

Environmental Impacts on Optimal Trade Policies

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Abstract: This paper examines the impacts of tightening environmental regulations on optimal trade and investment policies. We find that for a small open two-sector economy with an importable sector relying on foreign capital while emitting pollution, a more stringent environmental measure leads to a higher optimal tariff and possibly a higher optimal tax on foreign capital. This result holds whether or not there are capital tax credits in the foreign country. When such tax credits are in place in the foreign country, three possible cases regarding the domestic capital tax rate relative to the foreign rate are identified and examined. In one such case, multiple equilibria of optimal policies may exist.

1. Introduction

Liberalizing trade barriers has been the single major item discussed during numerous rounds of trade negotiations over the last two decades. Negotiations are particularly intense between the advanced industrialized nations and the developing/newly emerging countries. A notable example in the arena of the North-South trade negotiation is the bilateral trade agreement that was finally reached in November 1999 between the U.S. and China to pave the way for China to join the World Trade Organization (WTO). A key feature in the agreement is China's pledge to reduce industrial tariffs from 21 percent to 17 percent and agricultural duties to 15 percent in addition to opening the door wider to welcome foreign investment.

Almost concomitant with trade liberalization is the increasing outcry for environmental preservation especially in the advanced nations. Sustainable growth has become a vital goal for many countries that were signatories of the declaration reached at the 1992 Earth Summit meeting held in Brazil. It is noteworthy that free-trade advocates believe that trade liberalization promotes competition and enhances productivity leading to a win-win situation for all economies. Advocates also

claim that freer trade is conducive to environmental protection, as growth and higher living standards increase the general public's consciousness concerning the environment as they pursue a better quality of life.

In contrast to the free trade advocates, protectionists are concerned about the inability of firms in the developing countries to compete with foreign firms. They believe that protection is warranted from imports that compete with local firms. Furthermore, they worry that increasingly stringent environmental regulations will scare away foreign investors, decreasing job opportunities for local workers. Meanwhile, environmental activists express serious concern about marine destruction, widespread pollution and global warming resulting from trade and investment liberalization and globalization. In fact, the environmentalists, regarded as a kind of veiled protectionists, caught the media's attention by staging violent street protests that disrupted recent WTO meetings in Seattle at the end of 1999 and in Washington D.C. in April, 2000.

Apparently, there are extensive connections between trade and investment policies and environmental regulations. The issue of the interrelationship between freer trade, more international investment and better

environment is expected to become a major topic for discussion and deliberation at the future WTO meetings. The purpose of this paper is to make a modest contribution to identify possible interactions between trade liberalization and the environment in the presence or absence of tax credits. In particular, we will examine the impact of tightening environmental regulations on optimal trade and investment policies.¹ We find that for a small open two-sector economy with the importable sector using foreign capital and emitting pollution, more stringent environmental measures lead to a higher optimal tariff and possibly a higher optimal tax on foreign capital. This result may hold when tax credits on capital earnings are introduced in the foreign country.

The organization of this paper is as follows. Section 2 introduces a two-sector, specific-factor general equilibrium model for a small open, capital-importing economy. The assumptions and salient features of the model are delineated. The individually optimal as well as jointly optimal trade and investment policies in terms of tariff and capital tax respectively are derived and illustrated. The impact of a change in environmental regulation on the jointly optimal trade and investment policies is ascertained. The analysis in this section is relatively straightforward; it is conducted to set the stage for analyzing a set of more complex scenarios when tax credits become available for foreign capital in the foreign country. This is done in section 3 where three possible cases regarding whether a domestic tax or subsidy is levied on foreign capital and in the former case whether the domestic tax rate is higher or lower than the foreign rate. Multiple equilibria of optimal trade and investment policies are identified when a domestic subsidy is given to foreign capital. Finally, concluding remarks are presented in section 4.

