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Transfer of Pollution Abatement Technology and Unemployment

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Abstract

This paper investigates the effects of the transfer of pollution abatement technology on the level of urban unemployment, the total amount of pollution, and social welfare in a small, open Harris--Todaro economy. We show that these transfers reduce urban unemployment and decrease the total amount of pollution. However, social welfare is unchanged because the technology transfer does not affect factor prices.

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1 Introduction

In most trade negotiations, the difference in economic environments between developed and developing countries has been a major source of conflict. This is because the main interest of developing countries is often the elimination of poverty and structural unemployment through economic extension and growth, while the management of environmental problems is given rather less attention.

The cooperation of developing countries is indispensable for solving many global environmental problems. In recent years, developed countries have supported pollution abatement activities in many developing countries [1]. The transfer of pollution abatement technology is one of the more practical measures for abatement activity, wherein advanced countries assist with the introduction and promotion of cleaner technologies.

There are several studies concerning the transfer of pollution abatement technology. Stranlund (1996) notes the strategic relation in choosing the level of an abatement activity, and examines whether the technology transfer from a technologically advanced country to its less-advanced rival is implemented. Itoh and Tawada (2003) analyze the welfare effects of the technology transfer based on the Ricardian two-country model of Copeland and Taylor (1999). By using expenditure and revenue functions, Takarada (2005) generalizes Itoh and Tawada's (2003) model and analyzes the case of incomplete specialization [2]. In the above literature, however, the technology transfer has not yet been analyzed in a model including unemployment [3].

The main purpose of our paper is to reveal the effect of technology transfer on the level of urban unemployment, the total amount of pollution, and social welfare. Our research is related to Itoh and Tawada (2003) and Takarada (2005) in that the main objective of the analysis also concerns the transfer of pollution abatement technology. However, our work is different in that unemployment and a consumption externality are involved. In particular, because rising unemployment is an important problem for developing countries, we try to clarify the relation between technology transfer and unemployment. In addition, we consider the case where labor migrates between

[1] There are many instances of research concerning foreign aid and the environment. See, e.g., Copeland and Taylor (1995), Chao and Yu (1999), Hatzipanayotou, Lahiri, and Michael (2002), and Naito (2003).

[2] Michael and Van Marrewijk (1998) examine the welfare effects of untied aid and aid tied to capital transfers in a model in which unemployment of a Harris–Todaro type is embedded. However, environmental externalities are not included.

[3] For the analysis of environmental preservation and unemployment in an open economy based on a variation of the Harris–Todaro (1970) model, see, e.g., Chao and Yu (2004, Ch. 2 and 3).

sectors according to their expected utility, rather than their expected wage, in the same way as Issah, Khan, and Sasaki (2005) [4]. With this framework, we show that the pollution abatement technology's transfer reduces pollution emissions, increases urban unemployment, and does not change social welfare.

The paper is organized as follows. Section 2 presents the model. In Section 3, we consider the positive and normative aspects of the transfer of pollution abatement technology. The final section offers some concluding remarks.

2 The model

We use the standard model of a small open Harris–Todaro (H–T) economy with intersectoral capital mobility. The economy consists of an urban manufacturing sector and a rural agricultural sector. Let m and a represent the urban sector and the rural sector. Two final goods (X_m and X_a) are produced using inelastically supplied labor (L) and capital (K), and the production technology in both goods exhibits constant returns to scale. The rural wage and the rental price are flexible; however, the urban wage is rigid because of minimum-wage laws, implying that some urban labors are unemployed. Unlike the standard H–T model, we assume that the unemployed worker obtains an unemployment benefit (w_u) from the government and that rural labor migrates from the rural area to the urban area according to the expected utility in each area.

Because all the markets are perfectly competitive and the technology of both goods is constant returns to scale, the zero-profit conditions are expressed as:

$$p = c^m(\bar{w}, r), \tag{1}$$

$$1 = c^a(w_a, r), \tag{2}$$

where c^m and c^a are the unit cost functions in the urban and rural sectors, respectively, and p is the relative price of good X_m in terms of good X_a. Moreover, $\bar{w}$ is the urban minimum wage, w_a is the rural wage, and r is the rental rate of capital.

