

Optimal Trade and Privatization Policies in an International Mixed Market

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This paper examines the optimal trade and privatization policies in an international mixed market where a domestic public firm competes against domestic and foreign private firms. We consider a trade policy combination of production subsidy and import tariff, and compare the optimal trade and privatization policies under either Cournot or Stackelberg competition. We find that the optimal trade policies consist of a domestic production subsidy and an import tariff, which are identical under the two regimes regardless of the competition pattern. However, the optimal privatization policy depends on the competition patterns, whether Cournot or Stackelberg competition. In particular, the optimal privatization policy under Cournot competition is complete privatization, whereas that under Stackelberg competition is full nationalization. Finally, we show that if the government can only use a single trade policy instrument, the production subsidy gives a better social welfare benefit than the import tariff.

Keywords: Privatization policy, Trade policy, Production subsidy, Import tariff, Mixed Cournot oligopoly, Mixed Stackelberg oligopoly

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I. Introduction

With the continuous expansion of the open economy since the 1990s, studies on the welfare effects of privatization and trade policy instruments have been developed using the mixed oligopoly and strategic international trade theories. An international mixed oligopoly framework is used to investigate the coexistence and competition between state-owned and private firms, where the domestic government uses many policy instruments, such as privatization and trade policies, to improve market performance.

The research conducted by de Fraja and Delbono (1989) is one of the pioneering studies on mixed oligopoly, where a domestic welfare-maximizing public firm competes with several domestic profit-maximizing private firms. Fjell and Pal (1996) extend the analysis into an international context by constructing a Cournot model, under which a domestic public firm competes with both domestic and foreign private firms to examine the effects of an open door policy and foreign acquisitions. Fjell and Heywood (2002) extend this Cournot model into a Stackelberg model, where a Stackelberg public leader competes with both domestic and foreign private followers. They show that privatization of a public leader always increases the profit of the leader and decreases welfare.

Pal and White (1998) consider a production subsidy and an import tariff and examine the interaction between privatization and strategic trade policies under Cournot competition. Their study shows that if the domestic market is open to foreign competition, privatization always increases domestic social welfare and decreases the level of optimal subsidy. However, if the government uses an import tariff, privatization does not necessarily increase social welfare, and the impact on the optimal tariff also varies.

In a related paper on international trade, Brander and Spencer (1985) find that under Cournot competition, the exporting country faces the temptation of using export subsidy to shift profit from a rival firm to its own. Such an optimal subsidy policy can move the domestic firm to what would be, in the absence of a subsidy, the Stackelberg leader position. Thus, a subsidy helps social welfare reach the same level as that achieved with a domestic Stackelberg leader.

However, these previous studies only discuss full privatization and neglect the possibility of partial privatization, which is of utmost importance, as pointed out by Matsumura (1998) and Lee and Hwang

(2003). In reality, partially privatized firms are common in many Asian and European countries, where the government holds a non-negligible proportion of shares in privatized firms. In such situation, considering the optimal state ownership in privatized firms that the government should hold is necessary. For example, Huang, Lee, and Chen (2006) analyze the government's optimal shareholding strategy within the framework of mixed oligopoly.

The partial privatization approach with trade policies has received increasing attention in recent years. Chang (2005) constructs a mixed duopoly model, where a domestic public firm competes with a foreign private firm, and shows that if both privatization and tariff policies are used, neither full nationalization nor full privatization is optimal under Cournot competition, but full nationalization is always optimal under Stackelberg competition. Chao and Yu (2006) use a mixed oligopoly model to investigate the effect of partial privatization on optimal tariffs and show that foreign competition lowers the optimal tariff but partial privatization raises it. Han (2009) compares two strategic trade instruments between subsidy and tariff with partial privatization and shows that the government chooses full privatization when adopting a subsidy only, whereas partial privatization is chosen when adopting a tariff only.

Even though an active trade policy can have the combination of a production subsidy and an import tariff, in most research the interaction between a privatization policy and a combination of trade policy instruments has not been studied in detail. Furthermore, firms may engage in Stackelberg competition if one of them has some kind of advantage, enabling that firm to move first. For example, public firms that generally have significant scale and technology advantages play a significant role in the world economy.¹ Therefore, this paper raises several important questions on trade and privatization policies: How does the pattern of competition affect the optimal ownership structures in the privatization policy? Which combination of trade policy instruments should be used to promote welfare? What are the interactions between trade and privatization policies?

¹ Stackelberg leadership best describes certain critical industries, such as the telecommunications, electricity, and postal sectors. These industries are characterized by a combination of public ownership and service obligations, a historical monopoly position with a first mover advantage and increasing competition. For a discussion on Stackelberg leadership in a mixed market, see de Fraja and Delbono (1989), Fjell and Heywood (2002), and Chang (2005).

