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Environmental Control, Wage Inequality and National Welfare for a Tourism Economy

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Abstract
This paper examines the effects of environmental control on income distribution and welfare for an open economy with inbound tourism. The pollution input is considered as a mobile factor between sectors, and a rise in it raises the wages of skilled labor in the traded sector but can weaken the wages of unskilled labor in the non-traded sector. Thus, lax policy on environmental controls can be a source of rising wage inequality between skilled and unskilled labor. In addition, loosened environmental control lowers the price of the non-traded good and thus reduces the revenue from tourism exports. Stricter controls on pollution emissions can therefore narrow the wage gap and promote residents’ welfare. Nonetheless, to improve the production efficiency of the non-traded good sector, permit prices of emissions may need to be lower under imperfect competition.

Key words: Environmental control, wage inequality, welfare, tourism

JEL classifications: F10, Q38

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Introduction

Tourism is a growing and important industry in both developed and developing countries. For example, tourism contributes more than 10 percent of GDP for many economies. It is also an important source of earning foreign exchange and provides employment opportunities for domestic labor. Generally, tourist consumption in the receiving country is predominantly of non-traded goods and services. In an effort to attract tourists, phrases, such as Incredible India, Korea Sparkling, Malaysia Truly Asia, Uniquely Singapore, have been used.

However, the utility of visiting may be mitigated by increased environmental problems. This is especially the case for small island tourism economies (SITEs) that have delicate ecosystems. For many SITEs the growing tourism industry can strain existing resources, leading to congestion, degrading the quality of tourism services and lowering the attractiveness of the SITE as a tourism destination (Mohan, Nabin and Sgro, 2007). For instance, tourists often complain about the worsened air quality in Hong Kong. Environmental concerns for sustaining development and promoting tourism have therefore become a top priority for these economies.

There is a substantial body of work on the welfare effect of environmental controls for the small and large open economies. Environmental pollution harms consumers. According to the user pay principle, the optimal price of pollution emissions should be set equal to the direct marginal damage of pollution to consumers. However, in the presence of tourism, this pricing rule may need to be modified. Since the destination economy has its monopoly power on its non-traded goods, the presence of tourism creates a demand distortion (cf. Hazari and Sgro, 2004). A rise in tourism can increase welfare of domestic residents via the so-called tourism terms-of-trade effect. This effect in turn affects the pricing of pollution emissions. In order to capture the welfare benefit from tourism, we will show that the optimal price of pollution emissions needs to exceed its direct marginal damage to consumers. However, this result needs to be further modified when imperfect competition prevails in the non-traded sector.

On the other hand, in the wage-gap literature, the rising inequality between skilled and unskilled wages has attracted a lot of attention. This wage inequality can be caused by
trade liberalization (Wood, 1995; Leamer, 1998; Marjit, et al., 2003; Xu, 2003; Tokarick, 2005), technological difference (Davis, 1998; Francois and Nelson, 1998), outsourcing (Feenstra and Hanson, 1996), and foreign competition (Neary, 2002). Tokarick (2005), using a CGE model with non-traded sectors for the U.S. economy, shows that expanding trade by lowering trade distortions such as tariffs actually reduces wage inequality.

The purpose of this paper is to examine the distributional and welfare effects of environmental control for an open economy with inbound tourism. Lax pollution control encourages the production of the non-traded good, causing the price of the non-traded good to fall. Unskilled workers may suffer if they are the specific factor in the non-traded sector. The loosened environmental policy can widen the wage gap between skilled and unskilled labor. Furthermore, the fall in the non-tradable price lowers the revenue from tourism exports, resulting in a decline in the welfare of residents. Thus, strictly regulating the environment can yield a double dividend not only in narrowing the wage gap but also in promoting the welfare of the economy.

The paper is organized as follows. Using a general equilibrium framework, section 2 discusses the effects of environmental control on wages and welfare under perfect and imperfect competition. The optimal pricing rules of environmental regulation are then derived under both cases. The conclusions are provided in section 3.

