Ⅳ-479 A Macroeconomic Model For Damage Analysis of Sea Level Rise in Developing Countries

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1. Introduction

The impact of sea level rise due to global warming on developing countries facing sea is a great concern. This paper proposes a macroeconomic model for analyzing the impact.

2. Model

The model, based on the Harris -Todaro's model, describes a developing country including rural -urban migration and unemployment. The two regions in the country are the rural area and the urban area. The urban area specializes in production of manufactured good, while crops, fisheries, forest sectors are located in the rural area. The free mobility of people is assumed in the model.

2.1. Production

Each industrial sector chooses the level of output and input so as to maximize the profit formulated as follows.

$$\pi = \max_{X,N,L,K} P_i X_i - W_i N_i - R_i L_i - H_i K_i \quad (1.a)$$

$$s.t. \quad X_i = F_i(N_i, L_i, K_i) \quad (1.b)$$

where

$i = m$:manufactur, $i = c$:crops, $i = f$:fishery, $i = g$:forest,

Xi: output, Ni: labor input, Li:land input,

Ki: capital input, Pi: product price, Wi :wage,

R_i: land price, and H_i: capital rent.

In manufacture and fisheries, land input drops out from the production function and capital is ignored in forest By solving the above problems we can get the F.O.C and input demand functions as,

$$\frac{\partial \pi}{\partial N_i} = P\frac{\partial F}{\partial N_i} = W_i \quad (2.a), \qquad \frac{\partial \pi}{\partial L_i} = P\frac{\partial F}{\partial L_i} = R_i \quad (2.b),$$

$$\frac{\partial \pi}{\partial K_i} = P\frac{\partial F}{\partial K_i} = H_i \quad (2.c),$$

and

$$N_i = N_i^d(W_i, R_i, H_i, P_i) \quad (3.a)$$

$$L_i = L_i^d(W_i, R_i, H_i, P_i) \quad (3.b)$$

$$K_i = K_i^d(W_i, R_i, P_i) \quad (3.c)$$

2.2. Market equilibrium/disequilibrium

We assume that demand and supply in all markets in the rural area are in equilibrium, but in the urban area the labor market for manufacture is in disequilibrium. We assume that some price variables in the model are exogenous because their markets are internationally open, and wage in manufacture always remains at the exogenous minimum level ($\overline{W}$). Prices are classified as shown in the table.

Table 1 Classification of price variables

		Product price	Wage	Land rent	Capital rent
Rural	Crops	Pc :endogenous	Wr :endogenous	Re :endoggenous	H :exogenous
	Forestry	Pg: exogenous		Rg :endogenous	
	Fisheries	Pe :exogenous			
Urban	Manufacture	Pm :exogenous	$\overline{W}$:exogenous		

According to these assumptions we can formulate market equilibrium as,

$$N_c^d\left(W^r R_c H P_c\right)+N_g^d\left(W^r, R_g, P_g\right)+N_f^d\left(W^r, H, P_f\right)=N_R \tag{4}$$

$$L_c^d\left(W^r, R_c, H, P_c\right)=\bar{L}_c, \tag{5}$$

$$L_g^d\left(W^r, R_g, H, P_g\right)=\bar{L}_g, \tag{6}$$

$$N_T F^d\left(P_c\right)=F_c\left(W^r, R_c, H, P_c\right), \tag{7}$$

where d denotes demand functions

Here are 4 equations and 4 unknown variables W^r, R_c, P_c, R_g. The disequilibrium in the labor market in the urban area is expressed as,

$$P_m \frac{\partial F_m}{\partial N_m}=\bar{W} \text{ (=exogenous)} \tag{8}$$

2.3. Migration behavior

We introduce the indirect utility function as,

$$V_m=V\left(\bar{W}_m, P_c, P_f, P_g\right) \text{ for labors in the manufacture} \tag{9}$$

$$V_r=V\left(W_r, P_c, P_f, P_g\right) \text{ for labors in the rural area.} \tag{10}$$

The expected utility level in the urban area is,

$$E\left(\bar{V}_u\right)=\frac{N_m}{N_u}V_m+\frac{N_{ue}}{N_u}\bar{V}_{ue}, \tag{11}$$

where *ue* denotes unemployed people.

Assuming that location choice between the urban and rural areas is expressed by the Logit Model, we have the urban population as,

$$N_u=N_T\frac{\exp\left\{\theta E\left(V_u\right)\right\}}{\exp\left\{\theta E\left(V_u\right)\right\}+\exp\left(\theta V_r\right)} \tag{12}$$

θ : Logit parameter

Since all urban people can not be employed by manufacture, there exist unemployed people in the urban area,

$$N_{ue}=N_u-N_m \ . \tag{13}$$

The set of equations from (4) to (8) and (12) and (13) should be solved simultaneously for determining the state of macroeconomy in the developing country.

3. Impact of sea level rise

Although the model is applicable for any developing country, it has been built in the context of Banladesh. One of ADB reports says that about 11% (21%) of the national land in Banladesh is likely to be under the sea water if 45cm (100cm) relative rise in sea level occurs until 2070.

Therefore, in the model, the sea level rise is expressed as the decrease of the available land for corps and forest like,

$$\bar{L}_c \to \bar{L}_c+d\bar{L}_c \quad \left(d\bar{L}_c<0\right) \tag{14.a}$$

$$\bar{L}_g \to \bar{L}_g+d\bar{L}_g \quad \left(d\bar{L}_g<0\right). \tag{14.b}$$

The changes in the available land should be propagated into markets, migration, and therefore utility level. The flow chart for the propagation of the impact is illustrated in Figure 1.

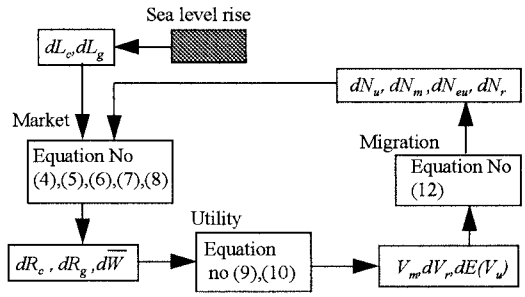

Figure 1 Flow chart of impact propagation

The change of each endogenous variable can be followed through comparative statics.

The social damage should be measured in the social welfare function. Since we introduce the Logit Model, the social welfare function to be specified consistently with it is,

$$SW=N_T\left(\frac{1}{\theta}\right).\ln\left\{\exp\{\theta E\left(V_u\right)\}+\exp\left(\theta V_r\right)\right\}. \tag{15}$$

4. Next stage of the researc

We are now preparing for the application of this model to the case of Bangladesh, and developing the monetary measure for the damage and for the benefit of prevention projects.

Reference

J.R.Harris and M.P.Todaro,(1970); Migration, unemployment and development: A two-sector analysis. The American economic review.

A.D.B.(1994); Climate change in Asia :Bangladesh country report.