# IDENTIFYING TRANSPORT INFRASTRUCTURE INVESTMENT WITH MAXIMUM IMPACT: A SAM-BASED SCGE APPROACH

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**Abstract:** The paper identifies the most appropriate transport infrastructure investment among three alternative transport modes – land, air, water – across five delineated regions in the Philippines. The analytical tool used is a spatial computable general equilibrium (SCGE) model with a five-region social accounting matrix (SAM) as database. An exogenous shock in the form of technological improvement in transport infrastructure is introduced for each transport mode in each region. This results to higher output elasticity with respect to transport input. The transport infrastructure with greatest impact on gross output is then isolated using a SAM-based SCGE model. The impact on relative welfare of households via equivalent variation concept and on interregional flows among production sectors via changes in spatial impedance ratio is then presented. The completion of Skyway project connecting Northern Luzon to Southern Luzon via National Capital Region is a concrete example of infrastructure project which meets aforementioned criteria.

***Key Words***: *Transport infrastructure, SCGE, Gross output*

## 1. INTRODUCTION

A substantial amount of scarce resources is invested in transport infrastructure projects in a developing country like the Philippines. Thus, the choice of location and type of the transport infrastructure investment becomes a critical variable in macro level decision-making. The benefits relative to the costs of such choice have to be evaluated so that optimal decision can be made.

This study addresses such concern by pinpointing the type and location of transport infrastructure investment that has the greatest impact on gross output in the whole Philippines. The analytical tool used is a spatial computable general equilibrium model with a five-region social accounting matrix (SAM) as database. An exogenous shock in the form of technological improvement across alternative transport modes (water, air and land) in each region is introduced. This leads to higher output elasticity with respect to transport input. Once the type and location of transport infrastructure improvement with the highest impact on output is determined, the effect on relative welfare of household income groups across regions is discussed. Change in welfare is measured in terms of change in equivalent variation. Next, the impact on interregional flows via a spatial impedance ratio is analyzed. Impedance ratio is the ratio of interregional trade flows to transport capacity. Better technology of particular regional transport infrastructure investment leads to higher output and consequently higher interregional trade flows. This causes an increase in the impedance ratio.

## 2. SURVEY OF TRANSPORT-ORIENTED GENERAL EQUILIBRIUM MODELS

This section presents a general survey of transport-oriented general equilibrium models devised for transport policy purposes**.** Differences in modeling transport in a general equilibrium setting arise from the way the transport cost concept is conceived.

In 1992, Buckley formulated a transportation-oriented general equilibrium model where capital and labor cannot shift at the interregional level. Therefore, factor income rates vary among regions and there is specialization among regions. In 1996, Elbers created a multi-region SCGE where some sectors adopt the Armington assumption and others adopt the rules of the theory of spatial price equilibrium. He solved SCGE using the rules of spatial price equilibrium analysis. In 1997, the Van den Bergh model was formulated**.** This is a multi-region spatial model in which goods produced by the regions differ from each other. The next class of general equilibrium models with transport sector is composed of network models. Network equilibrium models are used in engineering and operations research as a means of forecasting traffic flow. Today, they are integrated in CGE models to obtain estimates of cost per transport link. The possibility of inserting network equilibrium models into CGE models was first developed by Harker (1987) and then further elaborated on by Roson (1993) and Friesz (2000). Roson (1993) integrated network equilibrium and Walrasian equilibrium into a single model. He introduced space in his structure of general equilibrium, wherein a location in space is uniquely assigned to each economic agent and each movement across space creates a demand for transport. The search for global equilibrium is composed of the search for the equilibrium values of prices, the quantities of the goods and the costs associated with the links so that there is network equilibrium and economic equilibrium calculated simultaneously. In 1998, Friesz, Suo and Westin formulated an integrated network equilibrium- general equilibrium model with a transport sector. However, the model contained only one mode of transport. The demand for transport is non price-elastic and depended only on the production level of each sector.

In Asia in 2001, transport-oriented SCGE models were formulated in Japan by Miyagi, with the goal of estimating the geographic impact 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 earthquake 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 the Philippines, no SCGE model has been estimated yet and this model is the first endeavor in such direction. This is the first spatial general equilibrium model devised for the Philippines. Earlier papers written by Dakila & Mizokami (2006) showed various applications of the five region model in estimating impact of different transport-related policy shocks on significant regional macroeconomic variables. All previous CGE models about the Philippines were national in scope. These include the Agricultural Policy Experiment (APEX) model (1992); Bautista C. model (1987 & 1992); Bautista R. model (1986); Clarete (1984 & 1991); Cororaton (1989); (1988); Habito (1984 & 1989) and Jemio & Vos (1993).

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.

Despite the models already devised, general equilibrium models with a transport sector have certain limitations when used for transport project appraisal. An article by Tavassy, Thissen, Muskens, Oosterhaven (2002) pinpointed the main limitation of utilizing SCGE models is in the specification of transport costs within a spatial framework. Other areas of concern in SCGE were the problem of locational boundedness of economic activities and the impact of transport infrastructure on passenger flow. They attributed these problems to the lack of empirical data on the consumption of transport services by various sectors, a possible mismatch in the definition of transport costs as they are produced in transport models and as they are inputted in SCGE models. The article also described how the use of four-step transport models introduces inconsistencies in appraisal results. It stated that the use of iceberg transport costs is empirically acceptable in one-sector economy but can lead to underestimation of impact in those sectors most sensitive to the reduction in transport costs when applied to multi-sector models In the end, they proposed that hysteresis and locational boundedness of production should be taken into account in modeling transport within SCGE framework.