2. The Model and Analysis

We consider a small open economy that produces two goods: a traded good $X_1$ and a non-traded good $X_2$. Skilled labor ($S$) is used for the production of the traded good, while unskilled labor ($L$) is employed for the production of the non-traded good. However, production of one unit of good i emits $e_i$ units of pollution. This yields pollution emissions in sector i as: $Z_i = e_iX_i$, and total pollution emissions in the economy is: $Z = Z_1 + Z_2$. The government regulates the environment by issuing $Z$ units of tradable emission permits with unit price $r$. Since firms need to pay for pollution emissions, we can treat them as a production input. Following Ishikawa and Kiyono (2006), the production functions of goods $X_1$ and $X_2$ are therefore written as: $X_1 = X_1(S, Z_1)$ and $X_2 = X_2(L, Z_2)$. Let $w_1$ and $w_2$
be the skilled and unskilled wages. Choosing the traded good \(X_1\) as the numeraire, the relative price of the non-traded good \(X_2\) is denoted by \(p\).

The home economy consists of two types of consumers: domestic residents and foreign tourists. Domestic residents demand for both goods, denoted by \(D_i, i = 1, 2\), with quasi-linear preferences: \(u = U(D_1, D_2, Z) = D_1 + \nu(D_2) - \phi(Z)\), where \(\nu' > 0, \phi' > 0\) and \(u\) is the utility level. This gives the demand functions for goods: \(D_2 = D_2(p)\) and \(D_1 = I - pD_2(p)\), where \(I\) denotes residents' income. Due to quasi-linear preferences, residents' demand for the non-traded good depends on its price only while the income effect falls entirely on the demand for the traded good. As for tourists, they come and consume the unique goods produced in the economy. Following Copeland (1990), the locally produced non-traded good may capture this feature. Let \(D^*_2\) be the tourist demand for good \(X_2\), depending on its price \(p\) and the shift parameter \(\alpha\). Total demand for the non-traded good is given by \(D_2 + D^*_2\), which is in equilibrium equal to the domestic supply of the good:

\[
D_2(p) + D^*_2(p, \alpha) = X_2, \quad (1)
\]

where \(\partial D_2 / \partial p < 0\) and \(\partial D^*_2 / \partial p < 0\).

The budget constraint of the economy is described by the equality of consumption expenditure and production revenue by domestic residents. For this purpose, it is convenient to define the expenditure function of domestic residents as: \(E(1, p, Z, u) = \min \{D_1 + pD_2; u = D_1 + \nu(D_2) - \phi(Z)\}\), where \(u\) is the level of utility and \(E_u = 1\) for quasi-linear preferences. Here \(E_p (= D_2)\) denotes the compensated demand for the non-traded goods by residents and \(E_Z > 0\) measures the willingness to pay for pollution reductions or the marginal damage of pollution to domestic residents. In equilibrium, the budget constraint of the economy is:

\[
E(1, p, Z, u) = X_1 + pX_2. \quad (2)
\]

Note that from equations (1) and (2), we have the trade-balance condition: \(D_1 - X_1 = pD^*_2\). That is, the import value of good \(X_1\) is equal to the export value of the non-traded good demanded by foreign tourists. The formally non-traded good produced in the economy can be therefore converted into the exportable good by tourism.
(a). Perfect competition

We consider the first case when both the markets of the traded and non-traded sectors are under perfect competition. The income distributional effect of environmental control can be examined by the cost structure of productions. In equilibrium, unit cost is equal to unit price:

\[ c^1(w_1, r) = 1, \quad (3) \]
\[ c^2(w_2, r) = p, \quad (4) \]

where \( c^i(\cdot) \) denotes the unit cost function of sector \( i, i = 1, 2. \)

Turning to the factor markets, the full-employment conditions of labor and pollution permits require:

\[ w_1 c^1(w_1, r) X_1 = S, \quad (5) \]
\[ w_2 c^2(w_2, r) X_2 = L, \quad (6) \]
\[ w_1 c^1(w_1, r) X_1 + w_2 c^2(w_2, r) X_2 = Z, \quad (7) \]

where the subscript of the cost function denotes the partial derivative. By the envelope theorem, \( c^i_w = \frac{\partial c^i / \partial w_i}{w_i} \) represents the unit labor requirement and \( c^i_r = \frac{\partial c^i / \partial r}{w_i} \) is the unit pollution input for the production of good \( X_i. \)

