

Development of Computable General Equilibrium Model for Sierra Leone

Draft Report

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Abbreviations

CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
CIF	Cost Insurance and Freight
EPRU	Economic Policy Research Unit
FOB	
GDP	Gross Domestic Product
MAMS	Maquette for MDG Simulations (MAMS)
MOFED	Ministry of Finance and Economic Development
SAM	Social Accounting Matrix
SLIM	Sierra Leone Integrated Macroeconomic model
SUT	Supply Use Table
VAT	Value added Tax

1. Background/Introduction

The Economic Policy Research Unit (EPRU) within the Ministry of Finance and Economic Development (MOFED) has been implementing the Sierra Leone Integrated Macroeconomic (SLIM) to produce its macroeconomic forecasts. The SLIM model is a typical financial programming model which covers four sectors including the real, fiscal, external and monetary sectors. This model yields a set of accounts which are consistent with each other and has been used to produce the annual economic bulletin as well as providing the basis for negotiations with multilateral organizations. The model has overtime been complimented with forecasting modules with the objective of enhancing the robustness of results produced. While this model has served MOFED well, it has specific weaknesses that can only be addressed by complementing the tool with other modelling methods. Key among them include the level of aggregation of the model especially for the real sector. The second major weakness of the model is the fact that the framework cannot be used to simulate “what if scenarios” for policy questions of specific interest given that it has no feedback effects. For example being that Sierra Leone is a commodity dependent country, authorities would be interested to know the implications of commodity price shocks on the economy and how the various agents in the economy would be affected instantly and over time. This would require complementing the SLIM model with a more comprehensive Computable General Equilibrium model. The development of the CGE model is not meant to replace the SLIM model as both tools play different roles. Whereas the SLIM model is largely a forecasting tool, CGE models are mainly used to produce “what if” simulations.

CGE models have been widely used by policy makers. They are usually real models without the financial or banking system. CGE models are calibrated to a social accounting matrix of a given year using either GAMS, GEMPACK equipped with nonlinear optimization tools or any other high level programming environment. The social accounting matrix is the key source of information which would include the following information: (i) production activities of various sectors, their intermediate use of inputs, firm’s value added, (ii) various types of households depending on the level of aggregation which consume, earn income, pay taxes and save part of their income, (iii) government which consumes (spends) and taxes firms and households, and (iv) and external sector where the country engages in exports of part of its produce and imports to complement its domestic production. The development of the SAM therefore requires various sources of information of which key among them would include: (i) Supply Use Table (SUT) which captures the production activities in the country, intermediate use of inputs by firms, consumption by households and government, imports, and exports. The SUT also includes the Value added by firms. To a large extent it captures GDP in three forms including the income, expenditure and value added approach thereby providing another avenue to check consistency of the national accounts. The second key source of information is government statistics particularly on taxes, expenditure and savings. Lastly, the third source of information to develop the SAM is external data covering both exports and imports. The SAM is also enriched by household surveys which would usually have information on the shares of consumption in the total consumption basket of households as well as incomes of the various types of households. Labor force surveys are also useful especially where issues related to skills composition in value addition are of interest.

Given the brief description of the CGE model, this inception report attempts to outline some

of the key steps and road map that will be followed to develop the model. The inception report will also highlight briefly the methodologies that would be desired at the various stages of the road map and these methodologies will be expounded in the major report. The report will also make a justification for developing the model and the underlying data required. In particular, to develop a SAM the authorities would need to have a Supply User Table which can also be used for other purposes like rebasing the GDP.

2. Objectives of the assignment

The general objective of the assignment is to advise on improvements to the macro-economic forecasting model and to prepare a roadmap for transition to a Computable General Equilibrium (CGE) Model. This will include advice on the design of an input-output table, which is the first step in the construction of a social accounting matrix. Specific areas include the following:

- Design a road map for the development of CGE specifying the successive steps;
- Present a Supply User Table (of which the input-output table is a subset of the SUT) required for the CGE.
- Prepare methodology for development of the SAM and identify what is required.
- Review available datasets for the SUT and SAM.
- Work with statistics office to draft the questionnaire for an enterprise survey.
- Draft the methodological guidelines for the survey, including options to conduct the survey, sample frame design and framework to input field survey data; and
- Advise on the design of the survey (define sectors of activity, determine sampling technique).
- Advise on the types of CGEs and their methodological underpinnings and what might be required.
- Advise on the capacity development required at the various stages of the road map.