2. The Two-Sector, Specific Factor Model with Foreign Investment

Consider a small open, capital-importing economy which produces two types of traded goods, agriculture X_1 and manufacturing X_2 , and a pollutant Z by using labor, capital and land. While labor is intersectorally mobile, capital and land are sector specific. The production functions of X_1 and X_2 , respectively, are:

$$X_1 = X_1(L_1, T),$$

$$X_2 = X_2(L_2, K),$$

where L_i is labor employed in sector i ($i = 1, 2$), T is

land specific to X_1 , and K is foreign capital specific to X_2 . Capital is mobile internationally and labor is mobile only domestically. The manufacturing sector is the polluting industry which generates a pollutant, Z , as a by-product in producing X_2 .² Pollution harms consumers and lowers social welfare. The home government therefore imposes a pollution tax at the rate, s , on the pollutant emitted by sector 2.³ In addition, the home country also imposes a tariff on imports and a tax on foreign capital.

The home country is assumed to export good 1 and import good 2. Choosing good 1 as the numeraire, the home price of good 2, p , is equal to the foreign price, p^* , plus the specific tariff rate, t . The value of total domestic production can be represented by the revenue function:

$$G(1, p, s, K) = \max \{X_1(L_1, T) + pX_2(L_2, K) - sZ : L_1 + L_2 = L\},$$

where L is the endowment of labor. As labor (L) and land (T) are fixed, they are conveniently suppressed in the above revenue function. The usual properties of the revenue function prevail; namely, $G_p = X_2$, being the supply of X_2 , and $G_s = -Z$, denoting the pollution emission. Note that $G_K = p(\partial X_2 / \partial K)$, the value of the marginal product of capital, is equal to the domestic rate of capital return, denoted by r . A tax at rate t is imposed on capital, and the net return on foreign capital is therefore $r - t$.

The demand side of the economy is represented by the aggregate expenditure function:

$$E(1, p, Z, u) = \min \{C_1 + pC_2 : u(C_1, C_2, Z) = u\},$$

where u is the social utility function and $E_u > 0$. Here, $E_p = C_2$, being the demand for good 2. As pollution adversely affects utility, we have $\partial u / \partial Z < 0$. To maintain the same level of utility, more consumption on goods is needed for compensating the loss due to pollution, rendering $E_Z > 0$. While the sign of $E_{pZ} = \partial C_2 / \partial Z$ is a priori indeterminate, we assume for concreteness that $E_{pZ} < 0$; i.e., the consumption of good 2 decreases with an increase in the pollution level.⁴

Utilizing the above production and demand information, the home economy can be succinctly described by the following equations:

$$E(1, p, Z, u) = G(1, p, s, K) + tM + tK + sZ - rK, \quad (1)$$

$$M = E_p(1, p, Z, u) - G_p(1, p, s, K), \quad (2)$$

$$G_s(1, p, s, K) = -Z, \quad (3)$$

$$G_K(1, p, s, K) - t = r^*, \quad (4)$$

where M is the imports of good 2 and r^* is the given

world rate of return on capital. Equation (1) gives the home country's budget constraint: consumption spending equals revenue from production, plus import tariff revenue and revenues from taxing both foreign capital and pollution emission, minus payments to foreign capital. Equations (2) and (3) define the import of good 2 and the level of pollution emission, respectively. Finally, equation (4) is the equilibrium condition of the capital market that requires the same after-tax rate of returns between countries. Here, we assume no capital tax in the foreign country.

The model of (1) to (4), consisting four unknowns, u , K , Z and M , and three policy instruments, t , t and s , is amenable for our analysis. First, we carry out the welfare analysis for deriving the individual and jointly optimal rates of tariff and capital tax, and then we examine the impacts of changes in the pollution tax on optimal tariff and capital tax. The welfare effects of tariffs and investment taxes are obtained by totally differentiating (1):

$$E_u du = (s - E_Z)dZ + t dM + t dK. \quad (5)$$

The first term on the right-hand side of (5) represents the environmental impact on welfare, depending on the revenue from pollution taxes relative to the cost of pollution to consumers. The second and third terms are, respectively, the standard volume-of-trade effect with respect to the imported good and capital inflow. Apparently, the home welfare is maximized when $t = 0$, $t = 0$ and $E_Z = s$. That is, free trade in goods and unrestricted international capital movement, together with the Pigouvian tax on pollution emissions, is the first-best policy for a small open, capital-importing economy. However, free trade may not be optimal if the pollution tax is not set equal to its cost to consumers, with or without other types of distortions in the goods and factor markets. These issues will be systematically analyzed below.

