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Environmental Impact of Regional Port Infrastructure Improvement in the Philippines

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Abstract

The archipelagic geography of the Philippines necessitates the development of ports, which has a significant impact on interregional mobility. This paper explores the environmental impact of improving port capacity across five delineated regions in the Philippines. The study utilizes a spatial computable general equilibrium model with a five region social accounting matrix as database. The model consists of thirty-four production sectors (with disaggregation of the transport sector), fifteen household income groups (low, middle and high for each of the five regions), two primary inputs – labor and capital, and four institutions.

The environmental aspect of port development can be divided into nine groups namely: (1) water quality; (2) coastal hydrology; (3) bottom contamination; (4) marine and coastal ecology; (5) air quality; (6) noise and vibration; (7) waste management; (8) visual quality; (9) socio-cultural impacts.

This paper considers only the facet of water quality due to data limitations. Water pollution emission coefficients estimated for the Philippines will be applied to changes in production levels, which occur due to port development. The pollution effect will be compared with increments in gross output across regional production sectors and gains in relative welfare across regional household income groups.

In the end, the Philippine region with the highest output and welfare effect will be pinpointed as the ideal site of port expansion. However, this result will be compared with water pollution impact. Hopefully, policymakers can be guided in instituting environmental protection measures in the chosen region so that macroeconomic gains outweigh environmental degradation due to port development.

Keywords: environmental, impact, port, regional, infrastructure.

1. INTRODUCTION

Development of ports is a major type of transport infrastructure investment in an archipelago like the Philippines. The institution of the Strong Republic Nautical Highway (SRNH) by the government attests to its commitment towards improving interregional mobility in the Philippines via ports..

This paper is an experiment in exploring the economic and environmental impact of improving ports in five delineated regions in the Philippines. It will use a spatial general equilibrium (SCGE)model with five region social accounting matrix (SAM) database as the basis of alternative port investments in different locations. This has the end goal of defining potentially high-impact location of port infrastructure in the Philippines.

According to the UNESCAP, there are three sources of adverse environmental effects of port development□These are : (1) location of port, (2) construction and (3) port operation which includes ship traffic and discharges, cargo handling and storage and land transport. Location of ports involves the existence of landfills and position of development site. Construction implies construction activities in the sea and on land, dredging, disposal of dredged materials and transport of construction materials Port operation includes ship-related factors such as vessel traffic, ship discharges and emissions, spills and leakge from ships and cargo-related factors such as cargo handling and storage, handling equipment, hazardous materials, waterfront industry discharges and land transport to and from the port. Environmental aspects of port development are divided into nine groups : (1) water quality; (2) coastal hydrology; (3) bottom contamination; (4) marine and coastal ecology; (5) air quality ; (6) noise and vibration ; (7) waste management; (8) visual quality; (9) socio-cultural impacts.

The environmental impact of port development considered in this study is water quality. According to UNESCAP, it has five elements : (1) general features such as temperature, salinity, pH, color, transparency, oil and grease, and organic material concentration measured by total organic carbon (TOC), chemical oxygen demand (COD) or biochemical oxygen demand (BOD); (2) turbidity measured by suspended solids (SS); (3) eutrophication-related factors measured by dissolved oxygen (DO), nitrogen (N) and phosphorus (P); (4) harmful or toxic substances including heavy metals such as mercury, cadmium, lead and pesticides; and (5) sanitation-related factors determined by measuring the amount of coliform bacteria. Hence water pollution emission coefficients will be applied to estimate impact of location of port development.(UNESCAP:1992).

2. THEORETICAL FRAMEWORK

The paper now proceeds by describing the database and model used in measuring the environmental impact of port development

2.1 . A Five-Region Social Accounting Matrix (SAM) for the Philippines

The baseline data used in the calibration of the spatial general equilibrium model (SCGE) were taken from a specially constructed five-region social accounting matrix based on 1994 Philipine interregional input-output table (Mizokami & Dakila : 2006). 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. The SAM fills in the link in the circular flow from factor payments to household income and back to demand for output. J. Round elaborated on the main features of a SAM, which are threefold: (1) The accounts are in a SAM are represented as a square matrix; where the incomings and outgoings for each account are shown as a corresponding row and column of the matrix. The transactions are shown in the cells, so the matrix displays the interconnections between agents in an explicit way. Moreover, not only is the SAM square but also the corresponding row and column totals must be equal. (2) The SAM is comprehensive, because 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.

