

Environmental Tax, Trade, and Privatization

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The analysis presented in this paper explores the interaction among privatization, environmental, and trade policies. In particular, we consider the optimal environmental tax and tariff, and the effects of privatization of a public firm in international duopolistic markets with environmental damage. There are three main results. First, the optimal environmental tax is lower than the marginal environmental damage and the optimal tariff is strictly positive regardless of whether or not the home public firm is privatized. Second, privatization leads to the increase in the optimal environmental taxes and tariffs in both countries. Third, under the optimal environmental tax and tariff, privatization results in the reduction of social welfare and in environmental improvement.

Keywords: environmental tax, privatization, tariff, mixed oligopoly

JEL Classification Numbers: F12, H23, L33

1. Introduction

Recently, several oligopolistic industries have been observed in various countries, where partial or full privatization of public enterprises has been carried out while permitting the entry and operation of foreign firms. Most empirical literature indicates that, privatization creates several economic costs and benefits¹⁾. For example, in some developing countries, privatization of state-owned enterprises led to the improvement of economic performance, but it sometimes generated higher price levels because utility prices have been intentionally kept low from the welfare perspective.

However, the fact that privatization also affects the environmental outcomes does not receive due attention. Due to the failure of the centrally planned economies to control industrial pollution, several formerly state-owned enterprises in countries in transition have encountered issues concerning poor environmental quality. It is also observed that the privatized enterprises in industries such as electricity, gas, water, and waste disposals, tend to have a low number of pollution

¹⁾ For a recent survey, see Megginson and Netter (2001).

abatement equipments. Investors and buyers have been, particularly, concerned with regard to the potential liability arising from the historical environmental contamination and the improvement of abatement equipments. On the other hand, several empirical studies reveal a positive interrelation between privatization and environmental improvement. Previous cases have demonstrated that commercial pressures through privatization have eliminated the concern of environmental problems and that coping with environmental issues could result in a greater number of successful privatizations. However, it should be considered that ineffective environmental policy making would result in the decrease in the opportunities for environmental gains from privatization. Therefore, it is important to consider the effective environmental policy making and the appropriate conditions in order to promote environmental improvement through privatization.

Such structural changes through privatization provide an opportunity to analyze the interaction between privatization and environmental policies. In this paper, we consider the effects of privatization by incorporating environmental and trade policies in international markets²⁾. There is concern that privatization may not be welfare-improving in such cases if the gains from privatization would be counterbalanced to a greater extent by the costs from privatization. Thus, when the domestic public firms are privatized, the governments might have an interest in controlling environmental and trade policies in order to protect the privatized enterprises from the markets. In other words, the governments may have an incentive to "subsidize" the domestic privatized firms by modifying the environmental and trade policies in the process of privatization. The modifications in such policies will alter the quantity level, consumer surplus, profits, environmental damage, and social welfare. In fact, privatization led to significant alteration of the trade and subsidy policies to protect the domestic firms. In this paper, we primarily focus on the two questions: First, what are the optimal environmental tax and tariff before and after privatization of a domestic public firm? Second, does privatization increase or decrease the social welfare under optimal environmental and trade policies? In analyzing these questions, we consider the effects of privatization on the quantity level, consumer surplus, profits, and environmental damage before and after privatization.

To consider the above questions, we adopt the mixed oligopoly models, where state-owned welfare-maximizing public firms compete with profit-maximizing private firms³⁾. One of the questions considered by the literature on mixed oligopoly models is the decision by governments whether to privatize public firms or not. De Fraja and Delbono (1989), which is one of the pioneering papers in the analysis of mixed oligopoly models, showed that privatization decreases social welfare

²⁾ Several previous papers have investigated the use of trade policy to control pollution. For example, see Baumol and Oates (1988), Copeland (1996), Ludema and Wooton (1994), and Markusen (1975).

³⁾ For some analyses of mixed oligopoly models in a domestic context, see Barros (1995), Beato and Mas-Colell (1984), De Fraja and Delbono (1989, 1990), Matsumura (1998), and Nishimori and Ogawa (2002). In a foreign context, see Fjell and Heywood (2002), Fjell and Pal (1996), Pal and White (1998), and Serizawa (2000).

when the number of the private firms is significantly small in a mixed oligopoly. Fjell and Pal (1996) investigated an international mixed oligopoly. They showed that the effect of entry on welfare is ambiguous. However, the literature has not taken into account the polluting firms and the environmental policies. In other words, the interaction among privatization, environmental, and trade policies in the context of international mixed oligopoly models has not been yet investigated.

