183}$
$\theta_j^{MU} = \frac{620a-63\gamma}{4183} = \theta_i^{UM}$,	$q_{ij}^{MU} = \frac{157a-441\gamma}{4183} = q_{ji}^{UM}$
$\Pi_i^{MU} = \frac{7228505a^2+1439718a\gamma+280917\gamma^2}{34994978}$	
$\Pi_j^{MU} = \frac{2(1941689a^2+526050a\gamma+107163\gamma^2)}{17497489}$	
$SW_i^{MU} = \frac{4(13770746a^2-907774a\gamma+1274931\gamma^2)}{122482423}$	
$SW_j^{MU} = \frac{151665173a^2-9475578a\gamma+13308057\gamma^2}{367447269}$	

Table 1: ASYMMETRIC ORGANIZATIONAL FORM. For each variable, the first and second indices in the superscript are determined by i and j, respectively.

haul problem of logistic issue, thus, we consider the restriction[15] of $q_{ij}^{MU} = q_{ji}^{UM}$. Solving $\partial\Pi_T/\partial\tau_{ij} = 0$, $\partial SW_i^{MU}/\partial f_i = 0$ and $\partial SW_j^{UM}/\partial f_j = 0$ simultaneously yields

$$f_i^{MU} = \frac{9769a-9163\gamma}{58562}, \quad f_j^{MU} = \frac{35255a-18459\gamma}{175686},$$
$$\tau_{ij}^{MU} = \frac{3667a+65793\gamma}{175686}, \quad \tau_{ji}^{UM} = \frac{5624a+33999\gamma}{87843}.$$

Each port earns its profit through international shipments, which are negatively correlated to marginal cost of transport firm T in country i and j, while transport costs are positively correlated to the marginal cost of transport firm T in country i and j. Substituting f_i^{MU}, f_j^{MU} and $\tau_{ij}^{MU}, \tau_{ji}^{UM}$ into the market variables, we get the equilibrium values of incentive parameters, output, firms' profits, and social welfare in the asymmetric organizational form (see Table 1).

4.2. SYMMETRIC ORGANIZATIONAL FORM IN PUBLIC PORT OWNERSHIP

Given the public port ownership structures, the procedure in previous subsection allows us to calculate the equilibrium market values when both firms have the same organization forms.

[15] If we assume $q_{ij}^{MU} > q_{ji}^{UM}$ to reflect asymmetric output, by substituting τ_{ij} and τ_{ji} into q_{ij}^{MU} and q_{ji}^{UM}, we find that $q_{ij}^{MU}(\tau_{ij},\tau_{ji}) < q_{ji}^{UM}(\tau_{ij},\tau_{ji})$, which is inconsistent with the assumption of $q_{ij}^{MU} > q_{ji}^{UM}$. Similarly, in the analysis assuming $q_{ij}^{MU} < q_{ji}^{UM}$, the resulting equilibrium value is also inconsistent with the assumption.

$\beta_{ii}^{MM} = \frac{10a+3\gamma}{32}$	$\beta_{ij}^{MM} = \frac{2a-9\gamma}{64}$	
$q_{ii}^{MM} = \frac{10a+3\gamma}{16}$	$q_{ij}^{MM} = \frac{2a-9\gamma}{32}$	
$\Pi_i^{MM} = \frac{404a^2+204a\gamma+117\gamma^2}{2048}$		
$SW_i^{MM} = \frac{172a^2-12a\gamma+27\gamma^2}{384}$		
$\theta_i^{UU} = \frac{48a-7\gamma}{312}$	$q_{ii}^{UU} = \frac{7(8a+\gamma)}{104}$	$q_{ij}^{UU} = \frac{24a-49\gamma}{312}$
$\Pi_i^{UU} = \frac{3264a^2+1232a\gamma+441\gamma^2}{16224}$		
$SW_i^{UU} = \frac{3648a^2-336a\gamma+343\gamma^2}{8736}$		

Table 2: *MM* REGIME AND *UU* REGIME. For each variable, the first and second indices in the superscript are determined by i and j, respectively.

