Review of Development Economics, 2008
DOI:10.1111/j.1467-9361.2008.00455.x

Environmental Protection and Trade Liberalization in a Small Open Dual Economy

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Abstract

The author investigates the conditions under which environmental protection and trade liberalization might improve urban unemployment and welfare in a small open Harris–Todaro model with polluting urban manufacturing. While a tariff reduction decreases manufacturing employment, a rise in the pollution tax rate may *increase* it when a dirty input is complementary to capital. Environmental protection and trade liberalization are consistent in reducing the *level* of urban unemployment because they lower it under the same condition. They are consistent in increasing GDP if a rise in the pollution tax rate decreases manufacturing employment. Otherwise, trade liberalization will mitigate a decrease in GDP because of environmental protection if the degree of urbanization is low and if rural technology exhibits weak diminishing returns to labor. This GDP effect plays a central role in welfare improvement.

1. Introduction

In recent years, the governments of many developing countries have pursued policies to reduce domestic poverty through outward-oriented growth by liberalizing international trade (e.g. Mexico joined NAFTA and China the WTO). However, the speed and scale of outward-oriented growth have raised concerns about environmental quality in some developing economies. Latin American countries promoting trade liberalization, such as Chile and Mexico, suffer severe pollution in their metropolitan areas (Beghin *et al.* 2002:5–10). From these observations, the harmonization of environmental preservation and trade liberalization has gained practical importance for developing economies.

Despite a certain amount of success in outward-oriented growth, developing countries still need to cope with some domestic poverty. As a kind of poverty specific to these economies, urban unemployment arising from rural–urban migration has been focused on in development economics. Even today, a reduction of urban unemployment is one of the most important development goals in these economies. Not only that, but urban unemployment has begun to receive considerable attention because environmental degradation may be particularly severe on poor, unemployed people. Barbier (2002) points out that the economic welfare of a substantial and growing number of the poorest urban dwellers is threatened by the environmental hazards and health risks posed by pollution. Rao (2000) claimed that work on the links between environmental protection and poverty reduction must address the problems of

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low-income urban areas, such as squatter settlements. Therefore, to explore the harmonization of environmental protection and trade liberalization in developing economies, we should consider how these policies might affect urban unemployment.

This paper investigates when environmental protection and trade liberalization may improve urban unemployment and welfare, and explores the circumstances under which these two policies are consistent in a dual economy. To solve this problem, we ask three key questions in a small open Harris–Todaro (HT) model (Harris and Todaro, 1970) with a polluting urban manufacturing sector.[1] As a first step, we consider *whether manufacturing employment necessarily decreases with a rise in the pollution tax rate and a tariff reduction in the urban manufacturing sector*. This is not only because a change in employment in manufacturing plays a basic role in determining a change in urban unemployment, but also because the employment creation by environmental policies has been considered important for sustainable development in developing economies.[2] It is a problem worth analyzing because a rise in the pollution tax rate and a tariff reduction both raise production costs and therefore may reduce manufacturing output and employment. We find, however, that a rise in the pollution tax rate may *increase* manufacturing employment when a dirty input is a complementary factor to capital.

The second question is *whether there is a necessary trade-off between reducing urban pollution and reducing urban unemployment when environmental protection and trade liberalization policies are conducted*. We find that these policies are consistent because they reduce urban unemployment under the same condition. The third question is *under what condition a rise in the pollution tax rate and a tariff reduction will be consistent or may work in opposite directions in improving economic welfare*. They are consistent in increasing GDP if a rise in the pollution rate tax reduces manufacturing employment. Otherwise, trade liberalization will mitigate a decrease in GDP because of the environmental protection if the degree of urbanization is low and if rural technology exhibits weak diminishing returns to labor. This effect on GDP plays a central role in welfare improvement.