The main objective of this paper is to analyze the optimal policy choices for governments regarding privatization (full or partial) and trade policies (subsidy and/or tariff) in the framework of an international mixed oligopoly model. Our model shares some characteristics with the existing models of mixed market in many respects, but we can still differentiate this paper from its predecessors. First, we allow for partial privatization, unlike Fjell and Pal (1996), Pal and White (1998), and Fjell and Heywood (2002). Second, we consider an international oligopoly market, where a domestic public firm competes with both domestic and foreign private firms. This contrasts with the study by White (1996) and Myles (2002), where no foreign firms are involved, as well as the research by Chang (2005) and Chao and Yu (2006), which ignores the presence of domestic private firms. Third, we consider a combination of a production subsidy and an import tariff to examine the interaction of two strategic trade instruments and privatization policy. Contrary to our approach, previous studies employ a single instrument, such as production subsidy (Pal and White 1998) and import tariff (Chao and Yu 2006), or two individual policies of a subsidy or an import tariff (Han 2009). Finally, we examine a Stackelberg competition to compare the results with those under Cournot competition, as in Fjell and Heywood (2002) and Chang (2005).

We show that optimal trade policies consist of a strategic combination of domestic production subsidy and import tariff, which are identical under the two regimes regardless of the competition pattern. However, the optimal privatization policy depends on the competition patterns, whether Cournot or Stackelberg competition. In particular, the optimal privatization policy under Cournot competition is full privatization, whereas that under Stackelberg competition is full nationalization. Finally, we show that if the government can only use a single trade policy instrument, production subsidy gives better social welfare benefit than import tariff.

This paper is organized as follows. In Section 2, we introduce the model and describe the basic framework. We then examine the effects of privatization and trade policies on welfare under the Cournot model in Section 3 and under the Stackelberg model in Section 4. In Section 5, we compare the Cournot case with the Stackelberg case and provide an economic interpretation of the interaction between privatization and trade policies. The final section discusses the implications for future research.

II. The Model

We consider a country with a mixed oligopoly market that includes one partially privatized public firm (firm 0), one domestic private firm (firm h), and one foreign private firm (firm f). We assume that each firm produces a homogenous good with the same production technology, which is represented by a quadratic cost function as $C(q)=F+0.5q^2$, where F denotes the fixed cost. Furthermore, because the number of firms is fixed and we do not consider the entry problem, we set $F=0$ without loss of generality.

Let q_0 be the output of the privatized public firm 0, q_h the output of the domestic private firm h , and q_f the output of the foreign private firm f . The inverse market demand is linear and given by $P=1-Q$, where $Q=q_0+q_h+q_f$ denotes the total output produced by all firms, and P denotes the market price. Consequently, the consumer surplus is given by $CS=0.5Q^2$.

The domestic government uses a complete set of trade policy instruments, including a production subsidy s per unit of output provided to the domestic firms and an import tariff t per unit of output imposed on the foreign firms. Each private firm's objective is to maximize its profit under the government policy.

The domestic private firm h chooses q_h to maximize its profit,

$$\pi_h = (1 - q_0 - q_h - q_f)q_h - \frac{1}{2}q_h^2 + sq_h \quad (1)$$

and the foreign private firm f chooses q_f to maximize its profit

$$\pi_f = (1 - q_0 - q_h - q_f)q_f - \frac{1}{2}q_f^2 - tq_f \quad (2)$$

Following Matsumura (1998) and Lee and Hwang (2003), we assume that the partially privatized public firm is jointly owned by the government and the private sector. Therefore, it maximizes the share-weighted average of social welfare and its own profit defined as

$$T=(1-\theta)W+\theta\pi_0 \quad (3)$$

where π_0 denotes the profit of the privatized public firm 0,

$$\pi_0 = (1 - q_0 - q_h - q_f)q_0 - \frac{1}{2}q_0^2 + sq_0 \quad (4)$$

and W denotes the social welfare defined by the sum of consumer surplus plus domestic firms' profits and tariff revenue less the cost of the subsidy,

$$\begin{aligned} W &= CS + \pi_0 + \pi_h + tq_f - s(q_0 + q_h) \\ &= CS + Pq_0 - \frac{1}{2}q_0^2 + Pq_h - \frac{1}{2}q_h^2 + tq_f \end{aligned} \quad (5)$$

It should be noted that $\theta \in [0, 1]$ refers to shares owned by private investors; that is, the government owns a share of $(1 - \theta)$ of the firm; $\theta = 0$ means that firm 0 is a complete public firm that maximizes social welfare; and $\theta = 1$ means that firm 0 is a complete private firm that maximizes its profit. Thus, θ can be used to measure the degree of privatization. The firm becomes more profit oriented as the degree of partial privatization increases.