We assume that urban production generates pollution (z). The amount of pollution depends on the output of the manufacturing good, and is written

[4] Issah, Khan, and Sasaki (2005) note the effects of the provision of infrastructure on rural–urban migration.

as:

$$z = \lambda X_m, \tag{3}$$

where λ denotes pollution abatement technology. If λ is large (small), the technological level of pollution abatement is low (high).

Let us consider the employment conditions of labor and capital. The equilibrium condition of factor markets must satisfy:

$$L = c_w^a X_a + c_w^m X_m/(1-\mu), \tag{4}$$
$$K = c_r^a X_a + c_r^m X_m, \tag{5}$$

where c_w^i and c_r^i $(i = m, a)$ denote the partial derivative of c^i in the wage and rental rate, and stand for the unit requirements for labor and capital in sector i, respectively. In addition, $\mu = L_u/(L_m + L_u)$ denotes the urban unemployment rate, and L_m, L_u, and L_a are employed and unemployed labor in the urban sector and rural labor, respectively.

The government provides unemployment benefits to the urban unemployed, with total government expenditure given by $w_u L_u$. On the other hand, we assume that the government collects the entire urban capital revenue, and thus the total tax revenue is given by rK_m. Noting that $L_u = \mu L_m/(1-\mu) = \mu c_w^m X_m/(1-\mu)$ from $\mu = L_u/(L_m + L_u)$, we can represent a balanced government budget by:

$$r c_r^m = w_u c_w^m \mu/(1-\mu). \tag{6}$$

Next, we consider the individual utility in each situation. All the individuals of this country have the same utility function $U = u(w, \delta z)$, where w is a general notation of individual income, and δ is a parameter that represents the degree of external damage [5]. However, the income that they receive is different in each situation. If we denote the utility level of the employed labor in the urban sector, the unemployed labor in the urban sector, and the rural labor by U_m, U_u and U_a, respectively, the utility function in each situation can be expressed by:

$$U_m = u(\bar{w}, \alpha z), \tag{7}$$
$$U_u = u(w_u, \alpha z), \tag{8}$$
$$U_a = u(y_a, \beta z), \tag{9}$$

where y_a is the rural income. α and β correspond to the above δ and represent the degree of external damage in the urban sector and the rural sector,

[5] We assume that $\partial u/\partial w > 0,\ \partial^2 u/\partial w^2 < 0,\ \partial u/\partial z < 0$, and $\partial^2 u/\partial z^2 < 0$.

respectively. In the following analysis, we assume that pollution generated by the urban production has an influence on urban labor only. That is, $\alpha = 1$ and $\beta = 0$.

Finally, we provide the migration condition. When an individual migrates from the rural to the urban region, the environment of the city should have an influence on his or her decision making. Hence, we assume that labor migrates between sectors according to the expected utilities, even though the condition in the standard H–T model depends on the expected wages in each sector. Thus, the migration condition means that the expected utility in the urban sector (E_u) is equal to the expected utility of rural labor (E_a).

We define here the expected utilities in each sector so as to lead to the migration condition. In detail, the expected utility in the urban sector is represented by:

$$E_u = (1-\mu)u(\bar{w}, z) + \mu u(w_u, z). \tag{10}$$

On the other hand, we assume that rural labor receives as its income the average product in the rural sector. This is because the more general payment system in the rural sector is the sharing income system rather than the marginal product system. Therefore, the expected utility of rural labor is:

$$E_a = u\left(w_a + rK_a/L_a\right), \tag{11}$$

where K_a represents the level of the capital in the rural sector, and we abbreviate βz in the interest of brevity because $\beta z = 0$.

From the above-mentioned discussion, the migration condition is given by:

$$u\left(w_a + rK_a/L_a\right) = (1-\mu)u(\bar{w}, z) + \mu u(w_u, z), \tag{12}$$

or:

$$u\left(w_a + rc_r^a/c_w^a\right) = (1-\mu)u(\bar{w}, z) + \mu u(w_u, z). \tag{13}$$

The system of above simultaneous equations, (1)–(6) and (13), decides the following endogenous variables, $\mu, w_u, w_a, r, X_m, X_a$, and z.

3 The effects of the abatement technology's transfer

In this section, we investigate the effects of the transfer of abatement technology on welfare. First, let us analyze the comparative statics in the abatement technology's transfer.

