Commonwealth of Puerto Rico

Tax Reform Assessment Project

FLAGSHIP-PR: A Dynamic General Equilibrium Model of the Economy of Puerto Rico

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1 Introduction

This document introduces the FLAGSHIP-PR dynamic CGE model of the economy of Puerto Rico and summarizes the underlying theory and data. This document is prepared in satisfaction of the deliverable requirements of the Comprehensive Tax Reform Services Contract and Amendment of March 18th 2014, and May 9th, 2014 for the Corporate and Consumption Tax and Individual Income tax Computer Simulation Model Documentation and Simulation Results for Tax Reform. This document contains a detailed overview of the theoretical underpinnings and data sources of the Simulation Model and model simulation results requested by members of the Commonwealth's Treasury Department.

1.1 Background of the Flagship-PR model development

This document provides an overview of the model and method applied to economic modeling of the economy of Puerto Rico.

FLAGSHIP-PR is a customized application of the FLAGSHIP computable general equilibrium (CGE) modeling framework developed by Dr. Ashley Winston, Chief Economist for KPMG Australia and Director of the KPMG Institute for Economic Modelling. The database for FLAGSHIP-PR has been constructed by Dr. Winston and two senior members of the Institute's modeling team, Jodie Patron and Dr. Sang-Hee Han, with assistance from Dr. Jon Silverman, Dr. Seb Moosapoor, Dr. Uma Radhakrishnan and Dr. Vera Holovchenko from the KPMG US Economic and Valuation Services team.

Data for Flagship-PR has come principally from the Department of Treasury and Planning Board of the Commonwealth of Puerto Rico. Input on approach and data inputs used for Flagship-PR has also been provided by Edwin Rios and Waheed Murad, Department of Treasury.

The FLAGSHIP framework represents the current state of the art in CGE modeling. It is a direct descendent of a paradigm-changing modelling lineage with roots that go back to the 1960s, and which now underpins the practice of CGE modeling globally.

The FLAGSHIP framework is a development of the USAGE model of the United States, a 550 sector dynamic CGE model that continues to be used widely in the US Federal Government for policy and simulation analysis. USAGE was authored by Professor Peter Dixon, Professor Maureen Rimmer and Dr. Winston while at the Centre of Policy Studies (CoPS) at Monash University, and its development was funded over a period of 10 years by several US federal government agencies.

USAGE and FLAGSHIP are themselves the latest developments of the path-breaking ORANI and MONASH model tradition originated by Professor Dixon and developed over the past 40 years. The Dixon tradition of large-scale economic modelling is now a dominant paradigm in economic and policy modelling, with beginnings going back to the 1960s when Dixon studied under Nobel Prize winning economist Wassily Leontief at Harvard University. Dr. Winston completed a Masters and PhD under Peter Dixon and worked with him as a Senior Research Fellow at CoPS for over 15 years, a period that most notably culminated in the development of USAGE, the embedding of sophisticated CGE modeling techniques into several key US federal government agencies, and in research, analysis and policy assessments for input into the policy making process for congressional committees and the White House.

FLAGSHIP-PR applies this modeling framework to a newly constructed database for Puerto Rico, and includes modifications to the theory to customize its suitability to the specific needs of Puerto Rico.

1.2 Key Features of Flagship-PR

The model embodies an array of features that enhance its utility in policy analysis and economic modeling.

- FLAGSHIP-PR is implemented using the powerful GEMPACK modelling suite and the Intel Fortran Compiler. GEMPACK provides enormous flexibility in model design and implementation and is capable of handling models constructed from very large systems of equations.
- GEMPACK is used by over 400 institutions in over 70 countries.
- The FLAGSHIP-PR allows great flexibility in simulation design, in practice limited only by the economist's imagination and the constraints of economic theory. Experimental design is a key element of robust economic modelling. For example, the FLAGSHIP-PR model can be run in both comparative static or dynamic modes, and is not limited by traditional "short-run" and "long-run" closure constraints.
- The core FLAGSHIP-PR model distinguishes 90 sectors and 90 commodities.
- Primary factor inputs are distinguished by multiple types of capital, labor, land, and natural resource endowments.
- On the input side, production technology is handled by a multi-level production nest constructed entirely in the CRESH (constant ratio of elasticity of substitution, homothetic) functional form. This allows for a great deal of flexibility in the setting of substitution and technology parameters, including the ability to change functional form. Energy goods are treated separately to other intermediate goods and services in production, and are nested with primary factors in the production function.
- On the output side, FLAGSHIP applies a nested CRETH (constant ratio of elasticity of transformation, homothetic) transformation structure that accommodates multi-product industry sectors and the transformation possibilities they face between potential outputs. As in the case of the CRESH input structure, CRETH allows a great deal of flexibility in setting transformation possibilities and technology, and allows the functional form of the nest to be modified. The output nest also treats a commodity or service of a given statistical classification produced by several industries as heterogeneous with respect to the industry of source, and treats goods and services destined for export as heterogeneous with respect to those destined for domestic absorption.
- FLAGSHIP-PR distinguishes multiple labor occupations partitioned into low- and high-skilled groups, with the capacity to expand this detail limited only by the availability of data. The supply of labor is determined by a labor-leisure trade-off that allows workers to respond to movements in after tax wages deflated by choosing among a

range of price deflators (including the consumption deflator and the price of net national income) in determining the hours of work they offer to the labor market. Leisure enters the worker's utility function.

- Household consumption decisions are formed from a Klein-Rubin utility function and distinguish between subsistence and discretionary consumption. Household disposable income enters the decision that workers make in choosing between leisure and work.
- FLAGSHIP-PR can distinguish between multiple land types (dependent on application), including an array of agricultural land types.
- FLAGSHIP-PR can distinguish between multiple types of natural resource endowments, including various mining resource endowments, forestry assets and fishing stocks.
- FLAGSHIP-PR can distinguish between multiple types of productive capital, depending on the availability of data. Typical examples include residential and commercial structures, machinery, "biological" (e.g. livestock) and intellectual property.
- International trade can be disaggregated by source and destination for imports and exports respectively, with the ability to distinguish foreign regions limited only by data.
- FLAGSHIP models of other countries have been developed with emissions accounts, explicit modelling of both combustion and fugitive greenhouse emissions, and the ability to analyze an array of carbon policy regimes (including cap-and-trade, a carbon tax and direct regulation). Multiple electricity technologies are explicitly modelled in these cases. While emissions policies are yet to be implemented nationally in the US, the model will have the capacity to deal with such policy when it is inevitably implemented, with likely consequences for Puerto Rico.
- Government fiscal accounts and balance sheet are modelled, including the accumulation of public assets and liabilities. Government revenue flows are modelled, including a range of direct and indirect taxes, and income from government enterprise. Government spending includes public sector consumption, investment and the payment of various types of transfers (such as pensions and unemployment benefits).
- Investment behavior is closely linked with detailed modelling of business taxation and a variety of capital allowances. Representative firms in each sector are able to choose between debt, equity and retained earnings in determining their cost of capital, and this choice can be endogenous or imposed. The available supply of financial sources includes an assessment of the availability of retained earnings, the cost of debt tied to a leverage function, and both debt and equity face underwriting and transaction costs that vary with the magnitude of the flow.

- Foreign asset and liability accumulation is explicitly modelled, as are the cross-border income flows they generate and which contribute to the evolution of the current account. Along with other foreign income flows like payments to non-resident labor and unrequited transfers, FLAGSHIP-PR takes account of primary and secondary income flows in the current account; these are particularly important in the context of Puerto Rico as typically they are largely responsible for determining the balance on the current account.

- FLAGSHIP-PR models economic welfare in a variety of ways. For example, real net national income (a comparatively robust measure of economic welfare) is modelled and decomposed into over 40 contributing factors. When viewed from the expenditure side, net national income (NNI) includes private consumption, public consumption and net (of depreciation) savings in calculating a measure of welfare. When viewed from the income side, NNI adjusts income-side GDP for net foreign income flows and depreciation. Equivalent and compensating variation (traditional money-metric measures of economic welfare) are also included. Understanding the net income flows generated by the FLAGSHIP-PR balance of payments module allows both gross and net national income to be calculated, and allows economic welfare calculations to move beyond less useful measures like GDP; for an economy with a large deficit on primary income flows, GDP is a potentially a misleading measure of economic welfare.

- The modelling suite includes a database construction routine that allows rapid adjustments to be made to the FLAGSHIP database, most importantly in the modification of the database as new information is released. This ensures that the FLAGSHIP database is always as up-to-date as data availability allows, and can be adjusted at will according to the needs of simulation design and model development.

2 Overview of Flagship-PR

2.1 Model Outline and Context

A CGE model is a detailed quantitative economy-wide model. It contains equations based on the optimizing behavior of all the agents in the model — producers, households, government, exporters and capital creators. Using an initial snapshot of the economy derived from official input-output statistics and a large range of other data, a CGE model traces the consequences of a shock to the economy where responses by agents in the model depend on such things as prices, production activity, income, preferences, technological progress and macroeconomic factors and constraints. This approach yields solutions that give a great deal of detail about the effects of shocks by industry, commodity, factor of production and occupation, among many others.

CGE models are distant descendants of Input-Output (IO) models as pioneered by Nobel Laureate Wassily Leontief in the 1930s. With fixed technology coefficients, no resource constraints and minimal economic and behavioral theory, IO models can be overly optimistic or pessimistic about the consequences of economic shocks, and lack the capacity to handle change in fundamental growth factors like technological progress.

Limitations of the IO approach were addressed by Leif Johansen's 1960 MSG model of Norway. Johansen's approach of solving the model via percentage changes and exploiting the initial solution of the model allowed the introduction of a more active role for prices whilst maintaining the role of inter-industry linkages found in IO tables and emphasized in IO modelling.

Whilst attempts to develop CGE models were made elsewhere with varying degrees of success, a major class of models was developed in Australia from Johansen's approach. Countless single country models have been constructed following the ORANI tradition of Australia, and continue to have key roles in policy analysis in most developed countries. GTAP (a widely-used multi-country model primarily used to examine international trade issues) has much in common with ORANI and uses both Johansen's approach to solving the model and the GEMPACK software developed in Australia to run the model. Recursive dynamic and rational expectations models, such as the Australian MONASH and the USAGE model of the US, are descendants of ORANI.

FLAGSHIP-PR is a descendant of the USAGE model of the US, regarded as one of the most advanced CGE frameworks in the world. USAGE was co-authored by Dr. Ashley Winston, the lead author of FLAGSHIP-PR. With these genetics, the FLAGSHIP-PR model benefits *both* from a development lineage spanning over 50-years that has informed policy making in a large range of countries *and* a direct link to the cutting-edge of CGE model development.

FLAGSHIP-PR is a dynamic CGE model of the Puerto Rico economy. It has 90 sectors and *initially* took onboard data from the official 2002 input-output table. As of the time of writing, the data has been updated to 2012 via a simulation process. The model applies nested CRETH[1] transformation functions, nested CRESH[2] production functions for intermediate and primary factor inputs, a Klein-Rubin specification[3] for households and various approaches to demand for and supply of internationally traded goods. The CRESH and CRETH functional forms are particularly convenient as they allow the "switching" of functional form between Leontief, Cobb-Douglas, CES/CET (constant elasticity of substitution and constant elasticity of transformation respectively) and CRESH/CRETH via adjustment of the parameter settings.

The model's core database contains details about IO flows such as:

- patterns of sales of commodities by industry and other users, including which industries use which commodities as inputs into current production and capital creation;
- final demand by households, government and foreigners, and flows to inventories;
- use of margin services such as transport and retail and wholesale trade which facilitate the movement of commodities between suppliers and buyers;

[1] Constant ratio of elasticity of transformation, homothetic.

[2] Constant ratio of elasticity of substitution, homothetic.

[3] Klein, L.R. and H. Rubin, 1948-49, "A Constant Utility Index of the Cost of Living", Review of Economic Studies, 15, pp84-87. The Klein-Rubin form of utility functions is also referred to as Stone-Geary functions which are one of the most frequently adopted functions in the empirical literature on consumer behavior.

- taxes, which along with margins, lead to (an important) distinction between the price paid by users of a commodity and that which is received by the producer of the commodity; and
- payments to the primary factors of labor, capital and land.

A great deal of supplementary data is used that includes information on investment by sector, capital stocks, occupational splits, and so on.

2.1.1 Differences between CGE Models and Other Approaches

Input-Output (IO) models are a precursor of CGE models. Whilst CGE models use IO data as a key source of information, they differ significantly in structure and capability to IO models.

IO and CGE models share a detailed picture of inter-industry linkages and patterns of final demand, but two core differences between the frameworks are (a) price-driven optimizing behavior and (a) the inclusion of resource constraints.

In a CGE model, demand for (as an example) labor is driven by wages, the prices of other primary factor and material inputs and production technology. The supply of labor is related to wages and the prices of consumption goods. IO models determine prices only as an add-up of a cost vector with fixed technology and have no capability to endogenously determine price changes without direct user intervention.