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. Thus, the five-region SAM was constructed in order to analyze economic ripple effects of particular shocks on regional income disparity. 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 regional SAM. 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 for households, on the one hand, and household expenditure categories, on the other hand. In this respect, the Philippine Family Income Expenditures Survey (FIES) was the primary data source. Finally, the multi-region SAM was compiled based on the expanded PIRIO.

2.2. Description of the Model

2.2.1 Components of Model

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 identified) is done to enable the researcher to look into the impact of an improvement in transport infrastructure investment 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 regional poverty threshold as determined by the National Statistical Coordination Board. The high income households are those who earn 250,000 pesos and above annually. All the households earning income between the regional poverty threshold and the highest income bracket in the Family Income and Expenditure Survey (250,000 pesos and above) are classified as middle income households.

Regions	Factors	Sectors	Institutions
National Capital Region Northern Luzon Southern Luzon Visayas Mindanao	Labor Capital	Agriculture Industry Other Services WaterTransport Services Air Transport Services Land Transport Services Government Services	Household Firm Government Rest-of-the-World

:

2.2.2 Assumptions : (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 specifiying 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 of the aforementioned five regions with seven production sectors each, once capital market and one labor market.

2.2.3 Model Specification

The framework takes off from Mizokami model of two region economy in the Philippines with four production sectors including transport. (Mizokami, Itose, Dakila :2005). However, there are variations in specification of the production function. A three- 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 transposrt 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 consists of major blocks; namely the production block, income block, demand block, investment- savings block , price block , government sector, and external sector block.

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 is also a first attempt in constructing a five-region social accounting matrix as database for SCGE modeling in the Philippines. The interregional flow data derived from the input-output part of social accounting matrix were verified with primary data collected from a JICA-DOTC Survey on Interregional Passenger and Freight Flow

2.2.3.1 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.

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

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. Thus, the 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, value-added is combined with non-transport intermediate inputs under a Leontief technology, to produce a composite good, which is output net of transport; where Q_{1i}….Q_{2i} represent the nontransport intermediate input, $V_i$is the value added per sector and and the a_i represents the Leontief coefficient.

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$$Q_i^{NT} = \min\left[Q_{1i}/a_{1i}, Q_{2i}/a_{2i}, \ldots, Q_{nt,i}/a_{nt,i}, V_i/a_{vi} \right] \tag{2}$$

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.

$$Q_i = B_i {Q_i^{NT}}^{\beta_{1i}} W_i^{\beta_{2i}} A_i^{\beta_{3i}} La_i^{\beta_{4i}}\text{; where } \sum_{j=1}^{4} \beta_{ji} = 1 \tag{3}$$

where W is water transport intermediate input, A is air transport intermediate input and La is land transport intermediate input. W, A and L represent the different transport intermediate inputs which go into sector i. Thus, this specification allows substitutability among the various transport modes – water transport, air transport and land transport.

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. Let Π_{VA} represent this contribution of value added. Then the optimization problem is

$$\begin{aligned} &\text{maximize } \Pi_i^{VA} = pva_i V_i - w_i L_i - r_i K_i \\ &\text{subject to} \\ &V_i = A_i K_i^{\alpha_i} L_i^{1-\alpha_i} \end{aligned} \tag{4}$$

where V represents value added, and pva is its corresponding price. Since capital is immobile, of particular interest is the first-order condition for labor, which is

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

$$pva_i (1-\alpha_i) \frac{V_i}{L_i} = w_i \tag{5}$$

It is convenient to move next to the top stage of the production process, since this is likewise of Cobb-Douglas structure. There the optimization problem is

$$\begin{aligned} &\max imize\ \Pi_i = pd_i Q_i - w_i L_i - r_i K_i \\ &\text{subject to} \\ &Q_i = B_i Q_i^{NT^{\beta_{1i}}} W_i^{\beta_{2i}} A_i^{\beta_{3i}} La_i^{\beta_{4i}} \end{aligned} \tag{6}$$

and the corresponding first order conditions are

$$pd_i * \frac{\partial Q_i}{\partial Q^{NT}{}_i} = p_{NT} \text{ or } pd_i \beta_{1i} \frac{Q_i}{Q^{NT}{}_i} = p_{NT} \tag{7}$$

$$pd_i * \frac{\partial Q_i}{\partial W_i} = p_w \text{ or } pd_i \beta_{2i} \frac{Q_i}{W_i} = p_W$$

$$pd_i * \frac{\partial Q_i}{\partial A_i} = p_A \text{ or } pd_i \beta_{3i} \frac{Q_i}{A_i} = p_A$$

$$pd_i * \frac{\partial Q_i}{\partial La_i} = p_L \text{ or } pd_i \beta_{4i} \frac{Q_i}{La_i} = p_{La}$$

Finally, once output net of transport is determined, the different non-transport inputs as well as total value added can be derived using the fixed coefficients technology (2). While this may seem to over-determine value-added in the system, we take (5) as actually determining pva. We turn to this in greater detail in the section on prices.

