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Dissertation: **Applied General Equilibrium and Sustainability Indicators for Santiago**

1. Introduction and Central research questions

The accomplishment of more sustainable development (and urban sustainable development) requires a comprehensive methodology to perform sustainable impact assessment. Computable General Equilibrium (CGE) models are powerful tools to address sustainability issues by assessing the impacts of growth and policy interventions on the environment, economic performance and equity. Direct, indirect and induced effects can be evaluated on economic variables such as regional product and sector production, social variables such as poverty and income distribution and environmental variables such as emissions to air including local and global pollutants, or discharges to water and soil.

Therefore, sustainable indicators can be defined to provide a coherent framework to carry out tradeoff analysis systematically. The study of these tradeoffs may result in recommendations to move in the direction of sustainable development. The choice of these recommendations requires making value judgments which should represent a socially agreed understanding of sustainability.

The model to be developed should allow evaluating the economic, social and environmental impacts of different development paths for Santiago. These impacts will be related to specific sustainability indicators. The evolution of these indicators will be analyzed in a business as usual scenario, and examine their evolution under alternative scenarios, in particular scenarios with a specific concern relating to sustainable development. The scenarios allow to apply the methodology, examine its strengths and weaknesses, and to provide insight about scenarios and sustainable development based on the Risk Habitat understanding of sustainability and economic literature.

This dissertation will contribute to urban sustainable development through:

- Developing a model applicable at the subnational level (Metropolitan Region) that allows evaluating the impact on sustainability indictors of specific policies.
- The incorporation of the environmental quality as a variable relevant to consumer utility.
- A validated Social Accounting Matrix with an extension that incorporates the development of different sectors and that allows to quantify their environmental impacts.

The purpose of this dissertation is to provide a comprehensive tool for the Metropolitan Region of Santiago and to apply the methodology to answer the following central research questions:

(1) What is the effect of expected economic growth of the Metropolitan Region on key sustainable indicators? For example, the impact on poverty alleviation, income distribution, gender issues, emissions, energy use.
(2) What are the tradeoffs associated with different development paths?
(3) What sectors will develop more/less and how the development of specific sectors affect sustainability indicators?

Finally, the general equilibrium model which is being developed will provide a tool serving as guidance to decisionmaking and to compare different development paths. Yet, its contribution has limitations and omissions. Examples of important omissions are governance, the nature of the institutions or participation issues. As a consequence, the economic model proposed serves as a general reference which should be complemented with lower-scale models and qualitative considerations to serve as guidance in sustainable policy-oriented decisionmaking.

2. Background and context

The behavior of households and firms, and their interactions with the social, economic and environmental dimensions generate pressures on resource scarcity. In trying to establish sustainable development implications, it is important to quantify these pressures and associated opportunity costs.

To promote adequate public policies, it is necessary to have tools that make the ex ante analysis and quantification of effects possible. For this purpose, several

methodological choices are available as considered in the economic literature which characterize the relevant actors, and economic, social and environmental effects.

The literature provides a wide variety of economic models that depend on crucial assumptions. The most important categories of economic models available include:

- Partial Equilibrium Models
- General Equilibrium Models
- Input-Output Models
- Neoclassical Growth Models
- Neo-Keynesian Growth Models

These models are not necessarily isolated and many may be extensions of others or may be used simultaneously. This is the case of input-output and general equilibrium models since the latter category is an extension of the first by enabling substitution in the consumption and production of goods through the use of factors. General equilibrium models incorporate diverse functional forms and substitution elasticities, while input-output models assume fixed proportions of productive factors.

One case of simultaneous use of models is to employ general equilibrium and Neo-Keneysian models. These applications maintain the functional forms and structural character of the general equilibrium models, but do not calibrate key parameters. Instead, these are estimated using econometric methods just as is common practice in the Neo-Keneysian practice (McKibbin et al. (1999) and Carraro,Galeotti (1997)).

Zhang and Folmer (1998), and Böhringer (1998) compare and contrast the results obtained from different methodological approaches and conclude that good results are obtained in the short term for macroeconometric models and input-output models while in the long run general equilibrium and hybrid models.