The scarcity of resources (like factors of production) and income constraints ensure that the expansion of one sector of the economy imposes costs on other sectors, and that expenditure decisions have cross-commodity consequences in demand. In an IO model, there are no constraints on the availability of resources, and so prices cannot be linked to scarcity – as prices signals are a measure of relative scarcity, this is a major limitation.

Partial equilibrium models often have considerable details about behavioral responses to changes in prices and income, but lack the CGE feature of economy-wide constraints and feedback.
Macroeconomic forecasting models have an economy-wide focus and are often derived from optimizing behavior. However, they lack the sectoral, commodity and occupational detail that can be provided by a CGE model. CGE models yield results for macroeconomic aggregates such as consumption, GDP and the real exchange rate, but where it is useful to have a macroeconomic forecast, CGE models typically impose a specialized forecast driven by a dedicated macroeconomic model - the focus of CGE models is the detailed consequences of shocks and the macroeconomic outcomes that result as those shocks percolate through the broader economy.

2.1.2 Comparative Static and Recursive Dynamic Models

FLAGSHIP-PR is a recursive dynamic model of the Puerto Rico economy. Due to the closure flexibility provided by its design and the GEMPACK software, it can also run as a comparative static CGE model.

All CGE models begin with a snapshot off the economy represented in the database. Comparative static CGE models essentially analyze how different this snapshot would look if the economy it represents has fully responded to a set of shocks.

Comparative static simulations are often characterized by "short run" or "long run" assumptions, where these terms relate to the economic context. The economic short run is a period short enough such that fixed factors of production (like capital) are invariant; the long run is a period of time sufficient for all factors of production to become variable. The "short run" or "long run" assumption is imposed in a comparative static CGE model by a small set of core assumptions:

- "Short run" – fixed capital stocks and wages, variable aggregate employment and rates of return on capital, and (often) variable public sector budget and current account balances.

- "Long run" – fixed (or constrained) aggregate employment and rates of return, variable capital stocks and wages, and (often) controlled public sector budget and current account balances.

The short run assumes that any investment activity will only update capital stocks after a lag, that wages are "sticky", and that the long run constraints on public sector and net foreign liability accumulation are not binding. Conversely, the long run assumes that capital (and other fixed factors) are mobile, that unemployment will return to the NAIRU[4] (or some other concept of full employment), and that governments and countries can't be net borrowers for all time.

This is slightly misleading, however. There is no explicit accounting for time in a comparative static CGE model, hence its name. Labelling different closures as "short run" or "long run" is convenient, but shouldn't be taken to imply any firm assumption about time frames or inter-temporal optimization issues.

Dynamic CGE models show how variables such as capital and debt accumulate through sequences of outcomes for investment and saving. They also allow for market frictions, for example in allowing for sustained unemployment as labor is redistributed between sectors after a shock. Dynamic models also embody concepts of expectations, particularly as they apply to investment behavior:

- In a *recursive dynamic* model, the formation of an expectation about the future return on a current investment expenditure is driven by past and current data;

- In a *forward-looking expectations* dynamic model, expectations are formed by knowing the future profitability of investment with certainty. Such models are sometimes referred to as rational expectations models, although strictly speaking this label is misleading.

In practice, recursive dynamic expectations lead to errors by shareholders, as the future is predicted by the present and the past. In a forward-looking framework, an algorithm (usually a "shooting algorithm" of some type) is used to iterate through several (up to 30) simulation runs to generate the certain expectation of the value of "future" variables. Recursive dynamics are easier and less costly to implement and are generally more relevant to simulating responses to real world economic shocks because they embody an error in predicting the future, as economic agents do in the real world. Forward-looking expectations

[4] Non-Accelerating-Inflation Rate of Unemployment

are useful in simulating the reactions of agents to known future events (like an announced policy change), but unrealistically assume perfect foresight on other economic events.

2.2 Model Coverage

The following sections serve as a high-level technical documentation for the FLAGSHIP-PR model, describing underlying production and utility functions and derived first order conditions, and details of the model code. The model code is implemented using GEMPACK software and an Intel Fortran compiler. Key areas covered by the model (at the time of writing) include:

- Puerto Rico, a small open economy that trades with the rest of the world.
- The model has 90 sectors which use primary factors and intermediate inputs to produce their multiproduct output according to multi-level, nested CRESH production functions and subject to CRETH transformation functions.
- There are multiple types of labor distinguished by occupation. Labor supply responses are modelled in both comparative and dynamic contexts.
- There are multiple capital asset types used in production. The link between the supply of funds and demand for new capital is modelled subject to an inverse logistic function that relates required expected rates of return to capital growth rates.
- There are multiple types of land used in production Land types are "transformed" between sectoral uses by a CRETH transformation function.
- Imputed wages (payments for owner labor) are accounted for.
- There are 4 margin services that facilitate the sales of other commodities.
- One representative household, which owns all factors of production, chooses its consumption bundle according to a Linear Expenditure System (LES) which distinguished between for subsistence and "supernumerary" (or "luxury") consumption, and savings.
- One government, which collects taxes and issues debt, and expends funds on public consumption, household transfers, public investment, interest and public saving;
- Investment demand by commodity and industry that shows which sectors invest and what commodities are used to construct new units of fixed capital (often called "gross fixed capital formation"). Rates of return on investment are modelled with explicit accounting for source of finance and a range of corporate taxes and deductions, including an accrual-equivalent capital gains tax.
- Industries use nested CRETH transformation functions to decide the mix of products to make and how to allocate their products between domestic usage and exports – essentially meaning they do so in order to maximize profit – and a particular good produced by multiple sectors can be treated as heterogeneous based on source in the eyes of the consumer.

- All users including sectors, the representative household, Government and investors can choose their inputs from both domestic and imported sources according to a CES function which treats domestic and imported variants of commodities as being good but imperfect substitutes (known as an "Armington nest").

- Firms can choose between financing investment with retained earnings, debt or new equity, and do so in pursuit of maximizing the rate of return on a unit of investment subject to the availability of funds (for example, as retained earnings have finite supply in any one period).

- Exports are distinguished by sub-group including "traditional", "non-traditional", tourism and transport, and are given different theoretical treatments.

- A great deal of tax detail is modelled, accounting for both their efficiency effects and revenue capacity.

- The balance of payments is modelled explicitly.

- Detailed modelling of economic welfare by various measures is incorporated. For example, changes in Net National Income (NNI) - a relatively robust measure of economic welfare - are decomposed into around 40 distinct effects.

- Energy goods are nested with primary factors in the production function.

- Various frictions are incorporated for dynamic simulations, including stickiness in labor market adjustment in response to shocks on both the demand and supply sides.

- A range of summary measures and decompositions are included to aid in interpreting and analyzing output.

2.3 The Main Structure of FLAGSHIP-PR

2.3.1 The Nature of Markets

FLAGSHIP-PR determines supplies and demand of commodities through the optimizing behavior of agents in (mostly) competitive markets. Optimizing behavior also determines industry demand for different occupational classifications of labor, asset types of capital, categories of land and natural endowments.

The model has upward-sloping labor supply curves for industries and occupations. Labor supply is determined by a variety of wage definitions and demographic factors, while capital supply responds to rates of return.

The assumption of competitive markets implies equality between the "producer's price" and marginal cost in each sector. Prices adjust to ensure demand equals supply in all markets other than where sticky adjustment mechanisms are incorporated.

The producer price is the amount receivable by the producer from the sale of a unit of a good or service. It excludes trade margins and any transport charges required to deliver the good to the purchaser, excludes indirect taxes, but includes production taxes. Basic prices (i.e. marginal cost) plus production taxes paid by the producer constitute the producer price. Producer price plus margins plus indirect taxes on sales constitute the purchaser price.

The government intervenes in markets by imposing taxes of various types on income and expenditure flows, and on stock values (as in the case of property taxes) or changes in stock values (as in the case of capital gains taxes). This places wedges between the prices paid by purchasers and prices received by the producers which have consequences for allocative efficiency.

In capital markets, there is a positive relationship between the required (expected) rate of return on investment by the suppliers of funds and the growth rate of the sectors capital stock. In essence, investors require a higher rate of return to contribute funds to a firm that is seeking to expand its capital stock at a comparatively fast rate.

2.3.2 Demand for Inputs to Be Used in the Production of Commodities

FLAGSHIP-PR recognizes four broad categories of inputs: non-energy intermediate inputs, energy goods, primary factors and "other operating costs" (which include such things as interest on debt and inventory costs). These aggregates ate composed of multi-level nestings of a variety of material and service inputs, primary factors types and other costs such as interest on existing debt.

Firms in each sector choose the level and mix of outputs to maximize profit subject to market prices, CRETH transformation possibilities and output augmenting technological factors. Firms choose the mix of inputs which minimizes the costs of production for the level of output resulting from the profit-maximizing output mix. Firms choose inputs via a multi-level nested CRESH production structure.

2.3.3 Household Demand

The household buys bundles of goods to maximize utility via a Klein-Rubin utility function subject to a household expenditure constraint. The expenditure constraint reflects household disposable income, which is formed from gross national income (GNI) *minus* taxes *plus* government transfers. Consumption bundles are combinations of imported and domestic goods, with the choice between sources are handled by an Armington nest that renders the domestically produced and imported varieties imperfect substitutes.

2.3.4 Demand for Inputs to Capital Creation and the Determination of Investment

Capital creators (i.e. firms) in each sector combine inputs to form units of capital. In choosing these inputs, they seek to minimize the cost of creating an asset subject to CRESH production technologies similar to that used for current production, a key difference being that they do not use primary factors. The use of primary factors in capital creation is recognized through inputs of the construction commodity (service). The non-construction inputs in capital creation are considered to be intermediate inputs similar to the current production.

2.3.5 Governments' Demand for Commodities

In FLAGSHIP-PR, there are four broad ways of handling aggregate government consumption demand: (i) endogenously, by a rule such as moving government expenditures with household consumption expenditure or with domestic absorption, GDP, GNI or some other macroeconomic aggregate; (ii) government demand by commodity can be determined exogenously; (iii) each product/service consumed by government could be made to move with overall changes in government's real revenues; or (iv) a fully-specified CRESH consumption nest can be imposed.

2.3.6 Foreign Demand (International Exports)

At the time of writing, FLAGSHIP-PR adopts the small open economy specification of foreign demand for all goods. Each export-oriented sector faces its own finite-elasticity foreign demand curve, but the elasticities are large (around -10). Thus, a shock that improves the price competitiveness of an export sector will result in increased export volume at a lower world price. By assuming that the foreign demand schedules are specific to a product, the model allows for differential movements in world prices. Foreign demand is driven by foreign currency prices for Puerto Rico's exports, and so movements in the nominal exchange rate can have secondary impacts on export demand.

Details of agents' behavior are explained in later chapters of this report.

3. The General Equilibrium Core of FLAGSHIP-PR

3.1 Producers' Demand for Produced Inputs and Primary Factors

FLAGSHIP-PR producers recognize four broad categories of inputs:

- Non-energy intermediate inputs
- Energy goods
- Primary factors
- Other operating costs

A stylized representation of the production function is given below.

The representative firm in sector *i* chooses a profit-maximizing level of output for all potential types of output subject to relative output prices and transformation possibilities (i.e. technological constraints). For each good *Y* the profit-maximizing level of output is produced at least cost by choosing inputs of a primary factor and energy bundle *PFE*, a non-energy intermediate goods composite *Q*, and other costs *OCT* (for example, the costs of holding inventories), such that

$$Y_i = CRESH(PFE_i, Q_i, OCT_i)$$

and subject to technological constraints and the relative prices of these input bundles formed via appropriate CRESH price indexes. CRESH price indexes are formed from CRESH shares, which are themselves formed from combinations of values and substitution elasticities,

$$P_{CRESH} = \sum_{x=1}^{X} \frac{V_x \sigma_x}{\sum_{b=1}^{z} V_b \sigma_b} P_x$$

for all *X* components of the nest.

For multi-product firms, input choices are not made with respect to each good, but rather the firm can be thought of as buying itself a production-possibilities frontier.