We consider a two-stage game. In the first stage, the domestic government predicts the equilibrium outcome of the second stage and then chooses the degree of privatization and sets the production subsidy and import tariff to maximize the domestic social welfare. In the second stage, the firms observe the government's policy and then decide the strategic output levels.

In the following sections, we consider two regimes that differ with respect to the behavior of the semi-public firm 0: (i) Cournot oligopoly, where the semi-public firm sets its output simultaneously with that of the domestic private and foreign firms, and (ii) Stackelberg oligopoly, where the semi-public firm acts as a leader, choosing its output before the private firms do. In either case, we solve for the equilibrium by backward induction.

III. Optimal Trade and Privatization Policies under Cournot Competition

In a mixed market structure under Cournot competition, given the announced levels of θ , s , and t , the domestic private firm h chooses q_h to maximize (1), the foreign private firm f chooses q_f to maximize (2),

and the semi-public firm 0 chooses q_0 to maximize (3) at the same time. Solving the optimization problems simultaneously, we have the second-stage equilibrium output as follows:

$$q_0^c = \frac{\sigma - 3s - t - 2\theta + 9s\theta + 3t\theta}{\Delta_c} \quad (6)$$

$$q_h^c = \frac{2(1 + 3s + t + \theta)}{\Delta_c} \quad (7)$$

$$q_f^c = \frac{2 - s - 5t + 2\theta - 3s\theta - 3t\theta}{\Delta_c} \quad (8)$$

where $\Delta_c = 2(3\theta + 7) > 0$. We then derive the following equilibrium outcomes:

$$Q^c = \frac{2(5 + s - 2t + \theta + 3s\theta)}{\Delta_c} \quad (9)$$

$$P^c = \frac{2(2 - s + 2t + 2\theta - 3s\theta)}{\Delta_c} \quad (10)$$

$$\pi_0^c = \frac{(2 + 27s + 9t + 10\theta - 9s\theta - 3t\theta)(6 - 3s - t - 2\theta + 9s\theta + 3t\theta)}{2\Delta_c^2} \quad (11)$$

$$\pi_h^c = \frac{6(1 + 3s + t + \theta)^2}{\Delta_c^2} \quad (12)$$

$$\pi_f^c = \frac{3(2 - s - 5t + 2\theta - 3s\theta - 3t\theta)^2}{2\Delta_c^2} \quad (13)$$

$$CS^c = \frac{2(5 + s - 2t + \theta + 3s\theta)^2}{\Delta_c^2} \quad (14)$$

$$W^c = \frac{1}{2\Delta_c^2} \begin{pmatrix} 124 + 44s + 52t - 53s^2 - 121t^2 \\ -54st + 120\theta - 16s\theta + 48t\theta \\ +6s^2\theta - 114t^2\theta - 60st\theta - 4\theta^2 + 132s\theta^2 \\ +60t\theta^2 - 153s^2\theta^2 - 45t^2\theta^2 - 126st\theta^2 \end{pmatrix} \quad (15)$$

From the comparative statics, both subsidy and tariff increase the output and profit of the domestic private firm ($\partial q_h^c / \partial s > 0$, $\partial q_h^c / \partial t > 0$ and $\partial \pi_h^c / \partial s > 0$, $\partial \pi_h^c / \partial t > 0$), whereas they decrease the output and profit of the foreign private firm ($\partial q_f^c / \partial s < 0$, $\partial q_f^c / \partial t < 0$ and $\partial \pi_f^c / \partial s < 0$, $\partial \pi_f^c / \partial t < 0$). Thus, the policy instruments have a differential impact on the foreign firm's profit. Whereas a domestic production subsidy shifts the industry profit to the advantage of the domestic firms by strategically affecting the foreign firm's output choice, an import tariff directly extracts part of the foreign firm's profit and shifts it to the domestic firm.

Second, an increase in the subsidy increases the total industry output, decreases the market price, and increases the consumer surplus ($\partial Q^c / \partial s > 0$, $\partial P^c / \partial s < 0$, $\partial CS^c / \partial s > 0$). However, an increase in the tariff decreases the total industry output, increases the market price, and decreases the consumer surplus ($\partial Q^c / \partial t < 0$, $\partial P^c / \partial t > 0$, $\partial CS^c / \partial t < 0$).