In the presence of a given pollution tax, the second-best optimal tariff and the capital tax can be derived by using (5). Substituting the change of M from (2) into (5) gives:

$$(E_u - tE_{pu})du = t(E_{pp} - G_{pp})dt + [s - (E_Z - tE_{pz})]dZ + (t - tG_{pk})dK - tG_{ps}ds, \quad (6)$$

where $E_u - tE_{pu} > 0$.⁵ Note that the second subscripts in $E(?)$ and $R(?)$ represent the second partial derivatives. Here, $E_{pp} < 0$ and $G_{pp} > 0$, denoting respectively the negative demand for and the positive supply of good 2. Recall that we assume $E_{pz} < 0$. Furthermore, due to the

existence of the specific factor, K , in the production of X_2 , we have $G_{pk} = \partial X_2 / \partial K > 0$ and $G_{ps} = \partial X_2 / \partial s < 0$, as a pollution tax against sector 2 dampens its production.

A. Optimal Capital Taxes:

While a tax on foreign capital impedes capital inflow, the capital tax in the present framework can also lower pollution emissions via a reduction in the output of the polluting sector. The impacts of the capital tax on capital flows and pollution emissions are ascertained from (3) and (4) as:

$$dK/dt = 1/G_{KK} < 0, \quad (7)$$

$$dZ/dt = -G_{sK}/G_{KK} < 0, \quad (8)$$

where $G_{KK} = \partial^2 r / \partial K^2 < 0$ and $G_{sK} = -\partial^2 Z / \partial s \partial K < 0$. These results will be used for determining the welfare effect of a capital tax. Intuitively, a rise in the tax on foreign capital yields both positive and negative welfare effects. The tax gives revenue and also reduces pollution due to less production. Both events are welfare enhancing. On the other hand, the higher tax lowers capital inflows, causing less tax revenue from pollution. This is welfare reducing. The welfare effect of a capital tax is immediate from (6):

$$(E_u - tE_{pu})(du/dt) = [s - (E_Z - tE_{pz})](dZ/dt) + (t - tG_{pk})(dK/dt). \quad (9)$$

The first term on the right-hand side of (9) expresses that the detrimental pollution externality (E_Z) can be offset by pollution tax revenue, while the second term indicates that in the presence of tariffs, the harmful welfare effect of an inflow of foreign capital can be mitigated by investment tax revenue.⁶ In general, the overall welfare effect of capital taxes is indeterminate. By setting $du/dt = 0$ in (9), we obtain the optimal rate of capital tax (t^o):

$$t^o = (E_Z - s)(dZ/dt)/(dK/dt) + t[G_{pk}(dK/dt) - E_{pz}(dZ/dt)]/(dK/dt). \quad (10)$$

This states that $t^o = 0$ when $t = 0$ and $E_Z = s$; free capital movement is optimal when tariff is zero and pollution tax is set equal to its damage to consumers. However, for $t = 0$ only, t^o can be positive or negative depending on the relative amounts of E_Z and s . If the cost of pollution to consumers, E_Z , exceeds (falls short of) the benefit from pollution taxes, s , a positive (negative) t^o is needed to discourage (encourage) the inflow of foreign capital, which leads to more pollution emission (pollution tax revenue). Furthermore, as shown in the second term of (10), t^o has a positive relationship with t when $t > 0$. This is because tariffs lower welfare due to the over expansion

of the production of good X_2 . To mitigate this detrimental effect, a positive capital tax is needed.