Non-energy intermediate goods *Q* are composites resulting from a second level of nesting. The producer seeks to minimize the cost (given technology and relative prices) of creating the bundle *Q* such that

$$Q_i = CRESH(Q_{i,c})$$

for each intermediate good *c*. The solution for each Q_c then enters an Armington nest where the cost of creating the composite *c* from foreign or domestically sourced goods is minimized,

$$Q_{i,c} = CES(Q_{i,c,s})$$

where *s* is source. In determining the composition of the primary factor and energy bundle, the firm seeks to minimize the cost of creating *PFE* by choosing a primary factor composite and an energy-goods composite,

$$PFE_i = CRESH(PF_i, E_i)$$

subject to price indexes for these composites and technology. The relationship between primary factor use and energy need is assumed to be close to Leontief at this level, and so substitution elasticities are set close to zero. The individual energy goods are chosen to minimize the cost of *E*,

$$E_i = CRESH(Q_{i,e})$$

for all *e* energy goods, subject to prices and technology. The demand for primary factor composites is a driven by choosing a cost-minimizing combination that satisfies *PF*,

$$PF_i = CRESH(L_i, K_i, N_i, M_i, Z_i)$$

from capital *K*, labor *L*, land *N*, natural resource endowments *M*, and imputed owner labor *Z*, subject to technology and relative factor prices. Capital, *K*, is a lagged function of investment via a standard inter-temporal accumulation relationship (often called the "perpetual inventory" method) and a dynamic investment process involving expectations. Capital, labor, land and natural endowments are composites resulting from further levels of nesting. Labor *L* is a CRESH function of m occupations,

$$L_i = CRESH(L_{i,m})$$

subject to relative wage rates and labor-using technological constraints. Choice of capital asset type (in a given period *t*) is cost minimizing choice of *a* assets that achieves the demand for *K*,

$$K_i = CRESH(K_{i,a})$$

subject to capital rental prices for each asset and capital using technology. The choice of land type is done so as to minimize the cost of achieving *L* with a combination of *n* land types,

$$N_i = CRESH(N_{i,n})$$

subject to land rental prices and technology, and in simultaneous negotiation with a "land-holder" who transforms land across sectors – that is, chooses which industries to whom the land is supplied – subject to land rental prices (the marginal revenue product of land) and CRETH transformation possibilities,

$$NS_n = CRETH(N_{i,n})$$

This applies mainly to agricultural sectors, where the "type" of land can refer to soil type and climate. The allocation decision - the "supply" decision – for land is a function of industry bids, where the bids are land rentals, constrained by the transformation possibilities between uses (where "use" is determined by the sector in question) and the exogenous total acreage of a given land type *Nn*

Similarly, the choice of natural endowment types is done in the pursuit of minimizing the cost of *M*,

$$M_i = CRESH(M_{i,m})$$

by choosing a bundle of *m* endowments, again in negotiation with an "endowment holder" who allocates endowments based on a CRETH transformation function and endowment rental prices (the marginal revenue product of endowments),

$$MS_m = CRETH(M_{i,m})$$

Substitution and transformation possibilities are limited, and largely determined by the database structure; if a sector has an opening value of zero in its use of (let's say) fishing stocks, it cannot actually demand fishing stocks unless the economic modeler exogenously imposes a non-zero value on that sector. This ensures that fisherman don't demand iron ore deposits, and miners don't demand fishing stocks. It is possible, though, for miners to demand both iron ore and liquid natural gas deposits, for example.

As indicated above, the Flagship-PR model contains many types of input-affecting technical change. They include (but are not limited to):

- Specific commodity using technical change in specific or all industries
- Specific or all primary-factor-using technical change in specific or all industries
- Specific energy using technical change in specific or all industries
- Technical shift in a mix of domestically sourced and imported inputs in specific or all industries.

3.2 Cost of Output Including Production Taxes, Basic Prices and Zero Pure Profits in Current Production

The zero pure profits and market clearing conditions are key determinants of the price system in CGE models such as FLAGSHIP-PR. While general discussions about the relationships between them are made under the heading of market clearing conditions separately, more detailed discussions are provided in the context of the current production below.

FLAGSHIP-PR defines several sets of commodity prices including (but not limited to),

- Basic prices,
- Purchasers' prices
- Asset and rental prices of capital units

- A variety of wages measures
- Free-alongside and free-onboard export prices
- Customs-insurance-freight and landed-duty-paid import prices.

As explained above, basic prices for domestically sourced goods are the prices received by producers, i.e. basic prices exclude sales taxes and margin costs. For imported goods, basic prices (landed-duty-paid) are the prices received by the importers including import duties, but excluding sales taxes and margin costs associated with deliveries from the ports to domestic users.

As typically adopted in computable general equilibrium models, FLAGSHIP-PR assumes:

- Basic prices are the same for all final users and all producing industries in the case of domestically sourced goods and importers in the case of imported goods, and
- There are no pure profits in any economic activity such as producing, importing, exporting and distribution, *unless imposed by simulation assumptions.*

The zero-pure-profit assumption implies that the marginal revenue of an industry equals marginal costs including both variable and any imputed and actual fixed costs in the industry. This assumption does not rule out variable profits defined as revenue less variable costs. It does rule out pure profits, i.e. profits not accruing to a factor of production. This implies that any adverse events in an industry will (for example) reduce the profitability of using capital in the industry and lead to reductions in the rental value of capital in that industry.

Cost measures that are both inclusive and exclusive of production taxes are calculated effectively as a column sum of the input output table – the sum of all of the costs (prices multiplied by quantities) of the inputs that enter the production function. Total sales revenue – the sum of the prices of outputs multiplied by their volumes – are also calculated. The firms seek to optimize where the cost and revenue of an additional unit of output are equal, and thereby ensure the satisfaction of the *zero pure profit condition* required by the theoretical underpinnings of competitive markets.

The implications of the zero pure profit condition on the basic prices in current production are summarized below.

Given the constant returns to scale characterized in the model's production technology, the percentage change in the basic price in current production is defined as a cost-weighted average of the percentage changes in effective input prices. The percentage change in the effective input prices represent: (a) the percentage change in the cost per unit of input and (b) the percentage change in the use of the input per unit of output, i.e. the percentage change in the technical variable. The cost-weighted averages define percentage changes in average costs. In this way, the zero pure profit condition ensures that commodity prices are set to be equal to costs in producing that good.

3.3 Output Transformation between Exports and Domestic Goods

The FLAGSHIP-PR model allows product differentiation for domestic and export markets similar to the product differentiation in import markets imposed by the Armington nest. For example, a firm in Puerto Rico involved in both shipping its output to international markets and to the domestic market chooses the supply ratio between these two markets based on relative prices in those regions (i.e. the domestic and foreign region), and customizes its output mix to supply the appropriate volumes to maximize revenue. As the costs of producing the two varieties are the same, this serves profit maximization.

The FLAGSHIP-PR model uses a CRETH function such that more of an industry's output is directed towards the market where prices are rising, and so a higher share of a particular variety (domestic or exported) is produced.

The transformation elasticity can be set for each good. The applied parameter is the inverse of the transformation elasticity: if it set at zero (creating an infinite elasticity value), there can be no divergence between producer's prices in the domestic and export markets, rendering the export and domestic varieties as perfect substitutes, and therefore effectively as a homogeneous product. In this case, the exports tend to be highly sensitive to domestic price movements.

According to the zero-pure-profit conditions, the cost of exporting a unit of a commodity (that is, the revenue foregone by not selling on the domestic market) should be equal to the revenue received per unit of export made up of the foreign currency price converted to domestic currency before any export taxes or subsidies.

3.4 Demand for Inputs to Capital Creation

Capital creators for industries in FLAGSHIP-PR combine inputs to form units of capital. In choosing these inputs, they minimize costs subject to CRESH capital formation technologies and the asset prices of capital goods. No primary factors are used directly as inputs to capital formation: however, most capital formation requires inputs of construction, which in effect represents a technological bundle including primary factors that enter the capital creation process.

The capital-input demand equations are derived from the solutions to the capital-creator's two-part cost-minimization problem. At the bottom level, the total cost of the domestic/foreign-import composite is minimized subject to the CES Armington nest. At the top level of the nest, the total cost of an investment commodity composite is minimized subject to a CRESH function that takes on very small substitution elasticities, essentially imposing close-to-fixed proportions technology. This top-level assumption reflects the idea that (for example) a bus company needs buses and work-sheds in relatively fixed proportion such that changes in the price of buses or sheds will not have significant impacts on the quantities of the asset types chosen. It also means that *technological change, and not relative asset good prices*, is the primary driver of capital creation methods.

Note that the amount of investment for each industry is not determined here; what is determined here is the composition of investment. The *amount of industry investment* is determined by rates of return and expectations.

The derivation of the zero pure profit condition in capital creation is similar to the derivation of the zero pure profit condition in current production.

3.5 Household Demand for Commodities

The household aims to sell all its endowed factors to firms to earn income, and trades-off this income against leisure in making a labor supply choice. Households are savers, which also makes them the suppliers of funds to capital-creators, and they implicitly own all of the land and natural endowments.

At the macroeconomic level, total factor income net of tax and adjusted for net income payments to foreigners (i.e. the balance in primary income flows in the current account) – gross national income minus indirect and direct taxes - generates household disposable income. The household expends the income on consumption of goods and services and saves in proportions determined according to an average propensity to consume (which can be exogenous or endogenous). Therefore, the household income determination is one of the crucial linking factors between the production sector and the household sector.

Given household disposable income, the household then chooses the consumption bundle – the mix of consumption goods and services it buys - to maximize its Klein-Rubin utility[5], subject to preferences and relative prices, leading to the Linear Expenditure System (LES). At the lower level of the nest, least-cost combinations of domestic and imported varieties are combined in an Armington nest.

The name of the linear expenditure system derives from its property that expenditure on each good is a linear function of prices and expenditure. The form of the demand equations allows there to be 'subsistence' requirements for each good; these are shares of the total consumption of each good that are insensitive to price and income. This imposes the requirement that households require certain levels of food, clothing, shelter, etc. in order to be able to supply their labor and generate income.

Household demand for each commodity is divided into two parts: a subsistence and a supernumerary (or discretionary) part. Supernumerary consumption is often (misleadingly) referred to as "luxury consumption". The household can be thought of as first spending a fixed amount specific to each commodity regardless of income and price (the subsistence component), then allocating whatever remains of household income between commodities according to a Cobb-Douglas utility function[6] (the discretionary component). Implementing this requires empirical estimates of the Frisch parameter which is defined as the inverse of the share of luxury spending in total household spending and marginal budget shares.
A major advantage of the LES is that it allows for non-unitary expenditure elasticities without requiring complex parameter estimation. It also imposes fixed budget shares on discretionary spending due to the unitary substitution elasticities in the Cobb-Douglas structure.

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[5] For details on the derivation of demand in the LES, see Dixon, Bowles and Kendrick (1980) and Horridge *et al.* (1993).

[6] It is one of the most frequently adopted functional forms in the empirical consumer behavior analysis.

3.6 Foreign Demand for Puerto Rico Exports

Export commodities in Puerto Rico are modelled as facing downward-sloping, constant elasticity foreign export demand functions. Export demand is broken into sub-categories: traditional exports, non-traditional exports, tourism and transport.

Traditional exports are goods for which a significant share (say 25%) of domestic production is exported. Each of these goods has demand function in which its own price enters the equation. By contrast, non-traditional exports have demand functions in which a price index across all non-traditional exports enters the equation.

The logic behind this approach suggest that an individual traditional export good faces a fairly stable foreign demand curve, for which movements in prices are a good predictor of changes in demand. For non-traditional exports, demand waxes and wanes for reasons that have less to do with price, and so they are bunched together and treated like a composite in terms of their price responsiveness, while still having individual preference parameters that allow for specific exogenously imposed changes in the *position* of export demand curves. The position of export demand curves might change, for example, because of a change in the growth rate in GDP in a trading partner.

Tourism exports are handled by bundling a group of tourism related commodities – for example, hotels, restaurants, particular tourism-related goods and services like souvenirs and tours – and treating them like a single good. The foreigner purchases the bundle in fixed proportions, and the demands for the individual goods and services flow back into the demand functions faced by domestic suppliers.

Transport exports are essentially air and water transport. They are used to facilitate international trade. As such, these export demand function respond the demand for other internationally trade goods and services, including the tourism bundle.

There also a standard export demand function that can cover all goods and services or various subsets. This can be switched for subsets of goods and services, to allow for example non-traditional exports to be treated as traditional exports during a simulation.

3.7 Government Demand for Commodities

Usually, the size and composition of government demand is largely imposed by the modeler. This approach is taken based on the assumption that the government consumption bundle is not significantly effected at any given point in time by relative prices, and that the overall level of public sector consumption is not absolutely constrained in given period by the availability of revenue from taxes and public enterprise profits. The model does allow a more conventional demand structure for government consumption to be imposed if the modeler wishes.

The path of total government spending is usually exogenously imposed or tied to another macroeconomic aggregate. For example, if the simulation design needed to assume that government spending share of domestic absorption was fixed or would change in a known way, this can be imposed by exogenizing a ratio between the two macro aggregates and (potentially) shocking it. The model includes a range of ratios that can be applied, including equations that relate the percentage change in government consumption to the percentage change in GDP, GNI, and household consumption.

3.8 Inventory Demand

Inventories of commodity c are assumed to accumulate in proportion to output of commodity c in FLAGSHIP-PR. The variable is implemented as an ordinary change in inventories instead of a percentage change, because the volume of inventories in a period may be zero, negative or switch from positive to negative.

3.9 Margin Demand

Commodities in the margin set MAR are used as margin commodities in FLAGSHIP-PR. Typical elements of MAR are wholesale, retail trade, accommodation, water transport, port margins, air transport, land freight, general insurance and bank finance. These commodities, in addition to being consumed directly by the users (e.g., consumption of transport when taking holidays or commuting to work), are also consumed to facilitate trade (e.g., the use of transport to ship commodities from point of production to point of consumption). The latter type of demand for transport is a so-called demand for margins.