Finally, under the assumption that $4 - 9s - 3t > 0$, with an increase in the level of privatization, the output of the public firm decreases ($\partial q_o^c / \partial \theta < 0$), the output of the domestic and foreign private firms increases ($\partial q_h^c / \partial \theta > 0$, $\partial q_f^c / \partial \theta > 0$), and the total industry output decreases ($\partial Q^c / \partial \theta < 0$). Thus, the market price increases ($\partial P^c / \partial \theta > 0$) and the consumer surplus decreases ($\partial CS^c / \partial \theta < 0$). However, if $4 - 9s - 3t < 0$, the above results are reversed. Proposition 1 shows that the optimal levels of s and t can satisfy the former constraint; thus, the latter scenario does not arise in equilibrium.

Proposition 1. In a Cournot oligopoly with a foreign firm where the domestic government optimally uses a combination of a production subsidy and an import tariff, the optimal policy requires full privatization and a higher subsidy than a tariff.

Proof. The differentiation of W^c with respect to θ yields

$$\frac{\partial W^c}{\partial \theta} = \frac{8}{\Delta_c^3} (4 - 9s - 3t) (3 - 5s + 3t - 13\theta + 30s\theta + 12t\theta) \quad (16)$$

$$\frac{\partial^2 W^c}{\partial \theta^2} = -\frac{16}{\Delta_c^4} (4 - 9s - 3t) (118 - 255s - 57t - 78\theta + 180s\theta + 72t\theta)$$

Assuming that $4 - 9s - 3t > 0$ and $0 \leq \theta \leq 1$ for the interior solutions, the optimal θ is obtained as

$$\theta^c = \frac{3 - 5s + 3t}{13 - 30s - 12t} \quad (17)$$

Similarly, the differentiation of W^c with respect to s yields

$$\begin{aligned} \frac{\partial W^c}{\partial s} = \frac{1}{\Delta_c^2} [(22 - 27t - 8\theta - 30t\theta + 66\theta^2 - 63t\theta^2) \\ - (53 - 6\theta + 153\theta^2)s] \end{aligned} \quad (18)$$

Again, the optimal interior solution of s can be obtained from $\partial W^c / \partial s = 0$, which gives

$$s^c = \frac{22 - 27t - 8\theta - 30t\theta + 66\theta^2 - 63t\theta^2}{53 - 6\theta + 153\theta^2} \quad (19)$$

The differentiation of W^c with respect to t yields

$$\begin{aligned} \frac{\partial W^c}{\partial t} = \frac{1}{\Delta_c^2} [(26 - 27s + 24\theta - 30s\theta + 30\theta^2 - 63s\theta^2) \\ - (121 + 114\theta + 45\theta^2)t] \end{aligned} \quad (20)$$

The optimal interior solution of t can then be obtained from $\partial W^c / \partial t = 0$, which gives

$$t^c = \frac{26 - 27s + 24\theta - 30s\theta + 30\theta^2 - 63s\theta^2}{121 + 114\theta + 45\theta^2} \quad (21)$$

Simultaneously solving Equations (17), (19), and (21), we have the optimal θ , s , and t

$$\theta^{c*} = 1, \quad s^{c*} = 4/13, \quad t^{c*} = 2/13 \quad (22)$$

Finally, to check whether the assumptions for the interior solutions are satisfied, we have $4 - 9s - 3t = 10/13 > 0$ and $0 \leq \theta \leq 1$ in the equilibrium results in (22), which are consistent with the assumptions.

Substituting (22) into (6), (7), and (10), we obtain

$$q_0^{c*} = q_h^{c*} = P^{c*} = \frac{4}{13} \quad (23)$$

A combination of optimal privatization and trade policies makes the outputs of the privatized public firm and domestic private firm equal and induces the domestic firms to produce output, where the marginal cost is equal to the market price. Substituting (22) into (15), we obtain $W^{c*} = 9/26$.

The policy implications in Proposition 1 are as follows: If the government uses an optimal combination of a production subsidy and an import tariff, social welfare can be maximized. This induces the firms to produce output, where the marginal cost is equal to the market price. First, the subsidy largely increases the total industry output and the profits of domestic firms. Thus, its effect in improving social welfare is significant. Second, the tariff revenue is relatively small because an increase in the tariff lowers the total industry output. Third, although privatization decreases the domestic public firm's output and thus lowers the consumer surplus, it increases the domestic private firm's output. The total increase in net domestic profits is more than the total decrease in consumer surplus; thus, the welfare increases. As a result, the government chooses a relatively higher production subsidy, a lower import tariff, and full privatization.