The purpose of this paper is to investigate the impacts of privatization by incorporating the strategic environmental and trade policies within an international mixed duopoly serving two markets. We find that the optimal environmental tax is lower than the marginal environmental damage and that the optimal tariff is strictly positive, whether or not the public firm is privatized. Furthermore, the governments have a stronger incentive to use the environmental taxes as a rent-shifting tool rather than the tariffs before privatization, and *vice versa* after privatization. In addition to this, privatization improves environmental damage, but decreases social welfare.

The remainder of this paper is organized as follows: In section 2, a model is described. In section 3, we investigate the equilibrium outcomes. Section 4 concludes this paper.

2. The model

The present model follows the basic set-up of Tanguay (2001). Consider two countries⁴⁾. In each of the countries there is a government, which sets an environmental tax t to control pollution and a tariff μ to regulate an imported good. A monopolistic firm in each country concurrently provides a homogeneous good y for the home and foreign markets. The firms are assumed to generate one unit of pollution per unit of output. The total production by firm i ($i = 0, 1$) is $y_i = h_i + e_i$, where h_i and e_i denote the outputs produced by firm i for the domestic and foreign markets, respectively. In the case of mixed duopoly, the firm in the home country (firm 0) is a welfare-maximizing public firm⁵⁾, while the firm in the foreign country (firm 1) is its own profit-maximizing private firm. In the case of private duopoly, the two firms are assumed to be profit-maximizers. Consumers in each country buy the good q_i in the domestic market. The total consumption in country i is $q_i = h_i + e_j$ ($i \neq j$). The inverse demand function is linear, $P_i = a - q_i = a - h_i - e_j$, where a denotes the choke price. We assume that a is significantly large. The profit function of firm i is given as

$$\pi_i = (P_i - t_i - c)h_i + k(P_j - t_j - \mu_j - c)e_j, \quad (1)$$

⁴⁾ In this paper, we assume a segmented market. In this context, see Brander and Krugman (1983), Dixit (1984), and Venables (1985).

⁵⁾ In this paper, we assume that there exists no agency problem in the mixed oligopoly. With any agency problem, the public firm might not maximize social welfare. For the separation of ownership and control in mixed oligopoly, refer to Barros (1995).

where c is the constant marginal production cost⁶⁾ and k is a reduced proportion associated with additional informational costs, where $k \in (0,1]$. For the sake of simplicity, the value of c is assumed to be identical for all firms. In other words, this paper does not consider the difference in production technology across countries. Then, our study in this paper would be appropriate with regard to trade between analogous countries. Following Tanguay (2001), we fix $k = 1/2$, for simplicity. On examination of (1), we note that the first term of the right-hand side is simply the profit of firm i in the domestic market, while the second term reflects the profit of firm i in the foreign market.

The consumer surplus function is assumed to be $CS_i = q_i^2/2$. The environmental damage function is given by $D_i = dy_i$, where $d (> 1)$ denotes the marginal environmental damage and is assumed to be identical for the two countries. Note that the environmental damage function is increasing, reflecting that higher emissions increase environmental damage. The social welfare in country i is thus given as

$$W_i = CS_i + \pi_i + t_i y_i - D_i + \mu_i e_j. \quad (2)$$

Note that the second term of the right-hand side is the profit of firm i , the third is the tax revenue, and the fifth is the tariff revenue. The taxes and tariffs indirectly affect social welfare through their impacts on the firms' output. Note that when a is considerably large, $a - c - d$ ($= a$) is positive. This expression is required in order to avoid the irrelevance result and to simplify our model. The game is solved using backward induction. This is also a game of complete information. The solution satisfies the properties of the Cournot-Nash equilibrium.

3. Results

In this section, we solve the above model. We begin by describing the situation of mixed Cournot-Nash duopoly. Next, the situation of private Cournot-Nash duopoly is considered. Finally, the comparisons are investigated.