The relationship between t^o and t is plotted in Figure 1 as the upward-sloping t^o schedule, where the horizontal intercept given by the first term on the right-hand side of (10) is positive (negative) when $E_Z > (<) s$,⁷ and the slope is shown by the second term attached to t . Any vertical movements of t toward t^o will improve welfare. This can be seen by substituting t^o in (10) into (7) to yield:

$$(E_u - tE_{pu})(du/dt) = (dK/dt)(t - t^o). \quad (11)$$

Here, $du/dt < (>) 0$ when $t > (<) t^o$, implying that reducing (raising) the capital tax rate improves welfare when t is larger (smaller) than its optimal rate.

B. Optimal Tariffs

In contrast to the case of capital taxes, tariffs induce inflows of foreign capital (to bypass trade barriers) thereby leading to an expansion of the polluting sector X_2 and an increased level of pollution emission. These tariff effects can be verified by solving (3) and (4) as

$$dK/dt = -G_{Kp}/G_{KK} > 0, \quad (12)$$

$$dZ/dt = -G_{sp} - G_{sK}(dK/dt) > 0. \quad (13)$$

Intuitively, a tariff generates a variety of effects as follows: (i) more foreign capital inflow means more capital tax revenue and more pollution tax revenue. Both are good for welfare; and (ii) overproducing the importable good X_2 , and hence less imports and higher pollution emission are all welfare reducing.

Using (12) and (13), we can identify from (6) the various welfare effects of changes in tariffs as

$$(E_u - tE_{pu})(du/dt) = t(E_{pp} - G_{pp}) + [s - (E_Z - tE_{pZ})](dZ/dt) + (t - tG_{pK})(dK/dt). \quad (14)$$

A comparison of (14) with (9) reveals that the two welfare expressions are similar except for the appearance of the adverse volume-of-trade effect in the first term of (14). Given the ambiguity in (14), the optimal tariff rate can be obtained by setting $du/dt = 0$ in (14) as

$$t^o = [(E_Z - s)/A](dZ/dt) - t(dK/dt)/A, \quad (15)$$

where $A = (E_{pp} - G_{pp}) + E_{pZ}(dZ/dt) - G_{pK}(dK/dt) < 0$ by assuming $E_{pZ} < 0$. Equation (15) implies that $t^o = 0$ when $E_Z = s$ and $t = 0$. However, for $t = 0$, we have $t^o > (<) 0$ when $E_Z < (>) s$. That is, if the cost of pollution to consumers falls below (exceeds) the pollution tax rate, the optimal tariff rate will be positive (negative). Furthermore, for $t \neq 0$, the relationship between t^o and t is positive, plotted in Figure 1 as the t^o schedule. The vertical intercept of the t^o schedule is positive (negative)

when $E_Z > (<) s$, and the slope is simply $(dK/dt)A$. Any horizontal movements of t toward t^o will improve welfare. This can be seen by substituting t^o in (15) into (12) to yield:

$$(E_u - tE_{pu})(du/dt) = A(t - t^o). \quad (16)$$

This indicates that $du/dt > (<) 0$ when $t < (>) t^o$.

C. Joint Optimal Policies and Pollution Taxes

For a given pollution tax, we can solve from (10) and (15) the jointly optimal tariff and capital tax, t^{oo} and t^{oo} , as

$$t^{oo} = (E_Z - s)G_{sp}/[E_{pZ}G_{sp} - (E_{pp} - R_{pp})], \quad (17)$$

$$t^{oo} = (E_Z - s)[G_{pK}G_{sp} + (E_{pp} - R_{pp})G_{sK}]/[E_{pZ}G_{sp} - (E_{pp} - R_{pp})]. \quad (18)$$