Finally, as analyzed by Han (2009), we consider the case where the domestic government optimally uses only one trade policy instrument: either a production subsidy or an import tariff. First, if the government adopts a subsidy-only regime, we eliminate the effect of the tariff by setting $t=0$. Using (17), (19), and (21), we have the optimal s and θ

$$\theta_s = 1, s_s = 2/5 \text{ where } t_s = 0 \quad (24)$$

Substituting (24) into (15), we obtain $W_s = 17/50$.

Second, if the government adopts a tariff-only regime, we eliminate the effect of the subsidy by setting $s=0$. Using (17), (19), and (21), we

have the optimal t and θ

$$\theta_t = 9/25, t_t = 14/61 \text{ where } s_t = 0 \quad (25)$$

Substituting (25) into (15), we obtain $W_t = 41/122$.

Therefore, the government chooses complete privatization when adopting a subsidy-only regime, whereas it chooses partial privatization when adopting a tariff-only regime. The optimal s and t in a subsidy-tariff combination regime are less than that either in the subsidy-only or the tariff-only regime. Comparing the optimal levels of social welfare under the three different trade regimes in the Cournot competition, we have $W_{st}^{c*} > W_s^{c*} > W_t^{c*}$. Therefore, the equilibrium social welfare in a subsidy-tariff combination regime is more than that either in the subsidy-only or the tariff-only regime.

Corollary 1. *The optimal policy combination improves social welfare much more than in either the subsidy-only or the tariff-only regime.*

This implies that if the government can use only the one-trade policy instrument, it should obtain the second-best level of social welfare. The subsidy largely increases the total industry output and the profits of domestic firms, whereas the tariff revenue is relatively small because an increase in the tariff lowers the total industry output. Thus, the government should prefer production subsidy over import tariff.

IV. Optimal Trade and Privatization Policies under Stackelberg Competition

In a mixed market structure under the Stackelberg competition with a dominant semi-public firm, given the announced levels of θ , s , and t , firm 0 chooses q_0 to maximize (3). The domestic private firm h chooses q_h to maximize (1), and the foreign private firm f chooses q_f to maximize (2).

The second stage equilibrium is solved by backward induction. First, simultaneously maximizing (1) and (2) for a given s , t , and the output of the leader q_0 , we obtain the output response functions of private followers:

$$q_h(q_0, s, t) = \frac{2 - 2q_0 + t + 3s}{8} \quad (26)$$

$$q_f(q_0, s, t) = \frac{2 - 2q_0 - 3t - s}{8} \quad (27)$$

The semi-public firm 0 sets its output for given θ , s , and t , anticipating the reaction of the followers as given in (26) and (27).

$$q_0^s = \frac{18 - 5s - 7t - 2\theta + 29s\theta + 15t\theta}{\Delta_s} \quad (28)$$

where $\Delta_s = 2(7\theta + 25) > 0$. Using this solution for (26) and (27) gives the private firms' output:

$$q_h^s = \frac{2(4 + 10s + 4t + 2\theta - s\theta - t\theta)}{\Delta_s} \quad (29)$$

$$q_f^s = \frac{8 - 5s - 17t + 4\theta - 9s\theta - 9t\theta}{\Delta_s} \quad (30)$$

We can then derive the following equilibrium outcomes:

$$Q^s = \frac{2(17 + 5s - 8t + 3\theta + 9s\theta + 2t\theta)}{\Delta_s} \quad (31)$$

$$P^s = \frac{2(8 - 5s + 8t + 4\theta - 9s\theta - 2t\theta)}{\Delta_s} \quad (32)$$

$$\pi_0^s = \frac{(14 + 85s + 39t + 18\theta - 37s\theta - 23t\theta)(18 - 5s - 7t - 2\theta + 29s\theta + 15t\theta)}{2\Delta_s^2} \quad (33)$$

$$\pi_h^s = \frac{6(4 + 10s + 4t + 2\theta - s\theta - t\theta)^2}{\Delta_s^2} \quad (34)$$

$$\pi_f^s = \frac{3(8 - 5s - 17t + 4\theta - 9s\theta - 9t\theta)^2}{2\Delta_s^2} \quad (35)$$

$$CS^s = \frac{2(17 + 5s - 8t + 3\theta + 9s\theta + 2t\theta)^2}{\Delta_s^2} \quad (36)$$

$$W^s = \frac{1}{2\Delta_s^2} \left(\begin{array}{l} 1600 + 500s + 700t - 625s^2 - 1525t^2 - 750st \\ + 896\theta + 280s\theta + 392t\theta - 350s^2\theta - 854t^2\theta - 420st\theta \\ + 48\theta^2 + 708s\theta^2 + 428t\theta^2 - 1493s^2\theta^2 - 569t^2\theta^2 - 1670st\theta^2 \end{array} \right) \quad (37)$$

The comparative static results in the Stackelberg case are very similar to those in the Cournot case. Under both Cournot and Stackelberg competitions, these trade policy instruments have the same effect on the outputs and profits of private firms. Total industry output and consumer surplus increase with the production subsidy and decrease with the import tariff, and market price level decreases with the subsidy and increases with the tariff in both cases.