The present analyses are different from those in previous studies. First, this paper is different from that of Dean and Gangopadhyay (1997) and Chao *et al.* (2000) because we use a standard HT model with two final goods. Dean and Gangopadhyay examined the effects of the export ban on intermediate goods (e.g. timber) in the three-good model in which the production of intermediates causes environmental damage (e.g. deforestation). They consider primarily how the (second-best) optimal production and export taxes should be set in the presence of urban unemployment, and also show that an export ban aggravates urban unemployment in the short run but decreases it in the long run. Chao *et al*. developed an HT model in which agricultural products (exportables) and raw materials (importables, the use of which causes environmental damage) are produced in the rural area, while processed goods (nontradables) are produced in the urban area by using labor and raw materials. They find that in a small open economy, an increase in the preservation of raw materials does not result in additional urban unemployment. Although these studies deal with an important problem (deforestation), they use special HT models with a vertically related industrial structure. It is, however, of fundamental importance to examine the effects of environmental policies on urban unemployment in the standard HT model with two final goods.

An urban pollution tax in the standard model of a closed HT economy was analyzed by Daitoh (2003). He showed that the condition for an increase in manufacturing employment depends on the price elasticity of demand for manufactured goods, and that a sufficient condition for welfare improvement could be characterized by a low

range of initial pollution tax rates. Extending the model to an open economy, we find that the former condition depends on the substitute/complementary relations among factors of production. The latter condition turns out to depend on the degree of urbanization and the strength of diminishing returns to rural labor.[3]

2. The Model

Consider a specific-factor model of a small open HT economy, exporting a rural product x (numeraire) and importing an urban manufactured good y. Given the world price p^* of y, the domestic price is $p = p^* + t$ with a specific tariff t.

In the urban manufacturing sector, the institutionally fixed high wage rate w_M prevails. The representative firm produces y using labor L_M, sector-specific capital K, and a "dirty input" Z. The rental rate of capital r is given in a competitive domestic market. The dirty input is any factor of production with a negative externality on consumers' utility. For simplicity, we assume that the market for Z does not exist and that the government imposes a specific tax τ on the firm's use of Z.[4] Under constant-returns-to-scale technology, the constrained factor demand functions are:

$$L_M = c_W(w_M, r, \tau)\, y, \tag{1}$$

$$K = c_R(w_M, r, \tau)\, y, \tag{2}$$

$$Z = c_\tau(w_M, r, \tau)\, y, \tag{3}$$

where $c(w_M, r, \tau)$ is the unit cost function and the subscripts represent the partial derivatives. We assume that labor and capital are substitute factors.

ASSUMPTION 1. $c_{WR}(w_M, r, \tau) = \partial^2 c(w_M, r, \tau)/\partial r \partial w_M > 0$ *for all* $(w_M, r, \tau) > 0$.

The rental rate of capital is determined by the zero-profit condition:

$$p = c(w_M, r, \tau). \tag{4}$$

The labor allocations in the city and in the entire economy are:

$$L_M + L_U = L_C, \tag{5}$$

$$L_X + L_C = L, \tag{6}$$

where L_U is urban unemployment, and L_X, L_C, and L are rural, city, and total population, respectively.

The rural firm's production function is $x = f(L_x)$ with $f'(L_x) > 0$ and $f''(L_x) < 0$. We assume implicitly that land is a specific factor in the rural sector. In the competitive labor market, the rural wage rate w_X equals the marginal product of labor:

$$w_X = f'(L_X). \tag{7}$$

The labor allocation between rural and urban areas is determined by the Harris–Todaro migration equilibrium condition (HT condition):

$$w_X = w_M L_M / L_C. \tag{8}$$

Given p, τ, w_M, K, and L, (4) determines r and then (2) determines y. From (1) and (3), we get L_M and Z. Then (5) to (8) determine L_C, L_U, L_X, and w_X.[5]

3. Environment, Trade, and Labor Market

Now we consider the answers to the three questions. Throughout this paper, we assume that the manufacturing technology satisfies:

ASSUMPTION 2: $c_{RR}(w_M, r, \tau)/c_R(w_M, r, \tau) < c_{R\tau}(w_M, r, \tau)/c_\tau(w_M, r, \tau)$ *for all* $(w_M, r, \tau) > 0$.

This assumption seems reasonable because it can be rewritten as $(\partial K/\partial r)/K < (\partial Z/\partial r)/Z$. When Z is a substitute for K, it is clearly satisfied. Even when Z is complementary to K, it would be natural to suppose that the effect of a decline in r on its own demand K is stronger than its cross-effect on Z.