The FLAGSHIP-PR assumes that there are no margins on inventory accumulation. Demands for margins are proportional to the commodity flows with which the margins are associated, with an allowance for technological change that can be shocked if necessary. For example, the demand for margin type m = 'wholesale trade' on the flow of commodity c from industry i for use in current production moves with the underlying demand for that commodity and (potentially) cost saving or cost increasing technological change for the use of that commodity. For example, an upgrade in a port facility that reduced the cost of handling a shipping container can be modelled via adjustments to technological change in margins.

3.10 Market Clearing Condition and Price System

So far we have discussed household, producer and investor optimization behavior. Those optimization problems are not dependent on other agents' decisions but only on the given good and factor prices. In other words, optimization problems for the economic agents in the Puerto Rico economy have so far been solved separately. Therefore, there is no guarantee that the prices assumed by the household are the same as those assumed by the firms. More specifically, for the *c* commodity, the household assumes the demand for price of say *p3* while the firms assume the supply price *p1* and so far there is no link between them. Furthermore, even if these prices are the same, supply is not necessarily equal to demand for each good and for each factor at that price. In sum, to ensure the market equilibrium of each good and factor in terms of quantity and price, the model explicitly imposes the market clearing conditions – that is, we need a Walrasian auctioneer.

As discussed above, the price system underlying the model is based on two assumptions:

- that there are no pure profits in the production or distribution of commodities - the zero pure profit condition for production implies that the revenue in the industry is equal to costs in the industry (remembering that costs include returns to capital and other fixed factors, which are normal profits) ; and

- that the price received by the producer is uniform across all customers (except potentially in the case of export demand).

There are two types of price equations in the FLAGSHIP-PR:

- zero pure profits in current production and importing; and
- zero pure profits in the distribution of commodities to users.

The zero pure profits condition in current production for margin and non-margin commodities, and importing is imposed by setting unit prices received by producers of commodities (i.e., the commodities' basic values) equal to unit costs. Zero pure profits in the distribution of commodities is imposed by setting the prices paid by users equal to the commodities' basic value plus commodity taxes and the cost of margins.

To facilitate market clearing and zero pure profit equations, various sales aggregates must be computed.

3.11 Indirect Tax Aggregates

FLAGSHIP-PR contains considerable detail about indirect taxes and the model code allows the economist to introduce policy scenarios of various degrees of complexity.

Indirect taxes exist in the model by user, commodity and source, but it is frequently the case that the modeler will want to change tax rates for all users of a commodity by the same percentage. The inclusion of shift variables facilitates these types of uniform shocks.

The revenue from indirect taxes and tariffs is then calculated from changes in the tax rate and the base of the tax. In order to allow useful add-ups of macroeconomic aggregates, ordinary changes in tax and tariff revenues are also calculated.

3.12 Macro Accounting: GDP Income and GDP Expenditure

FLAGSHIP-PR contains many aggregate variables. In some cases, they are mainly useful for interpreting model results or imposing an appropriate economic environment. There are also equations that establish underlying accounting identities that exist in the model. For example, it must be the case that GDP from the income side equals GDP from the expenditure side – both in the initial solution in the database and after any simulation.

The macroeconomic variables include the trade balance, the terms of trade and the real exchange rate. Since the balance of trade may start at or pass through zero, it is not appropriate to define it as a percentage change variable. The real exchange rate and the terms of trade are both aggregate variables that are often useful in explaining results. Note that it is the real exchange rate and not the nominal exchange rate which indicates changes in competitiveness.

3.13 Investment

In a dynamic simulation, the link between investment and the capital stock is clear: the capital stock is the result of accumulated investment net of depreciation. In a comparative static model, the link is not so clear.

In comparative static simulations with FLAGSHIP-PR, investment by industry and economy-wide investment are determined by a combination of rules.

Determination of the number of units of capital to be formed for each industry depends on the nature of the experiment being undertaken. For comparative-static experiments, a distinction is drawn between the short run and long run. In short-run experiments, capital stocks in industries are exogenously determined. Industry investment in the short run can either be determined by the rate of return on capital or follow aggregate investment: for the former, that industry's investment will increase as the rate of return increases – that is, if the percentage change in capital rentals exceeds the percentage change in the cost of building a new unit of capital. Industries whose investment performance is not driven by short term profitability (for example, housing construction) can be made to follow aggregate investment.

In long-run comparative-static experiments, it is assumed that the aggregate capital stock adjusts to preserve an exogenously determined economy-wide rate of return, and that the allocation of capital across industries adjusts to satisfy exogenously specified relationships between relative rates of return and relative capital growth. Industries' demand for investment goods are determined by exogenously specified investment/capital ratios.

Economy wide investment can also be handled in different ways: It may be determined simply as the add-up of sectoral investment; it may be exogenously determined by the modeler. Total investment can also be made to move proportionally with household consumption or another macroeconomic aggregate.

The usual assumption in FLAGSHIP-PR is that capital is sector specific and once installed cannot move between sectors. We can also allow capital to be mobile between sectors by implementing via closure swaps that force industry rates of return to move together.

In dynamic simulations the treatment of investment is much more complex. We will leave a detailed description of this process for the full technical documentation to be delivered with in-person training.

3.14 Labor Market

FLAGSHIP-PR allows modelers to impose a variety of labor market conditions.

For example, in a typical long-run simulation total employment is usually assumed to be either exogenous or determined by a labor supply function, with real after-tax wages adjusting to equilibrate the labor market. This assumes that in the long run it is demographic factors that determine labor supply and the rate of unemployment converges to a full employment condition of some sort, perhaps a NAIRU.

In the short run, it may be desirable to allow employment to vary. This can be achieved by exogenizing either nominal or real wages. A number of shift variables can be used to shock the economy-wide wage, wages by industry and wages by occupation.

Wage relativities between industries and occupations are usually assumed to be fixed in both short and long run comparative static simulations. Effectively, this means that labor can move easily between industries and occupations and producers do not seek to change the occupational mix of their workforce.

In the case of investment, in dynamic simulations the treatment of labor market adjustment is much more complex, and we will leave a detailed description of this process for the full technical documentation. A key outcome of the dynamic treatment is that the labor market can carry sustained periods of unemployment into the future in response to adverse economic shocks.

3.15 Miscellaneous Equations and Equations for Analyzing Results

There is no theory in FLAGSHIP-PR to explain movements in the price of miscellaneous business costs called "other cost tickets". An equation allows the price of these costs to be shocked but otherwise assumes their price moves with a price index like the consumer price index or GDP deflator.

FLAGSHIP-PR contains many variables that are not required for the solution of the model, but are rather included to assist in understanding results and diagnosing problems. For example:

- Variables that decompose results according to sales destinations, expenditure categories, domestic and export shares and factor incomes are defined. These are very useful in identifying the combination of economic mechanism, initial data and closure that explains results.

- A number of formal checks on the model are calculated, allowing the modeler to check whether the model has been computed correctly.

- A considerable amount of information about the contents and consequences of the data is calculated and written to a summary file. In addition, results available in matrix form or by large number of sectors is aggregated and/or written in vector form for easier viewing.

- Some condensation of the model is performed. By omitting or substituting certain variables not of interest in a typical simulation, the number of equations required to be solved in FLAGSHIP-PR can be greatly reduced. This procedure greatly improves solution times.

4 Overview of Computational Method, Interpretation of Solutions, Closures, Equations and Sets

4.1 Overview of Computational Method

Many of the equations in FLAGSHIP-PR are non-linear, which presents computational difficulties in large equation systems. Following Johansen (1960), the model is solved by representing it as a system of linear equations relating changes in the model's variables. Results are deviations from an initial solution of the underlying non-linear model.

The system of linear equations is solved using GEMPACK. GEMPACK is a suite of programs for implementing and solving large economic models, and is used in hundreds of organizations in over 70 countries.

The linear version of FLAGSHIP-PR is specified in the TABLO syntax, which is similar to ordinary algebra. GEMPACK solves the system by converting it to an "Initial Value" problem and then using a numerical method (such as the Euler or Gragg methods) to solve the system.

GEMPACK uses a multi-step process coupled with extrapolation to generate exact solutions of the underlying, non-linear, equations, as well as to compute linear approximations to those solutions. For details of the algorithms available in GAMPACK, see Harrison and Pearson (1996). For introductions to the Johansen/Euler solution method, see Dixon and Rimmer (2002, Section 11) and Horridge *et al.* (1993).

Writing down the equation system of the model in a linear (change) form has advantages from computational and economic standpoints. Linear systems are easier for computers to solve and have more stable solutions. This allows for the specification of complex, detailed models, consisting of many millions of equations. Further, the size of the system can be reduced by using model equations to substitute out those variables that may be of secondary importance for any given experiment. In a linear system, it is easy to rearrange the equations to obtain explicit formulae for those variables; hence the process of substitution is straightforward.

Compared to their level counterparts (i.e. represented explicitly in terms of dollars or the number of persons), the economic intuition of the change versions (i.e. percentage or ordinary change impacts on the level form variables) of many of the model's equations is relatively transparent. For example, complex non-linear demand functions can be transformed into linear combinations of percentage changes, parameter values and updatable levels coefficients that often take the form of shares. In addition, when interpreting the results of the linear system, simple share-weighted relationships between variables can be exploited to perform back-of-the-envelope (BOTE) calculations designed to reveal the key cause-effect relationships responsible for the results of a particular experiment.

4.2 Nature of Dynamic Solution

Algebraically, dynamic models such as FLAGSHIP-PR take the form

Equation 1: $F(X)_t = 0$

where $(X)_t$ is a vector of length *n* referring to variables for year *t*, and *F()* is an *m*-length vector of differentiable functions of *n* variables. In simulations, given an initial solution for the *n* variables that satisfy equation 1, GEMPACK computes the movements in *m* variables (the endogenous variables) away from their values in the initial solution caused by movements in the remaining $n - m$ variables (the exogenous variables).

In deriving the linear equations from non-linear equations we apply the rules of calculus, for example:

- the product rule: X = ABC ⇒ $x = b + c$, where A is a constant,
- the sum rule: X = B + C ⇒ $Xx = Bb + Cc$.
- the power rule: $X = AB^c$ ⇒ $x = cb$, where A is a constant,

where all upper case values are levels and all lower case values (in these examples) are percentage changes.

The FLAGSHIP-PR results are reported as deviations in the model's variables from an initial solution. In the equations above, the *percentage* changes x, *b* and *c* represent deviations from their initial levels values X, B and C. The levels values (X, B and C) are solutions to the model's underlying levels equations for the values in the initial database.

Using the product-rule equation as an example, if A had the value 2, values of 100 for X, 10 for B and 5 for C represent an initial solution. Assume that we perturb the initial solution by increasing the values of B and C by 3 per cent and 2 per cent respectively, i.e. we set *b* and *c* at 3 and 2. The linear representation of the product-rule equation would give a value of *x* of 5, with the interpretation that the initial value of X has increased by 5 per cent for a 3 per cent increase in B and a 2 per cent increase in C. Values of 5 for *x*, 3 for *b* and 2 for *c* in the corresponding percentage change equation mean that the levels value of X has been perturbed from 100 to 105, B from 10 to 10.3 and C from 5 to 5.1.

In the example above, while satisfying the percentage-change equations, updating the levels values of X, B and C by their percentage changes does not satisfy the levels form of the product-rule equation i.e., $105 \neq 2 \times 10.3 \times 5.1$. Given the percentage changes to B and C, the solution to the non-linear equation is X = 105.06. Comparing the levels solution to the percentage change solution shows there is a linearization error of 0.06 (i.e., 0.06 = 105.06 - 105). We can eliminate the linearization error by the application of a multistep procedure which exploits a positive relationship between the size of the perturbation from the initial solution and the size of the linearization error.

The principle of the Euler version of the multistep solution method can be illustrated using the example above. Instead of increasing the values of B and C by 3 per cent and 2 per cent, break the perturbation into two steps. First, increase *b* and *c* by half the desired amount, i.e., 1.5 per cent and 1.0 per cent respectively. Solving the linear equation gives a value for x of 2.5 per cent. Updating the value of X by 2.5 per cent gives an intermediate value of X of 102.5 [i.e., $100 \times (1 + 2.5/100)$]. Now apply the remainder of the desired perturbation to B and C.

The percentage increase in A is 1.4778 per cent (i.e., $100 \times 0.15/10.15$)[7] and the percentage change in B is 0.9901 per cent (i.e., $100 \times 0.05/5.05$), giving a value for x (in our second step) of 2.4679 per cent. Updating our intermediate value of X by 2.4679 per cent, gives a final value of X of 105.045, which is closer to the solution of the non-linear equation of 105.06. We can improve the accuracy of our solution by implementing more steps and by applying an extrapolation procedure.

In the percentage-change form of the sum-rule equation, the levels values of the variables appear as coefficients. By dividing by X, this last equation can be rewritten so that *x* is a share-weighted average of *a* and *b*.

