最適環境政策與關稅保護
Optimal Environmental Policy and Tariff Protection

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中文摘要

廠商的總除污邊際成本對一國政府的最適貿易關稅以及環境污染稅的選擇，有很重大影響。本文研究發現，當總除污邊際成本呈現向下斜曲線時，則如果政府調高進口關稅，其最適環境污染稅也必定要跟著調高。另一方面，當總除污邊際成本呈現向上斜曲線時，則如果政府調高環境污染稅，其最適進口關稅就必須要跟著調高。

關鍵詞：污染控制，最適環境政策，污染排放稅，進口關稅，庫諾競爭

Abstract

A firm's total marginal cost, which is the abatement cost minus the pollution tax payment reduction per unit of abatement investment, plays an important role for a country's trade policy and environmental policy. If the total marginal cost function slopes downward, the optimal emission tax rate increase when the government increases its import tariff. On the other hand, if the total marginal cost function slopes upward, the optimal import tariff increases when the government increases its emission tax rate.

Keywords: pollution control, optimal environmental policy, emission tax, import tariff, Cournot competition

1. Introduction

Under international competitive framework, several papers have done a great contribution. The frontiers of this issue go to Markusen (1975) and Krutilla (1991). They points out that the tariff will distort away form the optimality when there exists emission tax. Similarly, when a county imposes a tariff, the equilibrium emission tax will not be optimal.[1] Copeland (1994), assuming a small open economy, shows the requirements to keep the social welfare unchanged when either tariff or emission tax changes.[2]

Hung (1994) studies the issue under an imperfect competitive international framework. He assumes two countries, with one firm being located in each. To grab a larger market share, the government will lower its emission tax on the domestic firm, which results in a welfare loss. Ludema and Wooton (1994) assumes only the home country consumes the polluting goods, and find that the foreign country will set a higher emission tax in order to persuade the home country to lower its import tariff. When the pollution is crossing border, Copeland (1996) proves that the home country will set a high tariff to reduce the output of the foreign country even though the foreign country has been imposing a higher emission tax rate.

In Perroni and Wigle (1994), empirical studies find that tariff does not influence a country's environmental policy. However, in Indonesia case, Lee and Roland-Holst (1997) using CGE model, proves that international trade may lead to an increase in pollution, depending on the choice of the emission tax.

[1] Krutilla advances the results, and finds that the emission tax is suboptimal under the consideration of tariff.
[2] Others under competitive framework are such as Conrad (1993), Kennedy (1994), and Simpson and Bradford (1996)

In this paper, the home country initially has a polluting oligopoly industry, facing a foreign firm importing the same good. A three-stage game model is set up. The government first chooses the import tariff (t) on the foreign firm as well as the emission tax rate (τ) on the domestic firms, then the domestic firms choose their abatement investment level (a_1 and a_2 for each), finally the all firms in the country choose their output level (q_i, i = 1, 2, 3). This setting differs from the existing literature in several folds. First, the home country industry is initially in an oligopoly market. This will change the competitive behaviors from a single firm in the country. Second, the domestic firms need also choose their abatement investment. The interdependence of a domestic firm's output and abatement investment can be also clarified under the influence of tariff and emission tax. Third, the home country chooses both the domestic emission tax and the import tariff, different from those papers concerning the foreign country's export tariff.

2. The Model

The government choice of the two policies occurs in the first period. In the second period, given the government policies, the domestic firms decide the investment of pollution abatement (a_1 and a_2 for each). The investment, including all kinds of effort and physical inputs for abating pollution, ensues the abatement cost $c(a_i)$ of per unit of product.[3] With this investment, part of the emitting pollutant through producing one unit of good is abated, and only the amount $e(a_i)$ remains. Assume that $c'(a_i) > 0$, $c''(a_i) > 0$, $c'''(a_i) = 0$, $e'(a_i) < 0$, $e''(a_i) > 0$, and $e'''(a_i) = 0$. Let $x(a_i) = c(a_i) + \tau e(a_i)$. It is obvious under our assumption that $x''(a_i) > 0$, and $x'''(a_i) = 0$.

For simplification of analysis in the three-stage game, we will assume the domestic demand function exhibits a linear form: P(Q) = 1-Q, where Q is the market output. Each domestic firm thus has its profit function as the following:

$$®^i = (1-Q)q_i - x(a_i)q_i,$$
$$where\ x(a_i) = c(a_i) - ²e(a_i),\ i = 1,2.$$

The profit function for the foreign firm on the other hand takes the following form:

$$®^3 = (1-Q)q_3 - (y+t)q_3,$$

3. Equilibrium behaviors

In the third stage, the three firms, two domestic firms and one foreign firm, Cournot-competes in home country. Solving for the equilibrium q_i, we have

$$q_i = \frac{1}{3}[-2x(a_i) + x(a_j) + (y+t)],\ i = 1,2$$

$$q_1 = \frac{1}{3}[x(a_1) + x(a_2) - 2(y+t)].$$

By calculating the comparative statics, we can build our first Proposition:

Proposition 1. The domestic quantity will increase while the import quantity will decrease if one of the following conditions occurs:
(a) The import tariff increases;
(b) The emission tax increases;
(c) The abatement investment increases and the marginal tax payment reduction is smaller than marginal abatement cost.