Manufacturing Employment

First, we will ask whether manufacturing employment necessarily decreases by a rise in the pollution tax rate and by a tariff reduction. Both policies will lower r, decrease y and Z (see the Appendix). Let us show the necessary and sufficient condition for a rise in L_M.

PROPOSITION 1. *(i) A rise in the urban pollution tax rate increases manufacturing employment if and only if the following inequality holds in the initial equilibrium:*

$$c_{W\tau} > (c_{WR}c_\tau/c_R) + c_W[(c_{R\tau}/c_R) - (c_{RR}/c_R)(c_\tau/c_R)]. \tag{9}$$

(ii) A tariff reduction on the manufactured good decreases manufacturing employment.

PROOF. By (1), (i) $dL_M/d\tau = y[c_{W\tau} - (c_{WR}c_\tau/c_R) + (c_W c_{RR}/c_R)(c_\tau/c_R) - (c_W c_{R\tau}/c_R)] > 0$ holds if and only if (9) holds. (ii) $dL_M/dt = (yc_W/c_R)[(c_{WR}/c_W) - (c_{RR}/c_R)] > 0$. □

The economic logic behind (i) is as follows. A rise in τ tends to increase the unit cost in (4). Given p, r must decline. These effects affect L_M through three channels. First, the scale effect of y decreases L_M. Second, the substitution effect by a decline in r also decreases L_M (recall $c_{WR} > 0$). Third, however, the rise in τ may increase or decrease L_M, depending on whether Z is a substitute or a complement to it.[6] If it is a complement, L_M decreases. Then all the three effects decrease L_M. If Z is a substitute, L_M tends to increase. If this positive effect dominates the two negative effects ($c_{W\tau} > 0$ is large in (9)), L_M will increase.[7] The case for $c_{W\tau} > 0$ seems realistically relevant in developing economies because one can easily find examples of Z being a complement to K (pollution-intensive machines or energy goods such as coal). The economic reason for (ii) is simpler. Because a reduction in t lowers p and r by (4), capital demand tends to increase. Given the supply of K in (2), it needs to be offset by a decrease in y. With $c_{WR} > 0$, the declines in r and in y both decrease L_M.

When we compare (i) with (ii), a tariff reduction always decreases L_M, while a rise in τ increases L_M if Z is a complement to K. Then, environmental protection works against trade liberalization, mitigating the negative welfare effect of decreasing L_M, which is less than optimal because of the fixed w_M. If a rise in τ decreases L_M, the environmental protection reinforces the negative welfare effect of trade liberalization.

Urban Unemployment

Next, we move on to the second question on urban unemployment and pollution.

PROPOSITION 2. *Suppose that a rise in the pollution tax rate and a tariff reduction decrease (increase) manufacturing employment. The level of urban unemployment declines if and only if the following relation holds in the initial equilibrium:*

$$\eta = [L_C/w_X][dw_X/dL_C] < (>)[w_M - w_X]/w_X. \tag{10}$$

PROOF. By (8), $dL_C/d\tau = -dL_X/d\tau = -[w_M/(L_C f''(L_X) - f'(L_X))](dL_M/d\tau)$. $dL_U/d\tau = dL_C/d\tau - dL_M/d\tau < 0$ holds iff $\{[w_M/(f'(L_X) - L_C f''(L_X))] - 1\}(dL_M/d\tau) < 0$. □

When L_M decreases, we rewrite (10) as $|f''(L_X)| < (w_M - w_X)/L_C$. If the rural land is not strictly limited, a rural labor expansion will slowly lower the ratio of land to labor, resulting in weak diminishing returns ($|f''(L_X)|$ is small). Then a rise in τ will reduce L_U if the degree of urbanization is low (L_C is small) and if plenty of rural lands are left.

Environmental protection will be consistent with trade liberalization in reducing the *level* of urban unemployment, because it lowers it under the same condition. Even when a rise in τ increases L_M, if their net effects decrease (increase) L_M, then L_U decreases iff (10) holds (with the corresponding inequality). It also means that these policies are consistent in reducing L_U.

