National Development for and from the Regions:

A Philippine Regional CGE for Impact Analysis

Presented to PEP Network

By

Brain Trust: Knowledge and Options for Sustainable Development, Inc.

In partnership with

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PHILIPPINES

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Abstract

The implementation of development interventions and the impacts of economic policies vary by location within a country. Moreover a country’s economic structure may have a distinct geographic dimension. Regional analysis is important to inform implementation of economywide adjustment policies, as well as geographic targeting of public investment.

These issues are particularly highlighted for the Philippines, an archipelagic country with large development disparities across regions, a dense concentration of manufacturing and services output in and around the national capital, and a policy environment stressing decentralization. The study proposes the construction of a regional CGE for the Philippines to support quantitative impact analysis of national and regional policies. The model will be a bottom-up trade model: the regions correspond to separate economies trading with each other in a national market. The regional economies closely corresponding to the sub-national units adopted in official policymaking. The model will be able to simulate outcomes for regional consumption and income (disaggregated by household income group), as well as regional production (disaggregated by sector). Policies to be analyzed can be national or regional in scope.

Capacity building consists of collaboration with junior researchers, as well as formulation and delivery of a training module for applying to support regional development planning. Dissemination will be undertaken in partnership with a national project aimed at policy reform and multi-sectoral capacity-building.
1. Introduction

For the Philippines (as in many other countries), a regional perspective is essential to the formulation of a national development policy. Progress in achieving the Millennium Development Goals varies widely across the country’s regions. Moreover, different regions play different roles within a country’s economic structure. In the recent State of the Nation Address (24 July 2006), the President of the Philippines framed the public investment policies in terms of “super-regions,” based on the principle of supporting the “natural advantages and natural resources of each section of our nation so that when harnessed together, the major economic regions of the nation are larger than the sum of its parts.”

Regional development seeks to address disparities in living standards across regions, as well as differences in welfare outcomes of various economywide policies. It also attempts to optimize the specific contribution of each region to the national economy. The main research questions to be addressed by the study are twofold:

a. What are the regional differences in welfare impacts for various economywide policies?

b. What are the economywide implications of various regional development policies?

To answer these questions, the study proposes to construct a regional computable general equilibrium (CGE) model of the Philippines. The CGE model will be applied to experiments on economywide fiscal policies such as tariff reform, as well as regional policies related to public investments. Implications of the analysis for the country’s regional and national development strategies will also be discussed. Important issues relevant to the economic development strategy can be addressed such as: prioritization of public investment under
fiscal constraints, the need to address development disparities across regions, and complementarity between market-level policies and ground-level investments.

2. Policy relevance

Setting

The UNDP (2005) classifies the Philippines as a middle human development country. Official statistics classify 30% of the population as poor, making mass poverty a paramount concern in development. The Philippines is an archipelago of over 7,000 islands and mostly mountainous topography (though on the larger islands there are narrow valleys and alluvial plains.) The country is divided into 16 administrative regions, which display striking development disparities (Table 1). The National Capital Region (NCR) has a per capita GDP of more than twice the national figure. NCR combined with the adjacent region of Southern Tagalog account for over 46% of national GDP, while containing only 28% of the total population.

Agriculture, which used to dominate the economy, currently accounts for only a minority share of GDP (19.6%), in common with other middle income countries. However the employment share of agriculture is much higher, at 37%; agro-processing and agribusiness activities, combined with basic agriculture, account for as much as 40% of GDP and up to two-thirds of employment (Habito and Briones, 2005). Moreover regions with lower per capita GDP also tend to have greater shares of agriculture in total output. This suggests that development needs and strategies should be fitted to the distinctive economic structure characterizing each region.
### Table 1: Selected regional indicators for the Philippines

<table>
<thead>
<tr>
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<tr>
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</tr>
<tr>
<td>Southern Tagalog (II)</td>
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<td></td>
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<tr>
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<td>3.5</td>
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<tr>
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<td>57.8</td>
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<td>Caraga</td>
<td>-</td>
<td></td>
<td>54.2</td>
<td>40.2</td>
</tr>
</tbody>
</table>

Note: Per capita GDP of Southern Tagalog and Caraga are reflected in the Southern Tagalog (I) and ARMM rows, respectively.

