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Unemployment, Environmental Policy, and International Migration*

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Abstract

In this paper, we investigate the effects of an increase in emission tax, a decrease in fixed manufacturing wage rate, and an increased inflow of foreign workers on competitive wages, the environmental stock, the economic welfare of the representative consumer, and employment in the presence of a pollution abatement equipment sector and unemployment. Our main findings are that an increase in emission tax and a decrease in the urban minimum wage rate decrease unemployment, and international immigration may increase the competitive wage rate, employment rate, stock of environmental capital, and economic welfare of the representative worker.

1. Introduction

Among the serious economic problems faced by developed countries like Japan, decreasing population and unemployment are the most difficult to deal with. One of the reasons is that these two phenomena are supposedly contradictory—a decreasing population usually implies a shortage of workers. In Japan, temporary economic recession generates a large number of unemployed persons—as many as 3.67 million as of September 2009, around 1 million more than the October 2008 figures. The working-age population of Japan has been decreasing since 1995, and it has become necessary to introduce foreign workers to sustain long-term economic performance. However, recent economic conditions have diverted attention from this impending issue to the pressing problem of how to supply enough job opportunities to domestic labor.

As the Japanese government recognizes, one of the promising growth industries to create enough job opportunities in developed countries is the environmental industry, which supplies environmental equipment and services. The importance of this industry is steadily increasing given the drive to reduce pollution from smokestack industries and preserve or improve the natural environment. Correspondingly, the global market of the environmental industry is also growing, and because of technical reasons, developed countries still hold relative advantages in the production of pollution

abatement equipments. The ideal scenario for developed countries is to attain economic growth by specializing in the environmental industry. After sufficient recovery, with lower unemployment, the industry would start introducing foreign workers and expanding both the economic magnitude of the sector and per capita income. The main subject of this study is to investigate the possibility of this scenario.

Several theoretical studies deal with environmental topics in an international trade model. With regard to the environmental industry, Merrifield (1988) analyzes the effects of equipment standards on trade and capital mobility. Copeland (1991) studies the trade in waste disposal services. Chua (2003) examines the effects of an emission tax on the trade pattern with a three-sector model in which one sector is the non-tradable pollution abatement service sector. Sugiyama (2003) also studies the effects of environmental policies with a two-sector model in which one sector produces pollution abatement equipment. Abe and Sugiyama (2008) analyze the structure of comparative advantage determined by international differences in environmental policies with a model incorporating pollution abatement equipment and examine the effects of an environmental policy in an open economy.

Several studies have been undertaken on the possibilities and effects of international migration with a two-country model considering the economic value of the

natural environment. Kondoh (2006) analyzes the welfare effects of international migration in the presence of trans-boundary pollution by using a simplified version of the Copeland and Taylor (1999) model, in which the developed country's pollution abatement technology is superior to that of the developing country. In the absence of trade, workers migrate from the developing country to the developed country. The developing home country surely gains, but whether the host country gains or not depends on the parameters, the abatement technology gap, and the magnitude of the coefficient of trans-boundary pollution. Kondoh (2007) extends his 2006 study by introducing two types of workers: unskilled workers, who contribute only to the production in the smokestack manufacturing industry, and skilled workers, who can contribute not only to production but also to the reduction of pollution. He extended his study again, introducing the pollution abatement equipment industry (Kondoh, 2009). Migration has positive effects on the wage rate, environment stock, and welfare of the worker in at least one country. Moreover, we showed the possibility that both countries gain from international migration. However, note that none of these studies considers unemployment of workers.

Concerning labor unemployment, Tawada (2007) introduces the natural environment into the Harris and Todaro (1970) model, investigates the effect of an

improvement in pollution abatement technology, and concludes that if the urban sector

is capital intensive, the improvement in pollution abatement technology induces an

increase in urban unemployment and a deterioration of the natural environment and

national welfare. Tawada's model includes two factors, labor and capital, and thus his

result depends on the difference in factor endowments between two economic areas.[1]

Even urban unemployment increases by the improvement in pollution abatement

technology; it reduces the environmental stock and economic welfare. Thus,

technological improvement would not always be an optimal policy. Chao, Kerkviliet, and

Yu (2000) develop a general equilibrium model with unemployment to examine the

optimal level of environmental preservation. They examine the effects of environmental

protection on unemployment and national income as well as the beneficial effects from

the availability and provision of environmental amenities.