3. Methodology

This section presents a general description of the methodology to be applied: the Computable General Equilibrium (CGE) approach. In particular, general features and options of implementation are introduced. Additionally, references are made to a

Chilean version of the model and which must be modified to make it applicable in a regional context and with an urban focus.

CGE models attempt to represent the circular flow of the economy. Agents interact in different markets exchanging production factors, goods and services, and money to reach market equilibria which determine prices and quantities. CGE models need to consider specifications related to production factors, prices, goods, income, savings and capital formation, demand, imports, export supply and demand, domestic market equilibria, and balance of payment equilibrium. In CGE models, sectors can vary according to the interests of the application and the level of aggregation available in the data. CGE models are real economy models and cannot be employed to analyze monetary issues.

In CGE models demand functions are obtained by consumers solving the utility maximization problem. Supply functions are the result of profit maximization. In general, markets are cleared to determine endogenously equilibrium prices and quantities in a competitive context. Equilibrium conditions are solved for the domestic and exchange (balance of payments) markets.

A Social Accounting Matrix (SAM) for the Metropolitan Region is key in the application of the CGE model. To solve a CGE model a SAM must be available to calibrate the model. Calibration requires initial values of all prices, including the exchange rate, subject to the usual normalization rule. Constants like production functions parameters are determined to reproduce exactly the levels of production, imports, exports, etc., of the reference year (year considered in the SAM).

A SAM is a square matrix whose corresponding columns and rows present the expenditure and receipt (income) accounts of economic actors. Each cell represents a payment from a column account to a row account. The total receipts and expenditure of each actor must balance resulting in that every row sum must equal the corresponding column sum.

A typical national SAM includes accounts for production (activities), commodities, factors of production, and various actors (“institutions”) which receive income and demand goods. Activities pay for intermediate inputs, factors of production, and indirect taxes, and receive payments for exports and sales to the domestic market.

In a SAM, the commodity account buys goods from activities (producers) and the rest of the world (imports), and pays tariffs on imported goods, while it sells commodities to activities (intermediate inputs) and final demanders (households, government, and investment).Gross domestic product (GDP) at factor cost (payments by activities to factors of production) or value added equals GDP at market prices. The following table presents the aggregate structure of a natinal level SAM.

Table 1 The Circular Flow and its Representation through the SAM (Agreggate Structure)

Receipts	Expenditures					
	Activities	Commodities	Factors	Domestic Institutions	Rest of World	Totals
Activities		Market sales		Home con-sumption		Activity income
Commodities	Intermediate inputs	Trans-actions costs		Final market demands	Exports	Commodity demand
Factors	Value added				Transfers	Factor income
Domestic Institutions	Taxes	Tariffs, Taxes	Income, Taxes	Transfers, Taxes, Savings	Transfers, Savings	Institution income
Rest of World		Imports				Foreign exchange outflow
Totals	Activity spending	Commodity supply	Factor spending	Institution spending	Foreign exchange inflow	

Additionaly, it is necessary to distinguish between dynamic and static CGE modeling. The latter is normally used to focus on shorter terms impacts of policies. The dynamic models focus more on trends and the impacts of shocks and policies on changes in this trend. It is now common practice to use both for in depth analysis of trade-offs and social effects.

A multiperiod (dynamic) model generally considers intraperiod problems that are solved in every period. To make the model dynamic, transitional equations are used to allow changes in variables and parameters to be used in the static model of the next period. Labor supply (related with population and labor force growth) and capital stock (as long as there is positive net investment) are increased each period and modify their structure.

The national level ECOGEM-Chile model is available and must be re-calibrated to the regional SAM. This model is characterized by sector multiplicity, occupational category differentiation, income quintiles, multiple trade partners, and specified productive factors. The model incorporates energy-input substitution as a way to reduce emissions, since emissions are related to the use of different inputs and not only to production levels as is usually considered in these models. The main equations are related to the production, consumption and external sectors.

