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Trans-boundary Pollution, Optimal Transfer, and International Migration

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Abstract

We analyse the welfare effects of international migration in the presence of trans-boundary pollution. We use a simplified Copeland and Taylor (1999) model, where the (developed) home country's pollution abatement technology is superior to that of the (less developed) foreign country. For the home country, transferring manufactured good to the foreign country could be optimal so as to reduce the trans-boundary pollution caused by foreign manufacturing industry and improve the productivity of domestic agricultural good under some conditions. If workers migrate from the foreign country to the home country, both total amount of optimal transfer and world economic welfare will increase.

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1. Introduction

Environmental degradation caused by pollution generated by industrial production has become one of the world's most serious problems. One of the reasons why this problem is difficult to solve is that less developed countries lack the ability and financial resources to control pollution. Furthermore, their governments often give priority to economic growth at the expense

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of the quality of the environment.

There is a substantial literature that deals with the issues of environmental degradation in the context of international trade and production specialization. Among recent studies, a prominent work is the the article by Copeland and Taylor (1999), who extended the Ricardian model of comparative advantage to a dynamic setting. They examined the natural recovery of environmental resources, and analysed the effects on economic welfare of international specialization and trade. Suga (2002) allowed for international differences in pollution rates, and studied the effects of trade on the environment in the context of trans-boundary pollution. Ito and Tawada (2001) considered the effects of transfer of pollution abatement technology from a developed country to a less developed country.

On the other hand, Kondoh (2006) studied the effects of international migration on pollution levels and welfare in the presence of trans-boundary pollution, both in the case with free trade in goods, and in the case of no-trade in goods. Kondoh (2004) also considered the special but realistic case in which there exist both imperfect competition and unonization of labour in the developed country.

It seems that there still remains an important subject that has not considered yet. Among all, the effects on pollution and economic welfare by choosing the optimal aid from developed country to less developed country would be worth studying. Transferring manufactured good could enhance economic welfare of the developed because it reduce foreign-origin trans-boundary pollution and thus it could also improve the productivity of domestic agricultural industry under some conditions. Moreover to investigate the effects on the optimal amount of transfer and world economic welfare in the case of international migration from less developed country to developed country also seem to be interesting subjects.

In order to motivate the model, let us take the case of Japan and China. A substantial amount of trans-boundary pollutants is generated by manufacturing activities in China, where abatement technology is not as advanced as that of Japan. By the way, total amount of aid from Japanese to China is quite huge and we can find that two different types of aid are included. The first type is technological transferring which support the improvement of productivity of recipient. This type of aid must be useful to reduce trans-boundary pollution directly if advanced pollution abatement technology is transferred. Ito and Tawada (2001) discussed this type of transfer. The second type is to transfer consumption goods. If Japan donate manufactured good to China, Chinese manufacturing production will decrease. This may also cause positive effects on the environmental capital of Japan because of reduced China-origin trans-boundary pollution. Moreover, since the wage rate in China is relatively low, international migration from China to Japan is potentially possible. Such migration must have impacts on the level of aid and economic welfare.

We propose to study the economic effects of international migration using the Copeland-Taylor model of trade and pollution, under the assumption that production of manufactured goods generates trans-boundary pollution. In our model, there are two countries, called Home and Foreign. The (developed) home country's pollution abatement technology is superior to that of the (less developed) foreign country. We consider the simple case where there is no trade in goods. The home country intends to choose optimal level of aid, namely transferring manufactured good to the foreign country. We show that under some conditions, even in this case, workers will migrate from the foreign country to the home country. Both the level of optimal transfer and world welfare will increase if international migration is permitted.

We present the basic model in Section 2. In Section 3, we consider the conditions in which transferring some amount of manufactured good should be optimal for the home country. We also consider the conditions in which workers would migrate from foreign to home if permitted. In Section 4 we analyse economic effects under migration. Concluding remarks are in Section 5.

2. The Model[1]

The world consists of two countries, Home and Foreign. There are two industries in each country. One is a smokestack manufacturing industry, that generates pollution, and the other is an environmentally sensitive agricultural industry that suffers from the pollution. The two primary factors of production are labour and environmental capital, which is a public input in the production of the agricultural good.