　We develop a three-good model based on a simplified Copeland and Taylor (1999)

model: a smokestack manufacturing final good, an environmentally sensitive

agricultural final good, and pollution abatement equipment supplied to the

manufacturing industry by the public sector. The purpose of this study is to investigate

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[1] The Harris-Todaro framework has been utilized extensively in development and trade literature. See, for example, Bhagwati and Srinivasan (1974), Khan (1982), Neary (1981), Beladi and Marjit (1996), Yabuuchi (1993), Gupta (1995), Chao and Yu (1996), Basu (2000), Marjit and Beladi (2003), and Beladi and Yabuuchi (2010).

the effects of an increase in emission tax, a decrease in the fixed manufacturing wage rate, and an increased inflow of foreign workers on competitive wages, the environmental stock, the economic welfare of the representative consumer, and employment in the presence of a pollution abatement equipment sector and unemployment. We find that (i) an increase in emission tax decreases unemployment, (ii) a decrease in the urban minimum wage rate also decreases unemployment, and (iii) under certain simple conditions, international immigration will cause positive effects on the wage rate, environment stock, economic welfare of the representative worker, and employment rate.

The paper is organized as follows. In Section 2, we set up the model. The effects of an increase in emission tax, a decrease in the fixed manufacturing wage rate, and an increased inflow of foreign workers on competitive wages, the environmental stock, the economic welfare of the representative consumer, and employment are studied in Section 3. Finally, Section 4 offers the concluding remarks.

2. The Model and Assumptions

We assume a small country with three industries: the smokestack manufacturing industry, which is located in an urban area and generates pollution; the

environmentally sensitive agricultural industry, which is located in a rural area and suffers from the pollution; and the pollution abatement equipment industry, which is managed by the public sector. We assume that the equipment functions as a filter, which helps to purify polluted air or water. The equipment improves the pollution abatement technology of the manufacturing industry. The two primary factors of production are labor and environmental capital; the latter is the specific factor in the production of the agricultural good.

The production functions of the manufacturing, agricultural, and pollution abatement equipment industries in this country are

$$M = L_M,$$ (1a)

$$A = \sqrt{E}L_A,$$ (1b)

$$D = \beta L_D,$$ (1c)

where E is the stock of environmental capital; M and L_M, respectively, the output and labor input of the manufacturing industry; A and L_A, those of the agricultural industry; D and L_D, those of the pollution abatement equipment industry; and β, the parameter that reflects the productivity of pollution abatement equipment.

The production activity in the manufacturing industry causes pollution, but pollution abatement equipment could improve the pollution abatement technology of the industry.

We assume that the emission of pollutants, denoted by Z, is proportional to the manufacturing output:

$$Z = (\lambda - \mu D)L_M . \tag{2}$$

Here, λ is the pollution abatement technology without any equipment, and μ is the efficiency of an equipment to improve the technology. We assume that pollution abatement technology improves proportionally with the number of equipments.

We assume that the stock of environmental capital decreases with the amount of emission, Z. Therefore, the net stock of environmental capital is

$$E = \bar{E} - Z , \tag{3}$$

where $\bar{E}$ is the natural stock level of environmental capital before damages.

The minimum wage rate of the manufacturing industry is $\bar{w}$, which is exogenously determined by negotiation between the employers and the labor union. Similar to the Harris-Todaro setting, urban workers can obtain $\bar{w}$ if employed, but no wage if not employed, by the manufacturing industry. The possibility of a worker being employed or not in every period depends on only random probability. On the other hand, as we do not assume fixed wage rates in the agricultural industry and public sector, the wage rate w in both sectors are equal.[2] In the equilibrium after domestic labor

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[2] Usually, the Harris-Todaro setting is applied to developing countries. In Japan, the unemployment rate in urban areas is not always higher than that in rural areas, and workers are not always unionized in urban areas. However, except for Hokkaido and Okinawa, the location of which is quite

mobility between the two regions, we have

$$w(L_M + L_U) = \bar{w}L_M ,$$
(4a)

or

$$w(1 + \eta) = \bar{w} ,$$
(4b)

where L_U denotes the number of unemployed workers, and $\eta (= L_U / L_M)$ is the ratio

of unemployed to employed workers in the urban area.