4.3 Closures of FLAGSHIP-PR

A Computable General Equilibrium Model typically has more variables (say its number is *n*) than equations (say its number is *m*). In order to solve the model, the number of endogenous variables must be the same as the number of equations (m), requiring the modeler to determine the value of some variables – either as a constant or via a shock. A choice of the *n-m* variables to be made exogenous is called a **closure**.

Many variables are naturally exogenous i.e. determined outside the model. These include tax rates, foreign prices and the position of foreign demand curves (in a single country model). Other variables that are usually exogenous are those included in the model to facilitate shocks, or relate to the economic environment under consideration. For example, in a short

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[7] Note that in our first step we have also updated the values of Y and Z, e.g., after the first step, our updated value of Y is 10.15 = 10×1.5/100.

run comparative simulation industry specific capital stocks are typically held fixed, while in the long run they are determined endogenously.
In general, by swapping variables between exogenous and endogenous categories a comparative static long-run closure can be converted to a comparative static short-run closure. In a dynamic context, forecasting and policy closures are developed in a similar way, by a series of swaps applied to the short-run comparative static closure.

A typical long-run comparative static closure includes:

- technological and taste change variables
- average propensity to consume or current account balance
- government consumption ratio to private consumption
- various export demand shifters
- foreign currency prices of imports
- tax and subsidy rates
- government's transfer to consumers or government budget balance
- tax compliance rates
- population
- numeraire assumption

The numeraire assumption is required as the perfectly competitive Walarsian economy only determines the relative prices only. This implies that a price needs to be set exogenously. This price is referred to as the numeraire as all the other prices are determined relative to this exogenous price. The consumer price or nominal exchange rate are typical choices for the numeraire. Note that the results for real variables are not affected by this choice.

A simulation involves observing the effect on the endogenous variables of changing the value of one or more exogenous variables. Shock statements are often of the form:

```
shock p3tot = 1;
```

which means: the CPI (which is one variable; a scalar) increases by 1%.

```
shock a1lab_i ("footwear") = - 5.07;
```

which means labor productivity in the footwear industry improves by 5.07%

```
shock f0tax_c = uniform 3;
```

which means that tax rates for all commodities increase by 3%.

Shocks may also be read from files, using statements like:

```
Shock powt0imp_c = file shocks.har header "TF";
```

This approach is particularly useful for imposing a different shock to each of a large number of industries or commodities.

4.4 FLAGSHIP-PR Represented in the TABLO Language

In a full documentation, description of FLAGSHIP-PR are generally organized around excerpts from the TABLO file, which implements the model in GEMPACK.

The TABLO language in which the file is written is essentially conventional algebra, with names for variables and coefficients chosen to be suggestive of their economic interpretations. The model description will be based on the TABLO file for a number of reasons.

First, familiarity with the TABLO code allows the reader ready access to the programs used to conduct simulations with the model and to convert the results to readable form. Both the input and the output of these programs employ the TABLO notation.

Second, familiarity with the TABLO code is essential for users who may wish to change the model.

Finally, by documenting the TABLO form of the model, there is an assurance that the model description is complete and accurate. However, as the model code is very large, only core equations are usually reported in a full-scale documentation. Such full-scale documentation is generally provided only for a training purpose.

GEMPACK is a bundle of programs designed to construct, run and analyse computable general equilibrium models. GEMPACK continues to be developed at Victoria University's Centre of Policy Studies[8].

GEMPACK contains software for:

- creating, storing and viewing data files associated with CGE models;
- a language similar to ordinary algebra for writing down the theory of model and converting it into computer readable instructions;
- interfaces for implementing the model and running simulations; and
- programs for viewing and analysing results.

4.5 TABLO Syntax and Conventions Observed in the TABLO Representation

Each equation in the TABLO model description is linear in the (percentage or ordinary) changes of the model's variables. For example, the bottom level of the industry labor demand equations in FLAGSHIP-PR, in which choice between occupations is made, appear as:

Equation (linear) E_x1ab *# Demand for labor by industry and broad occupation #*
(**all**,i,IND)(**all**,o,OCC)(**all**,r,DOMREG)
x1lab(i,o,r) - a1labio(i,o,r)=

x1lab_o(i,r)

-SIG1LAB(i,o,r)*[p1lab(i,o,r)-p1labio_n(i,r)]

-SIG1LAB(i,o,r)*[a1labio(i,o,r) - a1labio_n(i,r)];

[8] The Centre of Policy Studies has recently moved to Victoria University in Melbourne, Australia, from Monash University.

The first element is the identifier for the equations, which must be unique. In the FLAGSHIP-PR code, all equation identifiers are of the form *E_<variable>*, where <variable> is the variable that is explained by the equation in the model. The identifier is followed by descriptive text between # symbols. This is optional. The description appears in certain GEMPACK generated report files. The expression (all,i,IND)(all,o,OCC)(all,r,DOMREG) signifies that the equations are defined over all elements of the sets IND (the set of industries) and (OCC) job categories, and for each domestic region DOMREG (for which at the time of writing there is one – Puerto Rico).

Using set notation allows us to minimize the size of the code; in the equation declaration, with 93 sectors, one domestic region and (let's say) 10 occupations, there are actually 930 equations to be solved due to this single statement. In the FLAGSHIP-G model, a dynamic model of the global economy in the FLAGSHIP framework that distinguishes 41 regions of the world in a single model, there are single equation-statements that result in the calculation of over 16 million equations. Clearly, implementation of such large equation systems would not be possible without the ability to condense the syntax.

Within the equation, we generally distinguish between change variables and coefficients by using lower-case script for variables (changes) and upper-case script for coefficients (levels). Note, however, that the GEMPACK solution software ignores case. The only levels value in the equation above is a parameter (also conventionally written in uppercase) SIG1LAB(i,o,r) which is the CRESH elasticity of substitution between labor and skill types. A semi-colon signals the end of the TABLO statement.

4.6 The Core of the FLAGSHIP-PR Model

The CGE core is based on the small, open economy model of Puerto Rico with nested production and utility functions. Figure 4.1 is a schematic representation of the core's input-output database of Puerto Rico. It reveals the basic structure of the core.

The rows show the structure of the purchases made by each of the agents identified in the columns. Each of the commodity types identified in the model can potentially be obtained from local producers or imported from overseas (although, there will be many zeroes spread throughout the matrix). The source-specific commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments, are exported, and accumulated as inventories. There are domestically produced goods that are used as margin services which are required to transfer commodities from their sources to their users. Various types of indirect tax are payable on the purchases. As well as intermediate inputs, current production requires inputs of primary factors: labor (divided into occupations), capital (by asset type), agricultural and industrial land, natural endowments and imputed wages. The "other costs" category covers various miscellaneous industry expenses. Each cell in the input-output table contains the name of the corresponding matrix of the values (in some base year) of flows of commodities, indirect taxes or primary factors to a group of users.

Figure 4-1 is suggestive of the theoretical structure required of the CGE core, which includes: demand equations required for our 95 users (90 sectors plus 5 final demand); equations determining commodity and factor prices; market clearing equations; definitions of commodity tax rates. The equations of FLAGSHIP-PR'S CGE core can be grouped according to the following classification:

- producers' demand for produced inputs and primary factors;

- demand for inputs to capital creation;
- household demand;
- export demand;
- government demand;
- demand for margins;
- zero pure profits in production and distribution;
- indirect taxes;
- market-clearing conditions for commodities and primary factors; and
- national macroeconomic variables and price indices.

The MAKE multi-product matrix indicates that a commodity may be produced by more than one industry or that a single industry may produce more than one commodity.

Figure 4-1: The CGE core input-output database of Puerto Rico

		ABSORPTION MATRIX					
		1	2	3	4	5	8
		Producers	Investors	Household	Export	Govt.	Stocks
	Size	I	I	1	1	1	1
Basic Flows	C x S	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V8BAS
Margins	C x S x M	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	
Indirect Taxes	C x S x T_i	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	V8TAX
Labor	O	V1LAB					
Capital	K	V1CAP					
Land	N	V1LND					
Natural Resources	M	V1RES					
Imputed Wages	1	V1OWN					
Other Costs	1	V1OCT					
Production Taxes	Tp						

C = Number of commodities, I = Number of industries,

O = Number of occupation types, M = Number of margins,

S = Number of Sources, T = number of taxes (indirect and production),

K = asset types, M = land types, N = resource types

	MULTI PRODUCT MAKE MATRIX	
Size	I	Total
C	MAKE	
Total		

4.7 Naming System for Variables of the FLAGSHIP-PR Core

The following conventions are used (as far as possible) in naming variables of the CGE core.

- Names consist of a prefix, a main user number and a source dimension. The prefixes are:

  a ⇔ technological change, change in preferences

  f ⇔ shift variable

  p ⇔ price

  x ⇔ volume

w⇔value

- The main user numbers are:

  1 ⇔ industries, current production, inputs, primary factors;

  2 ⇔ industries, capital creation;

  3 ⇔ households;

  4 ⇔ foreign exports;

  5 ⇔ government

  6 ⇔ inventories.

  7 ⇔ imports

  9 ⇔ balance of payments.

- Ordinary change variables, as opposed to percentage change variables, are indicated by the prefix d_.

- Variable names may also include an (optional) suffix description, such as:

  cap ⇔ capital;

  imp ⇔ imports;

  lab ⇔ labor;

  land ⇔ land;

  mar ⇔ margins; and

  oct ⇔ other cost tickets

5 Development of the FLAGSHIP-PR database

The purpose of this document is to provide a summary of the data that KPMG has used to develop a database for FLAGSHIP-PR. KPMG has received multiple versions of several tax data files. The discussion in the document is limited to the final versions only. A separate document has been provided on a comprehensive discussion on the data collection and compilation to develop a database for FLAGSHIP-PR.

In collecting and analyzing data as part of the economic modeling portion of the project, KPMG worked closely with the Treasury, the Planning Board, and independent economists within Puerto Rico. Specifically, we discussed our approaches to certain aspects of the analysis and received formal feedback about how the analysis would comport with Puerto Rico specific data issues. By way of example, members of the Planning Board provided valuable advice on the state of the national accounts data and suggested approaches for dealing with Puerto Rico pricing data.

In many instances, in addition to the involvement of members of Puerto Rico's Treasury Department and its Planning Board, Puerto Rico's management team asked KPMG to work with economists in Puerto Rico who would provide the data to be used in this model.

Collectively, members of the Treasury, Planning Board, and independent economists referred by the Treasury, have provided significant insight into some of the unique aspects of the Puerto Rico economy which have guided the decisions on assumptions to be used and the sources of data. Their knowledge of the national accounts data guided the decisions to use certain price data and not others. Their review of the input tax data resulted in changes to the way information was aggregated into the various categories of income and to the exposure of some missing information.

5.1 Personal Income Tax Data

Taxpayer level personal income tax data for year ended 2012 was provided to KPMG by the staff at the Treasury in the form of three Microsoft Excel files titled "Long Form 2012 Part 1.xlsx" "Long Form 2012 Part 2.xlsx," and "Short Form 2012.xlsx". In addition, a separate Excel file titled "Employer NAICS with Taxpayer's serial number Taxable Year 2012N.xlsx" , which links the individual tax filer (both Long Form and Short Form) with the NAICS code of her employer, was provided by the Treasury. Individual taxpayers are identified by a serial number created by the Treasury to ensure is the absence of any personally identifiable information in the data. The Treasury also provided an Excel file titled "Layout Individual Tax Returns 2012 and Corporate Tax Returns 2011.xlsx", which serves as a data dictionary, linking the variables in the aforementioned files to Individual Income Return Forms 481.0 (Short Form) and 482.0 (Long Form). Listed below are the files containing Personal Income tax data provided by the Treasury:

Table 5.1: Personal Income Tax Files Provided by the Treasury to KPMG

1	Short Form 2012.xlsx
2	Long Form 2012 Part 1.xlsx
3	Long Form 2012 Part 2.xlsx
4	Employer NAICS with Taxpayer's serial number Taxable Year 2012N.xlsx
5	Layout Individual Tax Returns 2012 and Corporate Tax Returns 2011.xlsx

According to personnel at the Treasury, digital files are created manually from hard copies of all filed returns. The files are stored in REFO using Virtual Storage Access Method (VSAM) and were extracted using Qlikview business intelligence software.

In order to prepare the Personal Income tax data for incorporation into the Computable General Equilibrium (CGE) model, we first aggregated the various tax items at the North American Industry Classification System (NAICS) level. Subsequently, we mapped the NAICS level aggregates to the 92 sectors of the CGE model.[9] Since the Short and Long Form returns do not contain information on the taxpayer's employer's industry (NAICS code), we used corresponding W2 information provided by the Treasury. The Treasury used the Employer Identification Number (EIN) available in each taxpayer's W2 form to extract the industry information of her employer from the corresponding Corporate Tax Return. Each multi-establishment EIN can have more than one NAICS as NAICS is assigned at the establishment level. The Treasury provided KPMG with the highest earning NAICS for each EIN.