3.1. Before privatization: the mixed Nash duopoly

In this situation, firm 0 chooses its output in order to maximize social welfare of the home country, while firm 1 chooses its output in order to maximize its own profit. The structure of the game is as follows: In the first stage, governments set environmental taxes and tariffs, simultaneously. In the second stage, each firm strategically competes by choosing its output level.

Assuming interior solution, we have the second stage equilibrium output for the given environmental taxes and tariffs⁷⁾:

⁶⁾ In this paper, we neglect the fixed cost. However, this has no effect on our discussions.

⁷⁾ We use the superscripts MN and PN for the mixed Cournot-Nash and private Cournot-Nash duopolies, respectively.

$$h_0^{MN} = \alpha; \quad h_1^{MN} = (\alpha + 3d - t_0 - 2t_1 + \mu_1)/3; \quad (3)$$

$$e_0^{MN} = (\alpha - 3d + 2t_0 + t_1 - 2\mu_1)/3; \quad e_1^{MN} = (d - t_1 - \mu_0)/2. \quad (4)$$

The export levels of the home public firm and the foreign private firm are negatively related to the tariff set by the other government ($\delta e_i^{MN}/\delta \mu_j < 0$). The tariff raises the domestic price ($\delta P_i/\delta \mu_i > 0$) since it reduces domestic consumption ($\delta q_i^{MN}/\delta \mu_i < 0$). Therefore, the consumer surplus decreases with the tariff ($\delta CS_i/\delta \mu_i < 0$).

From (3) and (4), it can also be observed that an environmental tax set by the home government causes the home public firm to increase its output ($\delta y_0^{MN}/\delta t_0 > 0$) and the foreign private firm to reduce its output ($\delta y_1^{MN}/\delta t_0 < 0$). The results are rather interesting, because an increase in the environmental tax is expected to decrease the output of domestic firms and increase the output of foreign firms according to the standard literature on environmental economics. The intuition behind this result is as follows: Note that the home public firm's reaction function is $y_0^{MN} = (\alpha - d + t_0 - \mu_1 - h_1^{MN})/2$, while the foreign private firm's reaction function is $y_1^{MN} = (2\alpha + 2d - 2t_1 - \mu_0 - y_0^{MN})/2$. Then, an increase in the environmental tax shifts the public firm's reaction function upward, while it does not affect the reaction function of the foreign private firm. As a result, an increase in the environmental tax increases the production of the home public firm and decreases that of the foreign private firm. This result implies that the environmental tax will be a strategic instrument for the home government to distribute production from the foreign private firm to the home public firm. An additional effect of the home environmental tax is the reduction of the foreign private firm's output for local consumption, thereby expanding the foreign market for the home public firm.

However, note that an increase in the production results in an increase in the local environmental damage; consequently, the raising of the environmental tax set by the home government is paradoxically included in the increase in the local environmental damage, which will result in the reduction in the social welfare. In other words, the environmental tax in the home country might be used to lessen the distortion due to imperfect competition rather than to improve the environment. Thus, the optimal environmental tax will depend on the two conflicting effects: the production-distribution effect due to the increase in the total production of the home firm and the pollution-increasing effect due to the increase in the local environmental damage associated with the increase in the total production level.

Furthermore, it is observed that the effects of the tax in the foreign country on the home public firm's and the foreign private firm's total outputs are positive ($\delta y_0^{MN}/\delta t_1 > 0$) and negative ($\delta y_1^{MN}/\delta t_1 < 0$), respectively. This is simply known from standard strategic trade as the general rent-shifting effect, which implies that reducing the tax rate shifts the rent from the rival by expanding domestic production.

We now focus on the first stage. In this stage, each government sets the optimal

environmental tax and tariff in order to maximize the objective function (2). The governments' optimal choices with regard to the environmental taxes and tariffs are found by solving the first-order conditions:

$$\hat{t}_0^{MN} = d - (2\alpha/11); \quad \hat{t}_1^{MN} = d - (3\alpha/11); \quad (5)$$

$$\hat{\mu}_0^{MN} = \alpha/11; \quad \hat{\mu}_1^{MN} = 2\alpha/11, \quad (6)$$

where hat “ $\hat{\cdot}$ ” over the variable implies the equilibrium value. We observe that the governments have an incentive to introduce positive tariffs. It is also evident that the optimal environmental tax is below the marginal environmental damage ($\hat{t}_i^{MN} < d$)⁸⁾. This is what has become known as the rent-shifting effect. Note that the introduction of the environmental tax for the home country involves the production-distribution effect associated with increased total output and the pollution-increasing effect due to the increase in the environmental damage. Taking into account these two effects, the home government decides on the optimal environmental tax that is less than the marginal environmental damage. On the other hand, it can be also observed that the foreign government also sets the optimal environmental tax below the Pigouvian level. This is because the foreign government has an incentive to increase the share of the domestic firm in the markets.

