Trade liberalization, consumption externalities and the environment: a mixed duopoly approach

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Abstract

This paper studies the environmental tax and trade liberalization in a mixed duopolistic market wherein environmental damage is associated with consumption. In particular, we consider the effect of privatization on environmental tax and the effect of trade liberalization on the environment in an importing country. The results show that the optimal environmental tax in a mixed duopoly is higher than the Pigouvian level and the optimal tax in a pure duopoly. Furthermore, trade liberalization does not alter the environment.

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1. Introduction

It is observed that in many developing and eastern European countries, state-owned enterprises are faced with issues related to poor environmental quality and competition from foreign firms.[1] Although the privatization of such firms is expected to foster environmental benefits as well as greater production efficiency, privatization has been deterred by the poor environmental quality caused by the failure of the centrally planned economies to control pollution. This is because investors are concerned about the potential liability of accumulated environmental contamination and the cost of cleanup (Earnhart 2004). Additionally, such domestic firms are exposed to the dominance of foreign firms within the privatized markets that result from trade liberalization. There is concern that the inflow of foreign firms into these markets leads to the expansion of consumption and production in the importing countries and consequently results in environmental degradation.

This paper investigates the optimal environmental tax and the environmental effect of trade liberalization in a mixed duopoly wherein one public firm competes with one private firm.[2] As a benchmark, we use the study conducted by Lai (2004) to compare the optimal environmental tax before privatization with that after privatization. Lai (2004) considers the case of the environmental damage associated with consumption in a pure duopoly wherein one home private firm competes with one foreign private firm. Although it has been argued that trade liberalization results in the environmental degradation of the importing country,[3] Lai (2004) demonstrates that trade liberalization on the dirty good leads to environmental improvement.

This paper also considers the case of environmentally harmful consumption, as Lai (2004) does. Some examples of consumption-type negative externalities are medical waste and the effluent gas generated by cars and motorbikes. This paper assumes that the public firm's objective is not the maximization of social welfare including environmental damage, but the maximization of the sum of consumer surplus and the firm's profit. This is because the public firm would find it difficult to control the environmental damage as-

[1]For theoretical studies on environment-privatization relations, see Bluffstone and Panayotou (2000), Chimeli (2003), and Ohori (2006). Alternatively, for empirical studies, see Boyd (1996), Anderson and Zylicz (1999), Auer *et al.* (2001), and Lovei and Gentry (2002), among others.

[2]For some analyses of mixed oligopoly models in a foreign context, see Fjell and Pal (1996), Pal and White (1998), and Fjell and Heywood (2002).

[3]For previous theoretical studies regarding the issue, see, for example, Krutilla (1991), Walz and Wellisch (1997), and Damania *et al.* (2003).

sociated with consumption. Experience and empirical evidence also indicate that the public firms in many socialist countries have failed to internalize the negative externality and so degraded the environment although they might have tried to control pollution as well as production in order to justify *socialism* (Lovei and Gentry 2002). Therefore, we adopt this assumption.

In this paper, we find that when pollution is associated with environmentally harmful consumption, the optimal environmental tax rate in the case of a mixed duopoly is higher than both the standard Pigouvian level and the optimal tax rate in the case of a pure duopoly. This result implies that the privatization of the public firm decreases the optimal environmental tax. In addition, trade liberalization does not affect the environment. The remainder of this paper is organized as follows. Section 2 explains the basic model. Section 3 includes the results of the analysis. Section 4 presents conclusions.

2. The model

The present model follows Lai's (2004) basic set-up. Consider one public firm (firm 0) located in a home country and one private firm (firm 1) located in a foreign country. It is assumed that the public firm maximizes the sum of consumer surplus and its own profit, while the private firm maximizes only its profit. The home and foreign firms produce a homogeneous good and compete in the home country's market by choosing their quantity levels. It is assumed that the consumption of the good, given by q_i $(i = 0, 1)$, leads to pollution. Some examples of consumption-type negative externalities are medical waste and the effluent gas generated by cars and motorbikes. The home government sets the environmental tax t to control the pollution that results from environmentally harmful consumption. The aggregate demand for this commodity is represented by the inverse demand curve $p \equiv p(Q)$, where $Q = q_0 + q_1$. Q denotes the aggregate output. We assume $p' < 0$. In order to sharpen the study, it is also assumed that the inverse demand function is linear (i.e. $p(Q) = \alpha - Q$). The profit function of firm i is given as

$$\pi^0 = (p - c_0 - t)q_0 \text{ and} \tag{1}$$

$$\pi^1 = (p - c_1 - t - r)q_1, \tag{2}$$

where c_i is the constant marginal production cost and r is the tariff rate.[4] We assume $r \geq 0$. It is also assumed that the marginal production cost of the