Source: Basic data from NSCB; Per capita GDP data compiled in Manasan and Chatterjee (2003).
Creating linkages across locations separated by oceans and a rough terrain is difficult. The country’s logistics system remains a major source of market inefficiency. Poor roads, inadequate transportation systems, and inadequate market infrastructure for storage and warehousing contribute to damage, shrinkage and deterioration in the quality of farm products, as well as higher agricultural prices (Ordoñez, 2005). Studies have uncovered some degree of market disintegration in agriculture owing to geographic barriers, at least in the short run. Agricultural markets do tend to be integrated (Silvapulle and Jayasuriya, 1994; Coxhead et al, 2001), at least in the long run; for corn, market imperfections have been found to slow down the adjustment of regional prices to the market center in the national capital. These imperfections may be related to high transport costs and inadequacy of inter-island shipping vessels (Mendoza and Rosegrant, 1995). As commodities are more mobile than production factors, there is every reason to suspect that geographic barriers are even more formidable for factor movement, especially of labor. Adjustment problems related to geography may be one factor behind the failure of the country to respond to wide-ranging economywide policy reforms.

**Development strategy**

Postwar economic policy was dominated by an import substitution and inward-looking industrialization. The emphasis on heavy industries inadvertently promoted capital-intensive manufacturing located in cities. Pernia et al (1983) found that concentration of economic activities around the national capital was positively associated with effective protection rates. From the 1980s this protectionist stance was dismantled through a series of structural adjustment programs. In foreign trade, major reforms have been the elimination of
export taxes, the repeal of most quantitative restrictions, and the reduction in tariffs for many major commodities. Currently the average tariff rate is only 6.82%.

However the trade liberalization program remains far from complete. Protectionist policies have been enacted in favor of agriculture, ironically in the aftermath of WTO accession in the mid-1990s (David 2003). There remains a strong political resistance towards trade liberalization; opponents are wont to cite the potentially adverse impact on foreign competition on small farmers and the rural poor, as well as the inadequacy of government support for globally competitive agricultural sector.

All the recent national economic plans have highlighted the need to reduce development disparities between the regions; the current administration highlights “decentralized development” as one of its 10 basic goals. Decentralization is seen not only as the ends, but also the means towards economic development: since 1991 the government has largely devolved various government functions to local governments. Within this set-up, the regions provide the natural zone of convergence between regional and national government development strategies. Several mechanisms are in fact in place to promote coordination, such as the Regional Development Councils.

National policy recognizes modernization of agriculture as a precursor of regional development. Agricultural modernization entails an effective system of technology transfer, capital assistance and agricultural marketing services to the agriculture-dependent regions. Also essential would be public investments in irrigation and postharvest facilities. This would also require large public investments in quality road and transport infrastructure. The need to diversify infrastructure locations away from the highly congested capital is also highlighted (NEDA, 2004).
Within this policy context, quantitative simulations using an explicit regional model would be useful for both national-to-subnational and subnational-to-national issues. As an example of the former, trade policies of nationwide scope, mainly in the form of tariff and import restrictions favoring agriculture, need to be evaluated in terms of impact on economic welfare and distribution. Cororaton and Corong (2006) find that tariff reduction improves overall welfare but worsens poverty. This seems to support the contention that “opening national agricultural markets to international competition before basic market institutions and infrastructure are in place can undermine the agriculture sector with long-term negative consequences for poverty and food security” (FAO, 2005). Perhaps complementary policies need to be implemented to mitigate adverse impacts; a regional model can provide concrete guidance on synergies (if any) from combining tariff reform with public investment towards disadvantaged areas. For subnational-to-national policies, regional priorities for public investments (compelled by binding fiscal constraints) can be more readily assessed using estimates of benefits generated by regional CGE analysis of alternative regional allocations.

