E C O N O M I C S   B U L L E T I N

Export Processing Zones and Environmental Policy

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Abstract

In this paper, we consider the impact of establishing export processing zones on environmental policy. The model assumes that aggregate pollution is regulated by a quota so as to maximize domestic welfare, and the pollution target is implemented with a marketable permit system. We show that the emission quota may be strengthened with the formation of the zone even if firms located in the export processing zone have cleaner technology than those in the domestic zone.

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1 Introduction

To promote economic development, developing countries frequently establish export processing zones (hereafter, EPZs). By establishing EPZs, these countries can attract foreign capital, alleviate unemployment, and encourage the introduction of advanced technology. While their main concern is economic expansion and growth, environmental protection is not given a high priority. Developing countries are disinclined to undertake severe environmental policies because the policies raise domestic production costs and reduce international competitiveness. However, if the formation of the EPZ attracts foreign firms with clean technology, countries with EPZs could implement more lax environmental policies. Hence, it is important to investigate the environmental impact of the formation of EPZs. [1]

Since the pioneering work of Hamada (1974), various researchers have published analyses of EPZs. 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 incorporate nontraded intermediate goods is given by Din (1994), and Devereux and Chen (1995) investigate the case of three goods and many factors. Facchini and Willmann (1999) show that a duty free zone regime is Pareto-superior to free trade with a Dixit-Norman tax scheme, but Pareto-inferior to free trade with a lump sum redistribution scheme. Yabuuchi (2000) generalizes Din (1994) by incorporating variable returns-to-scale technology. While Devereux and Chen (1995) assume that one of the final goods produced in the domestic zone (hereafter, DZ) is protected by an import quota, Schweinberger (2003) analyzes the establishment of EPZs in a case where imported intermediate goods are regulated by quotas. [2]

The purpose of this paper is to examine the effect of creating an EPZ on the environment, and then to clarify the relation between the formation of the EPZ and environmental policy. Despite above various analyses, as far as the authors are aware, environmental problems have never been theoretically analyzed in an EPZ model. Hence, we introduce an external diseconomy, and investigate the influence of the formation of an EPZ on the level of an emission quota. We then show that, in our model, the emission quota may be strengthened by establishing the EPZ even if the EPZ's sector is less pollution intensive relative to the DZ's sector.

The paper is organized as follows. In Section 2, we present the model. Some comparative static results for the emission quota and the formation of an EPZ are given in Section 3. We then examine the welfare effects of these policies in Section 4. The relation between the formation of an EPZ and the optimal emission quota is analyzed in Section 5. The final section provides some concluding remarks.

[1] E.g., see Copeland (1994), Beladi et al. (1999), and Chao and Yu (2004) for a discussion of environmental regulation and international capital movements.

[2] Moreover, see Young and Miyagiwa (1987) and Datta Chaudhuri and Adhikari (1993) for the effects of establishing an EPZ in a country suffering unemployment.

2 The model

We consider a small open country that establishes an EPZ. Two final goods are produced ($X^i, i = 1, 2$). Production in each sector is assumed to exhibit constant returns-to-scale. We assume that sector 1 and sector 2 correspond to the DZ and the EPZ, respectively. Domestic capital is used only in the DZ, and foreign capital is accepted only in the EPZ. Pollution is generated as a by-product of their production processes. We treat pollution emissions as a factor of production that can move between these sectors. [3] Hence, each good is produced with sector-specific capital (K^i) and an imported intermediate good (M^i) in addition to the amount of pollution (Z^i). We specify the production function for X_i as $X_i = \min\{F^i(Z^i, K^i), M^i/a^i_m\}$, [4] where F^i satisfies the neoclassical properties.

The government of the country regulates the overall supply of pollution emissions by a quota ($\bar{Z}$), and emission permits are traded in the domestic market. [5] In addition, the government imposes an ad valorem tariff (t^i) on the imported intermediate good in each sector. Initially, these tariffs are at the same level in both sectors. We define the formation of an EPZ as a reduction in t^2 with keeping t^1 constant.