The production functions of the manufacturing and agricultural industries in the home country are

$$M = L_M , \tag{1a}$$

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

[1] The framework of the model is almost the same with Kondoh (2006).

where E is the stock of environmental capital, M and L_M are, respectively, the output and labour input in the manufacturing industry, and A and L_A are those of the agricultural industry. The output in the manufacturing industry does not depend on the environmental capital stock, and one unit of output is produced by one unit of labour. In contrast, labour productivity of the agricultural industry depends on the level of the environmental capital stock: one unit of labour input produces $\sqrt{E}$ units of output in the agricultural industry.

Production activity in the manufacturing industry generates pollution. We assume that the emission of pollutants, denoted by Z, is proportional to manufacturing output:

$$Z = \lambda L_M = \lambda M , \quad 0 < \lambda < 1 . \tag{2a}$$

Here, λ is a constant of proportionality. Any improvement in abatement technology is reflected by a decrease in this parameter. Pollution reduces the level of the environmental capital stock, and therefore manufacturing industry production causes negative externalities to the agricultural industry.

We now turn to the pollution generated by the foreign country. Variables relating to this country are marked with an asterisk. Let M^* be the manufacturing output of the foreign country. The relationship between emission and manufacturing output in the foreign country is

$$Z^* = \lambda^* M^* , \quad 0 < \lambda^* < 1 \tag{2b}$$

Pollution generated in one country has negative effects on the environment in that country, as well as on the environment of the neighbouring country. We assume that total damage done environment of the home country is

$$D = Z + Z^*/b = \lambda M + \lambda^* M^*/b . \tag{3}$$

where $1/b$ is called the coefficient of trans boundary spill-over. It is between zero and one. We assume that the stock of environmental capital will be reduced by an amount equal to the level of damage, D. Therefore the total stock of environmental capital that remains after damages have occurred is

$$E = \overline{E} - D \tag{4}$$

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

Concerning industry structure, we assume perfect competition with free entry both in manufacturing and in agriculture, so that the profit of each firm is zero. Let π_M and π_A be the total profits of the manufacturing industry and the agricultural industry, respectively. Then, under the assumption that both goods are produced, we obtain the following two equations,

$$\pi_M = p_M M - wL_M = 0 \ ,$$

$$\pi_A = p_A M - wL_A = 0 \ ,$$

where p_M and p_A are, respectively, the price of the manufactured and agricultural goods, and w is the wage rate. The above two equations yield

$$p_M = w \ , \tag{5}$$

$$p_A \sqrt{E} = w \tag{6}$$

The full employment condition of the home country is

$$L_M + L_A = L \ , \tag{7}$$

where L is the labour endowment of the home country.

On the demand side, we specify the following utility function of the representative consumer

$$U = a \log D_M + (1 - a) \log D_A \tag{8}$$

where both a and $1 - a$ are positive parameters, and D_M and D_A are, respectively, consumption levels of the manufactured good and the agricultural good. As the profit of each firm is zero, the GNP of the home country is equal to labour income, wL. Therefore, the demand for each good is obtained by solving the utility maximization problem, subject to the budget constraint $p_A D_A + p_M D_M = wL$. Thus, we have

$$p_M D_M = awL \ , \quad p_A D_A = (1 - a) wL \ ,$$

or,

$$D_M = \frac{aw}{p_A} L \ , \tag{9a}$$

$$D_A = \frac{(1 - a)}{p_A} wL \ . \tag{9b}$$

Equations (5) and (9a) yield

$$D_M = aL \ . \tag{10}$$

Therefore, in equilibrium D_M is independent of the relative price.

From equations (3) to (6), the price of the manufactured good in terms of the agricultural good is

$$p_M / p_A = \sqrt{E} = \sqrt{\overline{E} - \lambda M - \lambda^* M^* / b} \ . \tag{11}$$

We now model international migration between the two countries. Since our focus is on the international difference in the level of abatement technology, we assume that the foreign country is exactly the same as the home country except for the pollution-output relationship (2). We assume that the pollution abatement technology of the home country is more advanced than that of the foreign country. Formally, we state:

ASSUMPTION 1. $L = L^*$, $a = a^*$, $\overline{E} = \overline{E}^*$ *and* $\lambda < \lambda^*$,

where variables with an asterisk denote those of the Foreign country.

3. Optimal Transfer and Direction of International Migration

In this section, we consider the case where the home country intend to transfer some amount of manufactured good to the foreign country in order to reduce trans-boundary pollution. There is no trade in goods, perhaps because one of the two goods is non-tradable or one of the two governments prohibits trade.