3. Knowledge gaps and scientific contribution of the research

Regional analysis is a major recent extension of the CGE methodology. Regional CGEs can examine the geographic dimension of economic activity, a crucial consideration in the spread of economic development. Geography determines trade and transport cost, market integration, and factor mobility. Regional CGEs may be used to geographically disaggregate the impact of economywide policies. Furthermore, regional CGE models can examine the impact of regional development and welfare policies, such as geographically targeted transfers, location-based industrial incentives, and public investment allocation.
There are two approaches to regional CGE analysis: in the *top-down* approach, model equilibrium is obtained at the national level, and the national outcome is disaggregated to regional outcomes by some method (the simplest being fixed shares). In the *bottom-up* approach, each region is treated as a separate economy, linking with other regions through movements of goods and factors. The bottom-up approach is clearly a more flexible way of modeling regional interactions and outcomes, but is conditional on adequate data, in particular on sub-national, inter-regional flows.

Few regional CGEs have been constructed for the Philippines. One of the more recent ones is the TARFCOM model (Cabalu et al, 2001), which is patterned after Australia’s ORANI-G model. Regional breakdowns are top-down; this reflects the constraints to bottom-up regional modeling, mainly due to the absence of data on interregional flows of goods and services (Yap, 2001). There being no explicit theory of regional variations in prices, hence is less capable of capturing regional supply changes such as local excess demands or supplies of labor (Horridge, 2003).

The first fully bottom-up regional CGE model for the Philippines has been very recently developed by Dakila and Mizokami (2006). The model aims to analyze the impact of reducing “impedance”, a measure of the transport network congestion. The model is a spatial CGE using regional Social Accounting Matrices (SAMs) based on 1994 data, which capture intraregional and interregional flows. Construction of the data set is described in Dakila and Dakila (2004). The model has seven sectors, namely agriculture, industry, other services, air transport services, water transport services, land transport services, and government services. Four institutions are represented, namely households, firms, government, and the foreign sector. Households are disaggregated into three groups per
region, based on income bracket. Production and consumption are represented by Cobb-Douglas functions. Imports and exports are exogenous.

Our proposed model also takes a bottom-up approach based on regional data sets. Rather than formulating a spatial CGE however, the model intends to follow the formal analytics of a standard trade CGE, with interregional trade being represented by imports and exports to and from a region. Sectoral classification would also need to be selected so as to highlight regional economic structure and regional linkages. For greater usefulness in policy analysis, economic flows such as consumption, production, interregional and international trade, will all be modeled using price responsive, conventional functional forms. This will be the first regional CGE model for the Philippines with flexible analytical capabilities useful for policy analysis.

4. Method

Model structure

The model to be formulated is static, constant returns, competitive, and market-clearing. The sub-national economies are categorized according to the super-regions as defined in official policy, namely:

- Northern Luzon (Ilocos, CAR, Cagayan Valley)
- Metro Luzon (Central Luzon, Southern Tagalog, and NCR)
- Central Philippines (Bicol region, and all the Visayas regions)

* Significant spatial patterns of economic activity – namely agglomeration effects – require increasing returns technology, whether external to producers, or internal to producers (as in the “new economic geography”). This is a frontier area in regional modeling which potentially captures important structural features of regional economies. However increasing returns models involve complex, imperfectly competitive market structures which lie outside the scope of this study.
• Mindanao (all the Mindanao Regions).

Because the regional SAMs will have to be constructed from scratch, the model will adopt the minimal set of sectors necessary. These are:

• Cereals
• Livestock, Poultry, and Fisheries
• Other agriculture
• Agro-processing (Food, beverage, and tobacco manufacturing)
• Other industry
• Trade and Transport Services
• Other services

In sum there are four regions and seven sectors. Note that agriculture has been split up into three sectors to better reflect regional differences in the structure of the agricultural economy. Agro-processing is treated separately from other industries to incorporate linkages with agriculture. The trade and transport sector is treated separately because of its obvious role in economic linkages across space.

As usual there will be four institutions: households, firms, government, and the foreign sector. There are ten household groups per region based on the regional income deciles. There are two primary inputs, namely labor and capital. The primary inputs produce value added (based on CES technology), in combination with intermediate inputs (based on Leontieff technology).

We apply a modified version of “pool goods” (Nijkamp et al, 1986), which is noted for its parsimonious simplification of regional models. For each sector we distinguish an intraregional good, a national good, an interregional good, and a foreign good. Regional
output is a composite or transform of the intraregional and national good (which are imperfect substitutes). The national good in turn is a composite or transform of the interregional and foreign good (likewise imperfect substitutes). However each region’s interregional good is perfectly substitutable with another region’s.