2.2.3.2. 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 five regional groupings distinguished in this paper. The preferences of each household type are summarized by a corresponding Cobb-Douglas utility function:

$$U_i = C_1^{\delta 1} C_2^{\delta 2} \ldots\ldots\ldots\ldots\ldots C_n^{\delta n} \tag{8}$$

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 the 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 assumed to be 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 rth partition belongs to the rth region, then total income per household type is therefore given by

$$Y_{h,r} = \omega_{h,r} \sum_{i\in r} w_i L_i + \lambda_{h,r} \sum_i r_i K_i + Tr_{GOV,h,r} + Tr_{ROW,h,r} \tag{9}$$

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:

$$Yd_h = Y_h \left(1 - \tau_h\right) \tag{10}$$

where Y_d is disposable income and τ_h is the direct tax rate imposed on household h. The summation is now applied for 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.

$$\sum_i pd_i C_{ih} = c_h Yd_h \tag{11}$$

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 require that:

$$C_{i,h,r} = \delta_i c_{h,r} \left[\omega_{h,r} \sum_{i\in r} w_i L_i + \lambda_{h,r} \sum_i r_i K_i + Tr_{GOV,h,r} + Tr_{ROW,h,r}\right] \left(1 - \tau_{h,r}\right) / p_i \tag{12}$$

where $\omega_{h,r}$ is the labor income distribution parameter; λ is distribution parameter of capital income of households and τ is the income tax rate.

2.2.3.3 Government Sector

The model incorporates a national government sector, i.e. the behavior of regional 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:

$$Tar_i = tar_i \left(m_i\right) \tag{13}$$

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:

$$T_{Indirect,i} = tind_i \left(d_i + m_i \left(1 + tar_i\right)\right) \tag{14}$$

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

$$T_{Direct,h} = Y_h - Yd_h \qquad (15)$$

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

2.2.3.4 Investment-Saving Balance

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

$$S_h = \Sigma_h \left(Yd_h - C_h \right) \qquad (16)$$

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:

$$S_G = \Sigma_i Tar_i + \Sigma_i T_{Indirect,i} + \Sigma_h T_{Direct,h} - \Sigma_i G_i - \Sigma_h Tr_{GOV,h} - Tr_{GOV,FOR} \qquad (17)$$

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

$$S_{TOTAL} = S_h + S_{GOV} + S_{FOR} \qquad (18)$$

Conceptually, total savings should equal total investment. Our framework allows for statistical discrepancy by introducing a factor ϕ which transforms savings to investments. Investment distribution per sector is then modeled as constant proportion of total investment, with the distribution coefficients γ_i calibrated according to the sectoral distribution of investment in 1994:

$$I_i = \gamma_i \phi \left(S_{TOTAL} \right) \qquad (19)$$

2.2.3.5 Prices

The firm is assumed to maximize profits. The first order condition for this entails equating the marginal product to the marginal cost of labor.

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

$$pva_i \left(1 - \alpha_i\right) \frac{V_i}{L_i} = w_i \qquad (10)$$

For any given employment, equilibrium entails that the corresponding level of production equal the demand forthcoming at the employment level. This 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.

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

$$AC_i = \frac{\sum_j pd_j q_{ji} + w_i L_i + r_i K_i}{X_i} \qquad (20)$$

where X_i is the total output of commodity i and qji is the amount of inputs of j into industry i. Therefore, if we partition the input j's into two sets, NT, the non-transport inputs, and Trans, the transport inputs, the unit cost is divisible into three parts :

(1) $\frac{\sum_{j\varepsilon NT} pd_j q_{ji}}{X_i}$ the cost of non transport intermediate inputs per unitof X; (20.1)

(2) $\frac{\sum_{j\varepsilon Trans} pd_j q_{ji}}{X_i}$ cost of transport inputs; (20.2)

(3) $\frac{w_i L_i + r_i K_i}{X_i}$ the cost of value added per unit of X (20.3)

The excess supply for each commodity is given by:

$$ES_i = X_i - Q_i \qquad (21)$$

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

$$\Omega = \Sigma_i \left(pq_i * ES_i^{\ 2} \right) \qquad (22)$$

2.2.3.6 Equilibrium Condition :

Y = C + I + G + X- M

Where Y = aggregate supply

C= total consumption expenditures of the national economy

I = total investment expenditures of the national economy

G = total government expenditures of the national economy

M = total purchases of foreign-made goods by domestic residents

Investment = Savings where Savings = Φ (Y_d – C) & Φ is balancing Parameter; Y_d is disposable income & C is consumption expenditure

3. EMPIRICAL RESULTS

The empirical results below indicate the effect of port development in each of the five regions on critical macroeconomic and environment-related variables. The exogenous shock is port development in each region which can mean expansion of port facilities to accommodate large scale bulk shipping services.