Solving the optimal quantity levels for domestic consumption and export levels of each firm, we get

$$\hat{h}_0^{MN} = \alpha; \quad \hat{h}_1^{MN} = 7\alpha/11; \quad (7)$$

$$\hat{e}_0^{MN} = 0; \quad \hat{e}_1^{MN} = \alpha/11. \quad (8)$$

It is evident that the home public firm has no incentive to export the good under optimal environmental taxes and tariffs. Moreover, in equilibrium, the production level of the home public firm is greater than that of the foreign private firm ($\hat{y}_0^{MN} > \hat{y}_1^{MN}$); therefore, the consumption level in the home market is greater than that in the foreign market ($\hat{q}_0^{MN} > \hat{q}_1^{MN}$).

Substituting (5)–(8) into (1) and (2) and after rearranging, we obtain the following subgame perfect Nash equilibrium outcomes:

$$\widehat{CS}_0^{MN} = 72\alpha^2/121; \quad \widehat{CS}_1^{MN} = 49\alpha^2/242; \quad (9)$$

$$\hat{D}_0^{MN} = 18\alpha d/11; \quad \hat{D}_1^{MN} = 8\alpha d/11; \quad (10)$$

$$\hat{\pi}_0^{MN} = \alpha^2/11; \quad \hat{\pi}_1^{MN} = 9\alpha^2/22; \quad (11)$$

⁸⁾ In this analysis, however, the signs of the optimal environmental tax are ambiguous.

$$\hat{W}_0^{MN} = 62\alpha^2/121; \hat{W}_1^{MN} = 50\alpha^2/121. \quad (12)$$

From (9)–(12), it is evident that in equilibrium, the consumer surplus, the environmental damage, and the social welfare in the home country exceed those in the foreign country ($\hat{CS}_0^{MN} > \hat{CS}_1^{MN}$, $\hat{D}_0^{MN} > \hat{D}_1^{MN}$, and $\hat{W}_0^{MN} > \hat{W}_1^{MN}$), because the optimal total production and consumption levels in the home country exceed those in the foreign country. It is also observed that in equilibrium, the profit of the home public firm is less than that of the foreign private firm ($\hat{\pi}_0^{MN} < \hat{\pi}_1^{MN}$). These results are explained by the fact that the home public firm has an incentive to act in order to maximize the domestic social welfare rather than its own profit, while the foreign private firm has an incentive to act in order to maximize its own profit.

3.2. After privatization: the private Nash duopoly

In this situation, the two firms are assumed to be profit-maximizing private firms. In the final stage, the firms produce the good in order to maximize their own profit. Differentiating (1) with h_i and e_i , we obtain the following second stage outputs:

$$h_i^{PN} = (a - c - 2t_i + t_j + \mu_i)/3; \quad (13)$$

$$e_i^{PN} = (a - c - 2t_i + t_j - 2\mu_i)/3. \quad (14)$$

From (13) and (14) it is clear that setting the tariff decreases the export of the rival firm ($\partial e_j^{PN}/\partial \mu_i < 0$), while setting the tax reduces the total output of the domestic firm ($\partial y_i^{PN}/\partial t_i < 0$). This result is straightforward.

In the first stage, each government chooses the following optimal tax and tariff in order to maximize social welfare:

$$\hat{t}_i^{PN} = d - \alpha/6; \quad (15)$$

$$\hat{\mu}_i^{PN} = \alpha/3. \quad (16)$$

After privatization, the optimal tariffs are positive. It is also evident that the optimal environmental tax is below the marginal environmental damage ($\hat{t}_i^{PN} < d$), although the sign is ambiguous. In other words, the governments try to increase the share of the domestic firm and support its industry by lowering the environmental tax. This result is explained by the fact that the governments have an incentive to shift the rent from the foreign firm to the domestic firm.