In the second period, the domestic firms choose their own abatement investment levels.[4] To derive the comparative statics, we calculate the determinant Δ of the Jacobian matrix:

[3] To include marginal production cost, we can write the marginal cost function as $c(q_i, a_i)$. In this paper, we assume the marginal production cost as a constant, which is normalized at zero. The function $c(a_i)$ is just the marginal abatement cost.

[4] With abuse of the notation, keep in mind that the notation q_i hereafter represents the third-stage equilibrium quantity. That is, it takes the form: $q_i = q_i(a_1, a_2, t, ²),\ i=1, 2, 3.$

$$\Delta = \frac{1}{3}[q_i x'' - x'^2][q_i x'' - \frac{1}{3}x'^2].$$

By Cramer rules, we can obtain:

$$\frac{da_i}{d²} = -\frac{1}{9}\frac{3q_i e' - xe}{q_i x'' - x'^2} > 0.$$

$$\frac{da_i}{dt} = -\frac{1}{9}\frac{1}{q_i x'' - \frac{1}{3}x'^2} < 0.$$

Proposition 2 is thus build:

Proposition 2. A lower import tariff or a higher emission tax will induce a higher abatement investment of a domestic firm.

4. Optimal government policy

In the first stage, the government would choose its policies to maximize social welfare, which denoted as W is composed of domestic firms' profits, tax revenues, pollution damages, and consumer surplus:

$$W = ®_1 + ®_2 + tq_3 + ²(q_1 + q_2)$$

$$+ \frac{1}{2}(1-Q)Q - d(e_1 + e_2),$$

where d represents the damage measure of the emitting pollutants. The first-order conditions turn out to be:

$$\frac{dW}{dt} = \frac{1}{3}\Big[2(1-Q) - 2x - 6x'\frac{da_1}{dt}$$

$$-2d - 2t + 3q_3 + 2²\Big] = 0.$$

$$\frac{dW}{d²} = \frac{1}{3}\Big[-2e(1-Q) + 2ex - 6x'\frac{da_1}{d²}$$

$$-2ed - 2et + 6q_1 + 2²e\Big] = 0.$$

By some arrangement and calculations, we build the following Proposition:

Proposition 3. If $x' > 0$ and $x''(e + q_1) - \frac{1}{3}x'^2 > 0$, then a higher emission tax rate causes a higher import tariff.

When the total marginal cost function exhibits convexity with a relatively large curvature, ie., when x'^2/x'' is smaller, the unit abatement investment increase will cause a bigger total marginal cost of a firm. If the government increases its emission tax rate, it will cause a domestic firm to increase its abatement investment, and then decrease its output. The industry profit is lost to the foreign firm, and the industry price increases, dissipating the consumer surplus. A tariff increase can force the foreign firm return its profit gain, and thus enhance the social welfare.

Similarly, following the way deriving proposition 3, we can obtain the following Proposition:

Proposition 4. If $x' < 0$, $3q_1 x'' + x' - x'^2 < 0$, and $q_1 + d + t$ is sufficiently large, then a higher import tariff will push the emission tax rate higher.

When import tariff increases, marginal cost of the foreign firm increase, the domestic firms then enjoy a larger market share. To grab the chance of profit increase, the firms should cut their abatement investment. However, more abatement investment means more total marginal cost savings due to $x' < 0$, benefiting the social welfare. Therefore the government will set a higher emission tax rate to force firms put a higher abatement investment.

The damage measure plays a role for influencing the optimal emission tax when the import tariff changes. Its reasoning is similar to the above.

5. Conclusions

With specific linear demand, this paper finds that some findings are coincidental with the traditional wisdom, while some turn out to be different form the existing literature.

When the government decides its import tariff on the foreign firm ass well as the emission tax rate on the domestic firms, they are interdependent. If the total marginal cost slopes upward, i.e., if the tax payment reduction is less than the expenditure per unit of abatement investment, the import tariff will also rise if the government sets a higher emission tax rate, in order to prevent the foreign firm from stealing the welfare

gain. On the other hand, when the total marginal cost function slopes downward, i.e., when the tax payment reduction is greater than the expenditure per unit of abatement investment, the government will also increase its emission tax rate if it increase the import tariff, to prevent the domestic firms from cutting their abatement investment, with more of which reducing more emission, and benefiting the society more.

Moreover, if the total marginal cost slopes downward, the increase of abatement investment will increase the domestic firms' outputs, and will decrease the foreign firm's output on the contrary.

The increase of emission tax rate will always decrease a domestic firm's output, but increases the foreign firm's output. On the contrary, the increase of import tariff always increases the domestic firms' outputs, while decreases the foreign firm's output. Moreover, we observe that the abatement investment will increase when the emission tax rate increases, or when the import tariff decreases.

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