Both the subsidy and the tariff increase the output and the profit of the domestic private firm ($\partial q_h^s/\partial s > 0$, $\partial q_h^s/\partial t > 0$ and $\partial \pi_h^s/\partial s > 0$, $\partial \pi_h^s/\partial t > 0$), whereas they decrease the output and the profit of the foreign private firm ($\partial q_f^s/\partial s < 0$, $\partial q_f^s/\partial t < 0$ and $\partial \pi_f^s/\partial s < 0$, $\partial \pi_f^s/\partial t < 0$). An increase in the subsidy increases the total industry output, decreases the market price, and increases the consumer surplus ($\partial Q^s/\partial s > 0$, $\partial P^s/\partial s < 0$, $\partial CS^s/\partial s > 0$). However, an increase in the tariff decreases the total industry output, increases the market price, and decreases the consumer surplus ($\partial Q^s/\partial t < 0$, $\partial P^s/\partial t > 0$, $\partial CS^s/\partial t < 0$).

Based on the comparative static effects in terms of the degree of privatization, the effects of privatization in the Stackelberg case are the opposite of those in the Cournot case. Assuming that $22 - 95s - 53t < 0$, with an increase in the level of privatization θ , the output of the public firm increases ($\partial q_0^s/\partial \theta > 0$), the output of the domestic and foreign private firms decreases ($\partial q_h^s/\partial \theta < 0$, $\partial q_f^s/\partial \theta < 0$), and the total industry output increases ($\partial Q^s/\partial \theta > 0$). Thus, the market price decreases ($\partial P^s/\partial \theta < 0$), and the consumer surplus increases ($\partial CS^s/\partial \theta > 0$). Similarly, if $22 - 95s - 53t > 0$, the above results are reversed. Proposition 2 shows the optimal levels of s and t can satisfy the former constraint. Thus, the latter scenario does not arise in equilibrium.

Proposition 2. In a Stackelberg oligopoly with a foreign firm where the domestic government optimally uses a combination of a production subsidy and an import tariff, the optimal policy does not require privatization but does require a higher subsidy than a tariff.

Proof. The differentiation of W^s with respect to θ yields

$$\begin{aligned}\frac{\partial W^s}{\partial \theta} &= \frac{-8(22-95s-53t)^2\theta}{\Delta_s^3} \\ \frac{\partial^2 W^s}{\partial \theta^2} &= -\frac{16}{\Delta_s^4}(22-95s-53t)^2(25-14\theta)\end{aligned}\quad (38)$$

Assuming that $22-95s-53t < 0$ and $0 \leq \theta^s \leq 1$ for the interior solutions, regardless of the sizes of s and t , the optimal θ is obtained as

$$\theta^s = 0 \quad (39)$$

Similarly, the differentiation of W^s with respect to s yields

$$\begin{aligned}\frac{\partial W^s}{\partial s} &= \frac{1}{\Delta_s^2} [(250-375t+140\theta-210t\theta+354\theta^2-835t\theta^2) \\ &\quad - (625+350\theta+1493\theta^2)s]\end{aligned}\quad (40)$$

Again, the optimal interior solution of s can be obtained from $\partial W^s / \partial s = 0$, which gives

$$s^s = \frac{250-375t+140\theta-210t\theta+354\theta^2-835t\theta^2}{625+350\theta+1493\theta^2} \quad (41)$$

The differentiation of W^s with respect to t yields

$$\begin{aligned}\frac{\partial W^s}{\partial t} &= \frac{1}{\Delta_s^2} [(350-375s+196\theta-210s\theta+214\theta^2-835s\theta^2) \\ &\quad - (1525+854\theta+569\theta^2)t]\end{aligned}\quad (42)$$

The optimal interior solution of s can be obtained from $\partial W^s / \partial t = 0$, which gives

$$t^s = \frac{350-375s+196\theta-210s\theta+214\theta^2-835s\theta^2}{1525+854\theta+569\theta^2} \quad (43)$$

Substituting (39) into (41) and (43), we have

$$\theta^{s*}=0, s^{s*}=4/13, t^{s*}=2/13 \quad (44)$$

Finally, to check whether the assumptions for the interior solutions are satisfied, we have $22-95s-53t=-200/13 < 0$ and $0 \leq \theta^s \leq 1$ in the equilibrium results in (44), which are consistent with the assumptions.