3.1 Comparative Regional Impact on Relative Welfare

The figure below indicates it is the middle income group across most of the regions which experienced high relative welfare gains. A significant result though is that the Visayas low income class registered the highest relative welfare gain when infrastructure technological improvement takes place in Visayas water transport mode.

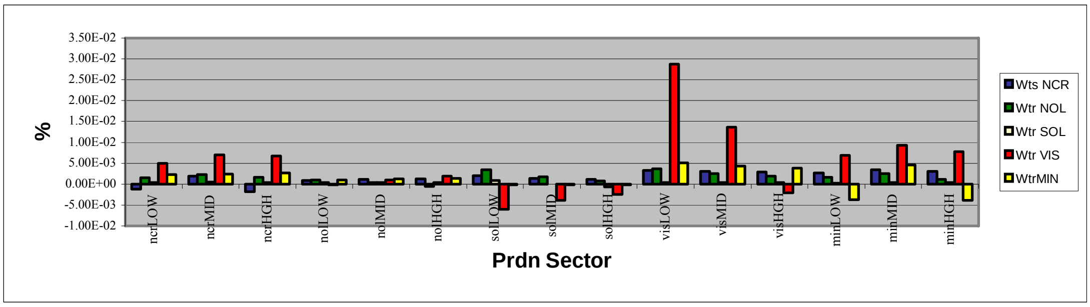


Figure 1: % Change in EV- Regl. HH Income Classes & Regl. Water Transport Mode

3.2 Comparative Regional Impact on Gross Output

In terms of gross output, it is again water transport Visayas which had the highest impact on output across the country with Mindanao water transport and NCR water transport following next.

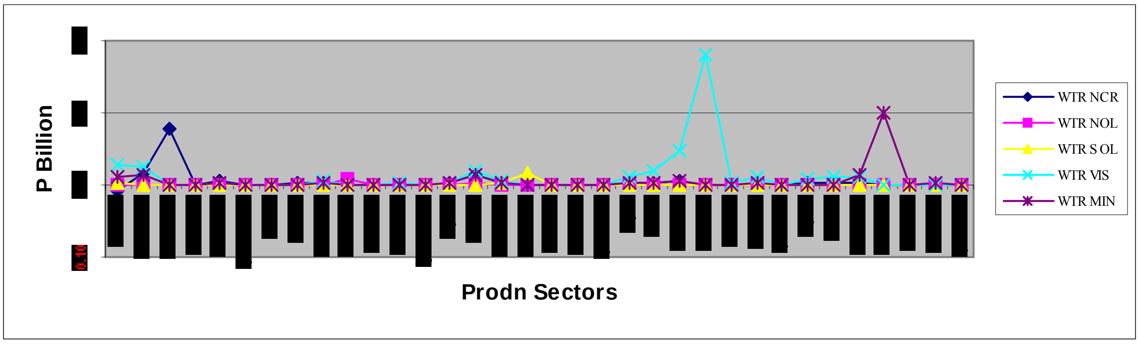


Figure 2 : Change in Gross Output – All Regional Water Transport Mode

3.3 Comparative Regional Impact on Consumption Levels

Across the Philippines, port development in the Visayas increased the consumption level of output of NCR industry sector and the other services sector of the four other regions. This proves the transport intensity of services sector across space and how major technological change in Visayas water transport augments consumption levels of services across the country,