Proposition 1. *In the international duopolistic markets, the optimal environmental tax is lower than the marginal environmental damage and the optimal tariff is strictly positive, regardless of whether or not the home public firm is privatized.*

Using (15) and (16), we obtain the following subgame perfect Nash equilibrium outcomes:

$$\hat{h}_i^{PN} = \alpha/2; \quad (17)$$

$$\hat{e}_i^{PN} = \alpha/6; \quad (18)$$

$$\widehat{CS}_i^{PN} = 2\alpha^2/9; \quad (19)$$

$$\hat{D}_i^{PN} = 2\alpha d/3; \quad (20)$$

$$\hat{\pi}_i^{PN} = 7\alpha^2/18; \quad (21)$$

$$\hat{W}_i^{PN} = 31\alpha^2/78. \quad (22)$$

3.3. Comparisons

We first compare the optimal environmental tax and tariff before and after privatization, in order to investigate the effect of privatization on these strategic policies. Using (5), (6), (15), and (16), it can be observed that privatization raises the optimal environmental taxes and tariffs in both countries ($\hat{t}_i^{MN} < \hat{t}_i^{PN}$ and $\hat{\mu}_i^{MN} < \hat{\mu}_i^{PN}$). In such a case, the increase in the optimal taxes and tariffs leads to the decrease in the production level and the improvement in environmental damage.

The result that privatization increases the optimal tariffs in both countries is straightforward. Thus, since privatization leads to more tightened competition, it is expected that the government has more incentive to raise the optimal tariffs in order to protect the privatized firm from the markets. However, the result that privatization increases the optimal environmental taxes is rather interesting, because it is expected that the more the competitive pressures, the stronger will be the incentive of the government to reduce the optimal tax in order to shift rent. This result implies that the governments have stronger incentives to use the environmental taxes as a rent-shifting device in the mixed duopoly rather than in the private duopoly. Proposition 2, therefore, presents the result.

Proposition 2. *Both governments have a stronger incentive to use the environmental taxes as a rent-shifting tool rather than the tariffs before privatization, and vice versa after privatization.*

The rationale behind the proposition is as follows: Note that in the international mixed duopoly the home public firm acts taking into account a portion of the local environmental damage, and then the home government can afford to use an environmental tax as a rent-shifting tool. After privatization, however, the privatized firm acts taking into account its own profit rather than the environmental damage and social welfare. Then, since the environmental tax set by the home government targets pollution, the tariff can be used as a rent-shifting tool⁹⁾.

⁹⁾ The result would be similar to that of Markusen (1975) and Baumol and Oates (1988). They have shown that if tariffs are eliminated, other instruments can be used as second best policies.

Further, we investigate overall comparisons of social welfare in different situations. From (12) and (22), it is observed that under optimal environmental taxes and tariffs, privatization of a public firm decreases social welfare in both countries ($\hat{W}_0^{MN} > \hat{W}_1^{MN} > \hat{W}_i^{PN}$). This result will be identical to that of De Fraja and Delbono (1989). They have shown that privatization worsens social welfare when the number of the entrants in a mixed oligopoly is significantly limited.

Such welfare reduction by privatization is brought about by the several conflicting effects. Consider the effects of privatization in the home country. The positive effects of privatization in the home country are as follows: the increase in the export level is ($\hat{e}_0^{MN} < \hat{e}_0^{PN}$), the tariff revenue is ($\hat{\mu}_0^{MN} \hat{e}_1^{MN} < \hat{\mu}_0^{PN} \hat{e}_1^{PN}$) and the profit of the home firm is ($\hat{\pi}_0^{MN} < \hat{\pi}_0^{PN}$), and the decrease in the environmental damage is ($\hat{D}_0^{MN} > \hat{D}_0^{PN}$). The negative effects of privatization in the home country are as follows: the decrease in the production and consumption is ($\hat{y}_0^{MN} > \hat{y}_0^{PN}$ and $\hat{q}_0^{MN} > \hat{q}_0^{PN}$), respectively and the corresponding decrease in the consumer surplus is ($\widehat{CS}_0^{MN} > \widehat{CS}_0^{PN}$)¹⁰. Then, it is observed that the positive effects of privatization are offset to a greater extent by the negative effects of privatization, and thus, welfare decreases.