Similar to asymmetric organizational form, the transport firm T and both ports of maximization problem are given by $SW_i^R = R_i + \Pi_i + CS_i$ and Π_T^R subject to $q_{ij}^R = q_{ji}^R$ where $R = MM, UU$. Thus, the transport firm T and both ports set freight rates and port charges as follows.

$$f_i^{MM} = \frac{22a-3\gamma}{192}, \quad \tau_{ij}^{MM} = \frac{10a+51\gamma}{192},$$

$$f_i^{UU} = \frac{48a-7\gamma}{273}, \quad \tau_{ij}^{UU} = \frac{120a+301\gamma}{1092}.$$

Substituting these values into the market variables, we get the equilibrium values of incentive parameters, outputs, firm's profits, and social welfare in the symmetric organizational form (see Table 2).

5. RESULTS FOR ENDOGENOUS ORGANIZATION FORM

Once the equilibria for the port ownership type and social welfare levels have been derived. In the first stage, each firm chooses organizational form given the port ownership structure. Each firm in each country has two organizational strategies: M-form and U-form.

Before analyzing endogenous organizational forms, we compare the equilibrium incentive parameters, port charges, freight rates and outputs to provide the intuition of the endogenous choice of organizational form. Hence, we obtain Lemma 1.

Lemma 1. *Suppose that both ports are in public ownership. Noting that* $Q_i \equiv q_{ii} + q_{ji}$*, the following inequalities hold with respect to quantities, port charges and incentive parameters.*

$$(i)\ \begin{cases} q_{ii}^{MU} > q_{ii}^{MM} > q_{ii}^{UM} > q_{ii}^{UU}, \\ q_{ij}^{UU} > q_{ij}^{MM} > q_{ij}^{MU} = q_{ij}^{UM}, \\ Q_i^{MM} > Q_i^{MU} > Q_i^{UU} > Q_i^{UM}. \end{cases}$$

$$(ii)\ \begin{cases} \beta_{ii}^{MU} > \beta_{ii}^{MM} > \theta_i^{UU} > \theta_i^{UM} > \beta_{ij}^{MM} > \beta_{ij}^{MU} > 0, \\ f_i^{UM} > f_i^{UU} > f_i^{MU} > f_i^{MM}, \\ \tau_{ij}^{UU} > \tau_{ij}^{UM} > \tau_{ij}^{MM} > \tau_{ij}^{MU}. \end{cases}$$

$$(iii)\ f_i^{UU} + f_j^{UU} + \tau_{ij}^{UU} > f_i^{UM} + f_j^{UM} + \tau_{ij}^{UM} > f_i^{MU} + f_j^{MU} + \tau_{ij}^{MU} > f_i^{MM} + f_j^{MM} + \tau_{ij}^{MM}.$$

Proof. Since those comparisons are simple with assumption $\gamma \in (0, \gamma^A)$, we can omit.

Lemma 1(i) suggests that given that organizational choices are fixed, $q_{ii}^{MM} > q_{ii}^{UM}$ and $q_{ii}^{MU} > q_{ii}^{UU}$ implies that a firm's supply to its own market is greater when it is in M-form than when it is U-form. This is because $\beta_{ii}^{MM} > \theta_i^{UM}$ and $\beta_{ii}^{MU} > \theta_i^{UU}$ in domestic market, which the owner of firm forces its manager to behave aggressively. On the other hand, they tend to enhance overseas supply if both firms decide to choose the same organizational form (i.e., $q_{ij}^{MM} > q_{ij}^{UM}$ and $q_{ij}^{UU} > q_{ij}^{MU}$). Contrast to the domestic market, we can understand that $\beta_{ij}^{MM} > \theta_i^{UM}$ and $\theta_i^{UU} > \beta_{ij}^{MU}$ in exporting market. Thus, in Lemma 1(ii), the owner of the firm with the U-form (M-form) in export (domestic) market offers its managers incentive parameters that make them behave more aggressively with higher incentive parameters. Furthermore, in Lemma 1(iii) related transport costs, the transport firm and both governments under public port ownership have more preference to set high port charge (i.e., f_i) or total cost (i.e., $f_i + f_j + \tau_{ij}$) when the firm chooses U-form than when the firm chooses M-form. This implies that the public port ownership wants to force firms to choose the M-form because firm's total output is larger under U-form than that under M-form. However, depending on the exporting rival j's organization choice, the firm T has an incentive to set higher freight rate (i.e., τ_{ij}) for the firm i.

