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Abstract

This paper investigates the relation between an export processing zone and a pollution quota in a small country. The model suppose that the pollution target is implemented with a marketable permit system, and the government sets the quota to maximize domestic welfare. Then we show that, if an increase in real income reduces marginal external damage, the pollution quota is relieved by the formation of an export processing zone. However, if the marginal damage is augmented with an increase in the income, the optimal quota might be strengthened by the formation of the zone.

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Keywords: export processing zone, international trade, environmental policy, pollution

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1. Introduction

In most trade negotiations, the difference in economic environments between developed and developing countries has been a source of conflict. Since the interests of developing countries are economic extension and growth, progress in the management of environmental problems is not easy [1]. In order to attain industrialization, developing countries frequently utilize the export processing zone (hereafter, EPZ) as a trade policy measure. By forming an EPZ, these countries partially enjoy the gains from free trade and experience more foreign capital inflow, which can lead to the creation of employment and the acquisition of foreign earnings [2]. Considering that EPZs have been opened in many developing countries, we should direct our attention to the environmental impact of the formation of EPZs, because, if the opening of EPZs attracts foreign firms with clean technology, countries with EPZs might implement looser environment policies. Hence, the purpose of this paper is to examine the welfare effect of the formation of an EPZ in a model involving a negative externality by pollution discharge and to clarify the correlation between the formation of an EPZ and environmental policy.

Since the pioneering work of Hamada (1974), various researchers have published analyses of EPZs [3]. Miyagiwa (1986) analyzes the effects of a subsidy to the EPZ. Young (1987) examines the effects of reducing the tariff on imported intermediate goods into the EPZ. The extension to the nontraded intermediate good is given by Din (1994), and the case where the production technology exhibits variable returns to scale is considered by Yabuuchi (2000). In recent years, the analysis of the EPZ has been generalized by using expenditure and GDP functions. Devereux and Chen (1995) assume a two goods and many factors model, and then point out the importance of the effect of capital inflow on factor prices. Whereas Devereux and Chen (1995) suppose that the final good of the domestic zone (hereafter, DZ) is protected by an import quota, Schweinberger (2003) analyzes the welfare effect of quotas on imported intermediate goods.

Despite these various analyses, as far as we are aware, environmental problems have never been theoretically analyzed under the framework of the EPZ [4]. Hence, we rearrange Young (1987) so that an external diseconomy is involved, and then derive the suggestive proposition. That is, we show that, if the government of the country sets the quota to maximize domestic welfare and the ratio of imported intermediate inputs to pollution levels in the production process of the EPZ is higher than in that of the DZ, the optimal pollution quota is relieved by forming an EPZ.

This paper is organized as follows. Section 2 presents the model. In section 3, we give preliminary comparative static results for the pollution quota and the formation of an EPZ, and we then examine the welfare effects of these policies in section 4. The relation between the formation of an EPZ and the optimal pollution quota is analyzed in section 5. The final section gives concluding remarks.

2. The model

We consider a small open country that establishes an EPZ. Two final goods are produced ($X^i, i =$

[1] There are many studies of trade and the environment, e.g., see Copeland and Taylor (1995, 2003).

[2] See Madani (1999) for a practical discussion of the EPZ.

[3] Although we use the term 'export processing zone' in this paper, there is no single term for such zones; for example, others refer to them as duty free zones, free trade zones, export zones, or special economic zones.

[4] See Copeland (1994) and Beladi et al. (1999) for a discussion of trade and the environment, including the inflow of foreign capital.

1, 2), and the production technology in both sectors exhibits constant returns to scale [5]. We suppose that sectors 1 and 2 correspond to the DZ and the EPZ, respectively. Domestically owned capital is used only in the DZ, and foreign capital inflow is accepted only in the EPZ. Sector specific capital (K^i) and imported intermediate goods (M^i) are used for the production of these goods. Pollution (Z^i) is generated as by-products in their production process. We treat pollution as a factor of production that can move between these sectors. The government of the country regulates the total amount of pollution by a quota ($\bar{Z}$), and pollution permits are traded in the domestic market. In addition, the government imposes an ad valorem tariff (t^i) on the imported intermediate inputs in each sector. Initially, these tariffs are at the same level in both sectors. The formation of an EPZ means that t^2 is reduced to the level below t^1.

