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APPLICATION TO THE DEVELOPING COUNTRY OF SCGE MODEL BASED ON 2-REGIONAL SAM

Shoshi MIZOKAMI
Professor
Department of Civil Engineering
Kumamoto University
2-39-1, Kurokami, Kumamoto,
860-8555 Japan
Fax: +81-96-342-3507
E-mail: smizo@gpo.kumamoto-u.ac.jp

Motoki ITOSE
Consultant
Maeda Corporation
10-26 Fujimi 2-Chome,
Chiyoda-ku , Tokyo
102-8151, Japan
Fax: +81-42-380-5771
E-mail: mustang_motoki@hotmail.com

Cristela Goce-DAKILA
Associate Professor
Economics Department
De la Salle University
2401 Taft Avenue, Manila 1004,
Philippines
Tel/Fax: +63-2-303-0867
E-mail: dakilac@dlsu.edu.ph

Abstract: Recently, developing countries have gradually been achieving economic development, at the cost of regional income disparity between urban and rural areas. One factor contributing to this is excess of transport infrastructure investment in central area and concomitant inefficiency of inter-regional trade due to high transport costs. In these countries, decision making on project implementation should be based not only on social efficiency from a macro point of view but also on the micro-economic effects felt by every region and every household. A spatial computable general equilibrium (SCGE) model, which uses Social Accounting Matrix (SAM) with two regions and two household-income levels as the database, is built to estimate the benefit of each region and household level from traffic infrastructure investment. Results show that traffic infrastructure investment in urban centers causes negative benefit in rural areas and induces further widening of the regional income gap.

Key Words: Economic Impact, SCGE, multi-regional SAM, Developing Country

1. INTRODUCTION

The main objective of this paper is to analyze the impact of transport infrastructure investment on inter-regional economic activity and regional economic welfare. Specifically, it aims to: (1) discuss the importance of regional SAM in analyzing welfare effects of transport infrastructure investment. (2) Build a SCGE model of National Capital Region (NCR) & Rest-of-the-Philippines (ROP) based on the 2-region SAM database. (3) Introduce transportation capacity restrictions in the model via an impedance function. (4) Simulate the impact of lower transport cost via improved transport infrastructure investment on welfare levels of households. It will utilize a 2-region SAM and an SCGE model as analytical tools for looking into welfare distribution effects of transport infrastructure investment projects.

To achieve the aforementioned objectives, the second section will give a basic exposition of the creation of a 2-region SAM .The third section will present a SCGE model based on a 2-regional SAM with 2 income level household grouping for each region. The fourth section will present simulation results of the welfare effects of improvement of transport infrastructure investment on each region individually and the two-interconnected regions.

Spatial computable general equilibrium (SCGE) models evolved from the early work on computable general equilibrium models pioneered by Shoven & Whalley, Leontief, Harberger, and Scarf. However, modelers and empiricists felt the need to introduce space so that the locational impact of transport policies can be completely captured. Multi-regional framework was then adopted and the once frictionless and perfectly competitive model, now expanded to consider transaction costs and imperfectly competitive market structures. Generally, SCGE models assume constant returns to scale, but have of scale. (Dixit & Stiglitz: 1977). Eventually firms, households, goods and factors are distinguished by location and transportation costs are integrated into the model.

Most of the SCGE models developed have been in Europe, USA, Japan and other developed economies. In Europe, Brocker developed CGEurope in 1999 which covered 800 regions. Brocker's model quantified regional welfare effects of transport related and financial-economic policies like Trans-European Networks (TENs) investments and transport pricing. Other European SCGE models developed include the BROBISSE model for Denmark (Caspensen et al 2000; the PINGO model in Norway (Ivanova et al 2002); the RAEM model for the Netherlands (Knaap & Oosterhaven: 2002). Other SCGE models include those developed in Sweden (Hussain & Westin: 1997; Nordman: 1998 and Sundberg: 2002). In the USA, the most recent interregional CGE model with transport sector was that developed by Lofgren and Robinson in 1999. In Asia, Miyagi (2001) created an SCGE model to assess the direct and indirect economic effects of a major highway link in central Japan. Other SCGE models for Japan include those constructed by Koike et al in 2000 and Ueda et al in 2001 which sought to analyze the economic impact of a major earth quake which damaged the high speed rail network to Tokyo. For Korea, the work of Hewings and Kim on the regional welfare impact of highways utilized an SCGE model (1999). For Brazil, Haddad and Hewing created a spatial CGE model with a transport sector under imperfectly competitive markets (2003). For China, the work by Li, utilized an interregional CGE model to determine the interrelationship among economic growth, energy use and environmental protection. (2003). For the Philippines, no SCGE model has been estimated yet and this paper is the first endeavor in such direction.

However, very few among the SCGE models mentioned have looked into welfare effects of transport infrastructure investment in terms of narrowing the interregional income disparity within a country. A recent study by Alemied et al. in 2003 explored this dimension by analyzing the effect on interregional equity of road network in Brazil. The study concluded that transport infrastructure could be an effective mechanism for reducing regional income disparities. This is because the poorer regions benefit more in terms of trade creation with economic integration with richer regions, which have large market potential. It is therefore within the aforementioned context that this study proceeds in determining the impact of transport infrastructure investment on interregional equity between two regions in the Philippines, namely the National Capital Region and the Rest-of-the-Philippines.