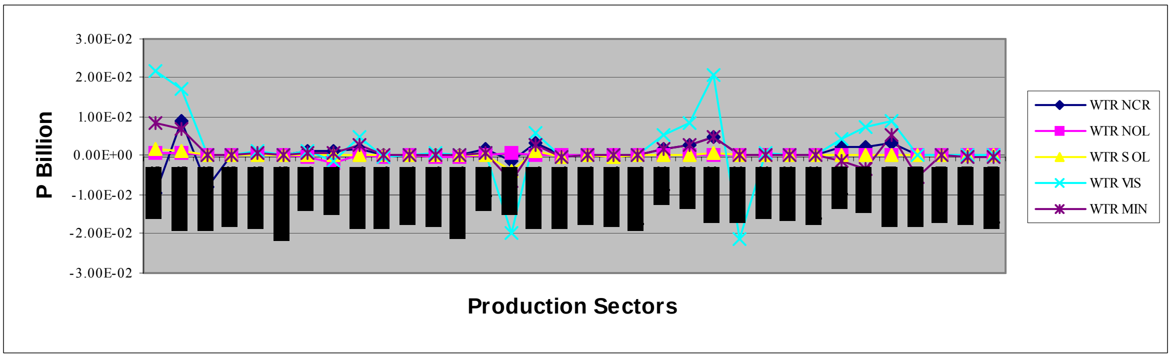


Figure 3 :Change in Consumption Levels –All Regional Transport Mode

3.4 Environmental Impact of Exogenous Shock

The three figures below indicate the environmental impact of changes in production level caused by technological improvement in port facilities. ..Water effluent emission & discharge coefficients were adopted. Water effluent emission & discharge coefficients were adopted; based on environmental studies undertaken by the ENRAP (

Environmental & Natural Resources Accounting Project - USAID-Philippines : 1996) and on the Carlos-Dakila paper (2002) The water effluent emissions used to measure environmental impact of changes in consumptions were : (1) biochemical oxygen demand (BOD); (2) suspended solid (SS); (3) total dissolved solid (TDS); (4) oil; (5) nitrates (NIT) and (6) phosphorus (PH). The estimated emission coefficients were averaged out for each of the five region's seven production sectors used in SAM and were applied to changes in production levels caused by the exogenous shock.

Among the five regions, the Visayas, Mindanao and NCR had significant environment-related results which merit discussion. It appears that the agricultural sector nationwide is the biggest emitter of water pollution as shown in the figures below. The industry sector was the second highest emitter of water pollutants across the whole Philippines.