In autarky, each country produces both goods and the following condition holds,

$$\sqrt{E} = p_M / p_A > p_M^* / p_A^* = \sqrt{E^*} ,$$

since $\overline{E} = \overline{E}^*$, $M = aL = a^*L^* = M^*$ and $\lambda < \lambda^*$. This means that the home country has comparative advantage in the production of the environmentally sensitive agricultural goods.

From equations (3) to (6), we obtain

$$\sqrt{E} = w / p_A > w^* / p_A^* = \sqrt{E^*} \qquad (12a)$$

$$w / p_M = w^* / p_M^* = 1 \qquad (12b)$$

Therefore the real wage rate of the home country is higher than that of the foreign country. Thus, if international migration is permitted, workers will tend to move from the foreign country to the home country.

3.1 Optimal Transfer

Let T denotes the amount of transferred manufactured good. From equation (10), the amount of manufactured good consumed by each person of both countries equals a, thus without trade, we can assert the following equations,

$$M - T = aL = D_M , \qquad (13a)$$

$$M^* + T = aL = D_M^* . \qquad (13b)$$

Straightforwardly, we have $dM / dT = 1$, $dM^* / dT = -1$.

Remembering that

$$D_A = A = \sqrt{E}L_A = (L - M)\sqrt{\overline{E} - \lambda M(T) - \frac{\lambda^*}{b} M^*(T)}\ ,$$

we can find the optimal amount of T which maximize U of equation (8) as follows,

$$\frac{\partial U}{\partial T} = -\frac{1-a}{L-M} + \frac{1}{2E}(-\lambda + \frac{\lambda^*}{b})\ . \tag{14}$$

Equation (14) implies that if $\lambda^*/b < \lambda$, then $\partial U/\partial T$ is always negative in sign and therefore $\tilde{T} = 0$, where $\tilde{T}$ denotes the optimal amount of transfer.

On the other hand, if $\lambda^*/b > \lambda$ is satisfied, making use of

$$\frac{\partial^2 U}{\partial T^2} = -\frac{1-a}{(L-M)^2} - \frac{1}{4E^2}(-\lambda + \frac{\lambda^*}{b})^2 < 0\ ,$$

$\tilde{T}$ should be some positive amount which satisfy $\partial U/\partial T = 0$. From equation (14), $\tilde{T}$ can be expressed as follows,

$$\tilde{T} = (1-a)L - \frac{2[\overline{E} - aL(\lambda + b/\lambda^*)]}{-\lambda + b/\lambda^*}. \tag{15}$$

Concerning with the foreign country, applying Assumption 1, we obtain,

$$\frac{\partial U^*}{\partial T} = \frac{1-a}{L^* - M^*} + \frac{1}{2E^*}(\lambda^* - \frac{\lambda}{b}) > 0\ . \tag{16}$$

Equation (16) implies that receiving transfer always enhances economic welfare of the foreign country. Now we present the following assumption.

ASSUMPTION 2: $\dfrac{\lambda^*}{b} > \lambda$

Assumption 2 means that the difference of pollution abatement technology between two countries is large enough. In other words, this condition implies that the damage on domestic environmental capital caused by one unit of foreign manufacturing production is larger than that caused by domestic production.

We now can assert the following proposition.

PROPOSITION 1: Assume both assumption 1 and 2 are hold. Then the home country could choose optimal transfer of manufactured good to the foreign country, which not only maximise domestic economic welfare but also enhance foreign economic welfare.

3.2 The Direction of International Migration

It is necessary to discuss the direction of international migration would change or not after optimal transferring policy is carried out by the home country. As aid is done by transferring manufactured good, the foreign country will produce less manufactured good to satisfy constant per-capita domestic demand on the manufactured good and the pollution level of the foreign country should decrease drastically. This may cause the reversal of relative advantage of production, namely the sign of $E - E^*$ may change from positive to negative. As mentioned in Section 2, relative advantage or the difference of the stock of environmental capital is the main reason of the real wage gap of the two countries. Thus migration occurs if permitted from the home (foreign) country to the foreign (home) country in the case of $E >(<) E^*$, respectively. Let investigate the sufficient condition to satisfy $E > E^*$. As

$$E - E^* = (1 - \frac{1}{b})[(\lambda^* - \lambda)aL - (\lambda + \lambda^*)\tilde{T}],$$

we can assert that if $a > 0.5$ and $\lambda^*/b >> \lambda \cong 0$ are satisfied, then $E > E^*$ holds anytime. The first condition is that demand on the manufactured good is relatively strong than agricultural good. The second condition is that pollution abatement technology of the home country is almost perfect while that of the foreign country is quite poor. Both conditions seem to be reasonable enough and thus we present the following assumption.