## 3. PRESENTATION OF FIVE-REGION GENERAL EQUILIBRIUM MODEL

### 3.1 Database

The benchmark data for the study are taken from a five-region social accounting matrix (SAM) constructed by the authors for the Philippines, using 1994 Philippine interregional input-output data (Mizokami & Dakila: 2005). The delineation of regions is based on the archipelagic geography of the Philippines. The disaggregation into seven sectors (with three transport sectors – water, air, and land mode) is done to enable the researcher to look into the impact of a change in transport capacity on alternative modes of transport and non-transport sectors. Households are divided into three income groups; namely low-income households, middle-income households and high-income households. Low-income households are all those who earn below the official Philippine regional poverty thresholds. The high-income households are those who earn 250,000 pesos and above annually, which is the highest income bracket in the Family Income and Expenditure Survey. The rest of the households comprise the middle-income class.

The foregoing five-region SAM was used to calibrate the baseline values of the SCGE model. A SAM represents transactions in a complete economic system during an accounting period, usually one year. It integrates, within a macroeconomic framework, several detailed accounts for factors of production and institutions—especially households. Round (2003) elaborated on the main features of a SAM, which are threefold: (1) The accounts in a SAM are represented as a square matrix, in which the incomings and outgoings for each account are shown in corresponding matrix rows and columns. The transactions are shown in the cells, so the matrix displays the interconnections among agents in an explicit way. The corresponding row and column totals in the SAM must be equal to each other. (2) The SAM is comprehensive:it portrays all the economic activities of the system (consumption, production, accumulation and distribution), although not necessarily in equivalent detail. (3) The SAM is flexible, in that, although it is usually set up in a standard, basic framework. There is a large measure of discretion both in the degree of disaggregation and in the emphasis placed on different parts of the economic system.

Table 1 Disaggregation of model

| Production sectors | Regions | Households |
|---|---|---|
| Agriculture (Ag)<br>Industry (Ind )<br>Water transport (WtrSrv)<br>Land transport (LndTr)<br>Air transport (AirTr)<br>Other services (OtSrv)<br>Government (Gov) | National Capital Region (NCR)<br>Northern Luzon (NOL)<br>Southern Luzon (SOL )<br>Visayas (VIS)<br>Mindanao (MIN) | Low income (Low)<br>Middle income(Mid)<br>High income (High) |

When a national SAM is split into regional SAMs (RSAM), the flow of income from production units to consuming units is given a spatial dimension. In line with this objective, a five-region SAM was constructed in order to analyze ripple effects of particular shocks, particularly on regional income disparity and other aspects of the regional economies. This RSAM is presented in detail in Dakila, C. and Mizokami, S. (2006). The main data source for the study is the 1994 five-region Philippine inter-regional input-output (PIRIO) table, which regrouped the 15 administrative regions of the country in 1994 (now 17) into five greater regions according to geographic proximity (Secretario: 2002). This regional classification is carried over to the present paper.

As described in Dakila and Mizokami (2006), there were three major activities undertaken to derive the RSAM. First, the coverage of the 1994 PIRIO was expanded. In particular, the personal consumption expenditures component in the final demands columns was further disaggregated according to income class. Greater attention was paid to the components of value added across sectors and import transactions were broken down into CIF values and tariffs and import taxes. Second, the PIRIO was transformed from an open-type input-output model (i.e., one with an exogenous household sector) into a closed input-output model, with the household sector endogenized within the production system of regional economies. This closed I-O framework accounted for the balance between the different sources of incomes of households. For this, the Philippine Family Income Expenditures Survey (FIES) was the primary data source. Finally, the multi-region SAM was compiled based on the expanded PIRIO. The interregional flows derived from multi-regional SAM were verified to be similar to those in survey of interregional freight and passenger flows conducted by JICA and DOTC team in the Philippines.(Dakila & Mizokami : 2006)

### 3 .2 Assumptions and Description of the Model

The assumptions adopted are as follows (1.)All product and factor markets operate under perfectly competitive conditions. (2) Economic agents like households and firms maximize an objective function subject to constraints. Households maximize utility whereas firms maximize profit. (3) Equilibrium is defined as a state where the actions of all agents are mutually consistent and can be executed simultaneously. Quantities adjust in the model and prices follow to equate the notional and effective demand for labor. (4) In this model, adjustment to equilibrium is implemented by specifying that markets adjust to minimize the sum of excess supplies. (5) Among the seven-production sectors; three belong to the transport sector, namely, water transport services sector, air transport services sector, land transport services sector. The demand for services of each type of transport mode is a derived demand associated with the demand of intermediate production goods. (5) Between the two factors of production, capital is immobile and labor is mobile among the five regions. (6) The economy has 36 markets. This is composed of thirty-four product markets with each of the aforementioned five regions with seven production sectors each (except NCR with 6 sectors), one capital market and one labor market. There is an insignificant agricultural sector in NCR and is therefore omitted. The framework takes off from Mizokami model of two region economy in the Philippines with four production sectors including transport. (Mizokami et al: 2005). However, there are variations in specification of the production function. A three-level nested production function is estimated. The transport sector intermediate input is isolated in the second level of production function. A more detailed disaggregation of transport sector is delineated – namely water transport services sector, air transport services sector and land transport services sector. Furthermore, another point of difference is that households in each region are decomposed into three income levels - low, middle and high. Finally, the rest-of-the-Philippines region is divided into four regions namely Northern Luzon, Southern Luzon, Visayas and Mindanao vis-à-vis National Capital Region.