This pair of equations yields a number of interesting results. If $E_Z = s$, free trade in goods and capital ($t^{oo} = 0$ and $t^{oo} = 0$) is optimal for the small open, capital-importing economy. This is the standard result. However, if $E_Z \neq s$, free trade may not be optimal. Consider first the case that $E_Z < s$, in which the tax revenue from pollution exceeds its cost to consumers. The expansion of the production of the polluting sector X_2 via tariff protection ($t^{oo} > 0$) and/or a capital subsidy ($t^{oo} < 0$) is therefore desirable. On the other hand, capital inflow may reduce welfare and hence a tax on foreign capital ($t^{oo} > 0$) may be needed. These two conflicting forces cause t^{oo} in (18) to be ambiguous. Note that the opposite reasoning applies to the case that $E_Z > s$, such that we have $t^{oo} < 0$ and $t^{oo} > 0$. The jointly optimal tariff and capital tax rates, t^{oo} and t^{oo} , can be illustrated in Figure 1 by the intersection point of the t^o and t^o schedules.

We now turn to the effects of a change in the pollution tax on the jointly optimal tariff and the capital tax. From (17) and (18), we obtain:

$$dt^{oo}/ds = -G_{sp}/[E_{pZ}G_{sp} - (E_{pp} - R_{pp})] > 0, \quad (19)$$

$$dt^{oo}/ds = G_{sp}G_{KK} + (E_{pp} - R_{pp})G_{sK}G_{KK}/G_{pK} < 0. \quad (20)$$

That is, a higher pollution tax unambiguously raises the optimal tariff rate, but the pollution tax effect on the optimal capital tax rate is indeterminate. This is due to the fact that the pollution tax on X_2 raises its cost and thus lowers its output. To offset this higher production cost effect, a rise in tariff to provide further protection to X_2 is needed. Alternatively, a reduction in the capital tax rate can help the X_2 sector. But a lower capital tax rate

inducing more capital inflows may lower welfare, and a rise in capital tax can discourage the harmful inflow of capital. In view of these two conflicting effects, the impact of a pollution tax on the capital tax in (20) becomes ambiguous.

The results in (19) and (20) are illustrated in Figure 1.

A rise in the pollution tax leads to rightward shifts of both the t^o and t^* schedules. This means that $dt^{oo}/ds > 0$, but $dt^{oo}/ds < 0$. The latter depends on the relative shifts of the two curves. We summarize the above results as follows:

Proposition 1: In a small open, two-sector economy with the importable sector emitting pollution, tightening environmental regulation via a pollution tax will lead to a higher optimal tariff. But the effect of the pollution tax on the optimal capital tax is indeterminate.

For a small developing economy depicted in this paper, promoting environmental preservation is incompatible with the goal of trade liberalization. This result sheds light on the heated debates among the various groups and countries with varying developmental stages in the recent round of talks on the WTO's trade liberalization.

3. Capital Tax Credits

The preceding model can be expanded to consider the effects of an introduction of capital tax credits by the source country on optimal trade and investment policies and the impacts on these policies as environmental regulations alter. In fact, the tax credit system has been in place in many developed and newly industrialized countries. Following the pioneering work of Bond (1991), we assume that tax credits exist such that the amount of taxes paid by foreign investors to the host country can be deducted from the tax liability in the source country. With the capital tax credit, the effective tax rate applicable to foreign capital becomes $\max(t, t^*)$, where t^* is the capital tax rate in the source country. In equilibrium, the after-tax rates of returns on capital are the same between countries:

$$G_K(1, p, s, K) - \max(t, t^*) = r^* - t^*. \quad (21)$$

Note that if the host country gives subsidies to foreign capital (i.e., $t < 0$), instead of taxes, all the subsidies (with repatriation of capital returns) would be captured by the source country. The tax credits become irrelevant here and, hence, the capital-market equilibrium condition remains essentially as in (4): $G_K - t - t^* = r^* - t^*$, and the

earlier analysis without tax credits holds.

When $t > t^*$, the tax credit available is t^* , and the capital market equilibrium in (21) is: $G_K - t = r^* - t^*$. This implies that for a given t^* , the earlier results derived (for $t^* = 0$) in the absence of tax credits in section 2 hold qualitatively. Thus, we would not duplicate the analysis.