In the following analysis, we designate the good of sector 1 as the numeraire, and we denote the relative price of the EPZ's good by p^* [6]. Since we assume that all the markets are perfectly competitive and the technology of both sectors is constant returns to scale, the zero profit conditions are expressed as

$$1 = \rho z^1(\rho, r) + r a_k^1(\rho, r) + q^1 a_m^1, \tag{1}$$

$$p^* = \rho z^2(\rho, r^*) + r^* a_k^2(\rho, r^*) + q^2 a_m^2, \tag{2}$$

where $q^i = (1+t^i)q^*$ denotes the domestic price of the imported intermediate good in each sector, r indicates the rental rate of the domestic capital, and ρ represents the price of the pollution permit. On the other hand, z^i, a_k^i, and a_m^i denote the unit factor requirements of pollution, capital, and imported intermediate goods in each sector, respectively.

Noting that the government regulates the total amount of pollution in the country, and then issues pollution permits, the factor market equilibrium conditions for pollution, domestic capital, foreign capital, and imported intermediate inputs are

$$\bar{Z} = z^1(\rho, r)X^1 + z^2(\rho, r^*)X^2, \tag{3}$$

$$\bar{K} = a_k^1(\rho, r)X^1, \tag{4}$$

$$K^* = a_k^2(\rho, r^*)X^2, \tag{5}$$

$$M^* = a_m^1 X^1 + a_m^2 X^2, \tag{6}$$

where $\bar{K}$ denotes the domestic endowment of capital, which is supplied inelastically, and M^* indicates the level of intermediate imports.

There are six endogenous variables: ρ, r, X^1, X^2, K^*, and M^* from eq. (1) to eq. (6).

3. Preliminary

In this section, we present comparative static results for the pollution quota and the formation of an EPZ by using the above six equations.

3.1. The case of a pollution quota

[5] Throughout this paper, we treat a_m^i as the constant variable in order to simplify our analysis. Moreover, our analysis is simplified by supposing a Leontief production function in each sector.

[6] We attach an asterisk to variables corresponding to the world.

Firstly, we consider the effects of a pollution quota. From eqs (1) and (2), we can confirm that a change in the quota does not affect the permit price and the rental rate of domestic capital. Moreover, from eq. (4), the production of the DZ is also not influenced by the quota. That is, $d\rho/d\bar{Z} = dr/d\bar{Z} = dX^1/d\bar{Z} = 0$. Considering these results, we obtain $dX^2/d\bar{Z} = 1/z^2 > 0$ from eq. (3). An intensification of the pollution quota decreases the EPZ's production only. Hence, noting that a_m^i is fixed from our assumption and $M^i = a_m^i X^i$, the effect on intermediate imports into the EPZ is written as

$$\frac{dM^2}{d\bar{Z}} = a_m^2 \frac{dX^2}{d\bar{Z}} = \frac{a_m^2}{z^2} > 0. \tag{7}$$

Eq. (7) shows that the amount of intermediate inputs imported to the EPZ is reduced by a reinforcement of the pollution quota.

3.2. The case of the formation of an EPZ

Unlike the pollution quota, a reduction in the tariff on the imported intermediate inputs into an EPZ affects the permit price and the rental rate of domestic capital. Totally differentiating eqs (1) and (2), we obtain the following comparative static results:

$$\frac{d\rho}{dt^2} = -q^* \frac{a_m^2}{z^2} < 0, \tag{8}$$

$$\frac{dr}{dt^2} = q^* \frac{a_m^2}{a_k^1} \frac{z^1}{z^2} > 0. \tag{9}$$

On the other hand, considering eqs (8) and (9), the effects on the production of each good are obtained from the total differentiation of eqs (3) and (4). That is:

$$\frac{dX^1}{dt^2} = -\frac{1}{a_k^1} \left(\delta_\rho^k \frac{d\rho}{dt^2} - \delta_r^k \frac{dr}{dt^2} \right) > 0, \tag{10}$$

$$\frac{dX^2}{dt^2} = \frac{1}{z^2} \left\{ \left(\frac{z^1}{a_k^1} \delta_\rho^k + \delta_\rho^z \right) \frac{d\rho}{dt^2} - \left(\frac{z^1}{a_k^1} \delta_r^k + \delta_r^z \right) \frac{dr}{dt^2} \right\} < 0, \tag{11}$$

where $\delta_\rho^k \equiv X^1(\partial a_k^1/\partial \rho), \delta_r^k \equiv -X^1(\partial a_k^1/\partial r), \delta_\rho^z \equiv -X^1(\partial z^1/\partial \rho) - X^2(\partial z^2/\partial \rho)$, $\delta_r^z \equiv X^1(\partial z^1/\partial r)$. All the δ are defined by the positive value. By using these comparative static results, we can derive the effect on the level of intermediate imports. Total differentiation of eq. (6) is given by

$$\frac{dM^*}{dt^2} = \left(\frac{z^1}{a_k^1} \theta \delta_r^k - \frac{a_m^2}{z^2} \delta_r^z \right) \frac{dr}{dt^2} - \left(\frac{z^1}{a_k^1} \theta \delta_\rho^k - \frac{a_m^2}{z^2} \delta_\rho^z \right) \frac{d\rho}{dt^2} < 0, \tag{12}$$

where $\theta \equiv a_m^1/z^1 - a_m^2/z^2$ denotes the relative ratio of the unit factor requirements for the pollution and the imported intermediate inputs in each sector.

Eqs (10) and (11) tell us that the effects of the formation of an EPZ on each product have reverse signs. However, if $\theta < 0$, the EPZ's good is pollution intensive relative to the DZ's good. In this case, when the government reduces the tariff on the EPZ's intermediate inputs, the increasing effect on the products of the EPZ is larger than the decreasing effect on those of the DZ. Therefore, the opening of an EPZ increases the total amount of intermediate imports ($dM^*/dt^2 < 0$).

4. The welfare effects of a pollution quota and the formation of an EPZ

In this section, the welfare effects of a pollution quota and the formation of an EPZ are examined. We take a representative consumer in a country and assume that pollution is a pure public bad for the consumer. The expenditure function that represents the minimum expenditure on final goods is described as $E(p^*, u + \phi(\bar{Z}))$, where u denotes the consumer's utility level [7].

Suppose that the government's revenue from the tariff is redistributed to the domestic households in a lump-sum fashion; the budget constraint of the country is written by

$$E(p^*, u + \phi(\bar{Z})) = X^1 + p^* X^2 - q^1 M^1 - q^2 M^2 - r^* K^* \\ + t^1 q^* M^1 + t^2 q^* M^2. \tag{13}$$

Hence, total differentiation of eq. (13) yields the effects on the utility level as

$$E_u du = (\rho - E_u \phi') d\bar{Z} + t^1 q^* dM^1 + t^2 q^* dM^2, \tag{14}$$

where $E_u \equiv \partial E / \partial u$. Under our assumption for the utility function, $E_u \phi'$ indicates the marginal willingness to pay for pollution reduction, and thus represents the marginal damage caused by pollution. Eq. (14) shows that there are two sorts of distortion in the economy. Since pollution gives the disutility to domestic consumers, the government has to correct not only the tariff distortion but also the external diseconomy.

4.1 The case of the pollution quota

Firstly, the effect of the pollution quota on welfare is derived from Eq. (14) as

$$E_u \frac{du}{d\bar{Z}} = (\rho - E_u \phi') + t^2 q^* \frac{dM^2}{d\bar{Z}}. \tag{15}$$

We have already shown in eq. (7) that the amount of intermediate goods imported into the EPZ is reduced by a reinforcement of the pollution quota, and thus the tariff revenue is decreased. Therefore, if the government sets the pollution quota at the optimal level, the permit price is lower than the marginal damage in order to weaken this effect.