Comparing equilibrium outcomes of firms' profits, we obtain the following

results: if $\gamma > \gamma^*(\gamma > \gamma^{**})$[16],

$$\Pi_i^{UM} - \Pi_i^{MM} = \frac{3(294724196a^2 - 471595652a\gamma - 536088855\gamma^2)}{35834857472} < 0,$$
$$\left(\Pi_i^{MU} - \Pi_i^{UU} = \frac{1525828464a^2 - 9877914032a\gamma - 5437593945\gamma^2}{283879261536} < 0\right),$$

and vice versa if $\gamma < \gamma^*(\gamma < \gamma^{**})$. However, from assumption $\gamma \in (0, \gamma^A)$ to ensure that quantities are positive, those become $\gamma^A < \gamma^*$ and $\gamma^A < \gamma^{**}$. Hence, those always hold $\Pi_i^{MM} < \Pi_i^{UM}$ and $\Pi_i^{MU} > \Pi_i^{UU}$.

The following proposition is immediate.

Proposition 1. *Suppose that both ports are in public ownership and Assumption holds. (i) the owner of firm i (j) chooses U-form (M-form), i.e., UM regime or MU regime; (ii) in equilibrium organization form, firm i is better off if it chooses U-form given rival firm's M-form, i.e.,* $\Pi_i^{UM} > \Pi_i^{MU}$.

Proposition 1 shows that when both ports are publicly owned, the equilibrium organizational forms of the two competing firms become asymmetric—one firm chooses a U-form while the other chooses an M-form. The intuition behind Proposition 1 is as follows. Each firm's internal structure (U-form or M-form) affects how aggressively its manager competes in both domestic and export markets.

Let us consider firm i's strategy. From Lemma 1((i)), each firm's choice of the U-form (M-form) provides incentives for greater export output given rival firm's choice of M-form (U-form) (i.e., $q_{ij}^{MM} > q_{ij}^{UM}$ and $q_{ij}^{UU} > q_{ij}^{MU}$). In the export market, both firms choose a strategy, taking a different organizational form than the rival firm. However, for the domestic market, each firm's choice of the M-form provides incentives for greater export output than under the U-form given rival firm's choice (i.e., $q_{ii}^{MU} > q_{ii}^{UU}$ and $q_{ii}^{MM} > q_{ii}^{UM}$). This would put the M-form in a "strong" position with higher output for domestic market. Since total output is larger when choosing M-form than when choosing U-form, it is better for a firm with M-form to commit to a strong position for both domestic and export markets to obtain greater profit. This strong position makes the rival firm react defensively ($\beta_{ii}^{MU} > \beta_{ii}^{MM}$ and $\theta_i^{UU} > \theta_i^{UM}$ in domestic market), and aggressively ($\beta_{ij}^{MM} > \beta_{ij}^{MU}$ in export market). These two effects reinforce each other, and government i with M-form forces rival country j to set lower port charge by port j but to set higher freight rates set by firm T (i.e., $f_i^{UM} > f_i^{MM}$ and

[16] $\gamma^* \equiv \frac{2a(267712\sqrt{745081} - 117898913)}{536088855}$ and $\gamma^{**} \equiv \frac{4a(54379\sqrt{14100619} - 176391322)}{776799135}$.

$\tau_{ij}^{MM} > \tau_{ij}^{UM}$) when the firm j chooses U-form. In other words, total cost when choosing M-form is smaller than when choosing U-form that can understand from Lemma 1((iii)), $f_i^{UM} + f_j^{UM} + \tau_{ij}^{UM} > f_i^{MM} + f_j^{MM} + \tau_{ij}^{MM}$. Compared to U-form, this M-form for country i leads to domestic protection effect with lower import volume in domestic market and greater output in export market. The M-form separates decisions for home and export divisions, making managers more aggressive in expanding output in each market independently.