[4]For simplicity, this paper neglects the fixed cost. However, this has no bearing on our discussions.

domestic firm is higher than that of the foreign firm ($c_0 > c_1 > 0$) because public firms are generally less efficient than private firms.[5] Furthermore, this paper considers trade liberalization to be tariff reduction.

The public firm's objective function is defined as the sum of consumer surplus and the firm's profit and is given as

$$U = \int_0^{q_0+q_1} p(\eta)d\eta - pQ + \pi^0. \tag{3}$$

The environmental damage function is given by $D = \theta Q$, where θ denotes the marginal environmental damage. We assume $\theta \geq 1$. It should be noted that an increase in environmentally harmful consumption results in an increase in environmental damage. Social welfare in the home country is thus written as

$$W = \int_0^{q_0+q_1} p(\eta)d\eta - pQ + \pi^0 + tQ + rq_1 - D. \tag{4}$$

The structure of the game is as follows: In the first stage, the government sets the environmental tax, anticipating how firms will react to the policy. In the second stage, each firm strategically sets its output level.

3. Analysis

First, we derive the optimal environmental tax in the mixed duopoly. Under the Cournot-Nash assumption, the domestic firm selects its output in order to maximize the sum of consumer surplus and its own profit U, while the foreign private firm chooses its output in order to maximize its own profit π^1. Differentiating (3) and (2) with respect to each output, we obtain the following first-order conditions:

$$p - p'q_1 - c_0 - t = 0, \text{ and} \tag{5}$$

$$p + p'q_1 - c_1 - t - r = 0. \tag{6}$$

Following this, the output effects of the taxes can be obtained by differentiating (5) and (6) with respect to t and q_i to obtain $\delta q_0/\delta t = 1/p'$ and $\delta q_1/\delta t = 0$. This demonstrates that an increase in the environmental tax reduces the market share of the less efficient public firm. Having obtained the results, it becomes possible to solve the optimal environmental tax in the

[5] See Cremer *et al.* (1989) for a justification of this assumption.

mixed duopoly. Differentiating (4) with respect to t yields

$$\begin{aligned} \frac{dW}{dt} &= \frac{\delta W}{\delta t} + \frac{\delta W}{\delta q_0}\frac{\delta q_0}{\delta t} + \frac{\delta W}{\delta q_1}\frac{\delta q_1}{\delta t} \\ &= q_1 + (t-\theta)\frac{1}{p'}. \end{aligned} \tag{7}$$

By setting $dW/dt = 0$ in (7) and using (5) and (6), we obtain the following optimal environmental tax:[6]

$$t^{MN} = -p'q_1 + \theta = \frac{c_0 - c_1 - r}{2} + \theta. \tag{8}$$

We then state the following proposition.

Proposition 1. *Suppose that the marginal production cost of the domestic firm is higher than that of the foreign firm. In an international mixed duopoly wherein the environmental damage is associated with consumption, the optimal environmental tax is higher than the marginal environmental damage (the standard Pigouvian level).*

As a benchmark, we consider the optimal environmental tax in the pure duopoly. In the regime, each firm selects its output in order to maximize its own profit π^i. Following the same procedure as that for the case of the mixed duopoly, we find the effect of the environmental tax on outputs to be $\delta q_i/\delta t = 1/3p'$. This indicates that setting the environmental tax leads to a decrease in output. After differentiating (4) with respect to t and rearrenging, we obtain the following

$$t^{PN} = \frac{1}{2}(p'q_0 - p'q_1 + 2\theta - r) = \frac{c_0 - c_1}{2} - r + \theta. \tag{9}$$

Clearly, this is the same as the optimal environmental tax rate derived by Lai (2004).

We now turn to a comparison between the optimal environmental taxes. Using (8) and (9), we have

$$t^{PN} - t^{MN} = -\frac{r}{2} < 0. \tag{10}$$

Therefore, we can describe the following proposition:

[6]We use the superscripts MN and PN for the mixed Cournot-Nash and pure Cournot-Nash duopolies, respectively.