The model presented below is a simple representation of an economic system with assumption of perfect competition in goods and factor markets and constant returns to scale in production. This is the start of promising experiments into the usage of SCGE modeling for developing countries with limited data like the Philippines. Also, it is recognized that recent advances in spatial computable general equilibrium (SCGE) modeling have incorporated such assumptions as increasing returns to scale, agglomeration economies, and imperfect competition in the model. Given that SCGE modeling is at its infancy stage in the Philippines, these modifications will be undertaken in future studies.

The originality of this model lies in the fact that this is the first spatial equilibrium model with a disaggregated transport sector in the Philippines. All Philippine CGE models devised in the past have been national in scope. This model differs from all previously surveyed as it manifests its transport-orientedness by the isolation of transport intermediate inputs in the second level of three-nested production function. This allows the assessment of the impact of any exogenous shock on transport-related variables such as transport intensity, environmental effects via application of emission coefficients and degree of substitution among different transport modes. This is also a first attempt in constructing a five-region social accounting matrix as database for a spatial computable general equilibrium (SCGE) model in the Philippines.

3.2.1 Household Sector

The model distinguishes between 15 representative households, with 3 household types (representing the low, middle, and high income classes) for each of the six regional groupings distinguished in this paper. The preferences of each household type are summarized by a corresponding Cobb-Douglas utility function:

$$U_h = \prod_i C_{ih}^{\delta_{ih}} \qquad (1)$$

Where $\delta_{ih}$ is the elasticity of the utility of the $h^{th}$ household with respect to consumption of the $i^{th}$ good. Each representative household maximizes its utility subject to its income constraint, which we describe below.

For each region, household labor income is assumed to be equal to the sum of the labor incomes that each household income group earns from supplying labor within the region. The endowments of labor of different income classes within a region are taken to be a constant. This then determines how labor income is distributed within each region.

Since capital is fixed, then each household income group is assumed to own a fixed share of total capital, and this ratio is maintained through the policy experiments. Household income is calculated as the sum of labor income ($w_i L_i$) plus that portion of capital income that accrues to the households ($\lambda_h \Sigma_i r_i K_i$), plus transfers from government and from the rest of the world. The latter two are exogenously determined. Thus, if we partition the indices h and i so that the $r^{th}$ partition belongs to the rth region, then we obtain total income per household type as:

$$Y_{h,r} = \omega_{h,r} \sum_{i \in r} w_i L_i + \lambda_{h,r} \sum_i r_i K_i + Tr_{GOV,h,r} + Tr_{ROW,h,r} \tag{2}$$

where the ω's are the labor income distribution parameters, and, as indicated, the summation is for industries belonging to the rth region. Total disposable income is found by subtracting direct taxes imposed on the household from the foregoing quantity:

$$Yd_h = Y_h \left(1 - \tau_h\right) \tag{3}$$

where $Y_d$ is disposable income and $\tau_h$ is the direct tax rate imposed on household h. Note that the summation now runs within each household type, so that we have dropped the subscript r referring to the partitioning across regions.

Each household type is assumed to consume a constant proportion of its disposable income. Thus, households maximize utility subject to the budget constraint

$$\sum_i pd_i C_{ih} = c_h Yd_h \tag{4}$$

Where $pd_i$ is the domestic price of the good and $c_h$ is the average propensity to consume of household h. Given the Cobb-Douglas utility function, the first order conditions yield the following consumption demands for each commodity by each household type in each region:

$$C_{i,h,r} = \delta_i c_{h,r} \left[ \omega_{h,r} \sum_{i \in r} w_i L_i + \lambda_{h,r} \sum_i r_i K_i + Tr_{GOV,h,r} + Tr_{ROW,h,r} \right] \left(1 - \tau_{h,r}\right) / p_i \tag{5}$$

3.2.2 Production Sector

Production is modeled assuming a three-stage production function. At the first stage, capital and labor are combined to produce value-added, using a Cobb-Douglas production technology.

$$V_i = A_i K_i^{\alpha_i} L_i^{1-\alpha_i} \tag{6}$$

Where for sector i and region r, V = value added, K = capital, L = labor, α = share of capital in value-added, and 1-α = share of labor in value-added. This specification of the Cobb-Douglas function assumes constant returns to scale. Capital is assumed to be immobile across sectors while labor is mobile.