2. A 2-REGION SAM FOR THE PHILIPPINES

2.1 Framework of 2-Region 2-Income Level SAM

A 2-region social accounting matrix (SAM) with two types of households for each region was constructed and used as database in calibrating the SCGE model. A SAM represents transactions in a complete economic system during an accounting period. It integrates within a macroeconomic framework some detailed accounts for factors of production and institutions – especially households – so as to focus on the living standards of different groups in society. (Round: 2002). When a national SAM is split into regional SAMS, the flow of income from production units to consuming units is given a spatial dimension. Thus, the 2-region SAM was constructed in order to analyze economic ripple effect on regional income disparity. It has the following disaggregation of economic agents. The regions are: Metro Manila area (NCR: National Capital Region) and the rest of the Philippines (ROP). The industries are primary industry, secondary industry, tertiary industry and transportation industry. Households are classified either as high-income households or low-income households in NCR and ROP, depending on a threshold annual income of PHP 60,000. There is only one government sector for both regions.

2.2 Methodology for Construction of 2-Region SAM

The 1994 2-region (NCR-ROP) interregional input-output (IRIO) table, taken from Japan Society for the Promotion of Science (JSPS) database, was used as basis for constructing the 2-region SAM. This IRIO table traces the flow of goods and services between sectors, intra-regionally as well as inter-regionally. The 4-sector IO table in the SAM is an aggregation of the JSPS IRIO table. The following steps were undertaken in the construction of the NCR-ROP IRIO table, in their sequential order:
Step-1: Compilation of intra-regional IO tables
Step-2: Construction of inter-regional commodity flow tables
Step-3: Integration, reconciliation and revalidation

For step-1, the compilation of intraregional IO was carried out using the following official data sources: (1) 1994 Census of Establishments, (2) 1994 Family Income & Expenditure Survey, (3) National Statistical Coordination Board gross regional domestic product (GRDP) and gross regional domestic expenditure (GRDE) data set and (4) 1994 Philippines Input-Output Table. To regionalize the 1994 Philippine national input-output table, a hybrid approach of estimation was used. This means that primary data were combined with secondary data using no-survey techniques. There were 5 statistical activities undertaken to generate the NCR and ROP IO table namely: (1) compilation of industry-by-product MAKE matrix; (2) construction of product-by-industry USE table of competitive imports type; (3) estimation of regional exports and imports using location quotient technique; (4) generation of product-by-industry use table of non-competitive imports type and (5) derivation of product-by-product use table of non-competitive imports type. For step-2, the inter-regional flow tables were constructed using an indirect method due to the absence of data on inter-regional commodity trade that fits into the conceptual framework of IO accounting, i.e. tracking the flows from producer to consumer. Existing NSO commodity flow statistics could not be directly used because these are flows between ports of origin and destination only. The compilation of the flow tables therefore made use of the Simple Location Quotient (SLQ) method. An SLQ is one measure of the region's self-sufficiency in production. If SLQ_i is less than unity, the region imports some of the output *i* from elsewhere, whether domestically- or foreign-sourced or both. On the other hand, if SLQ_i is greater than 1.0, the region exports some of its industry's output, either to the rest of the Nation or to foreign countries or both. If SLQ is equal to 1.0, the region is viewed as self-sufficient with respect to output *i*. The SLQ approach is used in estimating the import content of transactions for those sectors with SLQs less than unity. . Combining the NCR and ROP IO tables of the competitive type generates the 2-region IRIO table. Reconciliation and revalidation of the preliminary table is then effected.

To regionalize the national totals, various appropriate regional indicators were used. From the national totals taken from official data sources, the following components of primary inputs of IO table were estimated: (1) net land rent by industry; (2) direct taxes by industry and (3) tariffs by commodity. For net land rent, indicators derived from 1994 Census of Establishments (CE) determine a net land rent to gross output ratio. This ratio is applied to IO output to get estimated land rent by region. For total direct tax payments, the CE revenue data were used as proxy indicators in disaggregating total national direct tax payments by firms into regional and spectral dimensions. For tariffs, they were obtained in proportion to CIF (cost inclusive of freight) values of commodity imports. For the other cell entries in regional SAM, other indicators were used as deemed appropriate. For example, in the case of households as in household direct taxes, household savings, household income from rest-of-the-world and firm dividends to households, FIES indicators were used. In the case of firms, their savings and dividends to ROW were derived using IO output indicator. In the case of the government sector; government expenditures were taken from IO tables; and government savings were taken from IO output indicators.

Closing the SAM model with respect to households requires the estimation of vectors of regional household incomes. In this study, household income takes into account three sources of family incomes: a) salaries and wages, b) entrepreneurial income and c) transfer income. The basic sources of data are the 1994 FIES, government financial statistics by DOF and flow-of-funds data from the BSP. The 1994 FIES generates data on family income by source of income, by income class and by region. In addition, the FIES data provide indicators on savings as a component of the SAM. For consistency, FIES data are reconciled with the official estimates by NSCB on private consumption expenditures (PCE). One limitation of the estimation process is the lack of data on financial flows at the regional level. Hence, all finance-related accounts are treated as exogenous accounts.

3. SCGE MODEL BASED ON 2-REGION SAM

3.1 Assumptions

The framework assumes: (1) Economy includes four commodity-producing sectors, including one transport sector, two types of households for each region and one government sector. (2) The demand for the transport sector services is a derived demand associated with the demand of intermediate production goods. (3) There is imperfect substitutability of same type of goods produced in spatially separated regions, based on Armington assumption. (4) The production factors are capital and labor. Labor is able to move freely between both regions and industries. The capital is able to move freely only among sectors, although the movement between regions is not possible. (5) The economy has 11 markets. These are composed of 8 markets of 2-region and 4-industrial sectors and two capital markets and one labor market. All markets are perfectly competitive markets.