Let us consider firm j's strategy. Anticipating firm i's strategy, the level of port fee under the U-form has the domestic protection effect in market j (i.e., $q_{jj}^{MU} > q_{jj}^{MM}$) and the export prevention effect in market i (i.e., $q_{ji}^{MM} > q_{ji}^{MU} \Leftrightarrow q_{ij}^{MM} > q_{ij}^{MU}$) with higher charging $f_i^{UM} > f_i^{MM}$, and lower freight rates $\tau_{ij}^{MM} > \tau_{ij}^{UM}$. However, the total cost when choosing U-form is larger than when choosing M-form, $f_i^{UM} + f_j^{UM} + \tau_{ij}^{UM} > f_i^{MM} + f_j^{MM} + \tau_{ij}^{MM}$. Therefore, an increase in total transport cost (the port usage fee plus freight rates) enhances the domestic protection effect. Firm j always has an incentive in producing less with export when choosing U-form rather than choosing M-form. Given the rival firm's M-form, the firm j has an incentive to soften competition in both domestic and export markets, which implies that it exports a smaller output paying higher transport costs when it chooses the U-form than when it chooses the M-form. This leads to higher profit for the firm j. The U-form integrates decision-making across markets, leading the manager to behave more defensively because expansion in one market worsens competition in the other.

In summary, when a rival adopts M-form, switching to U-form becomes profitable. Since the total cost is higher when a firm chooses the U-form compared to the M-form, the firm will reduce its quantity, which in turn increases the firm's profit. Conversely, when the rival adopts U-form, choosing M-form is profitable since it allows the firm to commit to stronger output expansion and exploit the rival's restraint. Thus, each firm prefers the opposite organizational form of its rival: one chooses offensive M-form and the other defensive U-form. This mutual best-response pattern leads to the asymmetric equilibrium. Moreover, the M-form firm gains from a "strong-position" effect—producing more for export and forcing the rival government to lower its port fee—while the U-form firm gains from softer competition domestically. Together, these strategic interactions make the asymmetric organizational form stable in equilibrium.

Based on Proposition 1, we obtain the following.

Proposition 2. *Suppose that both ports are in public ownership and Assumption holds. Choosing M-form for the government and consumer surplus is socially*

desirable given rival firm's U-form, i.e.,

$$(i)\begin{cases} SW_i^{MU} > SW_i^{MM} > SW_i^{UU} > SW_i^{UM}, \\ CS_i^{MM} > CS_i^{MU} > CS_i^{UU} > CS_i^{UM}. \end{cases}$$

However, choosing U-form for firm and producer surplus is profitable given rival firm's M-form,

$$(ii)\begin{cases} PS_i^{UM} > PS_i^{UU} > PS_i^{MU} > PS_i^{MM}, \\ \Pi_i^{UM} > \Pi_i^{MU} > \Pi_i^{UU} > \Pi_i^{MM}. \end{cases}$$

where $CS_i = \frac{(q_{ij}+q_{ji})^2}{2}$ *is consumer surplus and* $PS_i \equiv \Pi_i + R_i$ *is producer surplus.*

Proof. See Appendix A.

Proposition 2 suggests that in equilibrium, choosing the organizational form for firms is profitable, but not socially desirable. In equilibrium, social welfare and consumer surplus are larger when the firm i chooses the M-form than when the firm i chooses U-form given rival firm's U-form (i.e., $SW_i^{UM} < SW_i^{MU}$, $CS_i^{UM} < CS_i^{MU}$) while firm i has a greater profit with U-form than with M-form (i.e., $\Pi_i^{MU} < \Pi_i^{UM}$)[17]. From the perspective of social welfare, it is desirable for government i to charge higher port fee when its own firm chooses M-form than when firm i chooses U-form. From Lemma 1(ii), total cost under MU regime is higher than that under UM regime, which implies that the more port profit, the more the revenue for the country. This results to enhance its own social welfare, compared to that when its own firm chooses U-form due to that $Q_i^{UM} < Q_i^{MU}$ leads to $CS_i^{UM} < CS_i^{MU}$. For the $SW_i^{UM} < SW_i^{MU}$, the effect of consumer surplus in $CS_i^{UM} < CS_i^{MU}$ dominates the effect of producer surplus in $PS_i^{UM} > PS_i^{MU}$. Each owner pursuing rational self-interest chooses U-form given rival's M-form as its organization even though choosing M-form is socially desirable. This occurs because the forward-looking government and firm including transport firm account for the impact of the incentive scheme on both consumer surplus and the social welfare decisions. That is, as with higher output decision for M-form than for U-form, the owner of firm with M-form optimally offers their managers incentive parameters that make them behave more aggressive compared to U-form, in both domestic and export markets. This is reversed when choosing U-form.