In stage 2 of the production process, value-added is combined with non-transport intermediate inputs under a Leontief technology, to produce a composite good, which is output net of transport.

$$X_i^{NT} = \min \left[ X_{1i}/a_{1i}, X_{2i}/a_{2i}, \ldots, X_{NTi}/a_{NTi}, V_i/a_{V,i} \right] \tag{7}$$

Finally, stage 3 combines output net of transport with transport intermediate inputs under a Cobb-Douglas production function to yield total output gross of transport of commodity i ($X_{T,i}$).

$$X_{T,i} = B_i \left(X_i^{NT}\right)^{\beta_{1i}} W_i^{\beta_{2i}} A_i^{\beta_{3i}} La_i^{\beta_{4i}} \tag{8}$$

where W, A and La represent the different transport intermediate inputs that go into sector i, namely, water, air and land transport. This specification allows substitutability between the various transport modes. Total output of sector i ($X_i$) is found by summing together total output gross of transport of commodity i ($X_{T,i}$), indirect taxes on i ($T_{indirect,i}$), direct taxes imposed on firms in sector i ($T_{direct,i}$), imports of i ($M_i$), tariffs imposed on i ($Tar_i$), and net dividends from the foreign sector into sector i ($Div_{For,i}$).

$$X_i = X_{T,i} + T_{Indirect,i} + T_{Direct,i} + M_i + Tar_i + Div_{For,i} \tag{9}$$

The firm is assumed to maximize profits. Because of the nature of the production function, profit maximization can be described in three stages. The bottom stage entails choosing the optimum levels of capital and labor so as to maximize the contribution of value added to profits. At the second stage, as noted above, value-added is combined with other intermediate non-transport inputs in a fixed coefficients (Leontief) technology to produce output net of transport. Finally, the top stage determines the optimal combination of transport inputs to deliver output to the region of destination. Then for commodity j, the optimization problem is

Maximize

$$\Pi_j = \mathrm{pd}_j X_j - \sum_i \mathrm{pd}_j \mathrm{Mat}_{i,j} - \mathrm{pva}_j V_j \tag{10}$$

subject to

$$\begin{aligned} X_j &= B_j {X_j^{NT}}^{\beta_{1j}} {W_j}^{\beta_{2j}} {A_j}^{\beta_{3j}} {La_j}^{\beta_{4j}} \\ X_j^{NT} &= \min\left[ X_{1j}/a_{1j}, \ldots X_{NTj}/a_{NTj}, V_j/a_{V,j} \right] \\ V_j &= A_j K_j^{\alpha_j} L_j^{1-\alpha_j} \end{aligned} \tag{11}$$

Where Π is total profits, $Mat_{ij}$ is the matrix of intermediate inputs of each commodity into commodity j, V represents value added, and pva is its corresponding price.

3.2.3 Government and the External Sector.

The model incorporates a national government sector, i.e., the behavior of local government units is not considered. Government enters the economy in several ways: it purchases output from each sector, imposes indirect taxes on production and tariffs on imported goods, and direct taxes on income of each household type. Government expenditures on each commodity are taken as exogenous in the model, while taxes are endogenous.

Tariff revenues per commodity equal the product of the tariff rates and import values:

$$Tar_i = tar_i \left( m_i \right) \tag{12}$$

Where $Tar_i$ and $tar_i$ are total tariff collections from i and the tariff rate on commodity i, respectively. Indirect tax collections are given by the product of the indirect tax rate imposed on domestic production and the rate imposed on imports of the product:

$$T_{Indirect,i} = tind_i \left( d_i + m_i \left( 1 + tar_i \right) \right) \tag{13}$$

Direct tax collections per household type in the model are computed as:

$$T_{Direct,h} = Y_h - Yd_h \tag{14}$$

At this stage of model specification, imports and exports are taken as exogenous.

3.2.4 Investment-Saving Balance

Total household savings in the model are given by the aggregate difference between household disposable income and consumption expenditures:

$$S_h = \Sigma_h \left( Yd_h - C_h \right) \tag{15}$$

We introduce a balancing factor ($\phi$) to account for any discrepancies between measured savings and investments.

Total government savings are the sum of the various revenue sources minus total government purchases of the outputs of the various sectors, total government transfers to households, and total net transfers of the government to the foreign sector:

$$S_G = \Sigma_i Tar_i + \Sigma_i T_{Indirect,i} + \Sigma_h T_{Direct,h} - \Sigma_i G_i - \Sigma_h Tr_{GOV,h} - Tr_{GOV,FOR} \tag{16}$$

Total foreign savings, $S_{FOR}$, are given by the current account deficit minus net dividends to foreigners. Therefore, total savings are

$$S_{TOTAL} = S_h + S_{GOV} + S_{FOR} \tag{17}$$

Conceptually, total savings should equal total investment. As noted previously, our framework allows for statistical discrepancy by introducing a factor $\phi$ which transforms savings to investments. Investment distribution per sector is then modeled as constant proportion of total investment, with the distribution coefficients $\gamma_i$ calibrated according to the sectoral distribution of investment in 1994:

$$I_i = \gamma_i \phi \left( S_{TOTAL} \right) \tag{18}$$

3.2.5 Demand

Total intermediate demand for commodities by the firm arises from its maximization of profits subject to the three-level production function. At the first level, the first order condition for profit maximization entails equating the marginal product to the marginal cost of labor.

$$pva_i * \frac{\partial V_i}{\partial L_i} = w_i$$

$$pva_i \left(1 - \alpha_i \right) \frac{V_i}{L_i} = w_i \tag{19}$$

where the marginal product of labor for each production sector is evaluated assuming that capital is immobile across sectors. For any given employment, equilibrium entails that the corresponding level of production equal the demand forthcoming at the employment level. Similar equations hold for the choice between output net of transport and the various transport inputs, at the third level of the production function. This equilibrium condition together with (11) determines pva. We turn to this in greater detail in the section on prices.