Regarding industry structure, we assume perfect competition with free entry both

in the manufacturing and agricultural industries. Let π_M and π_A be the total profits

of the manufacturing and agricultural industries, respectively, expressed as follows:

$$\pi_M = p_M M - \bar{w}L_M - tM ,$$
(5)

$$\pi_A = A - wL_A ,$$
(6)

where the agricultural good is the numeraire, p_M the price of manufactured good, and

t the specific rate of emission tax. The government supplies pollution abatement

equipment to the manufacturing industry free of charge. Thus, there is no cost to

introduce the equipment. Then, under the assumption that both goods are produced,

profit maximization conditions in the manufacturing and agricultural industries yield

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inconvenient for domestic migration, the unemployment rate in the Osaka region, the second largest urban area, has been the highest. Moreover, the lifelong income of an urban worker who is employed by a unionized large firm would be higher than that of a rural worker engaged in the agricultural or fishing industry. Therefore, we believe that the Harris-Todaro setting might be valid even in developed countries like Japan.

$$\frac{\partial \pi_M}{\partial L_M} = p_M - \bar{w} - t = 0, \tag{7}$$

$$\frac{\partial \pi_A}{\partial L_A} = \sqrt{E} - w = 0. \tag{8}$$

The full employment condition is

$$L_M + L_A + L_D + L_U = L, \tag{9}$$

where L is the labor endowment of this country.

The pollution abatement equipment industry is managed by the government. The budget constraint of the government is

$$wL_D = tM, \tag{10}$$

where the LHS of (10) is the labor cost in the pollution abatement equipment industry, while RHS is the tax revenue.

On the demand side, we specify the following social utility function:

$$U = (D_M)^\alpha (D_A)^{1-\alpha}, \quad 0 < \alpha < 1 \tag{11}$$

where D_M and D_A are aggregate consumption levels of the manufactured and agricultural good, respectively. Because of the zero profit of each firm and the government budget constraint, the GDP of this country is equal to labor income, $w(L_A + L_D) + \bar{w}L_M = wL$. Therefore, the demand for each good is obtained by solving the utility maximization problem, subject to the following budget constraint:

$$D_A + p_M D_M = wL. \tag{12}$$

Thus, we have

$$p_M D_M = \alpha w L, \tag{13a}$$

$$D_A = (1-\alpha)w L. \tag{13b}$$

$D_A (= A)$ is proportional to the income *(wL)* due to the property of the utility function as shown in (13b). On the other hand, A is equal to $w L_A$ because of the zero-profit condition. Thus, L_A is fixed at the level of $(1-\alpha)L$ in the present model. Therefore, the labor allocation mechanism à la Harris-Todaro is just between the manufacturing and pollution abatement sectors.

3. Comparative Statics: Autarkic Equilibrium

In autarky, the demand for manufacturing and agricultural goods is equal to the domestic output. Thus, we have

$$D_M = M, \tag{14a}$$

$$D_A = A. \tag{14b}$$

From (6), (8), (13b), and (14b) we have

$$L_A = (1-\alpha)L, \tag{15}$$

and making use of (4), (8), and (1c) we obtain

$$\beta(\bar{w}M - \alpha w L) + Dw = 0. \tag{16}$$

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On the other hand, from (7), (13a), and (14a) we have

$$\alpha w L - M(\bar{w}+t) = 0. \tag{17}$$

Finally, from (2), (3), and (8) we have

$$\bar{E} - (\lambda - \mu D)M = w^2. \tag{18}$$

Now we have three equations—(16), (17), and (18)—that determine the three

endogenous variables w, M, and D, given the exogenous variables $\bar{E}, \alpha, \gamma, L, t, \bar{w}$,

and λ.[3]