Under perfect competition, the framework of the economy is block recursive: Equations (3) – (7) determine the variables of \( w_1, w_2, r, X_1 \) and \( X_2 \) as functions of \( Z \) and \( p, \) and then by equations (1) and (2) the non-tradable price \( p \) is a function of \( Z. \) Specifically, the impact of environmental control on the skilled and unskilled wages can decomposed into the direct and the price-induced effects:

\[ \frac{dw_1}{dZ} = \frac{\partial w_1}{\partial Z} + (\frac{\partial w_1}{\partial p})(\frac{dp}{dZ}), \quad (8) \]
\[ \frac{dw_2}{dZ} = \frac{\partial w_2}{\partial Z} + (\frac{\partial w_2}{\partial p})(\frac{dp}{dZ}). \quad (9) \]

Since the pollution input \( Z \) is the mobile factor between sectors, the direct effects of its change can be deduced from Figure 1, in which the value of the marginal product curve of \( Z \) is downward sloping. The initial price \( r \) of tradable emission is given by point A. An increase in \( Z \) enlarges the horizontal axis and hence lowers its price as depicted at point A’ (i.e., \( \partial r / \partial Z < 0 \)). Because profits are zero under perfect competition, the lowered cost on pollution emission benefits both skilled and unskilled labor by raising their wages, \( \partial w_1 / \partial Z \)
> 0 and \( \partial w_2 / \partial Z > 0 \) according to equations (3) and (4). In addition, we can use Figure 2 to illustrate the price-induced effects of the change in \( Z \). A rise in \( p \) shifts the marginal product curve of \( Z_2 \) vertically, pushing up the price of pollution emission to point \( B' (\partial rl / \partial p > 0) \). This yields \( \partial w_1 / \partial p < 0 \) by equation (3). However, due to diminishing returns, the increase in \( r \) is less than the rise in \( p \), implying that \( \partial rl / \partial p < rl / p \) in the specific-factor model. This results in \( \partial w_2 / \partial p > 0 \) by equation (4).²

To derive the price-induced effects, we need to determine the impact of environmental control on the price of the non-traded good. Differentiating the goods-market equilibrium condition in equation (1), we obtain

\[
dp / dZ = (\partial X_2 / \partial Z)(\partial D_2 / \partial p + \partial D_2^* / \partial p - \partial X_2 / \partial p) < 0. \tag{10}
\]

where, \( \partial D_2^* / \partial p < 0 \), \( \partial X_2 / \partial p > 0 \) and \( \partial X_2 / \partial Z > 0 \). Under the specific-factors framework, an increase in the pollution input raises the supply of the non-traded good and hence its price. It is noted that due to quasi-linear preferences, the income effect has no impact on the non-tradable price.

By combining the direct and the price-induced effect in equations (8) and (9), we obtain the total effects of the change in pollution emissions on wages of skilled and unskilled labor. Since \( \partial w_1 / \partial p < 0 \), \( \partial w_2 / \partial p > 0 \) and \( dp / dZ < 0 \), the price-induced effect reinforces the positive direct effect on skilled wage but it mitigates the direct effect on unskilled wage. This results in \( dw_1 / dZ > 0 \) and \( dw_2 / dZ < 0 \). Thus, lax environmental control by increases in \( Z \) can widen the wage gap between skilled and unskilled workers.