4.2 The case of the formation of an EPZ

Secondly, we investigate the welfare effect of the formation of an EPZ. Although we suppose there is an external diseconomy by pollution discharge, the welfare effect of the tariff reduction follows Young (1987), because the total amount of pollution is unchanged as the policy instrument. Hence, we briefly explain these comparative static results.

Noting that tariffs on both sectors are initially at the same level ($t^1 = t^2$), the welfare effect of the formation of an EPZ is obtained from eq. (14) as

$$E_u \frac{du}{dt^2}\bigg|_{t^1 = t^2} = t^2 q^* \frac{dM^*}{dt^2} < 0. \tag{16}$$

Eq. (16) denotes that an improvement in welfare depends on whether the total amount of intermediate imports increases. However, we have already confirmed in eq. (12) that if, $\theta < 0$, a reduction in the tariff on the EPZ's intermediate inputs increases the total amount of intermediate imports. Hence, the welfare of the country is improved by the growth of the tariff revenue.

[7] We assume that the utility function is additive separable in the consumption bundle and pollution, and that the damage function $(\phi(\bar{Z}))$ has the following properties: $\phi'(\bar{Z}) > 0, \phi''(\bar{Z}) > 0$.

5. The formation of an EPZ and the optimal pollution quota

In this section, we examine the effect that the formation of an EPZ has on the pollution quota. In order to make the analysis, we suppose that the tariff of both sectors is initially at the same level and that the government of the country executes the optimal pollution quota.

Given $\bar{Z}, t^1$, and t^2, we obtain the utility level of the country from eq. (13). Note that a change in the quota does not affect the permit price and the rental rate of capital. Then, substituting eq. (7) into eq. (15), the optimal quota that implements welfare maximization satisfies the following condition:

$$A_z(\bar{Z}, t^1, t^2) \equiv B(t^1, t^2) - E_u[u(\bar{Z}, t^1, t^2) + \phi(\bar{Z})]\phi'(\bar{Z}) = 0, \tag{17}$$

where $B(t^1, t^2)$ is defined as

$$B(t^1, t^2) \equiv \rho(t^1, t^2) + t^2 q^* \frac{a_m^2}{z^2[\rho(t^1, t^2), r^*]}. \tag{18}$$

The first term of $B(t^1, t^2)$ is the permit price, which is equal to the value of the marginal product of emission in a competitive market. The second term represents the effect of the pollution quota on tariff revenue. Hence, eq. (17) means that the domestic pollution quota is chosen so that the marginal damage equals the sum of the permit price and the change in the tariff revenue. In other words, since a decrease in the pollution quota reduces the amount of intermediate inputs imported into the EPZ, the permit price is lower than the marginal damage.

From eq. (17), the effect of the formation of an EPZ on the optimal quota is given by

$$\frac{d\bar{Z}}{dt^2} = -\frac{A_{zt^2}}{A_{zz}}, \tag{19}$$

where subscripts z and t^2, which are attached to A_z, denote the partial derivatives by $\bar{Z}$ and t^2, respectively [8]. Since the quota does not influence the permit price, the denominator A_{zz} in eq. (19) is written as

$$A_{zz} = -\{E_{uu}(\phi')^2 + E_u\phi''\}. \tag{20}$$

The sign of E_{uu} closely depends on the shape of the utility function. Although we do not assume the sign, $A_{zz} < 0$, from the second-order condition of welfare maximization.

On the other hand, noting that $\rho_{t^2} = -q^* a_m^2 / z^2$ in eq. (8), A_{zt^2} is derived from eq. (17) as

$$A_{zt^2} = -E_{uu}\phi' u_{t^2} + B_{t^2}, \tag{21}$$

where B_{t^2} denotes the partial derivative by t^2, and is expressed by

$$B_{t^2}(t^1, t^2) = -\frac{t^2 q^* a_m^2 z_\rho^2 \rho_{t^2}}{(z^2)^2} < 0. \tag{22}$$

Eq. (21) shows that the influence of the formation of an EPZ on the optimal pollution quota is classified into two effects. The first term of the right hand side indicates the effect on the marginal damage that is caused through a change in the income. Although the opening of an

[8] We use the same subscripts in B, u, ρ, and r.