3.2 Behavioral Modeling of Economic Agents

(1) Commodity-Producing industries or Production Sectors (i =1, 2, 3)

The production function is of a two-level nested type, so that production decisions are made in two stages shown in Figure-1. In the first stage, the overall output level for commodity j is decided upon by combining inputs of a composite factor input (made up of labor and capital) and intermediate commodities consisting of the outputs of other industries. This first stage is characterized by fixed proportions of the various inputs, so that changes in input prices do not induce any substitution between the various input levels, and instead impact only on the overall level of output. Thus, the first level production decision is specified as of the Leontief type. In the second stage, the firm exercises some discretion with respect to (1) the amounts of capital and labor to be combined to produce the composite input, and (2) the sourcing of the intermediate inputs from the various industries. These intermediate inputs can come from any of two regions: the National Capital Region (NCR) and Rest-of-the-Philippines (ROP). Substitution in this second stage is characterized as follows: (1) each percentage change in the amount of labor input must be compensated for by a constant percentage change in the capital input; (2) for each industry, each one percentage change in the amount of intermediate input from the NCR must be compensated for by a one percentage change in the input coming from areas outside the NCR. Thus, substitution in the second stage is characterized as of the Cobb-Douglas type. Prices are classified into two types; those are producers' and purchasers' price. Production sectors maximize profit under given production technologies:

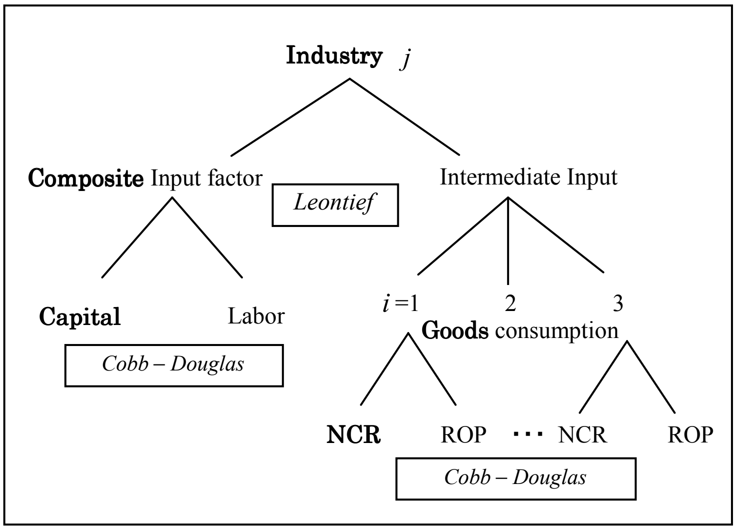

Figure-1. Nested Structure of Industries' Behavior

$$Max: \ \pi_j^s = p_j^s X_j^s - \sum_i^4 \sum_r^2 q_i^{rs} x_{ij}^{rs} - (1+\tau_j^s)(\rho^s K_j^s + \omega L_j^s) \tag{1}$$

$$s.t. \ \ X_j^s = \min\left\{ \frac{f_j^s(K_j^s, L_j^s)}{a_{oj}^s}, \min_i \left[\frac{\chi_{ij}^s}{a_{ij}^s} \right] \right\} \tag{2}$$

$$f_j^s(K_j^s, L_j^s) = A_{0j}^s (K_j^s)^{\alpha_{Kj}^s} (L_j^s)^{\alpha_{Lj}^s} \qquad (\alpha_{Kj}^s + \alpha_{Lj}^s = 1) \tag{3}$$

$$\chi_{ij}^s = A_{ij}^s \prod_r^2 (x_{ij}^{rs})^{\alpha_{ij}^{rs}} \tag{4}$$

From profit maximization, the derived demands for capital, labor, and the intermediate input are:

$$x_{ij}^{rs} = \frac{p_j^s \alpha_{ij}^{rs} \chi_{ij}^s}{q_i^{rs} a_{ij}^s} \tag{5}$$

$$L_j^s = \left(\frac{\alpha_{Lj}^s \rho^s}{\alpha_{Kj}^s \omega} \right)^{\alpha_{Kj}^s} \frac{a_{oj}^s X_j^s}{A_{0j}^s} \tag{6}$$

$$K_j^s = \left(\frac{\alpha_{Kj}^s \omega}{\alpha_{Lj}^s \rho^s} \right)^{\alpha_{Lj}^s} \frac{a_{oj}^s X_j^s}{A_{0j}^s} \tag{7}$$

where,

X_j^s: Total amount of production output by industry *i* in on *s*
x_j^s: Composite input factor *i* to industry *j* in region *s*
χ_{ij}^s: Intermediate input demand from industry *i* in region *s* to industry *j* in region *s*
K_j^s: Capital demand of industry *j* in region *s*
L_j^s: Labor demand of industry *j* in region *s*
a_{0j}^s: Value added rate of industry *j* in region *s*
a_{ij}^s: Intermediate input coefficient of industry *j* in region *s* for intermediate good *i*
A_{ij}^s, A_{0j}^s, α_{ij}^{rs}, α_{Kj}^s, α_{Lj}^s: Technological parameters of industry *j* in region *s*
p_j^s: Producers' price of commodity *i* in region *s*
q_i^{rs}: Purchasers' in region s for commodity *i* in region *r*
τ_j^s: Indirect tax rate of industry *j* in region *s*
ρ^s: Rate of return on capital in region *s*
ω: Wage rate

a_{0j}^s, a_{ij}^s, α_{ij}^{rs}, α_{Kj}^s, α_{Lj}^s and τ_j^s are estimated using SAM. A_{ij}^s, A_{0j}^s are parameters which should be calibrated.