Substituting (44) into (28), (29), and (32), we obtain

$$q_0^{s*} = q_h^{s*} = P^{s*} = \frac{4}{13} \quad (45)$$

A combination of optimal privatization and trade policies makes the outputs of the domestic public firm and private firm equal and induces the domestic firms to produce, where the marginal cost is equal to the market price. Substituting (44) into (37), we obtain $W^{s*} = 9/26$.

In the analysis, the trade policy instrument plays a large role in controlling the output of the foreign firm, which is neglected in previous studies, such as that of Fjell and Pal (1996). The outputs of domestic and foreign firms are jointly determined by the trade policy instruments. An increase in the tariff leads to a decrease in the foreign firm's output, which in turn increases the market price.

Let us compare this outcome with that in the Cournot case. The optimal s and t in a subsidy-tariff combination policy under Stackelberg competition are the same as those under Cournot competition. The equilibrium social welfare is also the same. However, if the domestic public firm acts as a Stackelberg leader and thus sets its output ahead of the private firms, the government, which wants to maximize social welfare, should retain sole ownership of the public firm.

The intuition behind this result is that when the government uses a strategic trade policy, privatization improves the social welfare of the country with a mixed market structure only if the public firm acts as a Cournot player. If the pre-privatized public firm has a Stackelberg leader position and thus has a first-mover advantage, we cannot expect any social welfare gain from privatization. Retaining the state ownership of the public firm is an effective policy instrument compared with the production subsidy and the import tariff. Therefore, a change in ownership structure has no influence on the organizational efficiency of the market. As a result, the domestic government chooses not to privatize when it

uses both trade policy instruments simultaneously in the Stackelberg oligopoly with a public leader.

Finally, consider the case where the domestic government optimally uses only one trade policy instrument, either production subsidy or import tariff. First, if the government adopts a subsidy-only regime, we eliminate the effect of the tariff by setting $t=0$. Using (39), (41), and (43), we have the optimal s and θ :

$$\theta_s=0, s_s=2/5 \text{ where } t_s=0 \quad (46)$$

Substituting (46) into (37), we obtain $W_s=17/50$.

Second, if the government adopts a tariff-only regime, we eliminate the effect of the subsidy by setting $s=0$. Using (39), (41), and (43), we have the optimal t and θ :

$$\theta_t=0, t_t=14/61 \text{ where } s_t=0 \quad (47)$$

Substituting (47) into (37), we obtain $W_t=41/122$.

Comparing the optimal levels of social welfare under the three trade regimes in the Stackelberg competition case, we have $W_{s,t}^{s*} > W_s^{s*} > W_t^{s*}$. Similar to the Cournot case, if the government can use only one trade policy instrument, it should prefer production subsidy to import tariff to obtain the second-best level of social welfare.

Corollary 2. *The optimal policy combination improves social welfare much more than in either the subsidy-only or the tariff-only regime.*

V. Comparison and Discussion

Comparing the Cournot with the Stackelberg case, we summarize the following comparative static effects of s , t , and θ . Table 1 shows that in the two cases, both subsidy and tariff decrease the foreign private firm's output and profit but increase the output and profit of the domestic private firm. However, in the Stackelberg case, the subsidy and the tariff decrease the domestic semi-public firm's output contrary to their effect in the Cournot case. This contrasts with the influence of trade instruments on the public leader's output under Stackelberg competition. Moreover, the degree of privatization influences all variables to the opposite direction between Cournot and Stackelberg.

TABLE 1
COMPARISON BETWEEN COURNOT AND STACKELBERG

	q_0'	q_h'	q_f'	π_0'	π_h'	π_f'	Q'	P'	CS'
s^c	+	+	-	+	+	-	+	-	+
s^s	-	+	-	+	+	-	+	-	+
t^c	+	+	-	+	+	-	-	+	-
t^s	-	+	-	+	+	-	-	+	-
θ^c	-	+	+	-	+	+	-	+	-
θ^s	+	-	-	+	-	-	+	-	+

As shown in Fjell and Heywood (2002), the public firm, as a Stackelberg leader, will always produce less than a Cournot competitor when maximizing welfare in a mixed oligopoly. That is, a decrease in q_0 increases q_h , and production substitution from firm 0 to domestic private firm h takes place. The reason is that the weighted average objective function of the domestic public firm 0 also depends on the output of the domestic private firm h . It can be verified that $\partial W(q_0, q_h)/\partial q_h > 0$. An increase in the quantity produced by the domestic private firm improves the social welfare. Therefore, the public leader prefers to produce less, anticipating that some of the reduction will be produced instead by the private firm. This would explain why the output level of a public Stackelberg leader is lower than that of a public Cournot competitor.