"Employer NAICS with Tax Payor serial number Taxable Year 2012N.xlsx" links each taxpayer in the "Long Form 2012.xlsx" and "Short Form 2012.xlsx" with the NAICS code of her employer. This file contains 1,048,575 records, of which 706,399 contain a singular NAICS code. There are 294,053 records that had missing NAICS information. In order to address the issue of duplicates, KPMG randomly selected one observation in instances where the serial number occurred more than once. To select the random sample, we first sorted the records by unique identifier and used STATA to generate random numbers with the random number seed '1407031100'. We next sorted the sampled population by random number and unique identifier. The sample was determined by selecting the first record associated with each serial number. This resulted in 862,682 unique records by serial number.

We then merged the above file to both the "Short Form 2012.xlsx" file and the merged Long Form 2012 file using the taxpayer serial number. Of the 741,951 records in the "Short Form 2012.xlsx" file, NAICS code was unavailable for 57,731 records. Of the 311,752 unique records in the Long Form 2012 file, NAICS code was unavailable for 139,690 records. With the NAICS information added to the Short Form 2012 and Long Form 2012 files, we aggregated the different variables at the NAICS level.

9 This is described in Appendix B of this document.

Intended Use of Personal Income Tax Data

Of the three categories of personal income tax – tax on wage and salary income, income tax on imputed wage and salary income, and tax on other non-wage income – the first two are directly incorporated into the CGE model data for each industry. The third category is only used as an aggregate to measure the overall personal income tax on non-wage income.

Wage and salary income tax by employer industry is used to estimate take-home (after-tax) wage income by labor employed in that industry. Wage and salary income tax is represented both in terms of the average wage income tax rate by industry (for revenue purposes) and the marginal rate attributable to average worker (for labor supply modeling). Overall average wage and salary income tax revenue reflect the employment levels, wage rates, and effective wage income tax rates. Different effective wage income tax rates across industries would reflect the different composition of occupations across production sectors.

Wage and salary income tax is also used to determine disposable household income, which in turn helps determine overall household consumption levels as well as household saving.

Estimates of imputed wage and imputed wage income tax will be used to adjust the gross operating surplus, which is the portion of income from production that represents returns to capital, in the CGE model data base, because gross operating surplus in the input output data base usually includes the imputed wage income components. While this is a fairly common categorization, this imputed wage income is not income accrued from the use of capital. By separating out imputed wage costs (including imputed wage income tax) from the reported gross operating surplus, the model can correctly estimate true capital costs for the use of capital allocated to each industry.

5.2 Business Tax Data

Business tax data was provided by the staff at the Treasury in the form of the seven Microsoft Excel files listed in the table below:

Table 5.2: Business Tax Files Provided by the Treasury to KPMG

1. Corporate Income Tax Return 2011 Data.xlsx
2. Selected Variables Exempt Businesses Taxable Year (2011 and 2012).xlsx
3. Partnership Income Tax Return Data 2011 (884, 844).xlsx
4. Additional Tax Return Data for CFCs 6 16 2014.xlsx
5. CFC-Non-Resident Withholdings FY2011-2013.xlsx
6. 2013-2014 General Fund Dependency on CFC (Tabla corp.xlsx)
7. Estimated Revenues for Corporations with (Patente) Base Year data 2011 (Top 100 Place Incorporated Updated).xlsx

5.2.1 Exempt and Non-Exempt Business Effective Tax Rate Calculations

Taxpayer level data was aggregated at the NAICS level for both 2011 and 2012. KPMG merged the 2011 NAICS level exempt business tax file, keeping only the NAICS and Total tax liability variable with the NAICS level Corporate Income tax file containing the Net Overpayment and Total Tax Liability variable. The purpose of this merge was to create a simple NAICS level file containing tax liability information of regular and exempt business in Puerto Rico for the Taxable year 2011. The final file contains 566 NAICS categories, all of which are present in the Corporate Income Tax 2011 file but only 214 of which are in the Exempt Business tax file. The purpose of this merge was to calculate the total tax payments by Exempt and Non-Exempt Businesses i.e., the sum of 3A10_Contribution Total and Net Overpayment from Form 480.20 and Tax Liability from 480.30(ii).

Total tax liability at the NAICS level was mapped into the 91 industry classification adopted for the KPMG CGE model. Using the 2011 gross surplus estimates for each of 91 industries[10], the effective tax rate for each industry was calculated by dividing the tax liability[11] by the Operating Surplus for the 2011 Puerto Rico's economy.

These 2011 effective corporate tax rates by industry were applied to the 2012 gross operating surplus estimated at the 91 industry level. The resulting 2012 corporate tax liabilities were further adjusted pro rata to meet the total corporate tax revenue collection reported in the Planning Board's statistical appendices.

5.2.2. Partnership Income Tax Data (Form 884 and Form 844)

Partnership income tax data for year ending 2011 was provided to KPMG by the staff at the Treasury in the form of one Microsoft Excel file titled "Partnership Income Tax Return Data 2011 (884, 844).xlsx". The file contains 2011 Partnership tax data from Forms 884 and 844 (Option 94).

The Partnership Income tax is stored in Puerto Rico Income Tax Administration System (PRITAS) using DB/2 database and extracted for use by KPMG using Qlikview business intelligence software.

5.2.3 Controlled Foreign Corporations (CFCs)

The Treasury provided KPMG with data on CFCs in three separate Excel files: (1) "CFC-Non-Resident Withholdings FY2011-2013.xlsx", (2) "Tabla corp.xlsx", and (3) "Additional Tax Return Data for CFCs 6 16 2014.xlsx".

The "CFC-Non-Resident Withholdings FY2011-2013.xlsx" contains information on Non-Resident Withholdings for CFCs for FY2011 through FY2013, identified by NAICS. Each row (total of 40 rows) represents a CFC identified by Control Number variable, and each column represents tax data for different fiscal years. KPMG aggregated this data to NAICS level using the pivot tables feature in Microsoft Excel. According to Personnel at the Treasury, the Non-

[10] The 2011 and 2012 estimates of gross operating surplus at a detailed industry level were prepared by Dr. Angel L. Ruiz, an expert on the Puerto Rico IO tables and a consultant to the Puerto Rico Planning Board.

[11] The tax liability used in the calculation of the effective tax rate exclude overpayment components. It is because for some industries, the total tax liability including overpayment turns out to be larger than the estimated gross operating surplus. This case can happen for some individual firms, but it is not assumed to occur at the highly aggregated industry level.

Resident withholdings data is stored in Puerto Rico Income Tax Administration System (PRITAS) using DB/2 database.

The "Table Corp.xlsx" file provides detailed information on Law 154 Receipts, Regular Tax Liability, and Non-Resident Withholdings Tax for all CFCs for FY2013 and FY2014. The CFCs are identified by name. In addition, the file also contains information on total regular tax liability and total Non-Resident Withholdings Tax for regular corporations.

Treasury provided KPMG with "Additional Tax Return Data for CFCs 6 16 2014.xlsx" file, which contains information on CFCs for FY2012. Each row in the file represents a CFCs, while the columns represent selected tax data. The tax data for CFCs is stored in Puerto Rico Income Tax Administration System (PRITAS) using DB/2 database.

5.2.4 Patente Nacional Tax Data

Personnel at the Treasury provided KPMG with company level data on estimated 2013 Patente Nacional using 2011 corporate tax data as the base for the calculations. Each record in the "Estimated Revenues for Corporations with (Patente) Base Year data 2011 (Top 100 Place Incorporated Updated).xlsx" file represents a company. For each of the 43,369 companies, both exempt and non-exempt identified by 'Number ID', we were provided data on place of incorporation (to help identify whether the company is domestic or inbound), a NAICS code, and Patente Nacional base. NAICS information was missing for 4,327 out of the 43,369 records. According to the Treasury, the place of incorporation information, although populated for the vast majority of the observations, is unreliable. For instance, Wal-Mart, a United States based company was identified as a company incorporated in Puerto Rico. The file also contains select line items from Schedule A of the 2013 Corporate Income tax return showing computation of the Patente Nacional.

5.2.5 Intended Use of the Business Tax Data

As discussed above, to prepare the corporate income tax data for incorporation into the CGE model, we first aggregated the various tax items on these returns at the North American Industry Classification System (NAICS) level. Subsequently, we mapped the NAICS level aggregates to the 91 sectors of the CGE model.

Corporate income tax will be used in the CGE modeling analysis to measure after tax rate of return on capital and consequently the desired level of investment. It also influences the financing choices of firms in seeking financial capital for investment. Firms' decisions about the desired level of capital are solutions to an optimization problem relating the objective of maximizing shareholder wealth to underlying constraints. The constraints are imposed by period-on-period cash flow, tax rates, tax allowances, physical depreciation rates and other relevant factors.

The scarcity of capital implied in a desired level of capital in any period is reflected in capital rental prices. These rental prices enter the rate of return functions which generate demand for investment goods. The resulting new investment is used to augment the existing capital stocks as next period's production. Rates of return on capital are influenced by the benefits and costs of a unit of capital at the margin: the benefits relate to the after corporate and other tax income streams they produce and the after tax and financing value of unused capital at the end of a period, while the costs relate to the after tax and financing cost of capital used during the period in producing output.

In sum, corporate taxes, capital allowances of various types and the costs of finance combined to both the benefits and costs of capital discussed above determine the financial policy of the firm (that is, its choice of financing sources) and the rates of return to shareholders.

5.3 Consumption Tax Data

Consumption Tax Data was provided by the Treasury to KPMG in the form of four Microsoft Excel files listed in the table below:

Table 5.3: Consumption tax Files Provided by the Treasury

1	IVU por NAICS 6d- 2009-2013.xlsx
2	Model SC 2303.1 (Declaration of Alcoholic Beverages) by Code (2011, 2012, 2013).xlsx
3	Excise tax by code fiscal years 2012, 2013.xlsx
4	Book3.xlsx (Automobile Excise tax)

5.3.1 Sales and Use Tax

The "IVU por NAICS 6d- 2009-2013.xlsx" file contains data on Sales and Use tax collected at both the local (cant_local variable) and central (IVU variable) levels for FY2009 through FY2012 at the 6-digit NAICS level. Each row in the file represents a NAICS code, while the columns contain tax collection information. We understand, per the provisions of Subtitle D of the Puerto Rico Internal Revenue Code of 2011, that a 6 percent sales tax is levied on taxable items in Puerto Rico, while Municipalities are required to levy a one percent Sales and Use tax on the same base. However, the Sales and Use tax data in "IVU por NAICS 6d- 2009-2013.xlsx" file did not reflect this provision. According to personnel the Treasury, the Sales and Use Tax data is stored in Puerto Rico Income Tax Administration System (PRITAS) using DB/2 database and extracted for use by KPMG using Qlikview business intelligence software. We mapped the NAICS level aggregates to the 91 sectors of the CGE model.[12]

5.3.2 Excise Tax

The Excise tax data was provided in three separate files for the following categories: Alcoholic Beverages, Automobiles Excise Tax, and all other Excise Tax. According to personnel at the Treasury, the Excise tax data are stored in ADABAS using DB/2 software.

"Model SC 2303.1 (Declaration of Alcoholic Beverages) by Code (2011, 2012, 2013)" provided by the Treasury contains information on indirect tax revenues by type of alcoholic beverage. The file includes details of Type of Spirit by Key of Tax Type along with the dollar amount of

12 The mapping process is described in Appendix B of this document.

the excise tax, and the date on which from SC 2303.1 was filed by the excise taxpayer for taxable years 2011, 2012 and 2013. In addition, each record defined by Key of Tax Type and Date contains a NAICS code (or multiple NAICS codes in some instances). KPMG aggregated the data by Type of Spirit Key of Tax Type for each of the taxable years.
Although NAICS information was available, KPMG assigned the Alcohol Excise Tax amount directly to the relevant CGE model code.

The "Book3" file provided by the Treasury contains data on automobile excise taxes for the fiscal years 2012 and 2013. This file contains 10,757 records, with each record providing information on tax collection, NAICS code, and year. This is a micro-level file in which NAICS or year level aggregations have not been performed. In addition, only 3,148 out of the 10,757 records contain NAICS information. KPMG assigned the Automobile Excise Tax data for the year 2012 to the relevant CGE model codes.

The file "Excise Tax by Code Fiscal Years 2012 and 2013.xlsx" contains 1,989 observations, each identified by a unique serial number.

In addition, the "Excise Tax by Code Fiscal Years 2012 and 2013.xlsx" file contains NAICS information. The NAICS information is missing for some records with 320 and 2800 codes. In addition, 15 percent of the records contain multiple NAICS code. KPMG initially aggregated the data to excise tax code level (as listed in the table above) using Microsoft Excel's pivot table feature. Although NAICS information was available, we assigned the excise tax amounts for the different commodities directly to the relevant CGE model code using FY2012 data. We allocated excise tax to codes 797, 920, and 2800, codes that could not be mapped to a particular CGE model code, proportionally to other categories based on share of total excise tax.