(2) Transport sector
Transport cost is the cost that is needed to ship the commodity from place of origin to place of destination and is paid to a transport agent. We need the transport sector to estimate the transport cost/margin as endogenous variable. The demand for transport sector services is the derived demand associated with the intra- and inter-regional shipment of production goods. Transport cost is paid to the transport agent existing in production region. The behavior of transport sector is formulated as minimization of transport cost under transport service demand constraint and is depicted as follows:

$$Min: \sum_{i}^{4}\sum_{r}^{2} q_i^{rs} x_{i4}^{rs} + (1+\tau_4^s)(\rho^s K_4^s + \omega L_4^s) \tag{8}$$

$$s.t. \quad X_4^s = T^s \qquad (i \neq 4) \tag{9}$$

Where, total transport service demand of transport agent is shown as follows:

$$T^r = \sum_{j}^{4}\sum_{s}^{2} x_{4j}^{rs} + ch_4^r + cg_4^r + cI_4^r + e_4^r - m_4^r$$

$$= \sum_{i}^{4}\sum_{j}^{4}\sum_{s}^{2} x_{ij}^{rs} d^{rs} \theta_i^{rs} + \sum_{i}^{4}\left(\sum_{m}^{4} ch_i^{rm}\, d^{rh} + cg_i^r\, d_i^{rg} + cI_i^r\, d^{rI} + e_i^r\, d^{re} - m_i^r\, d^{rm}\right)\theta_i^{rs} \tag{10}$$

The solution of the above optimization-programming problem yields to each derived demand function of intermediate input goods, labor and capital stock for transport sector. This derived demand function is the same as that of commodity- producing sectors.

(3) Households
Households are classified into classes: NCR-L, NCR-H, ROP-L and ROP-H, in terms of the income level and region. Each household attempts to maximize its utility under static short-run conditions. This consumption behavior is illustrated in a nested structure shown in Figure-2. At the first stage, the household determines consumption level of present goods and future goods. At second stage, households determine levels of composite goods using Cobb-Douglas functional form.

The household derives utility from the consumption of various goods, which are dated through time. For simplicity, the consumption of all future goods is aggregated into a composite called saving. The life cycle model of consumption implies that the household optimizes utility by evening out consumption through the life cycle, so that the average propensity to consume (and therefore the average propensity to save, σm) stays constant. There is thus a fixed proportion between current consumption and the present value of future consumption, which is encapsulated in saving. This reduces the utility maximization to a one period model.

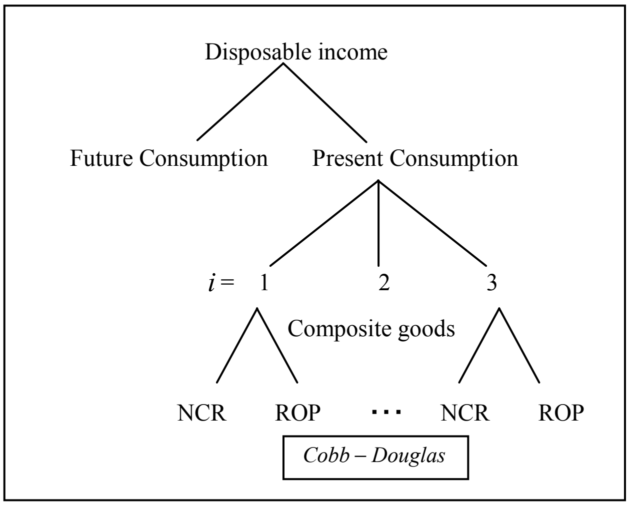

Figure-2. Nested Structure of Households' Behavior

Again, it is assumed that there is constant elasticity of substitution between the different commodities in consumption, and, for simplicity, consumption decision can be characterized by a Cobb-Douglas function. Households would be indifferent between the same amount of the commodity sourced from the NCR and from outside the NCR. There is, therefore, a second level sourcing decision, where the second level is likewise characterized by a constant elasticity of substitution equal to one and constancy of returns to scale. A second level relationship is specified as being of the Cobb-Douglas type. The utility maximization problem of household is as follows.

$$Max: \ U^m = \prod_i^4 \left(ch_i^m\right)^{\beta_{ih}^m} \qquad \left(\sum_i^4 \beta_{ih}^m = 1\right) \tag{11}$$

$$ch_i^m \equiv \prod_r^2 \left(ch_i^{rm}\right)^{\beta_{ih}^{rm}} \qquad \left(\sum_r^2 \beta_{ih}^{rm} = 1\right) \tag{12}$$

$$s.t. \ \sum_i^4 \sum_r^2 q_i^{rh} ch_i^{rm} = y_h^m \tag{13}$$

Household's consumption demand is as follows:

$$ch_i^{rm} = \frac{\beta_{ih}^m \, \beta_{ih}^{rm} \, y_h^m}{q_i^{rh}} \tag{14}$$

where,

$$H^m = \gamma_K^m \cdot \sum_s^2 \sum_j^4 \left[\rho^s \left(1-\eta_j^s\right) K_j^s\right] + \gamma_L^m \cdot \sum_s^2 \sum_j^4 \omega \cdot L_j^s + TrGH^m + TrOH^m \tag{15}$$

Household disposable income is derived as follows. Direct taxes are imposed on the sum of capital income, labor income and transfer payments from other households. Income from such sources, net of direct taxes, plus transfers from the government (which is tax-free) equals household disposable income. Household income equation takes the following form:

$$Y_h^m = \left(1-\tau_d\right)\left(H^m - TrHG^m\right) + TrGH^m - TrOH^m \tag{16}$$

Thus, income allocated to consumption equals disposable income multiplied by 1 minus the average propensity to save.

$$y_h^m = \left(1-\sigma^m\right) Y_h^m \tag{17}$$

where,

$TrGH^m$: Current transfers from general government to household segment m

$TrOH^m$: Current transfers from oversea to household segment m

$TrHO^m$: Current transfers from household segment m to oversea

η_j^s : Capital consumption rate of industry *j* in region *s*
τ_d^m : Direct tax rate from household segment *m* to general government
σ^m : Saving ratio of household segment *m*
H^m : Total amount of income of household segment *m*
Y_h^m : Total amount of disposable income of household segment *m*
y_h^m : Total amount of consumption expenditures of household segment *m*
β_{ih}^m, β_{ih}^{rm} : Allocation parameters of consumption by household segment *m*
γ_K^m , γ_L^m : Allocation parameters to household segment *m* of capital income and wages

τ_d^m , σ^m , β_{ih}^m , β_{ih}^{rm} , γ_K^m and γ_L^m are parameters which should be calibrated by using some statistics.