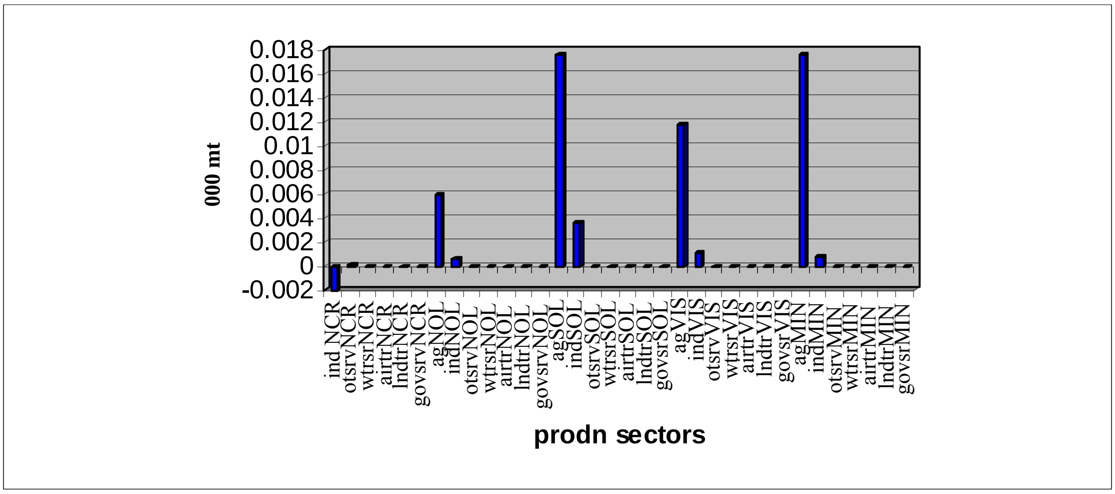


Figure 4 : Emisssion of Water Effluents– Water Transport NCR

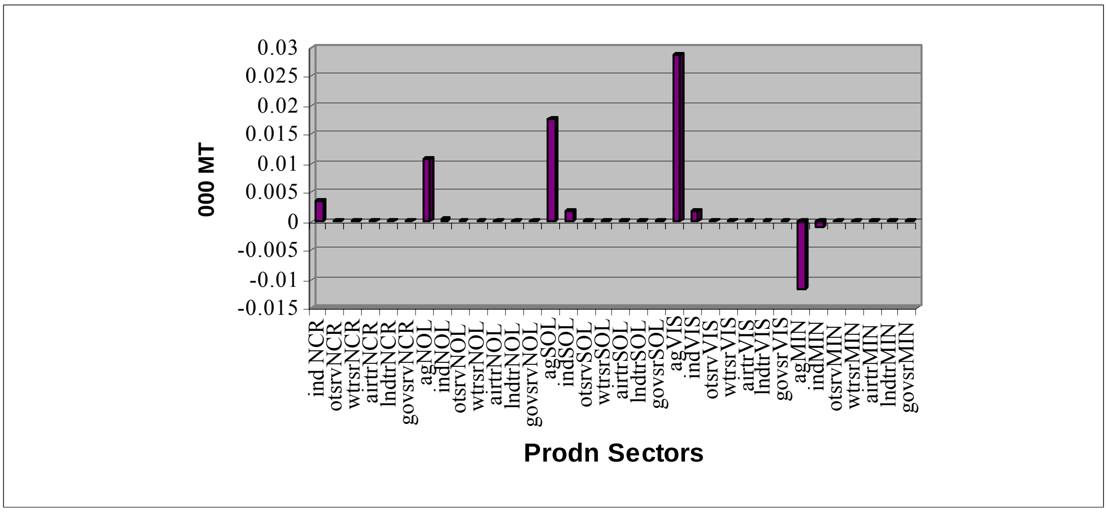


Figure 5 : Emisssion of Water Effluents – Water Transport MIN

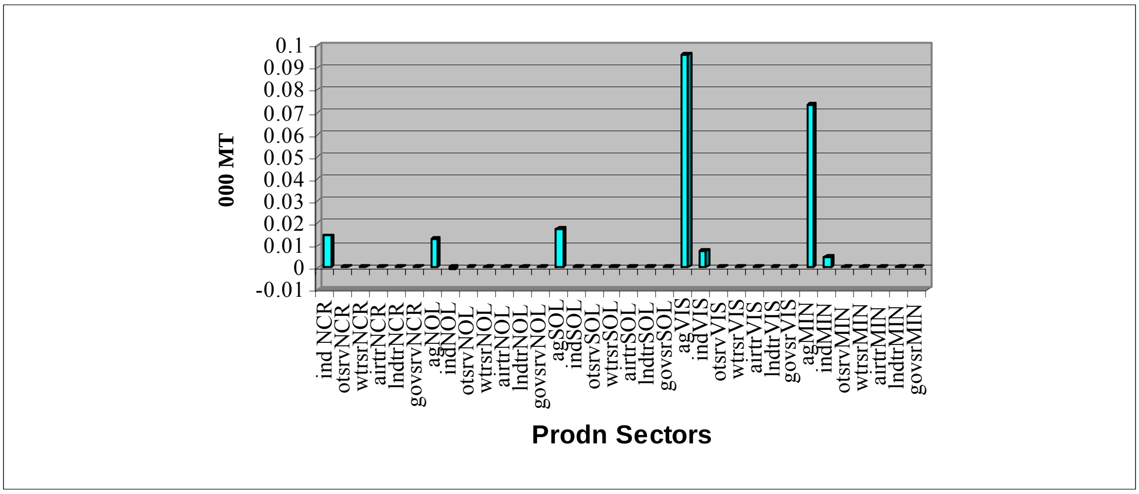
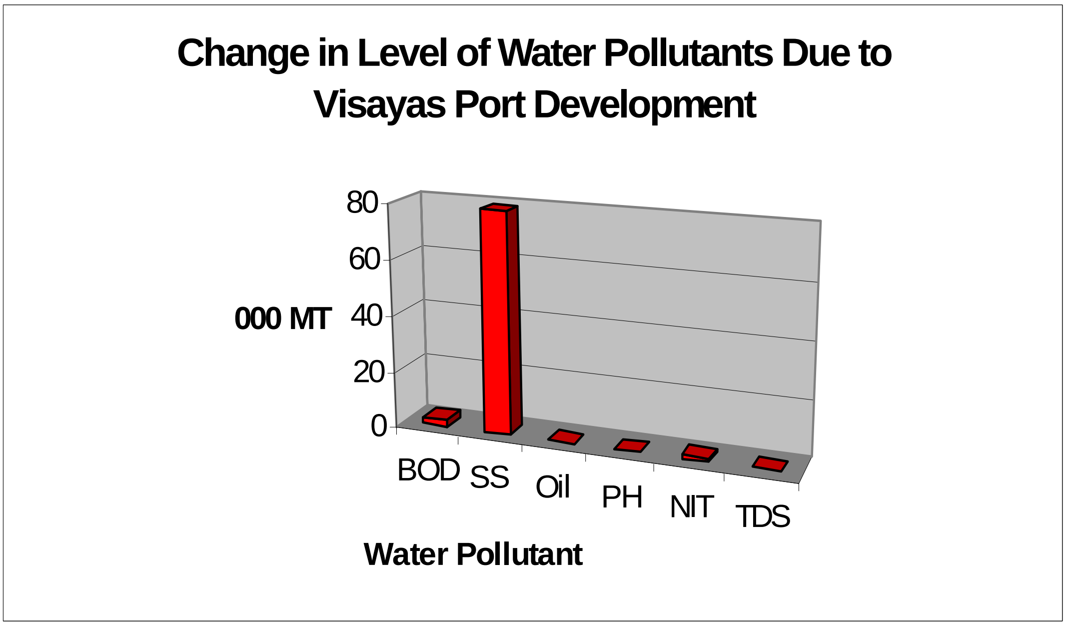