At the second level, each production sector combines value-added and every non-transport intermediate input according to a fixed proportions technology:

$$Mat_{i,j} = a_{ij} X_j^{NT} \tag{20}$$

where i runs through all the non-transport intermediate inputs and value added for each sector, j runs through all the production sectors in the economy, $Mat_{ij}$ is the matrix of interindustry flows in the economy, $a_{ij}$ represents the fixed coefficients technology, and, as before $X_j^{NT}$ is output net of transport for the jth sector.

Final demand in the economy originates from households (consumption demand), firms (investment demand), government spending, and the foreign sector (export demand). Consumption demand by households originates from the maximization of the utility function, as described in previous section. Although for simplicity, firms' investment demands are not described explicitly in terms of optimization, the level of investment is determined by the transformation of savings into such. Government and export expenditures are taken to be exogenously determined.

The domestic demand for commodity i consists of the total intermediate demand, plus the total final demands for consumption, investment, and government purchases, while the total composite demand, represented by $Q_i$, is the sum of the domestic demand and exports:

$$Q_i = \sum_j \mathrm{Mat}_{i,j} + \sum_h C_{h,i} + I_i + G_i + \mathrm{Exports}_i \qquad (21)$$

3.2.6 Prices and Equilibrium

For any given employment level, equilibrium entails that the corresponding level of production should equal the demand forthcoming at the employment level. This requirement, together with the first order conditions for profit maximization by the firms in each region, determines the price levels in the economy, relative to the price of labor. The labor price is assumed to be the numeraire, and is thus taken to be fixed. Since capital is a fixed factor, we take returns to capital as a residual determined by the identity:

$$r_i = \frac{\left(\mathrm{pva}_i * V_i - w_i^0 L_i\right)}{k_i^0} \qquad (22)$$

The total product cost can then be built up from the components in a standard way. Thus, average cost per unit is

$$AC_i = \frac{\Sigma_j \mathrm{pd}_j \mathrm{Mat}_{j,i} + \mathrm{pva}_i V_i}{X_i} \qquad (23)$$

Where $pd_i$ is the domestic (tax-inclusive) price of i. In equilibrium, the average cost equals the composite price $pq_i$ of the commodity (the composite price is the peso price of both domestically produced and imported commodities).

The excess supply for each commodity is given by:

$$ES_i = X_i - Q_i \qquad (24)$$

The model treats all the foregoing relationships as constraints in a nonlinear programming problem. Markets are assumed to operate so as to minimize the value of sum of squared excess supplies for all commodities; i.e., the objective of the programming problem is to minimize the quantity

$$\Omega = \Sigma_i \left(pq_i * ES_i^{\,2}\right) \qquad (25)$$

In equilibrium, therefore, the unit cost is divisible into three parts: (1) $\frac{\sum_j pd_j q_{ji}}{X_i}$, where the j's are the non-transport inputs give the cost of non transport intermediate inputs per unit of X; (2) the same formula with the j's taken to be the transport inputs yields the transport margin; and $\frac{w_i L_i + r_i K_i}{X_i}$ is the cost of value added per unit of X.

In the aggregate, the equilibrium condition is

$$Y = C + I + G + X - M \tag{26}$$

where Y is aggregate supply, C is total consumption expenditures of the national economy, I is total investment expenditures of the national economy, G is total government expenditures of the national economy, X are total purchases of locally-made goods by foreign sector, and M are total purchases of foreign-made goods by domestic residents of nation

## 4. EMPIRICAL RESULTS

The succeeding results indicate the impact of technological improvement in each transport mode – land, air and water – in each of five regions

### 4.1 Impact on Gross Output

4.1.1 Impact on Gross Output of All Transport Modes Across All Five Regions

Figure 1 indicates that technological improvement in NCR land transport services had the highest impact on output. Therefore, focus should be placed on improving the management of land transport services in the National Capital Region. This includes building wider road network, faster trains, or acquiring better land transport traffic equipments. It is almost double the increase in output of second and third biggest increment – land transport sector Northern Luzon and land transport sector Visayas.

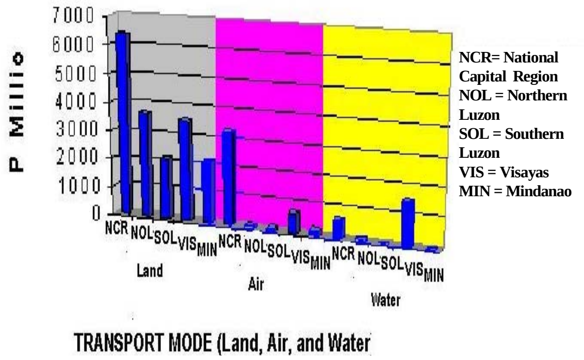


Figure 1 Change in Gross Output of all Regional Transport Modes

4.1.2 Impact on Gross Output Across Regional Production Sectors Due to Technological Innovation in NCR Land Transport Services Sector

Figure 2 indicates that the concentration of benefits of this exogenous policy shock is in production sectors in the National Capital Region namely land transport services, industry and other services sector. While this reinforces the primacy of the National Capital Region due to existence of agglomeration economies, spillover effects in Southern Luzon's industrial and agricultural sectors; and also in Visayas' industry and other services sector also occur. Mindanao's agricultural sector also benfitted from this policy shock. This indicates that interregional inequity in terms of output is reduced with exogenous shock.