For the endogenous freight rate, the internal organization of firms and the parameters of the incentive schemes offered to the managers are alternative ways

[17] Similarly, the port i has a greater profit with U-form than with M-form (i.e., $R_i^{UM} - R_i^{MU} = \frac{2(157a-441\gamma)(2974a+4515\gamma)}{367447269} > 0$).

of manipulating the incentives of manager for output decisions. We have already shown that managers prefer to be more defensive (offensive) in their long- or short-run decisions of U (M)-form compared to M (U)-form.

In contrast to the results reported by Barcena-Ruiz and Espinosa (1999), we will show in Corollary 1 below that the optimal organizational form does not change even when the managers take the output decision to maximize profit instead of a linear combination of sales and profits (the detailed derivations are available from the author on request). Based on simple calculations, we obtain the following corollary.

Corollary 1. *Suppose Cournot competition. If managers aim to maximize profits, the owner of firm i (j) chooses U-form (M-form), i.e., UM regime or MU regime; (ii) in equilibrium organization form, it holds* $\tilde{\Pi}_i^{UM} = \tilde{\Pi}_i^{MU}$.

Proof: Comparing equilibrium outcomes, we obtain the following results: if $\gamma > \gamma^{\dagger} \equiv \frac{a}{2}$,

$$\tilde{\Pi}_i^{UM} - \tilde{\Pi}_i^{MM} = \tilde{\Pi}_i^{MU} - \tilde{\Pi}_i^{UU} = \frac{12(a-2\gamma)(23a+19\gamma)}{21125} < 0,$$

and vice versa if $\gamma < \gamma^{\dagger}$. Since $\gamma^{\dagger} > \gamma^{A}$, those always hold $\tilde{\Pi}_i^{MM} < \tilde{\Pi}_i^{UM}$ and $\tilde{\Pi}_i^{MU} > \tilde{\Pi}_i^{UU}$. This completes the proof.

Note that the results in Corollary 1 are same as those in Proposition 1 except for the viewpoint of social welfare, which implies that social welfare under the incentive schemes is larger than that under managers maximizing profits. When managers maximize profits, the dominant strategy for the firm is to commit itself in the first stage to a strong position of expanding output decisions. In other words, the organizational form providing incentives for a greater output is preferred, since there is no intermediate stage for the rival to react, the relations of $q_{ii}^{MU} > \tilde{q}_{ii}^{MU}$, $q_{jj}^{UM} > \tilde{q}_{jj}^{UM}$ and $q_{ij}^{MU} < \tilde{q}_{ij}^{MU}$, $q_{ji}^{MU} < \tilde{q}_{ji}^{MU}$. The absence of manipulating incentives for the output decision forces the downstream firm to a more aggressive form of behavior. The result in Corollary 1 points out the irrelevance of commitment to the incentive parameters for the optimal internal organization when each downstream firm competes under the reciprocal trade.

6. DISCUSSIONS

As in mentioned in Section 2, if we consider that with the determination of managerial contracts at the stage three and the choice of the transport rates set

by firm T at the fourth stage, then an equilibrium organization form emerges as asymmetric organizational form, MU or UM regime when considering both public port ownerships. However, choosing M-form for a firm is socially desirable given rival's U-form, which is opposite result in the main timing of game (the detailed derivations are available from the author on request). However, the transport firm T has an incentive to offer freight rates before the determination of managerial contracts. This is because

$$\Pi_T^{MU} - \hat{\Pi}_T^{MU} = \frac{\Phi_1 a^2 - \Phi_2 a\gamma + \Phi_3 \gamma^2}{111489739934333082} > 0,$$

$$\Phi_1 \equiv 342847596480545, \quad \Phi_2 \equiv 2255000517056070,$$

$$\Phi_3 \equiv 1447797760228071.$$

Note that in equilibrium organizational form, $\hat{\Pi}_T^{MU}$ is the profit of the transport firm when the choice of the freight rates set by transport firm after each owner writes his or her manager's incentive contract.