Totally differentiating (16), (17), and (18),

$$
\begin{bmatrix} D - \alpha\beta L & \beta\bar{w} & w \\ \alpha L & -(\bar{w}+t) & 0 \\ 2w & \lambda - \mu D & -\mu M \end{bmatrix}
\begin{bmatrix} dw \\ dM \\ dD \end{bmatrix}
=
\begin{bmatrix} \alpha\beta w \\ -\alpha w \\ 0 \end{bmatrix} dL
+
\begin{bmatrix} -\beta M \\ M \\ 0 \end{bmatrix} d\bar{w}
+
\begin{bmatrix} 0 \\ M \\ 0 \end{bmatrix} dt . \tag{19}
$$

The determinant of the matrix of (19) is

$$
\begin{aligned}
\Delta = \beta\mu M[\alpha L t + (\bar{w}+t)L_D] \\
+ w[\alpha L(\lambda - \mu D) + 2w(w+t)] > 0
\end{aligned} \tag{20}
$$

3.1 An Increase in Emission Tax

First, let us consider an increase in the emission tax rate. From (19), simple

calculations yield

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[3] It might be necessary to remark that, from (15) and (16), we can easily derive (9). Usually, the government determines the tax rate t to maximize social utility, U. However, in our analysis, because of strong resistance by the manufacturing industry, we assume that the tax rate is lower than the optimal level and exogenously given. Moreover, to satisfy (18), we implicitly assume $\lambda - \mu D > 0$.

$$\frac{dw}{dt} = \frac{1}{\Delta} M[\beta\mu\bar{w}M + w(\lambda - \mu D)] > 0, \tag{21}$$

$$\frac{dM}{dt} = -\frac{1}{\Delta} M[(D - \alpha\beta L)\mu M + 2w^2], \tag{22}$$

$$\frac{dD}{dt} = -\frac{1}{\Delta} M[(D - \alpha\beta L)(\lambda - \mu D) - 2\beta w\bar{w}] > 0, \tag{23}$$

$$\frac{dL_U}{dt} = -\frac{dM}{dt} - \frac{1}{\beta}\frac{dD}{dt}$$

$$= \frac{1}{\beta\Delta} M[(D - \alpha\beta L)(\lambda - \mu D + \beta\mu M) + 2\beta w(w - \bar{w})] < 0 \tag{24}$$

Therefore, in this case, we can conclude that an increase in emission tax reduces unemployment.

Regarding the effect on the environmental capital stock, we have the following relationship from (8):

$$\text{sgn}\, dw = \text{sgn}\, dE, \tag{25}$$

Next, let us consider the effect on welfare. In this model, as the competing firms in the manufacturing industry make no profit, national welfare will be equal to the economic welfare of the workers. The expenditure function of a representative worker is defined as

$$e(p_M, u) = w, \tag{26}$$

where u denotes the utility level of a representative worker in this country. Totally differentiating (26),

$$\frac{\partial e}{\partial p_M} dp_M + \frac{\partial e}{\partial u} du = dw. \tag{27}$$

From Shephard's lemma, we have $\dfrac{\partial e}{\partial p_M} = m$, where m denotes per capita

consumption of the manufactured good. Given $m = \dfrac{M}{L} = \dfrac{L_M}{L} < 1$, and from (5), we have

$dp_M = dt$ under a constant fixed wage rate. Then (27) yields

$$\frac{\partial e}{\partial u}\frac{du}{dt} = \frac{dw}{dt} - m,\tag{28}$$

and the sign of (28) is not clear.

As a result, we can conclude the following proposition.

PROPOSITION 1

An increase in emission tax can reduce unemployment in urban areas and improve the

environmental capital stock level.

An increase in emission tax raises the government tax revenue. This helps to expand

output and employment in the pollution abatement sector (*D*). In turn, this helps lower

the emission of pollutants and increase the net stock of environmental capital (*E*). An

increase in productivity in the agricultural sector, due to the increase in environmental

capital, raises the output of the agricultural sector and the competitive wage rate. On

the other hand, the increase in the tax increases the price of the manufactured good.