However, if the public leader is privatized, the result will be reversed. As the privatization level increases, the dependence of firm 0's objective function on firm h 's output gradually decreases. A privatized firm always considers its profit and no longer cares about social welfare. Therefore, as a Stackelberg leader, the privatized public firm recognizes the inverse relationship between its output and those of its followers. Normally, a privatized Stackelberg leader produces more than if it were a Cournot competitor.

Except for the privatized public firm's output, subsidy and tariff have the same effect on all other outcomes in both the Cournot and Stackelberg cases, although they affect social welfare in different ways. Therefore, the optimal trade policies that consist of a domestic production subsidy and an import tariff are always identical regardless of the competition pattern of firms. White (1996) and Myles (2002) determine that when import tariff and privatization policies are left out, the optimal subsidy is identical regardless of whether the public firm simultane-

ously moves with the private firms or acts as a Stackelberg leader.

As presented in Table 1, the effects of privatization in the Stackelberg case are opposite those in the Cournot case. Privatization increases the domestic privatized public firm's output and profit, which increases total industry output and consumer surplus, but decreases all other outcomes under the Stackelberg competition, contrary to what occurs in the Cournot case.

Similar to the results of Pal and White (1998) that use the Cournot oligopoly model, when a domestic production subsidy is used, welfare always improves with privatization, as privatization shifts production from the higher-cost public firm to the lower-cost private firm, producing a cost saving effect. However, when we consider the Stackelberg oligopoly model, welfare always decreases with privatization, as increasing the privatization of the domestic public firm causes it to maximize profit instead of social welfare. If the pre-privatized public firm has a Stackelberg leader position and thus has a first-mover advantage, we lose the disciplining effect of nationalization of the public leader from privatization, as explained by Mukherjee and Suetrong (2009). Therefore, in the case of an international mixed oligopoly, the public firm that has a Stackelberg leader position can be considered an effective policy instrument to regulate the domestic industry.

In summary, privatization is related to the ownership and objective function of the public firm and to the type of competition in the market. Social welfare monotonically increases with the degree of privatization in the Cournot case, whereas it monotonically decreases with the degree of privatization in the Stackelberg case regardless of whether optimal trade policies are used.

VI. Conclusion and Future Research

We have examined the optimal trade and privatization policies in a mixed oligopoly, where a domestic semi-public firm competes against domestic and foreign private firms in a domestic market. We have considered the case where the domestic government uses a combination of production subsidy and import tariff and chooses the optimal levels of privatization and trade policies simultaneously to maximize domestic welfare under Cournot and Stackelberg competitions. We have also compared the effects of optimal privatization and trade policies in a mixed Cournot and a mixed Stackelberg oligopolies. We have also investigated

the interaction between trade and privatization policies.

We have found that the optimal trade policies consist of a domestic production subsidy and an import tariff regardless of the competition pattern. The optimal domestic production subsidy and import tariff are identical under the two regimes. However, the optimal privatization policy for the domestic government depends on the competition patterns. The optimal privatization policy under Cournot competition is full privatization, whereas that under Stackelberg competition is full nationalization. Finally, we have shown that if the government can only use a single trade policy instrument, the production subsidy provides better social welfare than the import tariff.

However, there are some important future studies that need to be conducted. First, for analytic tractability, we have developed a simple oligopoly model where domestic public, private, and foreign firms are identical in terms of cost function. We have also derived the result of the isomorphism between full privatization under Cournot competition and full nationalization under Stackelberg competition. However, these results may not be obtained from the different specifications of the model. Therefore, as analyzed in Lee and Hwang (2003) and Chang (2005), more general forms of cost function or asymmetric cost functions between public firm and private firms should be examined for the robustness of the results.

In addition, we have not included the entry of private firms after privatization in our analysis. Privatization attracts more domestic or foreign private firms by reducing the output of the public firm, thus leaving more residual demand for the potential domestic or foreign firms. The competition effect after privatization should be incorporated in the process of decision making on the optimal privatization and trade policies. As mentioned by Brander and Spencer (1985), the role of subsidy or tariff policies in providing the Stackelberg leader position to its domestic firm in the international oligopoly should be investigated.

Finally, we have focused on a single country case where domestic firms compete with a foreign firm. As suggested by Mukherjee and Suetrong (2009) and Lee and Xu (2010), if we extend the model to the case where multiple foreign firms and governments compete in the international trade, the cross-country equilibrium for privatization and trade policies should be taken into the consideration. In addition, we have assumed that the shares of the privatized public firm are sold to domestic investors only. Therefore, acquisition of the public firm by foreign investors can be an interesting area for future research.

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