(4) Government Sector
There is only one government sector. The government's inter-temporal budget constraint is:

$$\sum_m^4 \left(H^m - TrHG^m\right)\cdot \tau_d{}^m + \sum_s^2 \sum_j^4 \tau_j^s \cdot \left(\rho^s \cdot K_j^s + \omega \cdot L_j^r\right) + TrOG$$
$$= y_g + \sum_{m=1}^4 TrGH^m + SG + TrGO \tag{18}$$

Total government income is composed of income from direct tax as manifested by the first expression on the left-hand side plus government income from indirect tax from capital income and household income. These are the expressions on the left-hand side of the equation. On the other hand, government expenditures consist of transfers to households from government transfers overseas, government savings and other types of government income.

Cost minimization problem of government is formulated as follows.

$$Min:\ E = \prod_i^3 \left(cg_i\right)^{\beta_{ig}} \qquad \left(\sum_i^3 \beta_{ig} = 1\right) \tag{19}$$

$$cg_i \equiv \prod_r^2 \left(cg_i^r\right)^{\beta_{ig}^r} \qquad \left(\sum_r^2 \beta_{ig}^r = 1\right) \tag{20}$$

$$s.t. \quad \sum_i^3 \sum_r^2 q_i^{rg} cg_i^r = y_g \tag{21}$$

Government consumption demand (*cg*) is follows:

$$cg_i^r = \frac{\beta_{ig}\beta_{ig}^r y_g}{q_i^{rg}} \tag{22}$$

where,
$TrHG^m$: Transfer from general government to household segment *m*
$TrOG$: Transfer from general government to oversea.
$TrGO$: Transfer from oversea to general government
y_g : Total amount of available revenue of the government
SG : Government savings
β_{ig}, β_{ig}^r : Allocation parameters of the government consumption

(5) Savings- Investment Sector
Total amount of savings consists of the consumption of fixed capital and savings by

households, general government and Rest-of-the World (R.O.W). The budget constraint is as follows:

$$p_I\, I = \sum_s^2 \sum_j^4 D_j^s + \sigma Y_h + SG + SO \tag{23}$$

The net investment function follows the functional form of Leontief type:

$$I = \min_i \left\{ \frac{cI_1}{b_1}, \cdots, \frac{cI_4}{b_4} \right\} \tag{24}$$

$$cI_i = \prod_r^2 \left(cI_i^r\right)^{\beta_{iI}^r} \qquad (\sum_r^2 \beta_{iI}^r = 1) \tag{25}$$

The demand of the production goods that accompanies real investment (*cI*) is as follow:

$$cI_i = b_i I \tag{26}$$

$$cI_i^r = \frac{\beta_{iI}^r p_{iI} b_i I}{q_i^{rI}} \tag{27}$$

where,

p_I : Investment goods price
I : Real investment
D_j^s : Consumption of fixed capital or investment expenditures
SO : Savings of foreign sector
cI_i : Total Investment expenditures
cI_i^r : Investment expenditures of each region
b_i, β_{iI}^r : Technology parameter

(6) Foreign Sector

The expenses of foreign sector include the purchase of imports plus labor income from abroad plus transfers to government plus transfers to households. This is equal to revenues of foreign sector, which include exports plus labor income to the Philippines plus transfers to households plus transfers to government plus overseas savings. These are captured in equation below:

$$\sum_r^2 \sum_i^4 q_i^{r3} m_i^r + LI + TrGO + \sum_m^4 TrOH^m = \sum_r^2 \sum_i^4 q_i e_i^r + LO + \sum_m^4 TrOH^m + TrOG + SO \tag{28}$$

The volume of import and export are follows:

$$\text{import volume: } m_i^r = m_i^{r*} \left(X_i^r \big/ X_i^{r*} \right) \tag{29}$$

$$\text{export volume: } e_i^r = e_i^{r*} \left(q_i^{r5*} \big/ q_i^{r5} \right) \tag{30}$$

where,

LI : The employer income from the Philippines
LO : The employer income to the Philippines
m_i^r, X_i^r, e_i^r, q_i^{r3} : Volume of import, production quantity, export volume and price of the good *i* in overseas
m_i^{r*}, X_i^{r*}, e_i^{r*}, q_i^{r3*} : Volume of import, production quantity, export volume and price of the good *i* in overseas in benchmark year

3.3 Determination of Price in Price Block

(1) The Derived Demand for Production Factors
The derived demand equation for labor and capital are indicated below:

$$\text{Labor:}\ \ l_j^s = \left(\frac{\alpha_{Lj}^s \rho^s}{\alpha_{Kj}^s \omega} \right)^{\alpha_{Kj}^s} \cdot \frac{a_{0j}^s}{A_{0j}^s} \tag{31}$$

$$\text{Capital:}\ \ k_j^s = \left(\frac{\alpha_{Kj}^s \omega}{\alpha_{Lj}^s \rho^s} \right)^{\alpha_{Lj}^s} \cdot \frac{a_{0j}^s}{A_{0j}^s} \tag{32}$$