Each of these goods can be the object of demand or supply. Each layer of aggregation or transformation corresponds to a nested constant substitution elasticity function. Nesting occurs for the national/interregional good, and the national/foreign good. For industry \( i \) and region \( r \), Figure 1a represents the disaggregation on the supply side, while Figure 1b represents the aggregation on the demand side:
The above formulation draws partly from Adams et al (2002), who distinguish between the national good (composite of regional output) and the foreign good. It also draws from Brocker and Schnedier (2002), though they have imperfect substitution between goods from each region; they also collapse all external output (foreign goods and goods from other regions) into a single CES pool, though this appears to impose an unrealistic constant
elasticity of substitution between foreign and nationally-sourced goods. Appendix B provides the basic equations for a simplified regional model.

Consumption is modeled using a linear expenditure system. Household savings is a fixed proportion of household disposable income; all savings is transformed into private capital formation in each sector again by fixed coefficients. Households receive factor incomes through their ownership of fixed endowment of primary factors; they also receive net transfer incomes from government and the rest of the world. Within the model, government spends on final output (according to fixed shares allocation); it collects tax revenues from tariffs, direct income taxes, and indirect taxes. Government and foreign savings are part of total savings. Model closure is based on full employment, fixed foreign savings, and a flexible exchange rate.

Factor mobility assumptions allow alternative closure rules: in the short term both factors are immobile; in the medium term migration arbitrages between regional differences in the real wage; in the long term all factors are mobile (hence real factor prices equalize across regions.) Migration in the medium term can be modeled with constant migration elasticity as in Schreiner et al (1999), along with the suggested parametrization.*

The outline of the basic model (sans the regional extension) follows that Habito (1986), which in turn is an adaptation of Dervis, de Melo, and Robins (1982). The Habito model, both in its previous and updated versions, will be the main source of model elasticities, though other Philippine CGE models will be consulted. As usual a sensitivity

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* Factor mobility leads to either factor price equalization, or a corner solution with all factors migrating. The latter however is unlikely under constant returns. For example, the factor price equalization theorem shows that market equilibrium with equal relative factor prices is compatible with various regional factor endowments (subject to homothetic preferences and endowments lying within the diversification cone.) A corner solution is more likely with increasing returns models.
analysis will be implemented to check for robustness of key results relative to the elasticity magnitudes.

**Scenarios**

The model can be used for national-to-regional analysis, or regional-to-national analysis. For the former, we identify the removal of trade protection in agriculture as a scenario, as agriculture is seen to be critical to regional development. For the latter, we shall be incorporating infrastructure spending by the government on the regions. There are at least three options for incorporating such investment: first is to model infrastructure as a production factor; second is to model it as a location factor influencing the location of private investment; third is to examine its impact on interregional trade flows (Rietveld, 1989). We select the first option. Consider the following production function:

\[
QS = \alpha G^\beta \left[ \delta K^{-\rho} + (1 - \delta)L^{-\rho} \right]^{1/\rho}
\]

\(Q\) denotes output. \(G\) denotes the level of publicly-owned capital. The productivity parameter is \(\alpha\) while the parameter of substitution elasticity is \(\rho\). However \(G\) is allocated outside the price system, hence adjustments in \(G\) can be modeled in the same way as changes in the productivity parameter. The productivity shift will be determined exogenously in the scenarios, and applied only for agricultural as well as the trade and transport sectors.

The options to be considered are *regionally neutral*, *catch-up* and *concentration*: the first refers to productivity improvement for all the regions; the second to productivity improvement in the laggard regions (North Luzon, Central Philippines and Mindanao); the third refers to productivity improvements in the leading region (Metro Luzon). The regional
investment options may be combined with the tariff experiment above to examine complementarity between trade and investment policies.

Ultimately these regional scenarios are useful for illuminating the issue of investment priorities across space. This will require comparisons of investment benefits with investment costs. Costing can be done with the help of the figures from the Medium Term Investment Plan (2004-2010) prepared by the National Economic Development Authority. However analysis at this level will be done outside the model.