Using the ECOGEM-Chile model it is possible to solve the model for several periods and link them through a capital accumulation equation. Investment in a period becomes capital stock for the next. Capital is then assigned among sectors according to relative rates of return. For the calibration, a baseline scenario for the growth path is required and usually referred to as reference scenario. Exogenous variables include population, labor force, depreciation, GDP growth rates and capital/labor efficiency ratio. If alternative scenarios to are simulated, the technical efficiency parameter becomes constant and the capital growth is endogenously determined by the saving/investment relation.

4. First results

During these one and a half years important advances have been accomplished. This include the availability of a Regional SAM for Santiago, a detailed description, and understanding and operation of the national level CGE model. These results will hopefully be presented in Leipzig in September and are not included here since it would require extensive and detailed explanations not fulfulling the purposes of this report.

Regarding the regional SAM, in a master's degree dissertartion completed in June a regional SAM for the Metropolitan Region was developed. For this purpose, several sources of information and assumptions must be used in a long and exhaustive analysis. I participated in this student's evaluating commission and thus provided guidance to this work.This participation has enabled me to take part in the development and understanding of this SAM.

In very general terms, a regional SAM is identical to a national SAM but differ in the following two aspects:

- The accounts that make up a regional SAM consider the interactions among agents and sectors of the particular reguon.

- The account which considers transactions with the external sector is disaggregated into two accounts: Rest of the country and Rest of the World.

Other results consider carefull revision and applications of the national level CGE model. In particular, detailled attention has been provided to the description and understanding of all the equations which solve the model. In particular, the functional form of utility and production functions and the corresponding profit and utility problems are specified. Other conditions that are especified include the zero-profit, income and market-clearance conditions.

The application of the model is crucial to fully understand its full potential. In particular, the model calibrated to the national level is used in preliminary simulations. A baseline and alternative scenarios have been obtained. Scenarios have been simulated to replicate typical CGE applications on reducing trade taxes or increasing emission taxes.

My contribution will be to adapt the model to a Regional level using the Santiago SAM. This process will also require to identify sectors that have important implications on economic growth, environmental impacts and equity. Furthermore, this selection will require to focus on urban sustainability. Scenarios must also be carefully designed to help answer relevant questions. However, this definition must consider what is feasible to be accomplished in a limited temporal horizon. My objective is to have by the end of 2009 a first version of the model for Santiago and hopefully preliminary results. This requires to examine and incorporate the regional SAM to the model, to calibrate the model and to define a reference scenario.

The scope of my work is limited in expliciting the tradeoffs in the environmental, economic and social dimensions. However, this dissertation project does not consider to make definitive conclusions about sustainable development. A a definition and/or sustainability targets resulting from the project could be employed as criteria to analyze the tradeoffs and conclude about sustainability implications. Thus, these works' potential advances in a definition of sustainable development and/or definition of targets would contribute greatly in my dissertation work and the RHM project. The analysis of this criteria would be necessary after counting with an operational model, the scenarios, and results and indicators.

5. Perspectives

Next year will require to work hard in the implementation of the regional CGE model. For this purpose, the model must be carefully calibrated using the regional SAM for the Metropolitan Region. Additionally, simulations must be run to check for consistency and to look for possible improvements.

Once this initial work is undertaken, the next step requires to define scenarios relevant to the sustainability issue. These scenarios will be defined considering criteria about technical aspects of the CGE model and the relevance of the questions these scenarios may be able to capture. The results must be summarized in a coherent and comprehensive set of indicators. These indicators should help establish the tradeoffs resulting from the scenarios.

Due to the previous work and having the possibility to dedicate myself to my dissertation project I expect to have interesting results by June-July 2010. These results must be improved considering the opinion of my supervising commission and other experts. Hopefully, I will end my work by late 2010.

6. Open Questions

- Do other (young) researchers feel this project could complement their own works on urban sustainable development? What could I do to increase the potential complementarity?
- Have there been advances in defining sustainability targets for urban areas? Specific to Santiago and I could incorporate in the evaluation?
- Suggestions? Opinions?