On the other hand, for $0 < t < t^*$, we have $G_K(1, p, s, K) = r^*$ in (21). From this equilibrium condition, K can be solved as a function of p and s , but K is not related to t for a given r^* . The latter means that changes in the home capital tax rate will not affect the capital movement ($dK/dt = 0$) and hence nor the pollution emissions ($dZ/dt = 0$). These new results give rise to a welfare consequence different from that in the earlier case. Using (1) and (21), the welfare effect under the tax credit system becomes:

$$(E_u - tE_{pu})du = t(E_{pp} - G_{pp})dt + [s - (E_Z - tE_{pZ})]dZ + (-tG_{pK})dK - tG_{ps}ds + Kdt. \quad (22)$$

Comparing with (6) reveals that the last term on the right hand side of (22) is a new term, which shows that the home country now captures the shift of tax revenue. Since $dK/dt = dZ/dt = 0$ in the present case, the welfare effect of a capital tax for a given tariff rate ($dt = 0$) is:

$$(E_u - tE_{pu})(du/dt) = K > 0. \quad (23)$$

This suggests that the host country in the presence of a foreign tax-credit system can raise the capital tax rate up to the foreign rate (t^*) without incurring allocative losses.

With a tax credit in place, the optimal tax rate for the home country, t^o , for $0 < t < t^*$ is therefore $t^o = t^*$. Combining the forgoing analysis about the three cases under tax credits, namely $t < 0$, $t > t^*$ and $0 < t < t^*$, we sketch a kinked optimal capital rate schedule as illustrated in Figure 2: when $0 < t < t^*$ under tax credits, the optimal tax schedule rotates to coincide with the horizontal line t^* , and when $t < 0$ and $t > t^*$, the optimal tax schedule follows through and coincides with the earlier schedule t^o derived in the absence of tax credits.

We turn to examine the jointly optimal tariff and capital tax rates in the presence of tax credits. The jointly optimal rates depend upon the initial situation of the host economy. If a capital tax used at the outset is t^{oo} ($0 < t^{oo} < t^*$) as shown in Figure 2.a, then the jointly optimal capital tax rate will be t^* . That is, the host country would be better off by raising its tax rate up to t^* to capture the tax revenue from the source country. Substituting t^* into (15), we obtain the jointly optimal tariff rate:

$$t^o = [(E_Z - s)/A](dZ/dt) - t^*(dK/dt)/A. \quad (24)$$

Comparing t^{o*} in (24) and t^{oo} in (17), we obtain

$$t^{o*} - t^{oo} = - [(dK/dt)/A](t^* - t^{oo}), \quad (25)$$

which is positive because $dK/dt > 0$ and $A < 0$. With a foreign capital tax credit in place, the increase in the domestic capital tax rate to capture tax revenue leads to a higher tariff rate to attract tariff-jumping foreign capital.

The following proposition is immediate:

Proposition 2: For a small open two-sector economy with its importable sector using foreign capital and emitting pollution, its optimal capital tax and tariff rates increase as a result of the introduction of a tax credit system by the foreign country if $0 < t < t^*$ initially.

A more interesting case involves the use of a subsidy on foreign capital initially. When $t^{oo} < 0$, multiple equilibria of jointly optimal policies may exist. Specifically, Figure 2.b shows the existence of two equilibria, as indicated by points N and C. The first equilibrium N arises in the absence of the home country's response to tax credits available in the foreign country, and the second equilibrium C arises in the presence of the response to tax credits. The welfare comparison of these two equilibria can be obtained by tracing the welfare changes associated with the movement from point N to T, and then with the movement from point T to C. The former adjustment is welfare-worsening, whereas the latter shift is welfare-improving. If the welfare effect from T to C dominates the welfare change from N to T, a tax on foreign capital together with a tariff, as denoted by C, becomes the jointly optimal policy; conversely, a subsidy on foreign capital (jointly with an import subsidy) at point N remains the optimal policy. The following proposition is immediate:

Proposition 3: When a subsidy to foreign capital is initially in place, the introduction of a tax credit in the foreign country may cause the host country to replace its capital subsidy with a tax policy. The switch in policy also results in an increase of tariffs by the host country on the imports.