To enumerate, the scenarios for analysis are as follows:

**Scenario 1**: Tariff reduction – All tariffs for agricultural products no higher than five percent.

**Scenario 2**: Regionally neutral investment – productivity improvements of 5% for Metro Luzon and 10% in other regions,

**Scenario 3**: Catch-up investment – 15% productivity improvement in the laggard regions;

**Scenario 4**: Concentration investment – 10% productivity improvement in Metro Luzon;

**Scenario 5**: Reform with investment – Combination of Scenario 1 and 3.

### 5. Data requirements and sources

For constructing the regional data set, we shall largely follow the procedure discussed in Dakila and Dakila (2004). The data will be obtained mostly from official sources. The model will proceed by first constructing a national SAM, based on fairly standard methods and data sources as done for previous CGE models of the Philippines, i.e. the Input-Output
Table, the National Income Accounts, and others. The most recent data set available is for the year 2000.

The national SAM is the basis for formulating the four regional SAMs of the model. At the regional level, also for 2000 we shall make use of the National Statistics and Coordination Board’s (NSCB) Regional Accounts for Gross Regional Domestic Product (by value-added) and Gross Regional Expenditure (which breaks down regional spending into consumption, government spending, capital formation, and net exports.) Also required is the Annual Survey of Business and Industry (ASBI), the Domestic Trade data, the Family Income and Expenditure Survey (FIES), and the Labor Force Survey (LFS), all available from the National Statistics Office (NSO). The NSCB data will be the prior basis for the regional SAMs. The ASBI will be used to disaggregate payments made by sector at the regional level (gross output, net income, tax payments and other compulsory fees, as well as payments for labor and other inputs.)

There is no regional input-output data. We shall be using a combination of the location quotient approach, as well as SAM balancing techniques (e.g. RAS or cross-entropy methods). Flow of goods across regions (by sector, origin, and destination) can be estimated using Domestic Trade data; this data however does not capture flows of goods by land transportation, nor does it trace actual origin at point of production. However this data remains useful for disaggregating sectoral flows of goods across regions.

One important difficulty is the regional use of the trade and transport sector, as the data may reflect the location of the supplying firm being surveyed, rather than the actual location in which the service was produced. We shall attempt to apportion the trade and transport data according to the latter criterion, using both subjective expert opinion and
previous transportation surveys, such as the one conducted in 2004 by the National Center for Transport Studies of the University of the Philippines. Expert opinion can be obtained from officials of government agencies and industry heads (see Eskola, 2005).

Household income sources and expenditure items will be broken down with the help of the FIES, while the LFS will identify regional employment by sector (using assumptions on occupational groups), and therefore regional wages. In general, given paucity of actual data, compilation of consistent regional SAMs will entail numerous additional assumptions, which will be carefully documented for the purpose of validation and replication by other researchers.

6. Dissemination strategy

Dissemination will be two-pronged: first is through communication and publication strategy, including posting the model on the Brain Trust website, as well as through journal publications, and policy briefs. The second is a more targeted strategy of engagement and advocacy with policymakers, public officials, and NGOs, using the wide network of Brain Trust Inc. members within the government, the academe, and civil society. Targeted dissemination will be carried out in partnership with the Economic Policy Reform and Advocacy (EPRA) project of the USAID. EPRA has established a mechanism for broad and cross-sectoral support to the formulation, implementation, enforcement, and monitoring of policy reforms, involving government officials, NGOs, research institutions, and other policy think-tanks. Within the context of the proposed study, partnerships will be oriented towards organizations and officials in the various regions, for whom results of the study will be most directly relevant. Specific activities include:
a) Focus group discussion among academicians and research institutions involved or interested in the subject during project implementation. It will mainly be for purposes of consultation and validation but that would already inform participants of the model and project results.

b) Organization of a national multi-stakeholder policy forum that will explain the expanded model and how this can be used for planning, policy-making and resource allocation, as one of the culminating activities of the project. This forum will consist of key policy-makers in government (e.g., National Economic and Development Authority, Department of Trade and Industry, Department of Agriculture, Department of Budget and Management, Department of Interior and Local Governments, Department of Social Welfare and Development, local government executives), academe and research institutions and civil society, particularly those organizations engaged in the subject (e.g., Global Call to Action Against Poverty, CODE-NGO) and donor institutions.

c) Collaborating with key organizers such as the Philippine Economic Society, Philippine Institute for Development Studies, etc. for organizing economic forums that will present and discuss the methods and results of the study.