We examine next the welfare effect of pollution control on domestic residents. Totally differentiating equation (2) and then utilizing equation (1), we have

\[
dudZ = r - E_Z + D_2^* (dp / dZ). \tag{11}
\]

Recall that \( r = \partial X_1 / \partial Z_1 = p(\partial X_2 / \partial Z_2) \) represents the contribution of the pollution input to production, while \( E_Z \) expresses the direct marginal damage of pollution to domestic residents. In the absence of foreign tourists (\( D_2^* = 0 \)), the optimal environmental control is to set the price of pollution emissions equal to its direct marginal damage to domestic residents (\( r = E_Z \)). However, in the presence of tourism (\( D_2^* > 0 \), the non-traded good
becomes exportable and thus gives a terms-of-trade effect from exporting tourism services. Nonetheless, an increase in pollution emissions lowers the price of the non-traded good, resulting in an unfavorable terms-of-trade effect as indicated in the last term of equation (11). Therefore, pollution control should be stricter when tourism presents in the economy. By setting $\frac{dual}{dz} = 0$ in equation (11), we obtain the optimal pollution control in terms of the permit price under perfect competition:

$$r^* = E_Z - D_2^*(dp/dZ).$$  \hspace{1cm} (12)

That is, to capture the terms-of-trade effect of exporting tourism services, the price of pollution permits should exceed the direct marginal damage of pollution to domestic residents. In this case, a stricter control on emission permits is desirable for the economy with inbound tourism.

(b). Imperfect competition

We now extend the discussion to the situation in which monopoly prevails in the non-traded sector while perfect competition still remains in the traded sector. The profits of the monopolist in the non-traded sector are: $\pi^2 = pX_2 - C^2(w_2, r, X_2)$, where $C^2(w_2, r, X_2)$ is total cost of producing good $X_2$. Total cost consists of fixed cost $F(r)$ and marginal cost $m(w_2, r)$; the former depends on the price of the pollution input only but the latter is a function of unskilled wage and the pollution price. This gives total cost of producing non-traded good $X_2$: $C^2(w_2, r, X_2) = F(r) + m(w_2, r)X_2$.

On the demand side, due to quasi-linear preferences, demand for the non-traded good by domestic residents is given by $D_2 = D_2(p)$. Total demand by domestic residents and foreign tourists must equal total supply of the non-traded good produced in the economy: $X_2 = D_2(p) + D_2^*(p, \alpha)$. For a given tourist activity $\alpha$, the price of good $X_2$ set by the monopolist can be therefore expressed by $p = p(X_2)$, with $p' = 1/(\partial D_2/\partial p + \partial D_2^*/\partial p) < 0$. Therefore, the first-order condition of profit maximization by the monopolist is given by the equality of marginal revenue (MR) and marginal cost, as follows:

$$p(X_2) + p'(X_2)X_2 = m(w_2, r).$$ \hspace{1cm} (4')
Accordingly, we need to modify equations (6) and (7) on the employment conditions of unskilled labor and pollution input under the monopoly case:

\[ C_w^2 (w_2, r, X_2) = L, \quad (6') \]
\[ c_i^1 (w_1, r)X_1 + C_i^2 (w_2, r, X_2) = Z. \quad (7') \]

We then use the above production system of equations (3), (4'), (5), (6') and (7') to solve for the variables of \( w_1, w_2, r, X_1 \) and \( X_2 \) as functions of \( Z \). Because firms in the traded sector are price takers in the perfectly competitive market, the changes in skilled wages and pollution price must balance out to keep the unit cost constant. This can be seen from equation (1), as follows:

\[ \hat{w}_1 = - \left( T_{Z_1}/T_S \right) \hat{r}, \quad (13) \]

where \( T_{j1} \) represents the distributive share of factor \( j \) in sector 1 and “\(^{\hat{}}\)” denotes the percent change of a variable. However, the monopolist is the price setter in the non-traded sector, and the change in unskilled wages depends not only on the pollution price but also on the scale of production of good \( X_2 \). Totally differentiating equation (4'), we can obtain this result:

\[ \hat{w}_2 = - \left( \theta_{zz}^m / \theta_{r2}^m \right) \hat{r} - [(2 + \varepsilon) / \theta_b \theta_{r2}^m] \hat{X}_2, \quad (14) \]

where \( b = m/p < 1 \) and \( \theta_{j2}^m \) represents the distributive share of factor \( j \) in sector 2’s marginal cost. In addition, \( \varepsilon = - p/X_2p' > 0 \), being the price elasticity of demand for the non-traded good, and \( e = X_2/p''/p' < 0 \), expressing the curvature of the total demand function for the non-traded good. A rise in the supply of good \( X_2 \) lowers its price and hence marginal revenue under the stability condition that \( 0 < 2 + e \). Consequently, the reduction in marginal revenue leads to a fall in unskilled wages as stated in the last term of equation (14).