(2) The Price equation
Each production sector is a price taker. The price of goods produced by each sector from the zero profits condition in each region is equal to the total of the intermediate amount of consumption and the production factor cost including tax cost and the transport cost. Total value of the commodity is equal to the sum of the values of intermediate inputs plus value-added component inclusive of value-added tax, where all values are computed gross of transport cost. The resulting price equation is as follows:

$$p_j^s X_j = \sum_i^4 \sum_r^2 p_i^r x_{ij}^{rs} + \left(1 + \tau_j^s\right)\left(\omega L_j^s + \rho^s K_j^s\right) \tag{33}$$

By dividing values by the output level, the expression for the price level is obtained.

$$p_j^s = \sum_i^4 \sum_r^2 p_i^r a_{ij}^{rs} + \left(1 + \tau_j^s\right)\left(\omega\, l_j^s + \rho^s\ k_j^s\right) \tag{34}$$

$$P = \left[I - A^T(p)\right]^{-1} \left(1 + \tau_j^s\right)\left(\omega l_j^s + \rho^s k_j^s\right) \tag{35}$$

where,

a_{ij}^{rs} : The intermediate input coefficient to the area industry of area industry
θ_i^r : A common transport unit transformation parameter
d^{rs} : The transport distance between an/the area

The transport sector's price relies on transport distance between and within an area and the relationship between traffic volume and transport capacity.

$$A^T(p) = \begin{vmatrix} p_1^1 a_{11}^{11} & \cdots & p_4^1 \sum_i^3 a_{i1}^{11} \theta_i^1 \cdot d^{11} & p_1^2 a_{11}^{21} & \cdots & p_4^2 \sum_i^3 a_{i1}^{21} \theta_i^2 \cdot d^{21} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ p_1^1 a_{14}^{11} & \cdots & p_4^1 \sum_i^3 a_{i4}^{11} \theta_i^1 \cdot d^{11} & p_1^2 a_{14}^{21} & \cdots & p_4^2 \sum_i^3 a_{i4}^{21} \theta_i^2 \cdot d^{21} \\ p_1^1 a_{11}^{12} & \cdots & p_4^1 \sum_i^3 a_{i1}^{12} \theta_i^1 \cdot d^{12} & p_1^2 a_{11}^{22} & \cdots & p_4^2 \sum_i^3 a_{i1}^{22} \theta_i^2 \cdot d^{22} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ p_1^1 a_{14}^{12} & \cdots & p_4^1 \sum_i^3 a_{i4}^{12} \theta_i^1 \cdot d^{12} & p_1^2 a_{14}^{22} & \cdots & p_4^2 \sum_i^3 a_{i4}^{22} \theta_i^2 \cdot d^{22} \end{vmatrix} \tag{36}$$

3.4 Equilibrium Conditions

The equilibrium conditions in the market for goods market, transport services market and factor markets are:

(1) Goods and production factor market

Goods market: $X_i^r = \sum_s^2 \sum_j^4 x_{ij}^{rs} + \sum_m^4 ch_i^{rm} + cg_i^r + cI_i^r + e_i^r - m_i^r$; $(i = 1,2,3)$ (37)

Transport service market: $X_4^r = \sum_s^2 \sum_j^4 x_{4j}^{rs} + \sum_m^4 ch_4^{rm} + cg_4^r + cI_4^r + e_4^r - m_4^r \quad (i = 4)$ (38)

Labor market: $LS = \sum_s^2 \sum_j^4 L_j^s$ (39)

The capital market: $KS^s = \sum_j^4 K_j^s$ (40)

(2) Goods' price

The producers' price: $P = \left[I - A^T(p)\right]^{-1}\left(1 + \tau_j^s\right)\left(\omega \cdot l_j^s + \rho^s \cdot k_j^s\right)$ (41)

User price: $q_i^{rs} = p_i^r + p_4^r \theta_i^{rs} d^{rs}$ (42)

Equation (42) is the most important equation in the price block. It emphasizes the role of price in determining equilibrium values in SCGE model.

4. CALIBRATION OF PARAMETERS AND BALANCING ALGORITHM

The estimation of parameters used in SCGE follows in Table 1. The parameters used in Cobb-Douglas nested production function and Cobb-Douglas nested utility function are enumerated below. It is assumed that the parameters of SCGE are set up in such a way that

Table 1 List of Parameters

Model	Sector	Parameter	Dimension	Description of Parameter
Production Function	Industry	a_{0j}^s	$2s\times3j$=6	Ratio of value-added out of total output of industry *j* in region *s*
		a_{Kj}^s	$2s\times3j$=6	Share of Capital Income Out of Total Income
		a_{Lj}^s	$2s\times3j$=6	Share of Labor Income Out of Total Income.
		A_{0j}^s	$2s\times3j$=6	Intermediate input coefficient of industry *j* in region *s*
		A_{ij}^s	$2s\times3i\times3j$ =18	Intermediate input coefficient from composite good *i* in industry *j* in region *s*
		α_{ij}^{rs}	$2r\times2s\times3i\times3j$ = 36	Technological parameter which should be calibrated
		τ_j^s	$2s\times3j$=6	Indirect tax of Industry *j* in region *s*
Consumption Expenditure	Household	β_{ih}^m	$3i\times4m$ =12	Allocation Parameter of HH Conspn. Expenses
		β_{ih}^{rm}	$2r\times3i\times4m$ =24	Allocation Parameter of HH Conspn. Expenses by Region
	Government	β_{ig}	i =3	Allocation Parameter of Govt. Consumption Expenses
		β_{ig}^r	$2r\times3i$=6	Allocation Parameter of Govt. Consumption Expenses by Region
	Investment	β_{iI}	i=3	Allocation Parameter of Investment Sector
		β_{iI}^r	$2r\times3i$ =6	Allocation Parameter of Investment Sector by Region

next year's data set is reproduced exactly.