Proposition 2. *In an international mixed duopoly wherein the environmental damage is associated with consumption, the optimal environmental tax is higher than that in an international pure duopoly.*

This proposition implies that privatization decreases the optimal environmental tax. The reason is as follows. It should be noted that the domestic public firm is assumed to take into account not only its own profit but also consumer surplus. Then, the public firm in the mixed duopoly has more incentive to increase its production, and hence the pollution, than the private firm in the pure duopoly. Therefore, the government in the mixed duopoly has more incentive to reduce the aggregate output by setting strict environmental tax than the government in the pure duopoly. In other words, increased pressure on the environment due to higher output will strengthen environmental regulation. This is why the optimal environmental tax in the mixed duopoly is higher than the optimal tax in the pure duopoly.

Next, we consider the impact of a change in the tariff rate on the outputs of both the domestic and foreign firms in the mixed duopoly. Differentiating (3) and (2) with respect to r and q_i, we obtain $\delta q_0/\delta r = 0$ and $\delta q_1/\delta r = 1/2p'$, respectively. This indicates that a reduction in the tariff rate leads to an increase in the market share of the foreign firm. We use this result to derive the total impact of trade liberalization on the environment. Differentiating the environmental damage function with respect to r yields

$$\frac{dD}{dr} = \frac{\delta D}{\delta r} + \frac{\delta D}{\delta t}\frac{\delta t}{\delta r} = 0, \tag{11}$$

where $\delta t/\delta r = -1/2$, from equation (8).[7] The first term in the middle section of equation (11) denotes the direct effect on the environmental damage. The second term demonstrates the indirect effect on the environmental damage caused by the positive impact that a decrease in the tariff has on the environmental tax. Equation (11) demonstrates that when considering the indirect effect, a decrease in the tariff rate does not affect the environmental damage on the dirty good because the indirect effect offsets the direct effect by the same amount.

It is important to note that in the pure duopoly, a decrease in the tariff rate will lead to a decrease in the environmental damage associated with

[7]Some papers have discussed the relationship between reductions in trade policy instruments and the level of environmental tax. For example, see Walz and Wellisch (1997). In this paper, we can say that in the mixed duopoly, a tariff reduction increases the aggregate output and hence the pollution, which in turn, leads to an increase in the environmental tax.

consumption because the indirect effect of tariff reduction on the environmental damage exceeds the direct effect, as Lai (2004) demonstrates.[8] The difference between the results for these two regimes implies that from the viewpoint of environmental improvement, tariff reductions should be implemented after privatization. One reason for the difference is that the absolute value of the effect of a change in the tariff on the optimal environmental tax in the mixed duopoly ($\delta t^{MN}/\delta r = -1/2$) is less than that in the pure duopoly ($\delta t^{PN}/\delta r = -1$).

The following proposition summarizes the above discussion.

Proposition 3. *A tariff reduction has no effect on the environmental damage associated with consumption.*

4. Conclusion

Using the simple linear model, we have investigated the optimal environmental tax and trade liberalization in a mixed duopolistic market wherein the environmental damage is associated with consumption. The analysis has yielded some results that differ from those that are obtained in a corresponding pure Cournot duopoly. We have demonstrated that the optimal environmental tax in a mixed duopoly is higher than both the Pigouvian level and the optimal environmental tax in a pure duopoly. This implies that the privatization of the home public firm will decrease the optimal environmental tax. Furthermore, tariff reduction does not affect the environment.

These are robust conclusions because much empirical literature indicates that trade liberalization has not had little impact on the environment by inducing 'race-to-the-bottom' in environmental policies and may even have improved the environment.[9] However, this analysis has been based on the assumptions of the simple linear model and perfect information. Further study is required in the future to extend this simple model to the case of the general demand and cost functions under the agency problem.

[8]Note that in the pure duopoly, the output effect of a change in the tariff rate is shown as $\delta q_0^{PN}/\delta r = -1/3p'$ and $\delta q_1^{PN}/\delta r = 2/3p'$, and the effect of a change in the tariff on the environmental tax is $\delta t^{PN}/\delta r = -1$. Thus, the impact of a change in the tariff on the environment is $dD^{PN}/dr = \theta/3p' + 2\theta/3p'(-1) = -\theta/3p' > 0$.

[9]For the detailed review of the theoretical and empirical literature, see Sturm and Ulph (2002).

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