Since the pollution input is the mobile input, we can use Figure 3 to depict its price change, in which the initial price \( r \) is determined by the sector 1’s marginal product curve and the sector 2’s marginal revenue curve. An increase in \( Z \) enlarges the horizontal axis, thereby increasing output \( X_2 \) and lowering the price to \( r' \) (i.e., \( \hat{X}_2/\hat{Z} > 0 \) and \( \hat{r}/\hat{Z} < 0 \)). That is, an increase in the pollution permit always raises skilled wages \( \hat{w}_1/\hat{Z} > 0 \) by
equation (13) but it can weaken the favorable effect on unskilled wages \( \hat{w}_2 / \hat{Z} < 0 \) by equation (14) via the reduction in marginal revenue of producing good \( X_2 \). Lax environmental control can therefore widen the wage gap between skilled and unskilled labor when monopoly prevails in the non-traded sector.

We examine next the welfare effect of pollution control under monopoly. Totally differentiating equation (2) and then utilizing equation (1), we have

\[
du/dZ = r - EZ + \hat{D}_2 (dp/dZ) + (p - m)(dX_2/dZ).
\]

(15)

The monopoly distortion in producing non-traded good \( X_2 \) appears in the last term of equation (15). In the absence of tourism \( \hat{D}_2 = 0 \), the optimal permit price of emissions can be obtained by setting \( du/dZ = 0 \) in equation (15) as: \( r = EZ - (p - m)(dX_2/dZ) \). Since the monopolistic output of \( X_2 \) is below its competitive level, lower prices on emission permits are warranted for encouraging more production. Nevertheless, the presence of tourism contributes to the residents' welfare via the exports of tourism services \( \hat{D}_2 \). Accordingly, the optimal permit price of emissions is modified under monopoly to

\[
r^m = EZ - (p - m)(dX_2/dZ) - \hat{D}_2 (dp/dZ),
\]

(16)

where \( dp/dZ = p'(dX_2/dZ) < 0 \). If the gain on tourism exports exceeds the production loss of good \( X_2 \), a stricter control on emissions (i.e., higher prices of emission permits than \( EZ \)) is still desirable in promoting the welfare of domestic residents for the economy with imperfect competition.

3. Conclusions

In this paper, we have utilized a specific-factors model to study the effects of environmental control on income distribution and residents’ welfare for an open economy with inbound tourism. The pollution input is considered as the mobile factor between sectors, and a rise in it raises the wages of skilled labor in the traded sector but can weaken the wages of unskilled labor in the non-traded sector. Thus, lax policy on environmental control can be a source of rising wage inequality between skilled and unskilled labor. In addition, loosened environmental control lowers the price of the non-traded good and thus reduces the revenue of tourism exports. Stricter control on pollution emissions can
therefore yield a double dividend not only in narrowing the wage gap but also in promoting residents’ welfare. However, for improving the production efficiency of the non-traded good sector, permit prices of emissions may need to be lower under imperfect competition.

**Footnotes**

1. Tourism growth can also lead to a higher growth rate in the economy although there is some evidence that this may not always be the case. See, for example, Chao et al. (2008).
2. See Jones (1971) for these comparative-static results under specific-factors models.
3. Marginal revenue of producing additional good $X_2$ is: $MR = p + X_2p'$, and the change in it is: $dMR/dX_2 = p'(2 + e)$. The stability condition, $0 < 2 + e$, is derived in the appendix.
4. The derivations are provided in the appendix.
References