4. Demand Side and Welfare

Now we proceed to the third question on welfare improvement. The representative consumer's utility function $U(D_X, D_Y, Z)$ is homothetic in the consumption of rural good D_X and manufactured good D_Y. The marginal utility of each good is positive ($U_i = \partial U/\partial D_i > 0$, $i = X, Y$) and decreasing ($U_{ii} = \partial^2 U/\partial D_i^2 < 0$). The pollution exerts a negative externality ($U_Z = \partial U/\partial Z < 0$) and its marginal disutility is increasing ($U_{ZZ} = \partial^2 U/\partial Z^2 < 0$). Utility maximization implies $p = U_Y(D_X/D_Y, 1, Z)/U_X(D_X/D_Y, 1, Z)$. Denoting the relative demand function as ϕ, we get:

$$\phi(p, Z) = D_X/D_Y, \tag{11}$$

with $\phi_p(p, Z) = \partial\phi(p, Z)/\partial p > 0$. The government transfers the tax and tariff revenues to consumers in a lump-sum fashion.[8] Then aggregate expenditure equals GDP (evaluated in terms of domestic price) $G = x + py$ plus the tariff revenue:

$$D_X + pD_Y = x + py + t(D_Y - y). \tag{12}$$

We will proceed to show the sufficient conditions for welfare improvement.

PROPOSITION 3. *Suppose that a rise in the urban pollution tax rate decreases manufacturing employment. Then welfare improves if the two conditions below are both satisfied in the initial equilibrium: (a) GDP increases, i.e.*

$$p[dy/d\tau] > \Gamma(L_X, w_M)[dL_M/d\tau] \tag{13}$$

holds, where

$$\Gamma(L_X, w_M) = \frac{w_M}{1 + L_C|f''(L_X)/f'(L_X)|} > 0. \tag{14}$$

(b) $[U_x/U - 1/p^* + \phi(p, Z))]\phi_Z(p, Z) \leq 0$. *Under separable utility with* $\phi_Z(p, Z) = 0$, *the sufficient condition is (a) only.*

A rise in GDP plays a central role in welfare improvement. When $dL_M/d\tau < 0$ holds, (13) holds if $\Gamma > 0$ is large enough. Thus, a rise in the pollution tax rate increases GDP if the degree of urbanization is low (L_C is small) and if rural technology exhibits weak diminishing returns to labor ($|f''(L_X)/f'(L_X)|$ is small). When $dL_M/d\tau > 0$ holds, x and therefore $G = x + py$ always decrease. Condition (b) is needed in order for the pollution externality not to cancel out this GDP effect. Suppose that a reduction in pollution decreases the relative demand for the rural product ($\phi_Z > 0$). If, at the same time, the rate of decline in utility from the rural product U_X/U is lower (than $1/(p^* + \phi(p, Z))$, it tends to improve welfare (a similar reasoning holds for $\phi_Z < 0$).[9]

Next, for a tariff reduction, the sufficient condition includes the price elasticity of manufacturing output $\varepsilon_y = (p/y)(dy/dp)$.

Proposition 4. *A tariff reduction improves welfare if the three conditions below are all satisfied in the initial equilibrium: (a) GDP increases so greatly that*:

$$y[\varepsilon_y + (D_Y/y)] < \Gamma(w_M, L_X)[dL_M/dt], \tag{15}$$

holds; (b) $U_x\phi_p(p, Z)/U \leq [1 + \phi_p(p, Z)]/[p^* + \phi(p, Z)]$;
(c) $[U_x/U - 1/(p^* + \phi(p, Z)]\phi_Z(p, Z) \leq 0$. *Under separable utility with* $\phi_Z(p, Z) = 0$, *the sufficient condition is (a) and (b).*

A rise in GDP plays a central role in welfare improvement. If ε_y is small and Γ is large enough, (15) holds.[10] Intuitively, because a reduction in t decreases L_M, x increases. For GDP to increase, the increase in x must dominate the decrease in y. First, when ε_y is low, the decrease in y will be small. Second, when the rural technology exhibits weak diminishing returns to labor, w_X declines slowly. Then x will increase greatly until the expected wage rates are equal.

Condition (b) is needed for the GDP effect to survive. Defining $C = [p + \phi(p, Z)]D_Y$, (b) could be $(\partial U/\partial p)/U \leq (\partial C/\partial p)/C$ (C *is almost equal to* $[p^* + \phi(p, Z)]D_Y$ for small t): the rate of decline in the subutility from consumption is relatively small. Condition (c) can be interpreted similarly to Proposition 3.