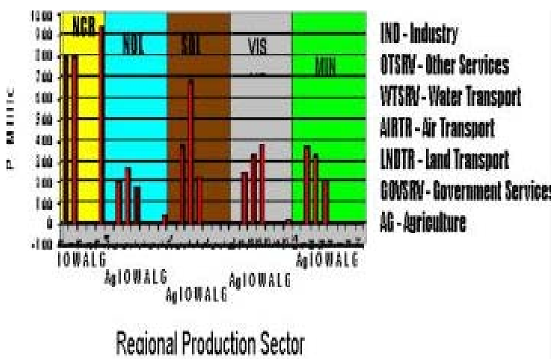


Figure 2 Change in Cross Output of Regional

### 4.2 Impact on Relative Welfare

4.2.1 Impact on Relative Welfare Across All Transport Modes In All Five Regions

A comparative analysis on impact of transport infrastructure improvement on relative welfare across regions (measured by change in equivalent variation – EV) is undertaken. Fig.3 indicates that technological change in NCR land transport and NCR air transport sectors have the highest impact on relative welfare across all fifteen regional household income groups.

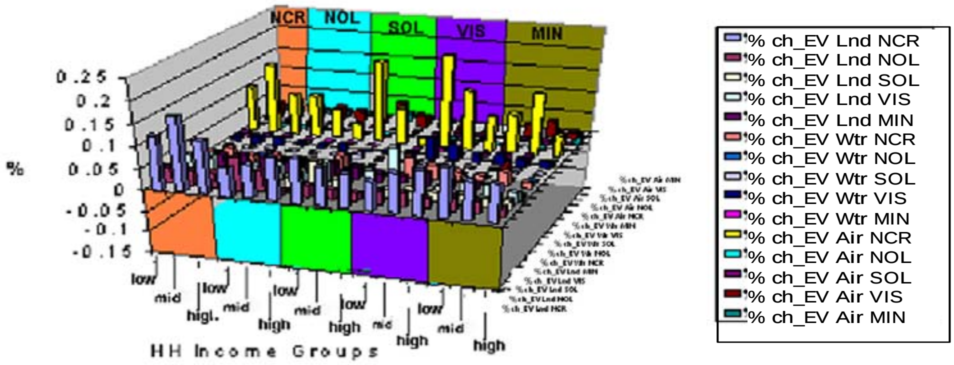


Figure 3 Impact on relative welfare across all regional HH income groups in all five regions

Focusing on NCR land transport improvements, Figure 4 indicates that improvement in NCR land transport has significant impact on middle income groups across the five regions. This maybe because most of them have their own land vehicles for work or leisure or business. The red middle bar graph in each box in Fig. 4 indicates the middle class' change in welfare.

4.2.2 Impact on Relative Welfare Across Households of Technological Improvement in NCR Land Transport Sector

The results indicate that the middle income households in NCR have the largest gain in relative welfare, followed by NCR high income groups and then NCR low income group.This affects intra NCR regional equity. It is also important to note that low-income households in Southern Luzon and the Visayas have the next highest incremental gain in welfare. This maybe due to the fact that households in these regions use intermodal scheme as in RORO (roll-on roll-off) which is classified as mobility via road .The red bar graph in the extreme left represents welfare gains of the lowest income groups. Those households which belong to Southern Luzon, Visayas and Northern Luzon experienced relatively high gains in equivalent variation. These households benefited from spill-over effects due to their proximity to the NCR. On the other hand, high income group in NCR had the highest relative welfare gain.

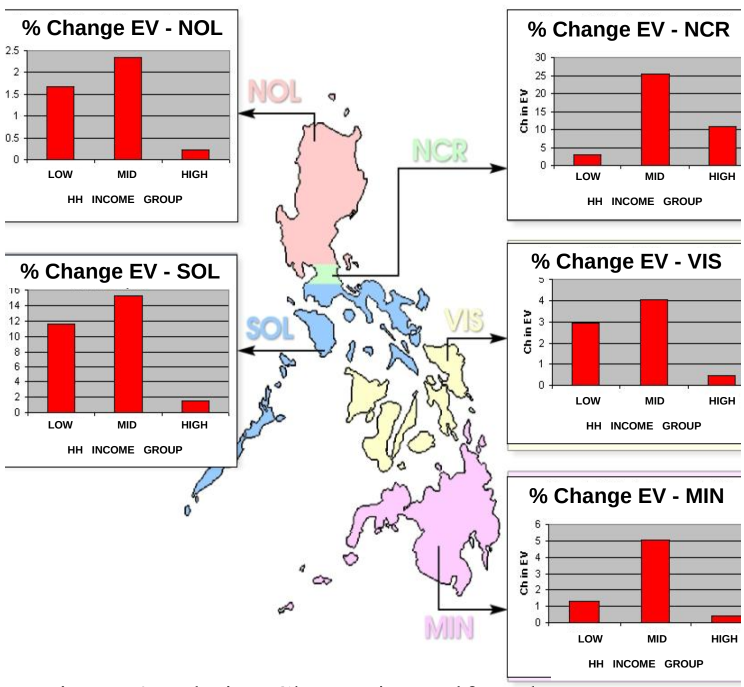


Figure 4 Relative Change in Welfare due to Technological Improvement in the NCR Land Transport Services Sector

This is explained by the fact that the location of improvement in land transport infrastructure in NCR creates immediate benefit to households residing in that region.