Using the above model, we can examine the impact of a pollution tax on the optimal tariffs under the tax credit system. Differentiating (24), we obtain:

$$dt^{o*}/ds = - (dZ/dt)/A > 0.$$

(26)

Proposition 4: When a tax-credit system is in place in the source country, tightening environmental regulation via a rise in pollution tax leads to an increase in tariffs for a small open, capital-importing economy.

This result reinforces the earlier result in Proposition 1 derived in the absence of tax credits.

4. Conclusion

This paper has examined the impacts of tightening the environmental regulations on optimal trade and investment policies. We find that for a small open, capital-importing economy, a more stringent environmental measure leads to a higher optimal tariff and possibly a higher optimal tax on foreign capital. This result holds whether or not there is a capital tax credit system in the foreign source country. We also found that when a tax credit is in place, multiple equilibria of optimal policies may exist if a subsidy in lieu of a tax is provided to foreign capital. Our results suggest that environmental protection can be incompatible with trade liberalization for a small, open economy with its importable sector relying on foreign capital.

Footnotes

1. While our main objective in this paper is to study the effect of environmental policy on optimal tariff, we will also touch upon the environmental policy impact on the optimal tax on foreign investment. In fact, there is a growing literature on the possible link between environmental standards and foreign investment. For example, Epping (1986) finds via a survey that firms consider favorable pollution laws relevant when deciding where to invest. Copeland and Taylor (1997) find that capital mobility tends to cause world pollution to rise, as pollution intensive production shifts to countries with lax environmental standards.
2. Pollution can be modelled as a by-product of the polluting industry (Copeland, 1994) or treated as an input in the production process (Yu and Ingene, 1982; Chao and Yu, 1997). Here, Z is a by-product of the polluting sector.
3. This is the so-called user-pay principle. See Copeland (1994).

4. Environmentalists plead people to consume less of the goods that cause pollution in production.

Alternatively, good X_2 and pollution can be substitutes, e.g., hiking shoes versus pollution.

If X_2 and pollution are complements, then $E_{pZ} > 0$, and the ensuing analysis would be reinterpreted accordingly.

5. $E_u - tE_{pu} = E_u(1 - mt/p) > 0$, where $m = pE_{pu}/E_u$ is defined as the marginal propensity to consume good 2.

6. See Brecher and Diaz Alejandro (1977) and Beladi and Marjit (1992) on immiserizing capital inflows. As for earlier studies on international investment and trade, see Kemp (1966), Jones (1967) and Batra (1986).

7. This diagrammatic technique is adopted from Neary (1993).

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Appendix

We compare the intercepts and slopes of the t^o and t^o schedules. From (10) and (15), the difference of the intercepts is:

$$(dZ/dt)/(dK/dt)?_t - (dZ/dt)/(dK/dt)?_t = -G_{sp}G_{KK}/G_{Kp} < 0.$$

The difference of the slopes is:

$$\begin{aligned} & [G_{pK}(dK/dt) - E_{pZ}(dZ/dt)]/(dK/dt)?_t - [G_{pK}(dK/dt) - E_{pZ}(dZ/dt) - (E_{pp} - R_{pp})]/(dK/dt)?_t \\ & = \{E_{pZ}[(dZ/dt)(dK/dt) - (dZ/dt)(dK/dt)] + (E_{pp} - R_{pp})(dK/dt)\}/(dK/dt)(dK/dt) \\ & = E_{pZ}G_{sp}G_{KK}/G_{Kp} - (E_{pp} - R_{pp})G_{KK}/G_{Kp} < 0. \end{aligned}$$