Relation between Environmental Protection and Trade Liberalization

Let us finally discuss the relation between environmental protection and trade liberalization from the viewpoint of welfare improvement. We will focus on conditions (a) for an increase in GDP.[11] If a rise in the pollution tax rate decreases manufacturing employment, then trade liberalization and environmental protection will be consistent in raising GDP. This is because both (13) and (15) are more likely to hold in similar situations where Γ is larger. Conversely, if a rise in the pollution tax rate increases manufacturing employment, GDP decreases. However, trade liberalization increases GDP if Γ is large enough. If the degree of urbanization is low and if rural technology exhibits weak diminishing returns to labor, trade liberalization will mitigate a decrease in GDP because of environmental protection.

5. Conclusions

In this paper I have investigated when environmental protection and trade liberalization may improve urban unemployment and welfare, and thereby explored the consistency of these two policies in a small open HT model with a polluting urban manufacturing sector. As a first step, we find that a rise in the pollution tax rate may *increase* manufacturing employment when a dirty input is a complementary factor to capital, while a tariff reduction necessarily decreases it. Second, a rise in the pollution tax rate and a tariff reduction are consistent in reducing the level of urban unemployment, because they lower it under the same condition. Finally, environmental protection and trade liberalization are consistent in increasing GDP if a rise in the pollution tax rate decreases manufacturing employment. Otherwise, trade liberalization will mitigate a decrease in GDP because of environmental protection if the degree of urbanization is low and if rural technology exhibits weak diminishing returns to labor. This effect on GDP plays a central role in welfare improvement.

For future research we should consider intersectoral capital mobility, endogenous determination of environmental policy, and the optimal combination of pollution tax and wage subsidies under free trade.

Appendix

Effects of Pollution Tax

By (4), $dr/d\tau = -(c_\tau/c_R) < 0$. By (2), $dy/d\tau = = (yc_\tau/c_R)[(c_{RR}/c_R) - (c_{R\tau}/c_\tau)] < 0$ under Assumption 2. By (3), $dZ/d\tau = Z\{(c_{\tau\tau}/c_\tau) + (c_\tau/c_R)[(c_{RR}/c_R) - 2(c_{R\tau}/c_\tau)]\}$. Because $c(w_M, r, \tau)$ is concave and therefore quasi-concave, the principal minors of its bordered Hessian alternate in sign, i.e. $c_{RR}(c_\tau)^2 - 2c_R c_\tau c_{R\tau} + c_{\tau\tau}(c_R)^2 \leq 0$, holds. Therefore we get $dZ/d\tau \leq 0$. □

Effects of Tariff Reduction

By (4), $dr/dt = 1/c_R > 0$. By (2), $dy/dt = -yc_{RR}/(c_R)^2 > 0$. By (3), $dZ/d\tau = (yc_\tau/c_R)\,[(c_{R\tau}/c_\tau) - (c_{RR}/c_R)] > 0$ under Assumption 2. □

Proof of Proposition 3

Totally differentiating $V = U(D_Y\phi(p, Z), D_Y, Z) = D_Y U(\phi(p, Z), 1, Z)$,

$$dV = U(\phi(p,Z),1,Z)\,dD_Y + D_Y[U_Z + U_X\phi_Z(p,Z)]dZ. \tag{A1}$$

Substituting (11) into (12), $[p^* + \phi(p, Z)]D_Y = G - ty$. Differentiating it,

$$dD_Y/d\tau = [1/(p^* + \phi(p,Z))][(dG/d\tau) - t(dy/d\tau) - D_Y\phi_Z(p,Z)(dZ/d\tau)]. \tag{A2}$$

Substituting (A2) into (A1), the change in the indirect utility is:

$$dV/d\tau = \frac{U(\phi(p,Z),1,Z)}{p^* + \phi(p,Z)}[(dG/d\tau) - t(dy/d\tau)] + D_Y\left\{U_Z + \left[U_X - \frac{U(\phi(p,Z),1,Z)}{p^* + \phi(p,Z)}\right]\phi_Z(p,Z)\right\}(dZ/d\tau). \tag{A3}$$