The logic behind the algorithm used to calculate equilibrium price and quantity in SCGE is as follows. The price variable should equal total factor incomes plus the transport cost. However, transport margin is affected by haul distance, which increases as traffic volume exceeds transport capacity. When price does not equal total primary factor income plus transport cost, it adjusts accordingly. Then final demand adjusts to price changes, and then output adjusts to changes in final demand. This happens until an equilibrium solution is reached where aggregate demands equals aggregate supply and both goods and factor market equilibrate. This happens via adjustments in factor incomes and transport margin. We skip the detail of balancing algorithm here because of the limitation in number of pages.

5. APPLICATION OF ECONOMIC RIPPLE EFFECT ANALYSIS CAUSED BY THE TRAFFIC BASE UPGRADING IN THE PHILIPPINES

5.1 Setting of Simulation Cases

Alternative scenarios are drawn which reflect different situations when traffic upgrading occurs due to transport infrastructure improvement. The setting is 10 years later than 1994, which is 2004, where transport distance becomes shorter by 10% due to traffic base upgrading. The assumption is that transport distance becomes long when the traffic volume between or within an area exceeds transport capacity.

The average annual growth rates of labor supply and capital supply in the Philippines are estimated over a period of 10 years using the following statistical sources: 2001 Philippine Statistical Yearbook (PSNA); Labor force participation rate and employment status 1994-2000; Gross regional domestic product 1994-2000; Ministry of Public Management, Home Affairs, Posts and Telecommunications Statistics Bureau) of the world; World Economic growth rate (GDP) 1995-2000. These estimates are indicated in Table 2.

Table 2 Average Annual Growth Rate of Economic Indices ('94-'04)

Annual average growth rate		%
Labor		1.658
Capital	NCR	6.038
	ROP	4.192
Foreign Sector		3.817

5.2 Introduction of Impedance Function

The main purpose of this research is that it examines where it is efficient to do what kind of traffic infrastructure investment, in a developing country wherein the lack of the traffic infrastructure between the regions is the bottleneck of transport. It is a known fact that traffic infrastructure upgrading enhances productivity in each region and encourages trade through lower transport margins and faster movement of goods and services. Currently however, transport capacity is not sufficient in facilitating flows of goods and services between National Capital Region and rest-of-the-Philippines. This is because principal road networks, harbors and airports need upgrading.

This study therefore assumes that Philippine traffic volume and transport capacity equilibrate in 1994. Beyond 1994, traffic volume increases and there is need for transport capacity to match the increase. When traffic between the regions exceeds transport capacity, transport distance based on transit-time distance changes in the upward direction. The user price equation is restated below:

$$p_j^s = \sum_i^3 \sum_r^2 p_i^r a_{ij}^{rs} + \left(1+\tau_j^s\right)\left(\omega l_j^s + \rho^s k_j^s\right) + \sum_i^3 \sum_r^2 p_i^r a_{ij}^{rs} \theta_i^{rs} d^{rs} \tag{43}$$

The expression on the extreme right-hand side of the equation above is the transport margin. There is no conversion of transport distance with traffic volume within NCR, within ROP and from NCR to ROP. The impedance function is introduced with a distance variable, which depends on traffic volume between ROP to NCR. The variable "d" is a common transport unit transformation parameter whose value is explained by the succeeding equation.

$$\begin{aligned} d^{rs} &= d^{ROP-NCR} = d_0^{rs}\left(\frac{x^{R-N}}{x_{cap}^{R-N}}\right) & x^{R-N} &\geq x_{cap}^{R-N} \\ d^{rs} &= d^{ROP-NCR} = d_0^{rs} & x^{R-N} &\prec x_{cap}^{R-N} \end{aligned} \tag{44}$$

where,

d_0: Transport distance of initial equilibrium condition in 1994

x_{cap}^{R-N} : Transport capacity between ROP-NCR of initial equilibrium condition in 1994

x^{R-N} : Traffic volume between NCR-ROP

5.3 Transport Unit Conversion Parameters

In SCGE model, an assumption of the model is that output and income are distinguished by place of production and residence. The quantity of transport services used over a certain dimension of space differs by the individual income and output of the producing region. A common transport unit conversion parameter is set up so that linear relationship exists between the traffic and transport service quantity of combined income and output of origin and destination.

The transport sector should be subdivided into air transport, land transport and water transport. Because the transport sector was not subdivided into previously mentioned categories, the estimated common transport unit conversion parameter was negative and no exact transport cost could be estimated. It was also impossible to get a significant parameter of interconnected regions like NCR to ROP. Therefore, the only parameter estimated was that of ROP-NCR. This link is the object of transport restriction condition. The estimation result is shown in Table 3.