In the following analysis, we designate good 1 as the numeraire and denote the relative price of good 2 by p^*. Since we assume that the country is small and production in each sector exhibits constant returns-to-scale, the zero-profit conditions are expressed as:

$$1 = \rho z^1(\rho, r) + r a^1_k(\rho, r) + q^1 a^1_m, \tag{1}$$
$$p^* = \rho z^2(\rho, r^*) + r^* a^2_k(\rho, r^*) + q^2 a^2_m, \tag{2}$$

where ρ represents the price of emission permits, r and r^* indicate the rental rates of domestic capital and foreign capital, and q^* is the world price of the intermediate good, and thus $q^i(= (1+t^i)q^*)$ means the domestic price of the intermediate good in each sector. On the other hand, z^i, a^i_k, and a^i_m denote the unit factor requirements of pollution, capital, and the intermediate good in each sector, respectively.

Noting that the government imposes the emission quota, the factor market equilibrium conditions for pollution, domestic capital, foreign capital, and the intermediate good are:

$$\bar{Z} = z^1(\rho, r)X^1 + z^2(\rho, r^*)X^2, \tag{3}$$
$$\bar{K} = a^1_k(\rho, r)X^1, \tag{4}$$
$$K^* = a^2_k(\rho, r^*)X^2, \tag{5}$$
$$M^* = a^1_m X^1 + a^2_m X^2, \tag{6}$$

[3]See Copeland and Taylor (2003) for details of production and pollution abatement technologies.

[4]Our results are retained in the case where a^i_m is variable, as long as we set appropriate assumptions about the substitutability or the complementarities among the three factors.

[5]Ishikawa and Kiyono (2006) examine how emission quotas, emission taxes, and emission standards affect a country's production and trade structures.

where $\bar{K}$ represents the domestic endowment of capital that is inelastically supplied. K^* and M^* denote the inflow of foreign capital and the aggregate supply of the intermediate good, respectively.

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

3 Preliminary results

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

First, we consider the effects of an emission quota. From (1) and (2), a change in the quota does not affect the permit price and the rental rate of domestic capital, and from (4), the level of output in the DZ is also not influenced by the quota; thus $d\rho/d\bar{Z} = dr/d\bar{Z} = dX^1/d\bar{Z} = 0$. Considering these results, we obtain $dX^2/d\bar{Z} = 1/z^2 > 0$ from (3). That is, the emission quota decreases only the EPZ's production. Hence, the effect on the total amount of intermediate imports is written as:

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

The emission quota reduces the overall supply of the intermediate good via a decrease in this good imported into the EPZ.

Second, we examine the effects of the formation of an EPZ. Unlike the emission quota, a reduction in the tariff rate t^2 accompanying the formation of an EPZ affects the permit price and the rental rate of domestic capital. Specifically, these effects are given by total differentiation of (1) and (2):

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

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

Considering (8) and (9), the impacts on the levels of outputs in the DZ and EPZ are obtained from (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 $\delta_\rho^k \equiv X^1(\partial a_k^1/\partial \rho), \delta_r^k \equiv -X^1(\partial a_k^1/\partial r), \delta_\rho^z \equiv -X^1(\partial z^1/\partial \rho) - X^2(\partial z^2/\partial \rho)$, and $\delta_r^z \equiv X^1(\partial z^1/\partial r)$. Every δ is defined by the positive value.

Moreover, totally differentiating (6), and then substituting the above comparative static results, we can derive the influence on the total amount of intermediate imports as:

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

where $\theta \equiv a_m^1/z^1 - a_m^2/z^2$ consists of the ratio of pollution to the intermediate good in each sector.

(10) and (11) show that the effects of the formation of an EPZ on each product have reverse signs. However, if $\theta < 0$, that is, the DZ's sector is pollution intensive relative to the EPZ's sector, the impact of a reduction in the tariff rate t^2 on the level of output in the EPZ is larger than that in the DZ. Therefore, the introduction of an EPZ increases the total amount of intermediate imports. In the following analysis, we assume $\theta < 0$.