ASSUMPTION 2': $a > 0.5$ and $\frac{\lambda^*}{b} >> \lambda \cong 0$

Under the above assumption, the home country still has comparative advantage in the production of the environmentally sensitive agricultural goods and the real wage rate of the home country is still higher than that of the foreign country. Thus, if international migration is permitted, workers will tend to move from the foreign country to the home country.

4. International Migration

Let us examine the case that international migration is permitted and immigrants intend to stay in the host country permanently. As the population of each country changes, emission will increase in the home country because of increased manufacturing production, but total damage to the home environment will not increase by as much, because of the decrease in emission generated by manufacturing production in the foreign country.

As migration from the foreign country to the home country should be equal with changing population of both countries, namely, $dL = -dL^* > 0$. From equations (13), we obtain

$$\frac{dM}{dL} = a + \frac{dT}{dL}, \tag{17a}$$

$$-\frac{dM^*}{dL} = a + \frac{dT}{dL}. \tag{17b}$$

The effect on the optimal transfer caused by international migration will be

$$\frac{d\tilde{T}}{dL} = \frac{(3a-1)\lambda + (1+a)\lambda^*/b}{-\lambda + \lambda^*/b} > 0, \tag{18}$$

and thus we can assert that the optimal transfer of the home country should increase by immigration.

Using the optimal condition which equation (14) should be equal to null and equations (17), we obtain the effects on economic welfare of both countries are as follows,

$$\frac{dU}{dL} = \frac{a}{L} + \frac{1-a}{L_A} > 0, \tag{19}$$

$$\frac{dU^*}{dL} = -\frac{a}{L^*} - \frac{1-a}{L_A^*}\{1 - \frac{dM}{dL}[1 + \frac{L^*-M^*}{2E^*}(\lambda^* - \frac{\lambda}{b})]\}. \tag{20}$$

Equation (19) shows that immigration cause positive effect on the economic welfare of the home country, while equation (20) shows the effect on the foreign country is ambiguous. These different results come from the definition of economic welfare of each country, which is derived from aggregate consumption of both goods in our model. Thus economic welfare of the home country should increase because of both increasing population and decreasing pollution. On the other hand, economic welfare of the foreign country may or may not increase because decreasing population cause negative effect while decreasing pollution cause positive effect.

Concerning world total welfare, $U + U^*$, remembering that $M > M^*$ yields $L_A < L_A^*$, we obtain

$$\frac{dU}{dL}+\frac{dU^*}{dL}=(1-a)\left(\frac{1}{L_A}-\frac{1}{L_A^*}\right)+\frac{1-a}{L_A^*}\left[1+\frac{L^*-M^*}{2E^*}\left(\lambda^*-\frac{\lambda}{b}\right)\right]\frac{dM}{dL}>0\,, \qquad (21)$$

which implies that international migration causes world welfare improvement.

Summing up above results, we can assert following Proposition.

PROPOSITION 2: Assume that both assumption 1 and 2’ are hold, and that international migration from foreign to home is permitted. Then the optimal amount of transfer of the manufactured good from home to foreign will increase. World total economic welfare will also increase.

5. Concluding Remarks

The main result of our paper suggests that Japanese government should not hesitate not only to introduce Chinese workers but also to transfer more domestic manufactured good to China. This is because both of two policies could contribute to reduce trans-boundary pollution from China. Moreover, adopting these policies would improve not only Japanese welfare but also world total welfare.

A few remarks should be added. Firstly, we exclude international trade in our model. The case of international migration under free trade is just studied by Kondoh (2006), and unlike the no-trade case, Kondoh concluded that the level of world pollution would increase under migration. This result comes from specialization of production under free trade and essentially may be valid with international transfer.

Secondly, in our paper, we assumed the environmentally sensitive good to be the agricultural good, and showed that the technologically developed home country had an advantage in the production of the agricultural good. This might seem to be a counterfactual result. However, one should not take the word agriculture in a literal sense, but should instead interpret agriculture to encompass technologically advanced industries that need relatively clean water and air, such as the computer industry or the medical instrument industry.

Thirdly, in modifying the model of Copeland and Taylor (1999) to allow for migration, we have simplified some aspects of that model: for example, the dynamic aspect relating to the natural recovery of environmental capital. A worthwhile extension of our research would be to analyse international migration while retaining the dynamic specification of the original

Copeland-Taylor model.

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