Because we assume a small open economy, $dw_a = dr = 0$ by equations of (1) and (2). Hence, from (3), we obtain:

$$dz/d\lambda = X_m + \lambda dX_m/d\lambda. \quad (14)$$

Noting that $dw_u = -w_u/\mu(1-\mu)d\mu$ from (6), the total derivatives of (4), (5), and (13) yield:

$$\begin{bmatrix} c_w^a & c_w^m/(1-\mu) & c_w^m X_m/(1-\mu)^2 \\ c_r^a & c_r^m & 0 \\ 0 & -A_m & A_\mu \end{bmatrix} \begin{bmatrix} dX_a \\ dX_m \\ d\mu \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ A_\lambda \end{bmatrix} d\lambda, \quad (15)$$

where $A_m, A_\mu, and A_\lambda$ are:

$$\begin{aligned} A_m &\equiv \lambda \{(1-\mu)u_z(\bar{w}, z) + \mu u_z(w_u, z)\} < 0, \\ A_\lambda &\equiv X_m \{(1-\mu)u_z(\bar{w}, z) + \mu u_z(w_u, z)\} < 0, \\ A_\mu &\equiv u(\bar{w}, z) - u(w_u, z) + u_w(w_u, z)w_u/(1-\mu) > 0. \end{aligned}$$

The determinate of the coefficient matrix in (15) is given by:

$$|E| \equiv -A_m c_r^a c_w^m X_m/(1-\mu)^2 + A_\mu\{c_r^m c_w^a - c_r^a c_w^m/(1-\mu)\} > 0. \quad (16)$$

If we assume the Khan–Neary condition as the stability condition in the standard H–T model [6], $c_r^m/c_w^m > c_r^a/c_w^a(1-\mu)$, then the determinant is positive.

Therefore, the following results are derived for the transfer of pollution abatement technology:

$$\begin{aligned} dX_a/d\lambda &= -A_\lambda c_r^m c_w^m X_m/|E|(1-\mu)^2 > 0, & (17) \\ dX_m/d\lambda &= A_\lambda c_r^a c_w^m X_m/|E|(1-\mu)^2 < 0, & (18) \\ d\mu/d\lambda &= |E|^{-1} A_\lambda\{c_r^m c_w^a - c_r^a c_w^m/(1-\mu)\} < 0. & (19) \end{aligned}$$

Moreover, substituting (18) into (14), we obtain:

$$dz/d\lambda = |E|^{-1} X_m A_\mu\{c_r^m c_w^a - c_r^a c_w^m/(1-\mu)\} > 0. \quad (20)$$

The transfer has no influence on factor prices, but decreases urban pollution. Thus, the expected utility in the urban area rises and rural labors migrate into the urban area. However, because urban employment does not rise and factor prices are unchanged, the migrating rural labors become unemployed in the urban sector and urban unemployment rises. In addition, the unemployment benefit decreases because government revenue does not change.

[6] See Khan (1980), Neary (1981), and Khan and Naqvi (1983) for this stability condition.

Having investigated the comparative statics of the abatement technology's transfer, we next define social welfare so as to examine the impact of the abatement technology's transfer. We assume that social welfare is the summation of the individual utility in each situation. Namely, the social welfare function (W) is defined by $W = L_m U_m + L_u U_u + L_a U_a$. Thus, considering (13), we can represent this function as:

$$W = Lu(w_a + rK_a/L_a)\,(= L\{(1-\mu)u(\bar{w}, z) + \mu u(w_u, z)\})\,. \quad (21)$$

Differentiating (21), and using the results of the previously found comparative statics, we can find the effect of the transfer of pollution abatement technology on social welfare. However, because social utility depends only on the factor prices, the technology transfer does not have an influence. We can summarize the above result by the following proposition.

Proposition 1 *The transfer of pollution abatement technology reduces emissions, aggravates urban unemployment, and decreases unemployment benefits. Social welfare is, however, unchanged because improvement in the abatement technology does not affect factor prices.*

4 Concluding remarks

We examine the effect of the transfer of pollution abatement technology on the level of urban unemployment, the total amount of pollution, and social welfare. Because the technology transfer improves the environment of the urban region, migration from the rural area to the urban area increases, and the number of manufacturing unemployed decreases. However, social welfare is unchanged because the technology transfer has no impact on factor prices.

In closing, let me point out a qualification. If we assume that pollution can be decreased by acquiring more production factors for abatement activities at a certain level in the production of dirty goods, the technology transfer may have an influence on factor prices. Hence, further research is required for a more general description of pollution abatement technology.

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