4 The welfare effects of an emission quota and the formation of an EPZ

In this section, we examine the welfare effects of an emission quota and the formation of an EPZ.

We take a representative consumer in the country. Pollution is a pure public bad for the consumer. We assume that the utility function is strongly separable in the consumption bundle and pollution, and is expressed as $U = u(C^1, C^2) - \phi(\bar{Z})$, where C^i denotes the consumption of each good and $\phi(\bar{Z})$ is a function that stands for the damage received from the pollution. [6] In this case, the expenditure function that represents the minimum expenditure on final goods is described as $E(p^*, \tilde{U})$, where $\tilde{U} \equiv U + \phi(\bar{Z})$.

Suppose that the government redistributes the tariff revenue to domestic households in a lump-sum fashion. The budget constraint of the country is written as:

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

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

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

where $E_{\tilde{u}} \equiv \partial E/\partial\tilde{U}$. $E_{\tilde{u}}\phi'$ indicates the marginal willingness to pay for pollution reduction, and thus represents the marginal damage caused by pollution. (14) shows that there are two sorts of distortion in the economy. Since pollution gives disutility to domestic consumers, the government has to correct not only the distortion of tariffs but also the external diseconomy.

First, the effect of the emission quota on welfare is derived from (14) as:

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

[6]The damage function has the following properties: $\phi'(\bar{Z}) > 0, \phi''(\bar{Z}) > 0$.

We have already shown in (7) that a reinforcement of the emission quota decreases the imported intermediate goods into the EPZ and then reduces tariff revenue. If the government sets the quota to the level by which welfare is maximized, the permit price is lower than the marginal damage in order to weaken the effect.

Second, we investigate the welfare effect of the formation of an EPZ. The welfare effect of the tariff reduction follows Young (1987) because the aggregate level of emissions is given as the policy instrument. Hence, we briefly explain the welfare effect.

Noting that the 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 (14) as:

$$E_{\tilde{u}} \frac{dU}{dt^2}\bigg|_{t^1=t^2} = t^2 q^* \frac{dM^*}{dt^2} < 0. \tag{16}$$

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

5 The formation of an EPZ and the optimal emission quota

In this section, we examine the effect that the formation of an EPZ has on the emission quota. To enable the analysis, we assume that the tariff of both sectors is initially at the same level, and that the government of the country executes the optimal emission quota.

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

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

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 emissions in a competitive market. The second term represents the effect of the emission quota on tariff revenue. Hence, (17) means that the emission quota is chosen in a way that the marginal damage equals the sum of the permit price and the change in the tariff revenue.

From (17), the effect of creating 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 differentiations with respect to $\bar{Z}$ and t^2, respectively. [7] Since the quota does not influence the permit price, the denominator A_{zz} in (19) is written as:

$$A_{zz} = -\{E_{\tilde{u}\tilde{u}}(\phi')^2 + E_{\tilde{u}}\phi''\} < 0, \tag{20}$$

where $E_{\tilde{u}\tilde{u}} \equiv \partial^2 E/\partial \tilde{U}^2$. $A_{zz} < 0$ from the second-order condition of welfare maximization. On the other hand, noting that $\rho_{t^2} = -q^* a_m^2/z^2$, from (17), the numerator A_{zt^2} in (19) is expressed as:

$$A_{zt^2} = -E_{\tilde{u}\tilde{u}}\phi' U_{t^2} + B_{t^2}. \tag{21}$$

In above equation, B_{t^2} is derived from (18):

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

where $z_\rho^i \equiv \partial z^i/\partial \rho < 0$.

(21) tells us that the influence of the formation of an EPZ on the optimal emission quota is classified into two effects. The first term on the right-hand side indicates the effect on the marginal damage caused through a change in real income. Although establishing the EPZ increases the utility level via the growth of tariff revenue, the increase leads to a change in the marginal damage. Generally, the marginal damage is increasing in real income, because environmental quality is a normal good. In this case, the utility function is strictly concave ($E_{\tilde{u}\tilde{u}} > 0$). then the formation of the EPZ raises the marginal willingness-to-pay for pollution reduction. Therefore, the first term in (21) has the effect of making the emission quota severe.