Appendix

Totally differentiating equations (3), (4'), (5), (6') and (7'), we have the changes of equations under monopoly:

\[ 0 = \theta_{S1} \dot{w}_1 + \theta_{Z1} \dot{r}, \]
\[ - (2 + e) \dot{X}_2 = s b \theta_{L2}^m \dot{w}_2 + s b \theta_{Z2}^m \dot{r}, \]
\[ \dot{X}_1 - s_{S1} \dot{w}_1 + s_{S1} \dot{r} = 0, \]
\[ \dot{X}_2 - s_{L2} \dot{w}_2 + s_{L2} \dot{r} = 0, \]
\[ \lambda_{Z1} \dot{X}_1 + \lambda_{Z2}^m \dot{X}_2 + s_{Z1} \dot{w}_1 + s_{Z2}^m \dot{w}_2 - (s_{Z1} + s_{Z2}) \dot{r} = \dot{Z}, \]

where \( \lambda_{ji} \) is the employment share of factor \( j \) in sector \( i \) (cf. Jones, 1965). Note that \( s_{S1} = \sigma_1 \theta_{Z1} \lambda_{S1} \), where \( \sigma_1 = c^1 c^i_{w}, c^i_{r}, \) etc. Letting a dot over a variable denote the time derivative, the adjustments of the system can be expressed as

\[
\begin{bmatrix}
\dot{X}_1 \\ \dot{X}_2 \\ \dot{w}_w \\ \dot{w}_r \\ \dot{r}
\end{bmatrix}
= \begin{bmatrix}
0 & 0 & -\theta_{S1} & 0 & -\theta_{Z1} \\
0 & -(2 + e) & 0 & -s b \theta_{L2}^m & -s b \theta_{Z2}^m \\
1 & 0 & -s_{S1} & 0 & s_{S1} \\
0 & 1 & 0 & -s_{L2} & s_{L2} \\
\lambda_{Z1} & \lambda_{Z2}^m & s_{Z1} & s_{Z2}^m & -(s_{Z1} + s_{Z2})
\end{bmatrix}
\begin{bmatrix}
\dot{X}_1 \\ \dot{X}_2 \\ \dot{w}_1 \\ \dot{w}_2 \\ \dot{r}
\end{bmatrix}
\]

The principal minors of the above coefficient matrices are:

\[ \Delta_1 = 0, \]
\[ \Delta_2 = 0, \]
\[ \Delta_3 = -\theta_{S1} (2 + e), \]
\[ \Delta_4 = \theta_{S1} [s b \theta_{L2}^m + s_{L2} (2 + e)] \]
\[ \Delta_5 = -\theta_{S1} \theta_{Z1} (s_{Z2}^m + s_{L2} \lambda_{Z2}^m) - (s_{S1} \lambda_{Z1} + s_{Z1} \theta_{Z1}) [s b \theta_{L2}^m + s_{L2} (2 + e)]. \]

The \( D \)-stability requires that the odd principal minors are non-positive and the even principal minors are non-negative (Quirk and Saposnik, 1968, p. 166). Hence, we need that \( 2 + e > 0 \) to assure \( \Delta_3 < 0, \Delta_4 > 0 \) and \( \Delta_5 < 0 \) for stability.

Solving the above changes of equations, we obtain the following comparative-static results:
\[
\hat{X}_1 / \hat{Z} = -s_{S_1} (eb \theta_{L_1}^m + s_{L_2} (2 + e)) / \Delta_5 > 0,
\]
\[
\hat{X}_2 / \hat{Z} = -eb s_{S_2} \theta_{S_2} (\theta_{L_1}^m + \theta_{Z_2}^m) / \Delta_5 > 0,
\]
\[
\hat{w}_1 / \hat{Z} = -\theta_{S_1} (eb \theta_{L_1}^m + s_{L_2} (2 + e)) / \Delta_5 > 0,
\]
\[
\hat{w}_2 / \hat{Z} = -\theta_{S_1} (eb \theta_{Z_2}^m - s_{L_2} (2 + e)) / \Delta_5 \geq 0,
\]
\[
\hat{r} / \hat{Z} = \theta_{S_1} (eb \theta_{L_1}^m + s_{L_2} (2 + e)) / \Delta_5 < 0.
\]
Figure 1. An increase in pollution emissions
Figure 2. A rise in the price of good $X_2$
Figure 3. An increase in pollution emissions under monopoly