Maintaining the framework of model, we now assume that firms, which produce a heterogeneous product, are competing for consumers under a linear demand function; $p_{ii} = 1 - q_{ii} - dq_{ji}$ and $p_{ij} = 1 - dq_{jj} - q_{ij}$, where d is the degree of imperfect substitutability. From the messy equations, we can have the equilibrium organizational form as follows. If γ is large, then the owner of firm i (j) chooses U-form (M-form), i.e, UM regime and vice versa if γ is small (the detailed derivations are also available from the author on request). Roughly speaking, all results we present here will still hold if our setting follows the literature, although the mathematical complexity would increase. Hence, we can reach our findings qualitatively as with the perfect substitutability.

7. CONCLUDING REMARKS

This paper attempts to shed light on firms' internal organization by using public or asymmetric port ownership structures under two-way trade market. By focusing on endogenous freight rates for shipping goods, we examined the endogenous choice of organization structure in quantity competition. Our main result is that if the port usage fee and freight rates are introduced and set before the firms' incentive parameters, then the asymmetric organization form emerges as UM or MU regime, even though choosing other organization form for governments and firms is or is not collectively profitable and socially desirable.

Worthy extension would be to examine whether our results are robust when incorporating discriminatory tariffs or free trade into an import-competing and

export rivalry models. Understanding how firms of different organizational structure would respond in light of port privatization or partial privatization among countries provides an important topic for future research. The extension of our model in these directions remains on the agenda for future research.

A. APPENDIX

Proof of Proposition 2 Based on the $\gamma \in (0, \gamma^A)$ where $\gamma^A \equiv a/9$, straightforward computations yield

$$SW_i^{MU} - SW_i^{MM} = \frac{84889100a^2 + 75448212a\gamma - 1348731405\gamma^2}{47033250432} > 0,$$

$$SW_i^{MM} - SW_i^{UU} = \frac{1060a^2 + 252a\gamma + 1085\gamma^2}{34944} > 0,$$

$$SW_i^{UU} - SW_i^{UM} = \frac{738127904a^2 - 1937315856a\gamma + 465487015\gamma^2}{152858063904} > 0,$$

$$CS_i^{MM} - CS_i^{MU} = \frac{(182938a - 17253\gamma)(1114a - 7845\gamma)}{35834857472} > 0,$$

$$CS_i^{MU} - CS_i^{UU} = \frac{(422382a - 40747\gamma)(20814a + 17815\gamma)}{212909446152} > 0,$$

$$CS_i^{UU} - CS_i^{UM} = \frac{(394224a - 48937\gamma)(7344a - 9625\gamma)}{212909446152} > 0,$$

$$PS_i^{UM} - PS_i^{UU} = \frac{52278081312a^2 - 40751062800a\gamma - 4965472085\gamma^2}{5961464492256} > 0,$$

$$PS_i^{UU} - PS_i^{MU} = \frac{54564608304a^2 + 134391172272a\gamma - 34475274715\gamma^2}{5961464492256} > 0,$$

$$PS_i^{MU} - PS_i^{MM} = \frac{5637877172a^2 - 29334566100a\gamma - 18737356995\gamma^2}{752532006912} > 0,$$

$$\Pi_i^{UM} - \Pi_i^{MU} = \frac{21(71a + 67\gamma)(361a + 105\gamma)}{34994978} > 0,$$

$$\Pi_i^{MU} - \Pi_i^{UU} = \frac{1525828464a^2 - 9877914032a\gamma - 5437593945\gamma^2}{283879261536} > 0,$$

$$\Pi_i^{UU} - \Pi_i^{MM} = \frac{4068a^2 - 24580a\gamma - 31095\gamma^2}{1038336} > 0.$$

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