7. Key references


8. Team members’ relevant training and experience

The individual members of the Team have lengthy experience and proven expertise in the skills and competencies required for the proposed study. The team will be closely guided by the developer of the original PhilCGE, a former Socioeconomic Planning Secretary, currently EPRA Project Director, as well as Chairperson of Brain Trust Inc. The lead researcher is a development economist with a track record in economic modeling. He was a key person in the development of a macroeconomic model for Ateneo de Manila University, as well as global and Asian supply-demand models of the fish sector for the WorldFish Center. Currently he is engaged in various consultancies related to macroeconomic, general equilibrium, and partial equilibrium modeling.

The junior researchers to be trained in the project are sector specialists who have worked extensively in the industry, agriculture, environment and natural resources sectors in the National Economic Development Authority. Two continue as consultants in the same fields and in sustainable development at the international, national and local levels. Following years of active work in civil society, they have also developed a wide network with both government and non-government organizations. The remaining two are currently based in NEDA.
9. **Expected capacity building and assignments**

The research component of the project is carried out in partnership with the National Economic Development Authority (NEDA). Capacity building will be undertaken in two components, namely research collaboration and training.

Research collaboration will be undertaken between the lead and junior researchers. The junior researchers are subdivided into two types of specialists:

1. Sector specialist – agriculture and social sector
2. Sector specialist – industry and regional development

In turn, each type of specialist will have a distinct concentration, one on policy and model evaluation, the other on data analysis. Hence there are four junior researchers (two each for the above types of sector specialists). Note though that throughout the study, the emphasis is on teamwork and collaboration across the broad range of tasks required, including data analysis, coding, model simulation, and report writing.

The two junior researchers focusing on data are both based in NEDA. One is an agriculture and social sector specialist, with a strong statistics background. The other is a regional development specialist, who will be tasked with compiling regional economic data based on expert opinion and secondary information. They will assist in compiling the regional datasets. The other junior researchers, who are based in Brain Trust Inc, will handle other modeling tasks, such as formulation of agricultural and regional policy experiments, evaluation of model parameters and simulation results, and elicitation of expert opinion on the breakdown of trade and transport costs to the regional level.

As for training, the project will prepare a training course on using the regional model as decision support for regional planning exercises. Implementation of the training course
will be undertaken on a demand basis, and subject to cost-sharing arrangements with participating institutions. Participants will include staff from local and national government agencies, and other parties interested in regional development. Marketing of the training component will be undertaken as a matter of course during dissemination activities.

10. List of past, current or pending projects in related areas involving team members (Selected, most recent)

USAID, Economic Policy Reform and Advocacy Project: Roehlano M. Briones – consultant; Cielito F. Habito – Project Director

Australian Center for International Agricultural Research, Economic and Market Analysis of the Live Reef Fish Food Trade in Asia-Pacific Project: Roehlano M. Briones – consultant (quantitative modeling of live reef food fish trade using the AsiaFish model)

WorldFish Center, Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Households in Asia (ADB RETA 5945): Roehlano M. Briones – postdoctoral fellow (assists in construction of the AsiaFish model)

DA - World Bank Mindanao Rural Development Programme: Ma. Lourdes M. Lagarde, Poverty Alleviation Specialist/Development Economist (assess poverty situation in provinces and municipalities of Mindanao; developed criteria and procedures for identifying target groups and geographic areas that should be prioritized for program interventions).

Appendix A. Revisions

The proposal has been extensively revised since the previous version submitted last May 15, 2006, and subsequently presented at the 5th annual PEP meeting. The revisions were made following consultations with the team members. The revisions are generally along the lines recommended by the steering committee and various commentators.

1. The motivation for regional analysis has been more clearly elaborated, particularly in the Introduction and Policy Relevance sections.