Figure 6 : Emission of Water Effluents – Water Transport VIS

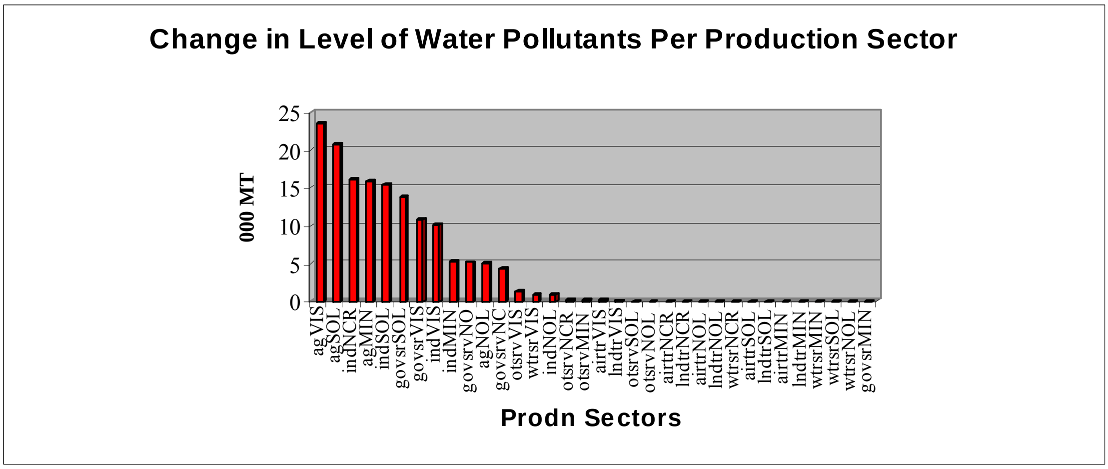
The discussion now moves to the impact of Visayas port development on overall amount of water effluent emission and vital regional macroeconomic variables. In comparative regional impact analysis, the Visayas region registered the highest gross output and relative welfare gains.

3.5 Visayas Port Development - Total Change in Water Effluent Emission

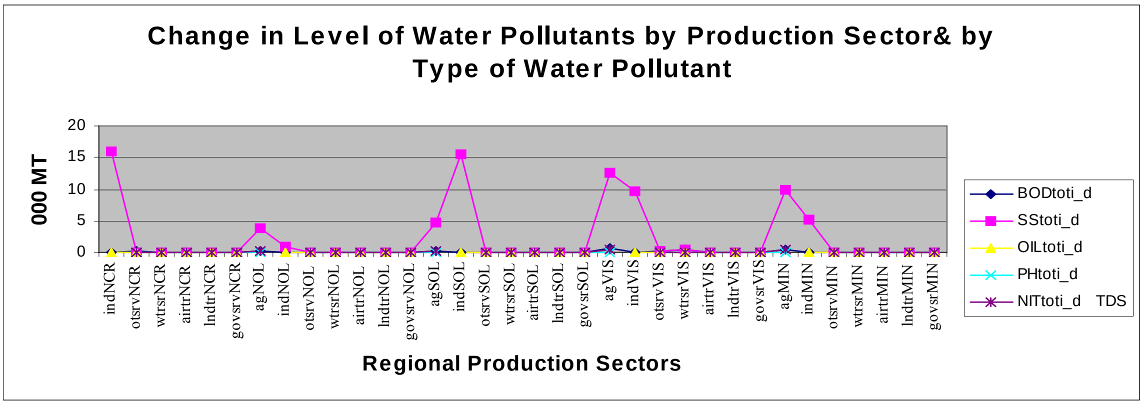
The results below indicate that port development in the Visayas occurs, would result in increases in water pollutants. The biggest increase comes from suspended solid.