This has a downward pressure on the output of sector *M*, while the increase in the

national income tends to increase the demand for the good. Therefore, the change in the output and employment of sector M is indeterminate. Thus, there is a possibility that the manufacturing output would increase in spite of the emission tax. However, it can be shown that the tax decreases unemployment eventually. This implies that the increase in employment of sector D is larger than the possible decrease in employment of sector M.

3.2   A Decrease in Urban Minimum Wage Rate

Second, let us consider a decrease in the urban minimum wage rate due to the negotiation between the employers and the labor union or some political consideration. From (19), simple calculations yield

$$\frac{dw}{d\overline{w}} = \frac{1}{\Delta} Mw(\lambda - 2\mu D)],$$ (29)

$$\frac{dM}{d\overline{w}} = -\frac{M}{\Delta}(\mu MD + 2w^2) < 0,$$ (30)

$$\frac{dD}{d\overline{w}} = -\frac{M}{\Delta}[D(\lambda - \mu D) + 2\beta wt] < 0,$$ (31)

$$\frac{dL_U}{d\overline{w}} = -\frac{dM}{d\overline{w}} - \frac{1}{\beta}\frac{dD}{d\overline{w}} > 0$$ (32)

$$\frac{\partial e}{\partial u}\frac{du}{d\overline{w}} = \frac{dw}{d\overline{w}} - m$$ (33)

Equation (29) implies that if pollution abatement equipment is not effective enough to reduce more than half of the original emission of pollution by the

manufacturing industry (i.e., $\lambda / 2 > \mu D$), a decrease in the urban minimum wage rate lowers the competitive wage rate. Therefore, in this case, the urban–rural wage gap will increase. On the other hand, if the pollution abatement equipment is sufficiently effective and can reduce more than half of the original emission of pollution by the manufacturing industry (i.e., $\lambda / 2 < \mu D$), a decrease in the urban minimum wage rate raises the competitive wage rate. In this case, from (33), we can conclude that the economic welfare of the representative worker will also increase. Thus, we establish the following proposition.

PROPOSITION 2

(1) A decrease in the urban minimum wage rate can reduce unemployment in urban areas.

(2) If pollution abatement equipment is sufficiently (not sufficiently) effective and can (cannot) reduce more than half of the original emission of pollution by the manufacturing industry, a decrease in the urban minimum wage rate would increase (decrease) the competitive wage rate. Moreover, the natural environmental capital stock will increase (decrease) and economic welfare will also increase (will not clear).

A decrease in the urban wage rate per se expands the output and employment of the manufacturing sector. Furthermore, it increases the production of sector D through the increase in the government tax revenue. Thus, a decrease in $\bar{w}$ expands both sectors, M and D, and increases employment in the sectors. This leads to a decrease in unemployment.

From (2), we obtain the induced effect on the emission of pollutants (Z) as

$$\hat{Z} = \hat{L}_M + (-\mu D)/(\lambda - \mu D)\hat{L}_D. \tag{34}$$

This implies that the elasticity of the emission of pollutants (Z) with respect to L_M is unity, while the elasticity with respect to L_D is $(-\mu D)/(\lambda - \mu D)$. Thus, it can be seen that an increase in L_M increases Z and an increase in L_D decreases it. Furthermore, considering (3), (8), and (10), (34) can be written as

$$(1 + 2\sqrt{E}/Z)\hat{Z} = [(\lambda - 2\mu D)/(\lambda - \mu D)]\hat{L}_D. \tag{35}$$

Therefore, emission increases (decreases) if $(-\mu D)/(\lambda - \mu D)$ is less (greater) than unity; i.e., $(\lambda - 2\mu D) > (<)0$. The increase (decrease) in the emission of pollutants (Z) leads to a decrease in the net stock of environmental capital (E). Then, this decreases (increases) the value of the marginal product of labor in sector A ($\sqrt{E}$), resulting in an eventual decrease (increase) in the competitive wage rate (w) according to the condition $(\lambda/2) > (<)\mu D$.

3.3 An Increase in the Total Amount of Workers

Finally, let us consider an increase in labor due to an inflow of foreign workers.