EPZ improves welfare by the growth of the tariff revenue, the improvement is tied to the change in marginal damage. This effect is closely related to the sign of E_{uu}. The second term denotes the effect on intermediate inputs into the EPZ. An intensification of the pollution quota decreases the EPZ's intermediate imports. However, since the tariff reduction raises the permit price and thus decreases the unit factor requirement for EPZ's pollution, the marginal revenue of the tariff is augmented by the opening of an EPZ ($B_{t^2} < 0$).

Hence, if E_{uu} is nonpositive ($E_{uu} \leq 0$), we can derive the definite relation between the optimal quota and the opening of an EPZ from eq. (21).

Proposition 1: *Suppose that the tariff on both sectors is initially at the same level and the government of the country executes the optimal pollution quota. In this case, if $\theta < 0$ and $E_{uu} \leq 0$, the formation of an EPZ relieves the optimal pollution quota.*
(Proof): $\rho_{t^2} < 0$ from eq. (17). If $\theta < 0$ and initially $t^1 = t^2$, $u_{t^2} < 0$ from eqs (12) and (16). Hence, if $E_{uu} \leq 0$, we can obtain $A_{zt^2} < 0$ in eq. (23), and then $d\bar{Z}/dt^2 < 0$. (Q.E.D.)

Fig. 1 denotes the determination of the pollution quota. The marginal damage is equal to the sum of the permit price and the change in tariff revenue. As shown in eq. (18), $B = \rho + t^2 q^* a_m^2 / z^2$ does not depend on the level of pollution quota; thus, the formation of an EPZ increases the marginal tariff revenue ($B_{t^2} < 0$). Hence, the horizontal line B^0 shifts up to B^1 with the opening. On the other hand, $E_u \phi'$ in eq. (17) denotes the marginal damage caused by pollution. Since the damage is augmented by a relaxation of the pollution quota, the line MD slopes upward. Moreover, if $E_{uu} < 0$, the damage is decreased with an increase in income. Hence, when the government of the country opens an EPZ, the line MD^0 moves to MD^1 in Fig. 1. As a result, the formation of an EPZ definitely loosens the optimal pollution quota from $\bar{Z}^0$ to $\bar{Z}^1$. If $E_{uu} = 0$, the line MD^0 does not shift. However, since the increasing effect of the marginal tariff revenue remains, the optimal pollution quota is moved to $\bar{Z}'^0$.

Finally, we note that, if $E_{uu} > 0$, there is a possibility that the optimal quota is strengthened by the formation of an EPZ, because the marginal damage is swollen with an increase in the income. In this case, although two effects of the opening of an EPZ have reverse signs in eq. (21), we can derive the sufficient condition for the optimal pollution quota to be reinforced.

Substituting eqs (12), (16) and (20) into (21), A_{zt^2} is written as

$$A_{zt^2} = \Omega + \frac{t^2 q^* a_m^2 z_\rho^2 \rho_{t^2}}{(z^2)^2} \left(\frac{E_{uu}}{E_u} \phi' Z^2 - 1 \right), \tag{23}$$

where $Z^2 = z^2 X^2$, and Ω is defined by

$$\Omega \equiv -\frac{E_{uu}}{E_u} t^2 q^* \phi' \left\{ \left(\frac{z^1}{a_k^1} \theta \delta_r^k - \frac{a_m^2}{z^2} \delta_r^z \right) r_{t^2} - \left(\frac{z^1}{a_k^1} \theta \delta_\rho^k + \frac{a_m^2}{z^2} X^1 z_\rho^1 \right) \rho_{t^2} \right\} > 0. \tag{24}$$