### 4.3 Impact on Interregional Flows of NCR Land Transport Infrastructure Improvement

Figure 5 herein shows the impact on interregional flows of choosing increase in land transport infrastructure via a spatial impedance ratio. Impedance ratio is defined as the ratio of interregional flows over transport capacity. The change in impedance ratio indicates the direction and relative magnitude of change in interindustry flow caused by the policy shock. The following observations are made: (1) All interindustry flows with origin and destination as NCR land transport services sector had positive changes in impedance ratio which signify trade creation; (2) Most trade flows with air transport services sector as destination sector in five regions experienced a decline in impedance ratio caused by a decline in interindustry flows. (3) Trade flows with water transport service sector as origin experienced the same trend. This may indicate some substitution of land transport in lieu of air and water transport mode for transport of goods and services across the Philippines (4) Another positive impact is that all traffic flows with destination in agricultural sector in Southern Luzon, Visayas and Mindanao experienced an increase in trade flow as manifested by increase in impedance ratio. This augurs well for the agricultural sector which has one of the highest transport margins among production sectors. (4) Trade creation and not diversion is manifested by spillover effects as can be seen by increase in flows with Southern Luzon industry as destination. (5) Many interregional flows in an archipelago like the Philippines are transported via RORO (roll-on-and roll-off; via both road and water transport modes). Philippine secondary data classify these interregional flows as transported via land. Hence there exists substitution in favor of land transport in many interregional flows when technological change occurs in land transport infrastructure.

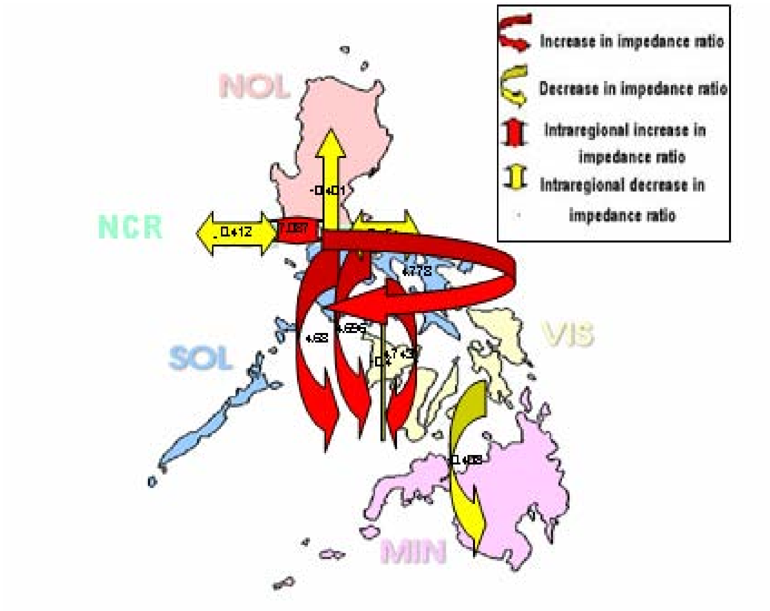

Fig. 5 Changes in Interregional Flows Across Regions

## 5. CONCLUSION

The above discussion shows how an interregional system-wide model of the economy can be used to pinpoint the transport infrastructure improvement which generates the highest increment in output in the economy. Technological improvement in transport sector results too many micro-level changes as in enhancement of speed and capacity which eventually leads to lesser travel time. However, given the secondary nature of database constructed, i.e. the multi-regional SAM, the impact of an exogenous shock on important details such as lesser travel time cannot be captured in detail at a micro level.

Technological improvements in NCR land transport infrastructure project had the greatest impact on gross output of most of the thirty –four production sectors. In terms of intraregional equity, the low-income groups of non-NCR regions like Southern Luzon and the Visayas registered significant relative welfare gains. There was also an increase in interindustry flows across regions in the Philippines as manifested by higher impedance ratios especially for traffic flows with NCR land transport services as destination sector.

Building more NCR land transport infrastructure has significant spillover and equity effects across the Philippines. It affects the spatial pattern of economic benefits, the value of economic benefits across production sectors and the distribution of benefits among household income groups. A concrete example of land transport capacity enhancement in NCR is the completion of the Skyway which will connect Northern Luzon and Southern Luzon by passing through NCR. This type of land infrastructure improvement will lead to substantial trade creation among the Luzon regions and NCR. Government is also planning to extend the Light Railway Transit (LRT) so that passengers can travel from Bulacan (Northern Luzon) to Batangas (Southern Luzon) by rail with no need for intermodal transfers.

In the end, targeting the appropriate type and location of transport infrastructure will lead to favorable results on efficiency of regional economic performance and on intraregional and interregional equity .