2. The method has been completely changed. The proposal now intends a full bottom-up regional model of the Philippines. This sidesteps the difficulties encountered earlier regarding the hybrid regional approach. On the other hand, this commits the researchers to constructing a regional data set. To maintain feasibility, we have limited the number of regions to four areas closely corresponding to the “super-regions” recently adopted in official policy. Moreover the number of sectors has been reduced to just seven, to maintain tractability in data set construction.

3. From No. 2, the description of data requirements, sources, and database construction has been considerably updated.

4. The scenarios are now clearly delineated and discussed (in the Methodology section).

5. The microsimulation component has been dropped, to maintain feasibility of the proposed research effort.

6. Basic equations for a simplified version of the model are now contained in another Appendix.
## Appendix B. Basic Equations

The indices are: \( r = 1, 2, 3, 4 \) for the regions; \( i, j = 1, 2 \ldots 7 \) for the sectors. For exposition purposes it is assumed that there is no government, no savings and investment, no transfers, and only one representative household per region. The variables are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Determining equation</th>
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<td>( QS_{ir} )</td>
<td>Output</td>
<td>13</td>
</tr>
<tr>
<td>( QSH_{ir} )</td>
<td>Output for intraregional (home) good</td>
<td>2</td>
</tr>
<tr>
<td>( QSN_{ir} )</td>
<td>Output for national good</td>
<td>3</td>
</tr>
<tr>
<td>( QSX_{ir} )</td>
<td>Output for interregional good</td>
<td>5</td>
</tr>
<tr>
<td>( QX_{ir} )</td>
<td>Output for export (foreign good)</td>
<td>6</td>
</tr>
<tr>
<td>( PS_{ir} )</td>
<td>Supply price</td>
<td>1</td>
</tr>
<tr>
<td>( PH_{ir} )</td>
<td>Home (intraregional) good price</td>
<td>23</td>
</tr>
<tr>
<td>( PSN_{ir} )</td>
<td>National good price</td>
<td>4</td>
</tr>
<tr>
<td>( PNR_{ir} )</td>
<td>Interregional good price</td>
<td>24</td>
</tr>
<tr>
<td>( px_{ir} )</td>
<td>Export price (exogenous)</td>
<td>NA</td>
</tr>
<tr>
<td>( QD_{ir} )</td>
<td>Demand</td>
<td>17</td>
</tr>
<tr>
<td>( QDH_{ir} )</td>
<td>Demand for home (intraregional) good</td>
<td>8</td>
</tr>
<tr>
<td>( QDN_{ir} )</td>
<td>Demand for national good</td>
<td>9</td>
</tr>
<tr>
<td>( QDM_{ir} )</td>
<td>Demand for interregional good</td>
<td>11</td>
</tr>
<tr>
<td>( QM_{ir} )</td>
<td>Demand for import (foreign good)</td>
<td>12</td>
</tr>
<tr>
<td>( PD_{ir} )</td>
<td>Composite demand price</td>
<td>7</td>
</tr>
<tr>
<td>( PDN_{ir} )</td>
<td>Demand price of national good</td>
<td>10</td>
</tr>
<tr>
<td>( pm_{ir} )</td>
<td>Import price (exogenous)</td>
<td>NA</td>
</tr>
<tr>
<td>( K_{ir} )</td>
<td>Capital input</td>
<td>15</td>
</tr>
<tr>
<td>( L_{ir} )</td>
<td>Labor input</td>
<td>16</td>
</tr>
<tr>
<td>( PVA_{ir} )</td>
<td>Price of value added</td>
<td>14</td>
</tr>
<tr>
<td>( PK_{ir} )</td>
<td>Price of capital input</td>
<td>20</td>
</tr>
<tr>
<td>( PL_{ir} )</td>
<td>Price of labor input</td>
<td>21</td>
</tr>
<tr>
<td>( QC_{ir} )</td>
<td>Consumption demand</td>
<td>18</td>
</tr>
<tr>
<td>( QID_{ir} )</td>
<td>Intermediate input demand</td>
<td>19</td>
</tr>
<tr>
<td>( coi_{ij} )</td>
<td>Input-output coefficient (sector ( i ) output required per unit sector ( j ) in region ( r ); parameter)</td>
<td>NA</td>
</tr>
<tr>
<td>( KE_{ir} )</td>
<td>Capital endowment in region ( r )</td>
<td>NA</td>
</tr>
<tr>
<td>( LE_{ir} )</td>
<td>Labor endowment in region ( r )</td>
<td>NA</td>
</tr>
<tr>
<td>( Y_{r} )</td>
<td>Factor income</td>
<td>22</td>
</tr>
</tbody>
</table>
1. “Determining equation” is conceptual, as the equation system is solved simultaneously.