Ω is positive from $\rho_{t^2} < 0$, $r_{t^2} > 0$, $E_{uu} > 0$, and $\theta < 0$. Hence, in eq. (23), if $E_{uu} \phi' Z^2 / E_u \geq 1$, we obtain $A_{zt^2} > 0$. In order to clarify the meaning of the sufficient condition, we rearrange the condition as

$$\frac{E_{uu}}{E_u} \phi' Z^2 - 1 = \epsilon_u \epsilon_z \beta_u \beta_z - 1 \geq 0. \tag{25}$$

E_u is the inverse of the marginal utility of income, and then we define the elasticity of E_u as $\epsilon_u \equiv (u + \phi)E_{uu}/E_u$, where $\epsilon_u > 0$ under the assumption $E_{uu} > 0$. $\epsilon_z \equiv \bar{Z}\phi'/\phi$ denotes the elasticity of ϕ. Since we assume that $\phi' > 0$ and $\phi'' > 0$, as long as the pollution discharge is not zero, $\epsilon_z > 1$. Moreover, $\beta_u \equiv \phi/(u + \phi) < 1$ indicates the share of the external damage to the utility level and $\beta_z \equiv Z^2/\bar{Z} < 1$ denotes the share of the pollution discharged from sector 2 to the aggregate pollution. Hence, if $\epsilon_u\epsilon_z > 1/(\beta_u\beta_z)$ in eq. (25), we can get $A_{zt^2} > 0$ from eq. (23).

Under the assumption $E_{uu} > 0$, when the formation of an EPZ increases the income of a country, the marginal damage is also increased. Thus, the larger the value of ϵ_u, the greater the effect of income on marginal damage. Similarly, when the value of ϵ_z is above one, the effect of the quota on marginal damage is emphasized further. Therefore, if the value of these elasticities is sufficiently large, the optimal pollution quota might be reinforced. The line MD^2 in Fig. 1 corresponds to this case. If $\epsilon_u\epsilon_z\beta_u\beta_z \geq 1$, the government definitely strengthens the optimal pollution quota to $\bar{Z}^2$.

6. Concluding Remarks

We have rearranged the model of the EPZ so that an external diseconomy is included, and then shown the relation between the formation of an EPZ and the optimal pollution quota. Further research is required in the following areas. Firstly, as mentioned in the introduction, there are various models for analyzing the EPZ. Therefore, we need to investigate whether our conclusion is also obtained with other frameworks. Secondly, to sharpen the focus, we supposed that the unit factor requirements for the intermediate good are fixed in each sector. However, in order to generalize our analysis, we must consider the case where these coefficients are allowed to be variable. Thirdly, we assume that all the markets including the pollution permit are perfectly competitive. Hence, it would be interesting to see how our result is modified under imperfect competition.

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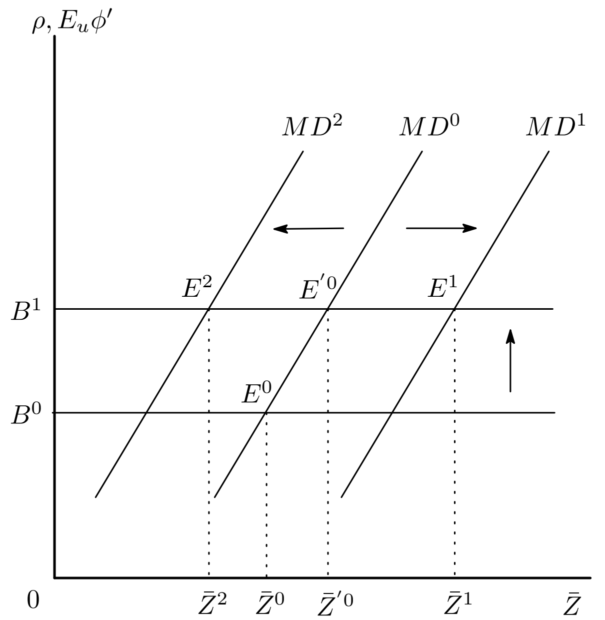

Fig. 1. The determination of the optimal pollution quota