5.3.3 Intended Use of the Consumption Tax Data

ACT 154 tax is imposed on gross receipts – the "producer's value" rather than the "purchasers' value" (which include margin costs like trade and transport, and other taxes). Therefore it is treated as a production tax rather than an indirect tax in the current CGE modeling framework. This implies ACT 154 tax is considered as part of the gross production costs of the 91 industries rather than as indirect tax which should be allocated across the commodity flows in the CGE data base.

Other taxes including sales and use tax, excise tax, and other miscellaneous taxes (covering toll gate tax and licenses) are treated as indirect taxes and are attached to each commodity flow in the model. The raw data provides the overall consumption tax by 92 commodities. The consumption tax estimates for each of 92 commodities will be allocated to different users, i.e., each industry, household, government and foreign agents. In this process, the tax status of exemption applied to specific users will be taken into account. In principle, the tax allocation across different users will be made in proportion to the total value of transaction for each user.

In FLAGSHIP-PR, it should be noted that the production matrix is diagonal (meaning that each commodity is produced by only one industry, and that each industry produces only one commodity) and so the industry / commodity nomenclatures are identical.

5.3.4 Reclassified aggregate Tax Variables

In the model, purchaser's prices will be different from producer's prices. The gap is represented by net tax components. As the tax revenue details are not defined according to the key aggregated variables used in the model, it is necessary to calculate implied aggregate tax rates associated with each aggregate variable.

5.3.5 Identification of Data Issues

Overall, there appears to be a high level of data availability across the required data list (discussed at the beginning of this section). There are four main issues to be considered further:

- some series are missing: the obvious missing data from the above list are variables relating to the capital markets such as capital stock and economic depreciation in constant prices (which will be different from accounting depreciation).

  At this stage, the capital stock series has been estimated by using the currently available real investment series and depreciation series. The real depreciation series can be derived by assuming its deflators are the same as the investment deflators.

- there are some data inconsistency issues over the longer-period data series.

  2001 data will be used as a linking factor to adjust the pre-2001 data series.

- data definitional issues - some redefinition has been required to allow the development of appropriate production and consumption behavior descriptor variables.

  where necessary, newly defined variables will be constructed using detailed information available from the Planning Board's statistical appendices.

- the problem of the quality of deflators which affects the reliability of the constant price series.

  Puerto Rico's trade with the US explains most trade volumes. As a result, alternative deflators for exports and imports will be constructed using the US trade deflators. As most investment goods are imported, alternative deflators of investment will be also constructed using the detailed import deflators

Given the recent refinements of consumer price index by the Planning Board, the consumer price deflators for both households and governments available in the national accounts will be used as they are. As the deflators for exports, imports and investment will be newly constructed, the GDP/GNP deflators will be also accordingly newly constructed.

5.3.6 Selection of Target Data Series

For the newly proposed macro model, the target variables are key national account aggregates only – specifically: private consumption; government consumption; investment; and foreign trades. The following two considerations will be taken into account when finalizing the aggregate modeling approach that is adopted:

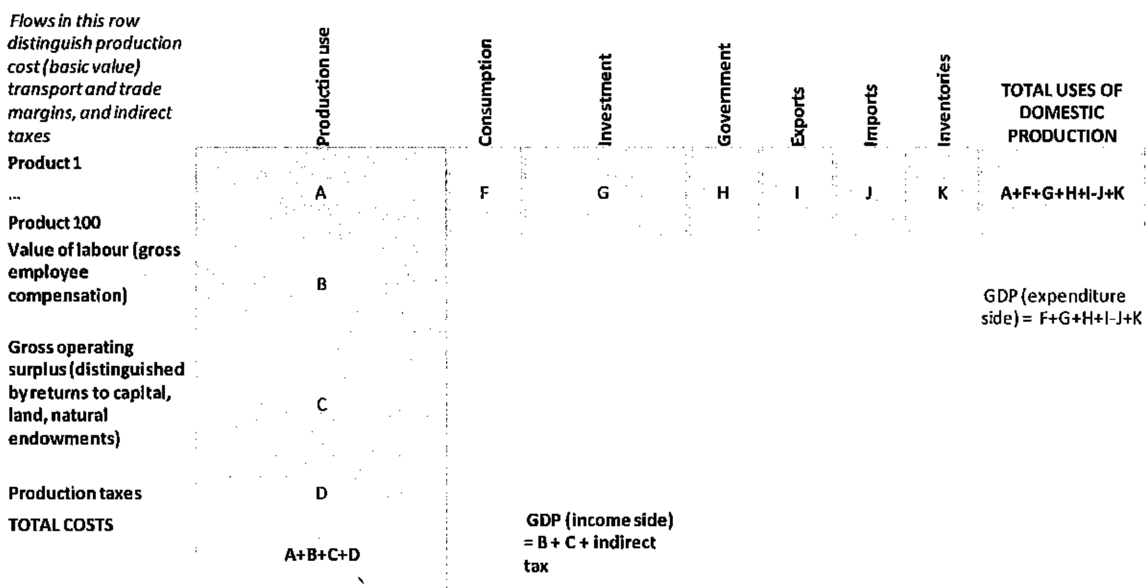
- When the aggregate historical movements are unexpectedly volatile (such as an investment series for a specific period), it is worthwhile investigating the disaggregated components to identify which ones best explain the volatility. In this case, additional information can be gained from modelling more detailed disaggregates.

- Detailed disaggregation of exports and imports at the commodity level will be useful when alternative export and import deflators are constructed – this would provide weights for the individual deflator series13.

5.4 National Accounts Data for use in the CGE model

A key component of the modeling is to construct a detailed empirical picture of the Puerto Rico economy. A key component of this detailed picture is provided by an input-output (IO) table, with the 2002 IO table from the Planning Board used as the starting point. The figure below provides a simple illustration of the IO database.

Figure 5-1: The input-output table structure



The 2002 Puerto Rico input-output table distinguishes 94 industries producing 94 commodities.

- Each production column provides information on the cost structure of each industry, including the industry's use of intermediate inputs, labor and returns to fixed factors (e.g. returns to capital, land and other natural endowments, and imputed wages to owners).

13 The individual deflators of detailed trade goods can be constructed using the corresponding US trade deflators. To construct an aggregate deflator index for exports and imports, the value shares of individual trade goods are used as weights for their individual deflators. As the value shares change over time, the weight system will be continuously updated.

- Each row shows the distribution of each commodity to different uses, including production, private consumption, gross fixed capital formation (investment, private and public), public consumption and exports.

The IO table was manipulated and rebalanced using a routine written in the GEMPACK software language. GEMPACK is also used for running the CGE model simulations.

For database manipulation and construction, the ability of this software suite to deal with very large arrays of data in complex ways affords us significant scope for checking and rebalancing raw IO data.

5.4.1 Issues in using IO data for the purpose of CGE modeling analysis

IO tables released by statistical agencies often contain errors that are only obvious when the table is analyzed in detail – these may include such things as negative margins on flows, negative implied taxes rates (when not appropriate), inconsistencies between aggregate sourcing of commodities and trade flows, misallocated values of various types, etc. Multi-step database construction routines are created to check (in part) consistency according to IO accounting concepts and economic theory, report the errors and then "cleanse" the database in ways consistent with appropriate notions of correctness that flow from these conventions.

Having passed through this checking and rebalancing routine, the database moves on to creating information in the database that was initially absent. For example, the official Puerto Rico input output table contains no explicit information about the per-flow distribution of margins and indirect taxes and the distribution of direct taxes across sectors. It also treats investment as a commodity vector without distinguishing sectoral gross fixed capital formation. These limitations are typical of IO tables in many countries and regions, but limit the usability of the data for detailed economic modeling.

5.4.2 Adjustments of IO data for the purpose of CGE modeling analysis

The above limitations were addressed in various ways[14]:

- It is preferable to distinguish the use of commodities for gross fixed capital formation by investing sector. The commodity vector for investment can be thought of in two ways: an add-up of the commodity use for capital creation purposes (from the totals), and as an indication of the average "technology" of capital creation for the entire economy (from the shares of each commodity in the column total). To properly understand how structural effects on the economy stem from changes in a particular subset of the production base, it is necessary to understand the technology of capital creation in each sector – that is, we need to turn the investment vector (i.e. a column of commodity use) into a matrix (i.e. a table of commodity use by each industry). The missing information relates to the technology for capital creation in each sector (the shares of commodities in each industry column). We make the assumption that capital creation in Puerto Rico proceeds with similar technology to that in the United States; that is, assume that (for example) buses, buildings, machinery and primary factors are used in similar proportions in a representative as compared to a US company. By using a detailed CGE database (constructed previously by KPMG economists) of the United States that incorporates an investment matrix, we mapped values for commodity use in investment by 534 sectors in the US database into the

14 More detail is to be provided in the full model documentation at a later time.

91 Puerto Rican sectors and calculated the shares of commodity use by IO sector in such a way that (a) the correct "capital creation technology" was retained while (b) the row totals equaled the values in the original investment column.

- We found no information on per-flow margin use for the economy of Puerto Rico. The official Puerto Rico IO table includes four sectors that we identified as margins: (1) road freight transport, (2) water transport and ports, (3) air transport, and (4) "trade" (representing wholesale and retail margins). These totals enter the Puerto Rico IO table as four rows of intermediate use to each sector producing the commodities, and four rows of purchases for each final demand agent (households, investors, government, exports and inventory accumulation). Knowing (therefore) the column totals, we needed information about the share of the purchasers' value of a particular flow that was comprised of margins – that is, the services that assist in its transfer from producer to purchaser. In effect, we needed to take each value for a given margin in each column and spread it across the flows of commodities in that column. Again, we made use of the shares in the US CGE database to attribute these margins to each flow in such a way that (a) the shares reflected those in a remapped (535 US IO commodities to 92 Puerto Rican IO commodities) and (b) added to the correct scalar totals in each column implied by the official Puerto Rico IO table.
- Indirect taxes were deduced from the detailed taxation data as described in the previous sections.e. Where information existed to distinguish between implied average taxation rates for a particular commodity flow to a particular user, this information was applied to appropriately distinguish the tax on that flow from the average. Where such information did not exist, the average of the residual tax collections was applied ad valorem across the remaining commodity flows, in effect imposing the assumption that these flows faced common average indirect taxation rates.
- Direct taxes for each sector were ascribed to sector-of-origin using a similar method to that for indirect taxes. A key difficulty concerned taxes on gross operating surplus; several sectors in the official IO table reported negative gross operating surplus, but detailed data on taxation revenue implied positive direct tax payments. This implies that some firms within these sectoral aggregations were profitable and paying income taxes, while the sum of all firms' gross operating surplus in that sector was negative. This inconsistency at the aggregate level implies a negative tax rate on capital income in those sectors, which is clearly not true. At the time of writing, an essentially atheoretic linkage between overall industry activity and the level of tax payments on gross surplus has been applied; a more sophisticated handling of this discrepancy is planned for a version of the model utilizing the newer IO table due to be released in 2015.

Another example of database augmentation made at this stage was the creation of a split of the gross operating surplus data. Typically, gross operating surplus is reported in a single row in an IO table, and does not distinguish the gross income flows due to the sub categories of fixed factors (capital, land, natural endowments and so on). Information was sourced from (a) the more detailed 1992 official IO database and from Dr. Angel L. Ruiz, an ex-academic consultant to the Puerto Rico Planning Board. This split is critical in assuring accuracy on several fronts; for example, the correct determination of returns to capital for calculation of rates of return, and the correct estimation of tax bases for things like property taxes and corporate taxes.

Having completed this stage of the routine, the final phase of the database program is designed to (a) format the data in the manner required by the model's equations and (b) create a set of output files in header array format for use as the model database. Additional detail on the construction of the CGE database, including the role of the GEMPACK construction routine, will be provided in final model documentation.

5.4.3 Key Economic Indicators in the CGE database

As the latest available official input-output table refers to the year 2002, the model database was updated to 2011-12 by aligning it with the latest national accounts data for economic growth and inflation from 2002 to 2012.

This process ensures that the 2011-12 model database is fully compatible with key National Accounts data. This includes advancing the database to match the 2011-12 GDP by Industry and Expenditure data (private consumption, government consumption, changes in inventories, capital expenditure and trade).

The resulting 2011-12 CGE data base provides detailed commodity and industry disaggregation of the key national accounts variables such as gross domestic product, household consumption, government consumption, investment, exports and imports. The production side of the national accounts represented by value added components of each industry - the total compensation of employees and gross operating surplus - is also reflected in the CGE data base. Appendix A contains a list of CGE model sectors.

5.4.4 Data Source for sectoral compositional updates from 2002 to 2012

Various input-output (IO) information from 1997 to 2012 is provided by Dr. Ruiz. Such IO information appears to be compatible with the Planning Board's national accounts data at a reasonable level. From this observation, the sectoral growth rates generated from these tables are assumed to be compatible with the macro growth rates derived from the Planning Board's statistics. Dr. Ruiz's IO information is based on a 382 industry classification. Using a mapping between the 382 classification and 91 classification based on the NAICS concordance, the value added estimates of 382 industries developed by Dr. Ruiz has been aggregated into the 91 sectors.