From (19), simple calculations yield

$$\frac{dw}{dL} = \frac{1}{\Delta} \alpha w^2 (\lambda - 2\mu D), \tag{36}$$

$$\frac{dM}{dL} = \frac{\alpha w}{\Delta} (\mu DM + 2w^2) > 0, \tag{37}$$

$$\frac{dD}{dL} = \frac{1}{\Delta} \alpha w [D(\lambda - \mu D) + 2\beta wt] > 0, \tag{38}$$

$$\begin{aligned}
\frac{dL_U}{dL} &= -\frac{dM}{dL} - \frac{1}{\beta}\frac{dD}{dL} + \alpha\beta \\
&= \alpha\beta w(\lambda - \mu D)(L - L_D) + \alpha\beta^2 \mu M[(\bar{w} + t - w)L_D + \alpha t L] \\
&> 0
\end{aligned} \tag{39}$$

$$\frac{\partial e}{\partial u}\frac{du}{dL} = \frac{dw}{dL} \tag{40}$$

Equation (39) implies that unemployment of the host country will surely increase as a result of immigration. Further, if β is sufficiently small, then dL_U/dL will be sufficiently small to satisfy $d(L_U/L)/dL < 0$, which implies the unemployment rate in the domestic labor market will decrease. If β is small, then the productivity of sector D is low. Thus, sector D requires a large amount of labor to satisfy the social needs for the production of manufacturing and agricultural goods. Therefore, in this case, immigrant workers are absorbed in sector D and contribute to reduce unemployment as well as possible increase in environmental capital and welfare.

To obtain (40), it is necessary to consider that, from (5), constant t and $\bar{w}$ imply constant p_M. As described in section 3.2, if pollution abatement equipment is not effective enough to reduce more than half of the original emission of pollution by the manufacturing industry, international immigration would increase the competitive wage rate. Therefore, in this case, the urban–rural wage gap will decrease. Further, from (25) and (40), international immigration will decrease the environmental capital stock and welfare of the host country. It may be noteworthy to mention that the unemployed to employed ratio in sector $M(\eta)$ decreases in this case, since it can be seen from (4b) that $(1+\eta)dw = -wd\eta$.

On the other hand, if the pollution abatement equipment is sufficiently effective and can reduce more than half of the original emission of pollution by the manufacturing industry, international immigration would lower the competitive wage rate. Therefore, in this case, the urban–rural wage gap will increase. Further, from (25) and (38), international immigration will decrease the environmental capital stock and welfare of the host country.

Thus, we establish the following proposition.

PROPOSITION 3

(1) International immigration may reduce the rate of unemployment (L_U / L).

(2) If pollution abatement equipment is sufficiently (not sufficiently) effective and can (cannot) reduce more than half of the original emission of pollution by the manufacturing industry, international immigration would reduce (enhance) the ratio of unemployed to employed workers (L_U / L_M) and enhance (reduce) the competitive wage rate, the natural environmental capital stock, and social welfare.

Therefore, if pollution abatement equipment is sufficiently effective and can reduce more than half of the original emission of pollution by the manufacturing industry, extended international immigration is quite a preferable policy. It would reduce the ratio of unemployed to employed workers and enhance the stock of the natural environment (and the productivity of agricultural industry), competitive wage rate of rural workers, and economic welfare.

4. Concluding Remarks

We developed a three-good general equilibrium model with a pollution abatement sector and urban unemployment. The effects of an emission tax, a fixed manufacturing wage rate, and immigration on the competitive wage rate,

environmental capital stock, and national welfare have been investigated in this framework. Our main findings are that (i) an increase in emission tax decreases unemployment, (ii) a decrease in the urban minimum wage rate also decreases unemployment, and (iii) under certain simple conditions, international immigration will have positive effects on the wage rate, environment stock, economic welfare of the representative worker, and employment rate.

It has been assumed throughout that an emission tax is fixed and imposed by the government according to some political or institutional consideration. However, alternatively, it may be assumed that the government imposes the optimal tax. Furthermore, the present model can be extended to the trading world and used to examine the effects of the variables on trade and factor movements. These constitute important issues to be investigated in future research.

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