On the other hand, the positive effects of privatization in the foreign country are as follows: the increase in the export level of the domestic firm is ($\hat{e}_1^{MN} < \hat{e}_1^{PN}$), the consumption level is ($\hat{q}_1^{MN} < \hat{q}_1^{PN}$), the consumer surplus is ($\widehat{CS}_1^{MN} < \widehat{CS}_1^{PN}$), the tariff revenue is ($\hat{\mu}_1^{MN} \hat{e}_0^{MN} < \hat{\mu}_1^{PN} \hat{e}_0^{PN}$), and the decrease in the environmental damage is ($\hat{D}_1^{MN} > \hat{D}_1^{PN}$). The negative effects of privatization in the foreign country are as follows: the decrease in the foreign firm's production is ($\hat{y}_1^{MN} > \hat{y}_1^{PN}$), its profit is ($\hat{\pi}_1^{MN} > \hat{\pi}_1^{PN}$), and the tax revenue is ($\hat{t}_1^{MN} \hat{y}_1^{MN} > \hat{t}_1^{PN} \hat{y}_1^{PN}$). Therefore, it is observed that the net effect is negative, and thus welfare decreases.

Proposition 3. *When the optimal environmental tax and tariff are set in the international duopolistic markets, privatization of the home public firm results in the deterioration of social welfare and in environmental improvement in both countries.*

The effect that the optimal environmental damage before privatization is greater than that after privatization, would be attributed to the targets of the environmental tax. The environmental tax targets the rent-shifting rather than the environmental improvement before privatization, and *vice versa* after privatization, as demonstrated by Proposition 2. Then, the alteration in the policy target of the environmental tax through privatization affects pollution.

4. Concluding remarks

The analysis presented in this paper explored the interaction among privatiza-

¹⁰ The effect of privatization on the tax revenues is ambiguous. Then, the effect depends on the values of α and d .

tion, environmental, and trade policies. In particular, we considered the effects of privatization of a public firm in international mixed duopolistic markets with environmental damage. There are three main results. First, the optimal environmental tax is lower than the marginal environmental damage and the optimal tariff is strictly positive regardless of whether or not the home public firm is privatized. Second, privatization leads to the increase in the optimal environmental taxes and tariffs in both countries. This implies that the governments have a stronger incentive to use the environmental taxes as a rent-shifting tool rather than the tariffs before privatization, and *vice versa* after privatization. Third, under the optimal environmental tax and tariff, privatization results in the reduction of social welfare and in environmental improvement.

This paper will be the first step in studying the interaction among privatization, environmental policy, and international trade. However, there are some limitations in our analysis. First, this paper ignored the productive efficiency. One of the purposes of privatization of public sectors in general is to improve the productive efficiency (cf., the promptness of the public sectors' incentive for cost reduction). In countries tackling environmental issues, privatization, in particular, may need to be carried out so as to present incentives to the public sectors to develop pollution abatement equipment. Therefore, it is necessary to include the expenditure for abatement equipment into the mixed oligopoly model.

Second, similar to most papers on mixed oligopoly, we, too, did not deal with the principal-agent problems. We assumed that the firms face no agency issue due to the separation of ownership and control¹¹⁾. The public enterprise will, in fact, be less efficient than our assumed public firm due to extravagant expenditure arising on account of political reasons.

Third, we assumed that the number of firms is exogenous; however, this assumption may be inadequate, because privatization has generally been designed to stimulate the increase of new entrants. Then, the introduction of endogenous firms may change the outcomes.

Fourth, we did not consider the situations of dynamic games and cooperation between countries. This paper finds that the optimal environmental tax would be set below the marginal environmental damage. This result will call our attention to the issue where a "race to the bottom" in environmental taxes might occur in order to enhance international competitiveness if both home and foreign countries would be in the situation of dynamic settings. Also, it is our conjecture that cooperative policy making will induce a higher environmental tax than non-cooperative policy making. When the optimal environmental and trade policies are set under cooperation, privatization may lead to improvement in both social welfare and environmental damage between countries. These considerations require future study.

¹¹⁾ See Schmitz (2002), who discussed partial privatization under the agency problem.

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