The second term denotes the influence on intermediate inputs into the EPZ. An intensification of the emission 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 tariff revenue is augmented by establishing an EPZ as shown in (22). Hence, the second term acts in the direction where the optimal quota is relaxed.

Note that, if $E_{\tilde{u}\tilde{u}} > 0$, two effects of the opening of an EPZ have reverse signs in (21). However, we can derive the sufficient condition for the optimal emission quota to be reinforced. Substituting (12), (16), and (22) into (21), A_{zt^2} is written as:

$$A_{zt^2} = \Omega + \frac{t^2 q^* a_m^2 z_\rho^2 \rho_{t^2}}{(z^2)^2}\left(\beta_u \beta_z \epsilon_u \epsilon_z - 1\right), \tag{23}$$

[7] We use the same subscripts for the partial derivatives of B, U, ρ, and r.

where we define the elasticity of $E_{\tilde{u}}$ as $\epsilon_u \equiv \tilde{U}E_{\tilde{u}\tilde{u}}/E_{\tilde{u}}$, where $\epsilon_u > 0$ under the assumption $E_{\tilde{u}\tilde{u}} > 0$. $\epsilon_z \equiv \bar{Z}\phi'/\phi$ 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, $\beta_u \equiv \phi/\tilde{U} < 1$ 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. On the other hand, Ω is defined by:

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

where Ω is positive from $E_{\tilde{u}\tilde{u}} > 0$, $\theta < 0$, $\rho_{t^2} < 0$, and $r_{t^2} > 0$.

Therefore, if $\beta_u\beta_z\epsilon_u\epsilon_z \geq 1$ in (23), we can get $A_{zt^2} > 0$, then $d\bar{Z}/dt^2 > 0$.

Proposition: *Suppose that the DZ's sector is pollution intensive relative to the EPZ's sector, and environmental quality is a normal good. In this case, if $\beta_u\beta_z\epsilon_u\epsilon_z \geq 1$, the formation of an EPZ reinforces the optimal emission quota.*

Figure 1 denotes the determination of the emission quota. The marginal damage is equal to the sum of the permit price and the change in tariff revenue ($E_{\tilde{u}}\phi' = B$). As shown in (18), B does not depend on the emission quota; thus, the formation of an EPZ increases only the marginal tariff revenue. This effect shifts up the horizontal line B^0 to B^1. On the other hand, since the marginal damage is augmented by a relaxation of the emission quota, the line MD slopes upwards. Moreover, if $E_{uu} > 0$, an increase in income raises the damage. Thus, the line MD^0 moves to MD^1 by a reduction in the tariff rate t^2.

In the sufficient condition $\beta_u\beta_z\epsilon_u\epsilon_z \geq 1$, the larger the values of ϵ_u and ϵ_z, the more the effects on the marginal damage grow. Therefore, if these elasticities are sufficiently large, the formation of the EPZ makes the emission quota severer from $\bar{Z}^0$ to $\bar{Z}^1$.

6 Concluding remarks

We have extended a model of the EPZ so that an external diseconomy is included, and then demonstrated the relation between the formation of an EPZ and the optimal emission quota. Our analysis reveals that the emission quota may be strengthened by establishing the EPZ even if the EPZ's sector is less pollution intensive relative to the DZ's sector. Further research is required in the following areas.

First, as discussed in the Introduction, there are various models for analyzing EPZs. In particular, one of the main reasons developing countries establish these zones is to alleviate unemployment. Therefore, we need to investigate whether our conclusion is also obtained in a model where unemployment exists.

Second, we assumed that all the markets including that for pollution permits are perfectly competitive. It would then be interesting to see how our results are modified under imperfect competition.