2. Functional forms are referred to by shorthand (either CET or CES or LES); CCET or CCES denote conditional supply (demand) functions from CET (CES). The following are based on these nested constant elasticity functions:

\[ QS_{ir} = CET(QHS_{ir}, QSN_{ir}) ; \]
\[ QSN_{ir} = CET(QSX_{ir}, QX_{ir}) ; \]
\[ QD_{ir} = CES(QDH_{ir}, QDN_{ir}) ; \]
\[ QDN_{ir} = CES(QDM_{ir}, QM_{ir}) . \]

The equations are:

Supply price determination
\[ PS_{ir} \cdot QS_{ir} = PH_{ir} \cdot QSH_{ir} + PNH_{ir} \cdot QSN_{ir} \]  (1)

Conditional supply of intraregional (home) good:
\[ QSH_{ir} = CCET(PH_{ir}, PS_{ir}, QS_{ir}) \]  (2)

Conditional supply of national good:
\[ QSN_{ir} = CCET(PSN_{ir}, PS_{ir}, QS_{ir}) \]  (3)

National good supply price determination:
\[ PSN_{ir} \cdot QSN_{ir} = PNR_{ir} \cdot QSX_{ir} + px_{ir}QX_{ir} \]  (4)

Conditional supply of interregional good:
\[ QSX_{ir} = CCET(PNR_{ir}, PSN_{ir}, QSN_{ir}) \]  (5)

Conditional supply of export good:
\[ QX_{ir} = CCET(px_{ir}, PSN_{ir}, QSN_{ir}) \]  (6)

Demand price determination:
\[ PD_{ir} \cdot QD_{ir} = PH_{ir} \cdot QDH_{ir} + PDN_{ir}QDN_{ir} \]  (7)

Conditional demand for intraregional (home) good:
\[ QDH_{ir} = CCES(PH_{ir}, PD_{ir}, QD_{ir}) \]  (8)

Conditional demand for national good:
\[ QDN_{ir} = CCES(PDN_{ir}, PD_{ir}, QD_{ir}) \]  (9)

National good demand price determination:
\[ PDN_{ir} \cdot QDN_{ir} = PNR_{ir} \cdot QDM_{ir} + pm_{ir} \cdot QM_{ir} \]  (10)
Conditional demand for interregional good:
\[ Q_{DM} = CCET(P_{NR}, P_{DN}, Q_{SN}) \]  \hfill (11)

Conditional supply of export good:
\[ QM = CCES(p_{m}, P_{DN}, Q_{DN}) \]  \hfill (12)

Primary production:
\[ QS = CES(K, L) \]  \hfill (13)

Price of value-added:
\[ PVA, QS = PK, K + PL, L \]  \hfill (14)

Conditional demand for capital:
\[ K = CCES(PK, PVA, QS) \]  \hfill (15)

Conditional demand for labor:
\[ L = CCES(PL, PVA, QS) \]  \hfill (16)

Demand by source:
\[ QD = QC + QID \]  \hfill (17)

Consumption demand:
\[ QC = LES(PD_1, ..., PD_r, Y) \]  \hfill (18)

Intermediate input demand
\[ QID = \sum_{j=1}^{r} co_{ij} QS \]  \hfill (19)

Factor market clearing for capital
\[ \sum_{i=1}^{r} K = KE \]  \hfill (20)

Factor market clearing for labor
\[ \sum_{i=1}^{r} L = LE \]  \hfill (21)

Determination of factor income per region
\[ Y = PK, KE + PL, LE \]  \hfill (22)

Market clearing for the intraregional good
\[ QDH = QSH \]  \hfill (23)

Market clearing for the interregional good
\[ \sum_{r=1}^{4} QSR = \sum_{r=1}^{4} QDR \]  \hfill (24)