With $dy/d\tau < 0$, $U_Z < 0$ and $dZ/d\tau < 0$, $dV/d\tau > 0$ holds if (a) $dG/d\tau > 0$ and (b) in the text. By $x = f(L_X)$, (a) holds iff $p[dy/d\tau] > -dx/d\tau = -f'(L_X)[dL_X/d\tau]$. By (8), $dL_X/d\tau = \{w_M/[L_C f''(L_X) - f'(L_X)]\}[dL_M/d\tau]$. We get (13). □

Proof of Proposition 4

By (11) and (12), $[p^* + \phi(p, Z)]D_Y = G - ty$. Differentiating this yields:

$$dD_Y/dt = \frac{1}{p^* + \phi(p, Z)}[(dG/d\tau) + (D_Y - y) - t(dy/d\tau) - D_Y\{1 + \phi_p(p, Z)\} - D_Y\phi_Z(p, Z)(dZ/dt)]. \tag{A4}$$

Substituting (A4) into (A1) yields, with $dp = dt$,

$$dV/dt = \frac{U(\phi(p, Z), 1, Z)}{p^* + \phi(p, Z)}[(dG/dt) + (D_Y - y)] + D_Y\left\{U_Z + \left[U_X - \frac{U(\phi(p, Z), 1, Z)}{p^* + \phi(p, Z)}\right]\phi_Z(p, Z)\right\}(dZ/dt) - \frac{U(\phi(p, Z), 1, Z)}{p^* + \phi(p, Z)}[D_Y\{1 + \phi_p(p, Z)\} + t(dy/dt)]. \tag{A5}$$

With $dy/dt > 0$, $U_Z < 0$ and $dZ/dt > 0$, $dV/dt < 0$ holds if (a) $(dG/dt) + (D_Y - y) = (dx/dt) + p(dy/dt) + D_Y < 0$, (b) $D_Y U_X \phi_p(p, Z) \leq \left[U_X - \frac{U(\phi(p, Z), 1, Z)}{p^* + \phi(p, Z)}\right] D_Y[1 + \phi_p(p, Z)]$, and (c) in the text. Rewriting (a), $y[(p/y)(dy/dp) + (D_Y/y)] < -(dx/dt) = \Gamma(w_M, L_X)(dL_M/dt)$. We get (15). □

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Notes

1. If pollution came from the urban informal sector, we could consider a trade-off between pollutions from the formal and informal sectors. This is beyond the scope of this paper.
2. Renner (1991) stressed the employment creation effects of environmental policies. Mehmet (1995) emphasized close ties between sustainable development and employment-creating development in developing economies.
3. This paper could be regarded as a complementary study to Copeland (1994). He derived conditions for welfare-improving environment and trade policy reforms with a competitive labor market. His analysis is not suitable to economies with unemployment.
4. Treating pollution as an input is standard in the literature (Pethig, 1976; McGuire, 1982). If production pollutes clean air, the quantity of pollution can be regarded as a dirty input. Furthermore, Copeland and Taylor (1994) showed that emissions can be formulated as an input if pollution is generated as a joint product of the good and is reduced by abatement.
5. If we incorporated abatement, urban employment would be more likely to increase by a rise in the pollution tax rate. Rather we will show circumstances under which urban employment can increase even if we assume away abatement labor.
6. Because a substitute relation is dominant among the factors, three cases are possible under $c_{WR} > 0$: (1) all factors are substitutes, (2) Z is a complement to K ($c_{R\tau} < 0$ and thus $c_{W\tau} > 0$), and (3) Z is a complement to L_M ($c_{W\tau} < 0$ and thus $c_{R\tau} > 0$).
7. Because the net effect of τ and r are ambiguous, $dL_M/d\tau > 0$ is possible.
8. Beghin *et al*. (2002: 255) suggested that the revenue-neutral tax reforms must be potentially important in developing countries. We do not, however, impose revenue neutrality on the government's budget because it has not yet been discussed in reference to a real society.
9. A rise in the pollution tax rate increases the volume of trade if GDP increases and if the reduction in pollution lowers the relative demand for the rural product.
10. A tariff reduction increases GDP if and only if $y[\varepsilon_y + 1] < \Gamma(w_M, L_X)[dL_M/dt]$ holds.
11. Notice that conditions (b) in Proposition 3 and (c) in Proposition 4 are the same.