In terms of sectoral breakdown, the biggest emitter of water pollution is Visayas agricultural sector. The next highest emitters of water pollutants are SOL agriculture, NCR industry, Mindanao agirculture and SOL industry.

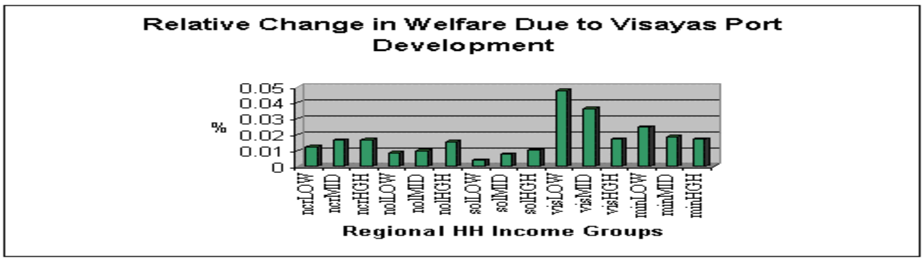


The graph below gives a comparative picture of level of water pollutants by regional production sector. Suspended solids coming from all agricultural sector have the highest emission level of water pollution.



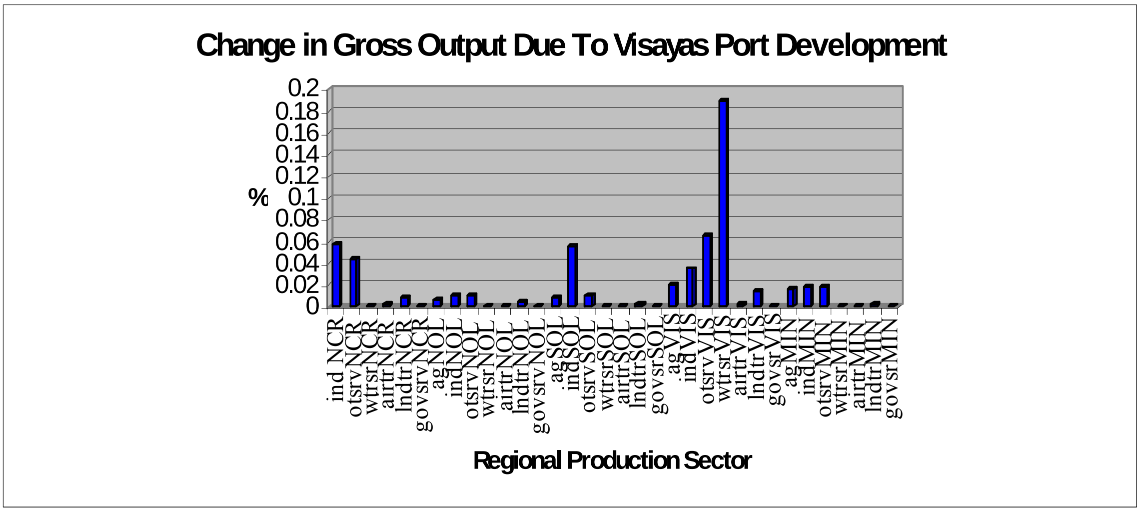
3.6 Visayas Port Development - Change in Welfare Across Regional HH Income Groups

The welfare effects indicate that Visayas low-income and middle-income groups are the main beneficiaries of Visayas port development This is a positive intraregional equity effect. Next in rank are the low-income and middle income groups in Mindanao. This maybe due to the fact that most goods consumed by Mindanaoans are transported through Visayas ports. There is also a huge inflow of passengers coming from Mindanao going to the Visayas.



3.7 Visayas Port Development - Relative Change in Output

In terms of relative change in output, the Visayas water transport services sector and other services sector registered the highest increment in output.This result backs up the finding that the gains in output impact mainly in the region where port development took place.- the Visayas.



4. CONCLUSION

The preceding discussion highlighted how an economy-wide interregional general equilibrium model can give some general indications of the environmental impact of port development across regions in the Philippines.

Based on general aggregated indicators used in the study, it appears that port infrastructure development should be instituted within the Visayas water transport services sector.. It has the highest positive impact on relative welfare, gross output and consumption levels .
However, a major caveat is that this policy direction may have adverse effect on the environment as far as water pollution is concerned. This is so because the sector with the highest amount of water pollutant emission is the agricultural sector and the biggest increment registered isin the Visayas region. Among the water pollutants, it is suspended solid which had the highest level of emission in the Visayas.. A possible policy direction for government is to institute environmental protection measures so that the gains in welfare and output far outweigh the environmental harm caused by port development in the Visayas.

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