Using the 91 sector version of Dr. Ruiz's IO information, the growth rates of four value added components – wage components, gross operating components, indirect tax components and subsidies component – of the 91 industries from 2002 to 2012 have been estimated. After some adjustment to remove "zero" values and mapping inconsistencies, final value added estimates of the 91 sectors for each year have been derived.

These annual industry value added estimates have been used in upgrading the 2002 CGE database to the 2012 economy. The same data is also used to apply the corporate income tax data and wage income tax data to the 91 sectors.

It should be noted that there are official data sources for sectoral value added. They include:

- In_PIB-2002.xlsx: value added items by industry for 2002
- In the Planning Board statistical appendix: the national accounts files also provide 20 sector value added components.

The above sectoral information has not been fully utilized in the CGE database development. The main reasons are:

- value added is only provided in net terms, i.e. excluding depreciation,
- gross value added items are provided in aggregate – without separating out the major four components as in Dr. Ruiz's IO information, and
- The exact mapping between the 20 sector classification developed by the Planning Board and the 91 sector (with 92 commodity) classification adopted in the CGE model cannot be properly established.

6 Comparative Static Simulation Results

This section summarizes the key CGE model results under 31 different tax policy simulations that KPMG was asked to produce throughout the course of the project. The scenarios to be simulated were chosen by Puerto Rico's management. Treasury staff reviewed the analysis to ensure consistency with their knowledge of the Puerto Rico economy.

For each scenario the general equilibrium effect of the tax experiment on revenue, disaggregated by revenue from a Goods and Services Tax (GST), individual income tax, and sales and use tax (IVU), is reported. In addition, each simulation produces an aggregate impact on government revenue and impact on real gross domestic product. These figures are reported in the tables below as well.

Unless otherwise stated, GST simulations assumed a $75,000 small business exemption (SBE).

Table 1: Replacement of Current Sales Tax (IVU) with 14% GST. Replacement of current individual income tax with new income tax with exemption levels of $60,000/$30,000 for married and single taxpayers.

Variable	65% GST Compliance	75% GST Compliance	85% GST Compliance
Change in GST Revenue	$5,400	$6,204	$7,002
Change in IVU Revenue	($1,148)	($1,152)	($1,156)
Change in Income Tax Revenue	($465)	($478)	($490)
Change in Net Annual Revenue	$3,804	$4,593	$5,376
Percent Change in Real GDP	(0.35)	(0.48)	(0.62)

Table 2: Replacement of Current Sales Tax (IVU) with 16% GST. Replacement of current individual income tax with new income tax with exemption levels of $60,000/$30,000 for married and single taxpayers.

Variable	65% GST Compliance	75% GST Compliance	85% GST Compliance
Change in GST Revenue	$6,147	$7,059	$7,963
Change in IVU Revenue	($1,152)	($1,156)	($1,161)
Change in Income Tax Revenue	($477)	($491)	($505)
Change in Net Annual Revenue	$4,537	$5,432	$6,319
Percent Change in Real GDP	(0.47)	(0.63)	(0.79)

Table 3: Replacement of Current Sales Tax (IVU) with 14% GST. Replacement of current individual income tax with new income tax with exemption levels of $70,000/$35,000 for married and single taxpayers.

Variable	65% GST Compliance	75% GST Compliance	85% GST Compliance
Change in GST Revenue	$5,402	$6,206	$7,004
Change in IVU Revenue	($1,147)	($1,151)	($1,155)
Change in Income Tax Revenue	($646)	($657)	($669)
Change in Net Annual Revenue	$3,627	$4,417	$5,201
Percent Change in Real GDP	(0.27)	(0.41)	(0.55)

Table 4: Replacement of Current Sales Tax (IVU) with 14% GST. Replacement of current individual income tax with new income tax with exemption levels of $70,000/$35,000 for married and single taxpayers.

Variable	65% GST Compliance	75% GST Compliance	85% GST Compliance
Change in GST Revenue	$6,149	$7,061	$7,965
Change in IVU Revenue	($1,151)	($1,156)	($1,160)
Change in Income Tax Revenue	($657)	($670)	($683)
Change in Net Annual Revenue	$4,361	$5,257	$6,145
Percent Change in Real GDP	(0.40)	(0.56)	(0.72)

Table 5: Replacement of Current Sales Tax (IVU) with 14% GST with and without exemption on food related goods and services (assuming 75% GST compliance rate). Replacement of current individual income tax with new income tax with exemption levels of $70,000/$35,000 for married and single taxpayers.

Variable	14% GST on All Goods and Services	14% GST with an exemption on food
Change in GST Revenue	$6,206	$5,512
Change in IVU Revenue	($1,151)	($1,147)
Change in Income Tax Revenue	($657)	($656)
Change in Net Annual Revenue	$4,417	$3,730
Percent Change in Real GDP	(0.41)	(0.32)

Table 6: Replacement of Current Sales Tax (IVU) with 16% GST with and without exemption on food related goods and services (assuming 75% GST compliance rate). Replacement of current individual income tax with new income tax with exemption levels of $70,000/$35,000 for married and single taxpayers.

Variable	16% GST on All Goods and Services	16% GST with an exemption on food
Change in GST Revenue	$7,061	$6,268
Change in IVU Revenue	($1,156)	($1,150)
Change in Income Tax Revenue	($670)	($668)
Change in Net Annual Revenue	$5,257	$4,473
Percent Change in Real GDP	(0.56)	(0.45)

Table 7: Replacement of Current Sales Tax (IVU) with 14% GST at various compliance rates. No change in individual income tax regime.

Variable	65% GST Compliance	75% GST Compliance	85% GST Compliance
Change in GST Revenue	$5,397	$6,201	$6,998
Change in IVU Revenue	($1,149)	($1,153)	($1,157)
Change in Income Tax Revenue	($95)	($109)	($124)
Change in Net Annual Revenue	$4,168	$4,595	$5,735
Percent Change in Real GDP	(0.49)	(0.63)	(0.77)

Table 8: Replacement of Current Sales Tax (IVU) with 16% GST at various compliance rates. No change in individual income tax regime.

Variable	65% GST Compliance	75% GST Compliance	85% GST Compliance
Change in GST Revenue	$6,143	$7,055	$7,958
Change in IVU Revenue	($1,153)	($1,157)	($1,162)
Change in Income Tax Revenue	($108)	($125)	($141)
Change in Net Annual Revenue	$4,899	$5,791	$6,675
Percent Change in Real GDP	(0.62)	(0.78)	(0.94)

Table 9: Replacement of current individual income tax with new income tax structure with exemption levels of $70,000/$35,000 for married and single taxpayers. No change in IVU and no introduction of a GST.

Variable	
Change in GST Revenue	$0
Change in IVU Revenue	$2
Change in Income Tax Revenue	($570)
Change in Net Annual Revenue	($565)
Percent Change in Real GDP	0.22

Table 10: Replacement of Current Sales Tax with 14% GST with 75% compliance rate and various small business exemption (SBE) levels. Replacement of current individual income tax with new income tax with exemption levels of $70,000/$35,000 for married and single taxpayers.

Variable	$75K SBE	$100K SBE	$200K SBE
Change in GST Revenue	$6,206	$6,158	$5,735
Change in IVU Revenue	($1,151)	($1,151)	($1,149)
Change in Income Tax Revenue	($657)	($657)	($655)
Change in Net Annual Revenue	$4,417	$4,370	$3,951
Percent Change in Real GDP	(0.41)	(0.40)	(0.35)

Table 11: Replacement of Current Sales Tax with 16% GST with 75% compliance rate and various small business exemption (SBE) levels. Replacement of current individual income tax with new income tax with exemption levels of $70,000/$35,000 for married and single taxpayers.

Variable	$75K SBE	$100K SBE	$200K SBE
Change in GST Revenue	$7,061	$7,007	$6,527
Change in IVU Revenue	($1,156)	($1,155)	($1,153)
Change in Income Tax Revenue	($670)	($669)	($667)
Change in Net Annual Revenue	$5,257	$5,203	$4,729
Percent Change in Real GDP	(0.56)	(0.55)	(0.50)

Table 12: Replacement of Current Sales Tax with 14% GST at 75% compliance rate and various goods and services exempted. Replacement of current income tax with new income tax with exemption levels of $70,000/$35,000 for married and single tax payers.

Variable	14% GST on All Goods	14% GST w Electricity Exemption	14% GST w Water Exemption	14% GST w Medicines Exemption
Change in GST Revenue	$6,206	$6,098	$6,172	$5,819
Change in IVU Revenue	($1,151)	($1,152)	($1,151)	($1,152)
Change in Income Tax Revenue	($657)	($658)	($657)	($653)
Change in Net Annual Revenue	$4,417	$4,308	$4,383	$4,038
Percent Change in Real GDP	(0.41)	(0.41)	(0.41)	(0.32)

Table 13: Replacement of Current Sales Tax with 14% GST at 75% compliance rate and various goods and services exempted. Replacement of current income tax with new income tax with exemption levels of $70,000/$35,000 for married and single tax payers.

Variable	14% GST on All Goods	14% GST w Medical Services Exemption	14% GST w Educational goods and services exemption	14% GST w all necessities exemption
Change in GST Revenue	$6,206	$5,657	$6,009	$4,253
Change in IVU Revenue	($1,151)	($1,153)	($1,152)	($1,150)
Change in Income Tax Revenue	($657)	($652)	($657)	($646)
Change in Net Annual Revenue	$4,417	$3,869	$4,218	$2,477
Percent Change in Real GDP	(0.41)	(0.38)	(0.45)	(0.22)

Appendix A

Listed below are the CGE model sectors along with the corresponding Standard Industrial Classification (SIC) code.

SIC Code and Description

00100 Sugar Cane

00200 Other Agriculture, Forestry & Fishing

00300 Agricultural Services

11000 Mining

15100 New Construction

15200 Building Maintenance and Repair

20100 Meat and Meat Products

20200 Milk and Dairy Products

20300 Canned and Preserved Fruits and Vegetables

20400 Grain Mill Products

20500 Bakery Products

20610 Sugar Mills, Refineries & Confectionery

20820 Beer, Malt & Alcoholic Beverages

20870 Bottled and Canned Soft Drinks

20900 Miscellaneous Food Products

20910 Canned and Cured Fish

21000 Tobacco Products

22000 Textile Mill Products

23000 Apparel and Accessories

24000 Lumber and Wood products

26000 Paper and Allied Products

27000 Printing and Publishing

28100 Petrochemicals

28300 Drugs and Pharmaceutical Preparations

28400 Other Chemical Products

29100 Petroleum Refining

29200 Other Petroleum Products

30000 Rubber and Plastic products

31000 Leather and Leather Products

32100 Stone, Clay, Glass and Concrete Products

33000 Primary Metal Products

34000 Fabricated Metal Products

35000 Machinery, Except Electrical

36000 Electrical and Electronic Machinery

37000 Transportation Equipment

38000 Professional and Scientific Instruments

39000 Miscellaneous Manufacturing Industries

41100 Local Passenger Transportation and Taxicabs

41200 Buses

42000 Motor Freight Transportation and Warehousing

44000 Water Transportation

45000 Air Transportation

47100 Transportation Services

47200 Travel Agents

48100 Telephone, Telegraph, and Cable

48300 Radio and Television Broadcasting

49100 Electricity and Irrigation services

49200 Gas and Sanitary Services

49400 Water and Sewerage Services

50000 Wholesale and Retail trade

61100 Commercial Banks

61200 Mortgage Banks and Brokers

61300 Saving and Loan Associations

61400 Credit Unions

61500 Security and Loan Brokers

61600 Personal Credit Institution, 61700 Conditional Loan Credit Institutions, 61800 Other Credit Institutions[15]

63100 Life, Accident, and Health Insurance

63200 Other Insurance

63300 Insurance Agents, Brokers, and Services

65100 Real Estate

70110 Tourists Hotels

70120 Other Hotels and Lodging Places

72100 Laundry, Cleaning, and Garment Services

72200 Photographic Studios

72300 Beauty and Barber Shops

72600 Funeral Services

72900 Shoe Repair, Cleaning and Other Personal Services

73100 Advertising

73200 Other Business Services

75100 Automotive Rental and Leasing

75200 Automobile Parking

75300 Automotive Repair and Other Repair Services

78100 Motion Pictures Production and Distribution

78300 Motion Pictures Theaters

78400 Theatrical Producers, Orchestras and Entertainers

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[15] SIC codes 61600, 61700 and 61800 have been aggregated into the same CGE model code.

78500 Race Tracks and Stables

78600 Other Miscellaneous Recreation Services

80100 Physicians and Surgeons

80200 Dentists

80600 Hospitals

80700 Medical and Dental Laboratories

80800 Miscellaneous Health Services

81100 Legal Services

81200 Educational Services

81300 Engineering and Architectural Services

81400 Accounting and Auditing Services

83000 Non-Profit Organizations Services

88000 Domestic Services

90100 Commonwealth Government

90200 Municipal Government

90300 Federal Government

99000 Non-Classified Industries