References

[1] Beladi, H., C. C. Chao, and R. Frasca (1999), "Foreign Investment and Environmental Regulations in LDCs," *Resource and Energy Economics* 21: 191–199.

[2] Chao, C. C. and E. S. H. Yu (2004), *Environmental Policy, International Trade, and Factor Markets*, Amsterdam: Elsevier.

[3] Copeland, B. R. (1994), "International Trade and the Environment: Policy Reform in a Polluted Small Open Economy," *Journal of Environmental Economics and Management* 26: 44–65.

[4] Copeland, B. R. and M. S. Taylor (2003), *Trade and the Environment*, Princeton: Princeton University Press.

[5] Datta Chaudhuri, T. and S. Adhikari (1993), "Free Trade Zone with Harris-Todaro Unemployment," *Journal of Development Economics* 41: 157–162.

[6] Devereux, J. and L. L. Chen (1995), "Export Zones and Welfare: Another Look," *Oxford Economic Papers* 47: 704–713.

[7] Din, M.-U. (1994), "Export Processing Zone and Backward Linkages," *Journal of Development Economics* 43: 369–385.

[8] Facchini, G. and G. Willmann (1999), "The Gains from Duty Free Zones," *Journal of International Economics* 49: 403–412.

[9] Hamada, K. (1974), "An Economic Analysis of the Duty Free Zone," *Journal of International Economics* 4: 225–241.

[10] Ishikawa, J. and K. Kiyono (2006), "Greenhouse-Gas Emission Controls in an Open Economy." *International Economic Review* 47, 431–450.

[11] Miyagiwa, K. (1986), "A Reconsideration of the Welfare Economics of a Free-Trade Zone," *Journal of International Economics* 21: 337–350.

[12] Schweinberger, A.G. (2003), "Special Economic Zones and Quotas on Imported Intermediate Goods: A Policy Proposal," *Oxford Economic Papers* 55: 696–715.

[13] Yabuuchi, S. (2000), "Export Processing Zone, Backward Linkages, and Variable Returns to Scale," *Review of Development Economics* 4: 268–278.

[14] Young, L. (1987), "Intermediate Goods and the Formation of Duty-Free Zones," *Journal of Development Economics* 25: 369–384.

[15] Young, L. and K. Miyagiwa (1987), "Unemployment and the Formation of Duty-Free Zones," *Journal of Development Economics* 26: 397–405.

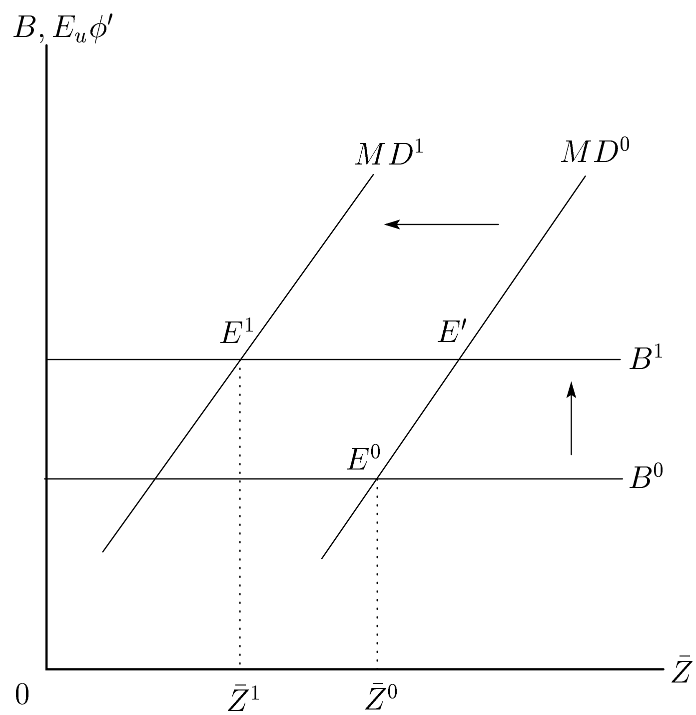

Figure 1: The determination of the optimal emission quota