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Appendix 1 List of Endogenous and Exogenous Variables

| Variable name | Description | Size |
|---|---|---|
| | **Production sector** | |
| $\mathbf{mat_{ij}}$ | Intermediate inputs flow from industry i to industry j | 1156 |
| $\mathbf{intpnt_i}$ | Total non-transport intermediate inputs into industry i | 34 |
| $\mathbf{intp_i}$ | Total Intermediate Inputs into industry i | 34 |
| $\mathbf{Intptr_i}$ | Total transport inputs into industry i | 34 |
| $\mathbf{V_i}$ | Total value added in i | 34 |
| $\mathbf{X^{NT}_i}$ | Output (net of transport) in industry i | 34 |
| $\mathbf{X^{T}_i}$ | Output (gross of transport) in industry i | 34 |
| $\mathbf{X_i}$ | Total output in industry i | 34 |
| $\mathbf{ES_i}$ | Excess supply of commodity i | 34 |
| **GDP** | Gross domestic product | 1 |
| **Ω** | Sum of Squared Supplies in the Economy | 1 |
| **Imped** | Impedance ratio (trade flow/capital input or capacity) | 34 x 34 x 15 =17,340 |
| **Δ IMPED Ratio** | Change in Impedance Ratio | 34 x 34 x 15 =17,340 |
| | **Inputs** | |
| $\mathbf{L_i}$ | Labor demand in industry i | 34 |
| $\mathbf{K_i}$ | Value of capital inputs in industry i | 34 |
| | **Incomes** | |
| $\mathbf{Y_{LH}}$ | Labor income of household h | 3X5=15 |
| $\mathbf{Y_{LR}}$ | Total labor income for the region | 3X5=15 |
| $\mathbf{Y_L}$ | Total labor income | 1 |
| $\mathbf{Y_K}$ | Total capital income | 1 |
| $\mathbf{HHOS_i}$ | Total household share in capital income of industry i | 34 |
| **HHOS** | Total household share in capital income | 1 |
| $\mathbf{YD_H}$ | Total disposable income of household h | 3X5=15 |
| $\mathbf{Y_H}$ | Total income of household h | 3X5=15 |
| | **Demand** | |
| $\mathbf{C_{H,i}}$ | Consumption by household h of commodity i | 3X5X34=510 |
| $\mathbf{C_H}$ | Total consumption by household h | 3X5=15 |
| $\mathbf{U_H}$ | Utility of household h | 3X5=15 |
| $\mathbf{EV_H}$ | Equivalent variation for household h | 3X5=15 |
| **Utot** | Total utility | 1 |
| $\mathbf{D_i}$ | Domestic demand for commodity i | 34 |
| $\mathbf{Q_i}$ | Composite (domestic + foreign) demand for commodity i | 34 |
| | **Prices** | |
| $\mathbf{P_{VA,i}}$ | Price of value added of commodity i | 34 |
| $\mathbf{P_{D,i}}$ | Domestic price of commodity i including tax | 34 |
| $\mathbf{P_{M,i}}$ | Domestic price of imports of commodity i | 34 |
| $\mathbf{P_{Q,i}}$ | Composite (domestic + export) price of commodity i | 34 |
| $\mathbf{P_{X,i}}$ | Price of output of commodity i | 34 |

| | | |
|---|---|---|
| **$r_i$** | Return on capital in industry i | 34 |
| **CPI** | Consumer price index | 1 |
| | **Government** | |
| **$T_{Direct,H}$** | Direct tax collections from household h | 3X5=15 |
| **$T_{Direct}$** | Total direct tax collections | 1 |
| **$T_{Indirect, i}$** | Total indirect tax collections from industry i | 34 |
| **$T_{Indirect}$** | Total indirect tax collections | 1 |
| **$Tar_i$** | Tariff collections from inputs into i | 34 |
| **Tar** | Total tariff revenue of government | 1 |
| **$Y_G$** | Total income of government | 1 |
| | **Savings** | |
| **$S_h$** | Savings of household h | 3X5=15 |
| **$S_H$** | Total savings of households | 1 |
| **$S_G$** | Savings of government | 1 |
| **$S_F$** | Foreign savings | 1 |
| **$S_T$** | Total savings | 1 |
| | **Total Endogenous Variable** | **37,210** |
| **Exogenous variables and parameters** | | |
| | **Production sector** | |
| **$a_{ij}$** | Input-output coefficient | 20X20=400 |
| **$a_{Vi}$** | Coefficient of value-added in input-output matrix | 20 |
| **$A_i$** | Scale parameter in 1st level Cobb-Douglas production function | 34 |
| $\alpha_i$ | Coefficient of inputs in 1st level Cobb-Douglas production function for i | 34X2=68 |
| $\beta_i$ | Coefficient of inputs in 3rd level Cobb-Douglas production function for i | 34X4=136 |
| | **Inputs** | |
| **$KR_i$** | Real capital in industry i | 34 |
| | **Demand** | |
| **$M_i$** | Imports of commodity i | 34 |
| **$Exports_i$** | Exports of commodity i | 34 |
| **$C_h$** | Marginal Propensity to Consume of household h | 3 X 5=15 |
| $\delta_{ih}$ | Parameter in Cobb-Douglas Utility Function for household h | 34 X 15=510 |
| | **Prices** | |
| **$w_i$** | Wage rate in industry i | 34 |
| **$P_{E,i}$** | World price of exports of i | 34 |
| **$P_{M,i}$** | World price of imports of i | 34 |
| | **Incomes** | |
| **$HHOS_H$** | Total household operating surplus from informal transactions | 3X5=15 |
| **$YFOR_H$** | Household transfer receipts from foreign sources | 3 X 5=15 |
| $\lambda$ | Capital income distribution to households | 34 |
| | **Government** | |
| **$Tr_{Direct,H}$** | Direct tax rate on household h | 3X5=15 |
| **$Tr_{Indirect, i}$** | Indirect tax rate on industry i | 34 |
| **$Tarr_i$** | Tariff rate on imports of i | 34 |
| **$Y_{GOV,H,R}$** | Total government transfers to household h | 3X5=15 |
| | **Total exogenous variables** | **1549** |