Table 3 ROP-NCR Common Transport Unit Conversion Parameter

Industry	Parameters	Value
Primary	$\theta_1^{ROP-NCR}$	0.00495
Secondary	$\theta_2^{ROP-NCR}$	0.00071
Tertiary	$\theta_3^{ROP-NCR}$	0.01018

6. SIMULATION RESULTS

6.1 Concept of Household Welfare

Welfare is measured in terms of equivalent variation (EV). EV is the change in money income that would put the household on the new indifference curve at the old prices. EV measures the scale of welfare change achieved through transport infrastructure improvement, which would put households on a higher utility level at previously existing prices. The profits of the industry in the equilibrium condition are all zero and the welfare gains go to the household. The welfare gains to low-income and high-income households depend on their absolute levels of income. The utility maximization problem of households yields the equivalent variation of a price change in one of the goods:

$$EV^m = e\left(q^{(0)}, u^{m(N)}\right) - e\left(q^{(0)}, u^{m(0)}\right) = \frac{u^{m(N)} - u^{m(0)}}{u^{m(0)}} y_h^{m(0)} \tag{45}$$

EV_m : Equivalent variation of a price change on households

$u^{m(0)}$: Utility level of households before traffic infrastructure upgrading

$u^{m(N)}$: Utility level of households after traffic infrastructure upgrading

$y_h^{m(0)}$: The amount of final consumption expenditures of households before traffic infrastructure upgrading

6.2 Effect of Transport Infrastructure Improvement on Household Welfare

Results indicate that transport infrastructure investment in NCR cause negative benefit to both low-income and high-income households in rest-of-the-Philippines and positive benefit to NCR households. On the other hand, transport infrastructure improvement in ROP alone, leads to welfare gains in ROP households and welfare losses to NCR households. This lessens income disparities between NCR and ROP; if transport planning is focused on ROP. This is deemed best for equity and efficiency. Moreover, in the case where transport infrastructure improvement takes place within one region, whether NCR or ROP, the welfare gains are higher for rich households than poor households. The result works the other way round, meaning higher welfare losses for rich households than poor households when

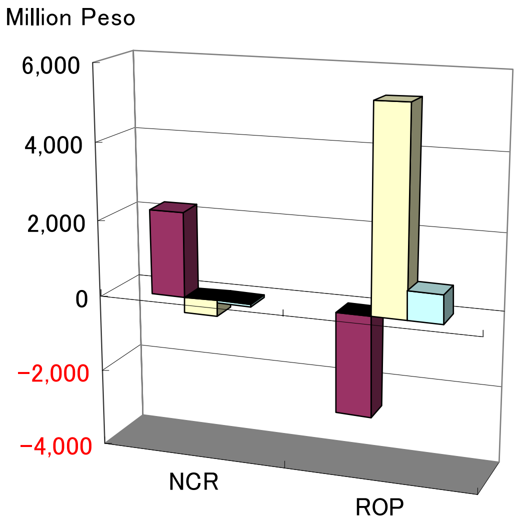

Figure-3. Regional Total Equivalent Variation

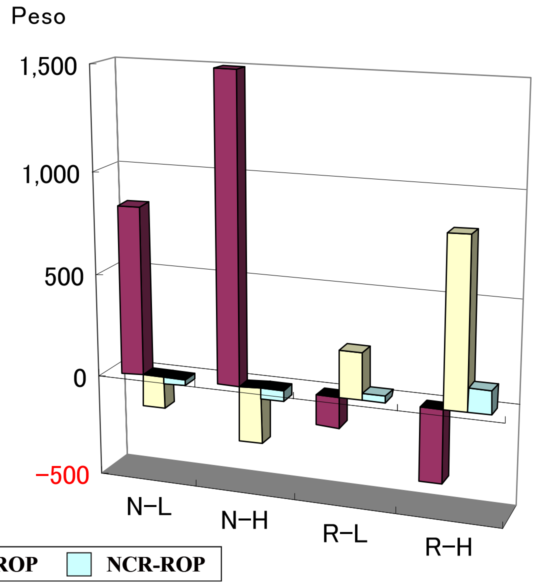

Figure-4. Equivalent Variation of HH *m* inadequate transport infrastructure investment takes place.

These results come from 4 different simulation cases where in traffic infrastructure improvement takes place: Case-1: no improvement occurs; Case-2: Infrastructure improvement takes place within NCR only; Case-3: Infrastructure improvement takes place within ROP only and Case-4: Infrastructure improvement establishes better links between ROP to NCR with transport capacity restriction. Figure-3 shows the amount of regional total equivalent variation and Figure-4 shows the amount of equivalent variation of Household type *m* by case, respectively. The interim results show that investment in NCR cause negative benefit in ROP households, thus, causing wider income disparity gap. Moreover, investment in ROP lessens income disparity and is deemed best for economic efficiency.

7. CONCLUSION

The preceding discussion presented the theoretical model and empirical results of traffic infrastructure upgrading under assumption of 2-region, 2-income level per region in the Philippines. Measurement of benefits using simulated cases of single –region infrastructure improvements versus multi-regional infrastructure improvements lead to useful and interesting insights.

Infrastructure improvement, which connects the rest-of-the Philippines region with the National Capital Region, leads to optimal social welfare gains as it leads to narrowing the income gap between rich region like NCR and other poor regions that belong to the rest-of-the Philippines. Investing in transport infrastructure, which improves transport capacity between ROP and NCR, results to higher welfare gains to households in ROP than in NCR. This will lessen income differential between two regions and lessen rural-urban migration, which leads to high unemployment in urban areas in NCR. Consequently, unemployment in NCR, which is mostly urban unemployment, will go down and more Filipinos will seek jobs or work in the rest-of- the Philippines, which is predominantly a rural area.

However, more concrete and definitive policy action can be undertaken if the rest-of the Philippines were broken down into critical regions and the model is expanded to a 5-region model. This is one subject of future research. Other areas of research within the realm of creating the data base for Philippine SCGE model are: (1) updating of basic database of multiregional SAM; (2) more precise estimation of common transport unit transformation parameter under different simulation assumptions; (3) creation of local government sector for each region; (4) expansion of spatial dimension into 5-region analysis.

The initial findings of 2-regional SCGE model put together for a developing country like the Philippines point to important policy directions and policy impact. In the end, through all of these discussions, the importance of effective transport infrastructure investment planning is emphasized. This will lower transport margins, which translates to high multiplier effects. Ultimately, social gains will be maximized and the desired equity and efficiency effects will be attained.

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