3. Justification for the Development of Computable General Equilibrium Model

Development of the CGE model for Sierra Leone will greatly enhance the analytical capacity of the authorities. The underlying model structure of the CGE model is underpinned by the SUT which are usually rich in the production structure, demand by various agents and the relationship of Sierra Leone to the rest of the world in form of its exports and imports. The well disaggregated production structure would enable analysis of policy implications on various activities and the multiplier effects as well. This tool will be useful in assessing the various potential sources of growth for both the production and expenditure side of GDP. The tool could also be useful to assess the policy implications on the structural transformation of the Sierra Leone economy over time.

Poverty and income distribution remains a key concern for any policy maker. Currently, the PRSP is the planning framework linking poverty to various policy choices implemented by government. However, analytically there is a missing link between expected poverty reduction and the policy choices at hand. CGE models have been used to fill that gap through two major methods. First is by having disaggregating representative households according to (regions, incomes, urban/rural, gender etc.) it is possible to use this tool to assess the implications of policy changes on various types of households. The second alternative is to link the CGE model to micro household datasets through micro-simulation models. These models are rich enough to capture what if implications of policy choices on poverty and income inequality.

Unemployment especially among the youth remains one of the key challenges in many countries including Sierra Leone. Given the various categories of labor (unskilled, semi-skilled, and skilled) in CGE models they can provide rich analytical information on the implications of policies on labor market outcomes. The various types of skills could be tied with the demand for various types of education provided (primary, secondary, tertiary and vocational). This model could therefore be useful in assessing the implications of policy choices on skills formation and employment effects.

Government is usually faced with budgetary constraints given the limited resource envelope. The level of disaggregation of government demand (infrastructure, education, health, security etc.) could be very useful in assessing the tradeoffs involved in the allocation of resources. Because of the multiplier effects of government demand on other activities, it is possible to use the CGE model to assess the implications of expenditure choices on the entire economy.

There is always a tradeoff between the set tax rates and their implications on the tax base as well as tax collection. High tax rates can potentially shrink the tax base and thereby defeat the purpose of increasing the level of tax revenues. Such intricate relationship can only be captured by using a detailed CGE model which has various agents (firms, households) as tax payers.

Many countries are now switching back to producing long-term plans and embedding them with Sustainable Development Goals. The long-term benefits between investing now in infrastructure vis-à-vis human capital development (education and health) can only be captured in a multi sector CGE model. This tool would therefore be critical for producing consistent simulations over the medium and long-term periods to meet the SDGs.

There is considerable interest by countries to adopt Green Growth Strategies with the objective of circumventing the challenges of climate change. Sierra Leone has an opportunity of developing the SUT which is detailed enough to include activities that are considered critical

for Green Growth. The CGE model with a supplier user table embedded with green growth opportunities would be very useful in quantifying the benefits of green growth.

The various steps required to develop a Computable General Equilibrium model for Sierra Leone will also come with benefits. Sierra Leone has never developed a SUT before. SUTs provide a coherent and consistent framework for estimating GDP (together with its major components) from the production, income and expenditure approaches of GDP simultaneously, and thereby enables balanced estimates of GDP to be compiled that are identical in all the three approaches. Therefore by developing the SUT for the GDP, this objective would simultaneously be achieved.

Sierra Leone is overdue to rebase its GDP (currently based on 2006 prices) since the production structure of the economy must have changed. The rebasing of the GDP is therefore overdue and the SUT would provide an underpinning for this exercise. Under the SUT framework there is no scope for statistical discrepancy, as this framework enables the national accountants to scrutinize the flows of goods and services in both supply and use tables and make appropriate adjustments in the weak areas of estimation, either on the supply or on the use sides, in a systematic manner. It is indeed recommended to compile SUT tables after every five years for purposes of rebasing GDP.

The SUT will provide a coherent framework for the reconciliation of data sets from various sources. Currently the Statistics department is involved in compilation of various type of statistics through surveys. The SUT is the overall tool which incorporates all primary economic data into a framework that is interconnected and integrated. Some of the key sources of this data include administrative sources, industrial surveys, household income-expenditure surveys, investment surveys, foreign trade statistics and balance of payments statistics. To the extent possible, the SUT will be used to identify inconsistencies in various data sources and provide a systematic way on how to address the inconsistencies.

This exercise will also greatly enhance the capacity of the statistics department and enable them to meet the challenges in implementing 2008 SNA. To a large extent compilation of the SUT will not only improve the quality of the national accounts but also enhance the capacity of the authorities.

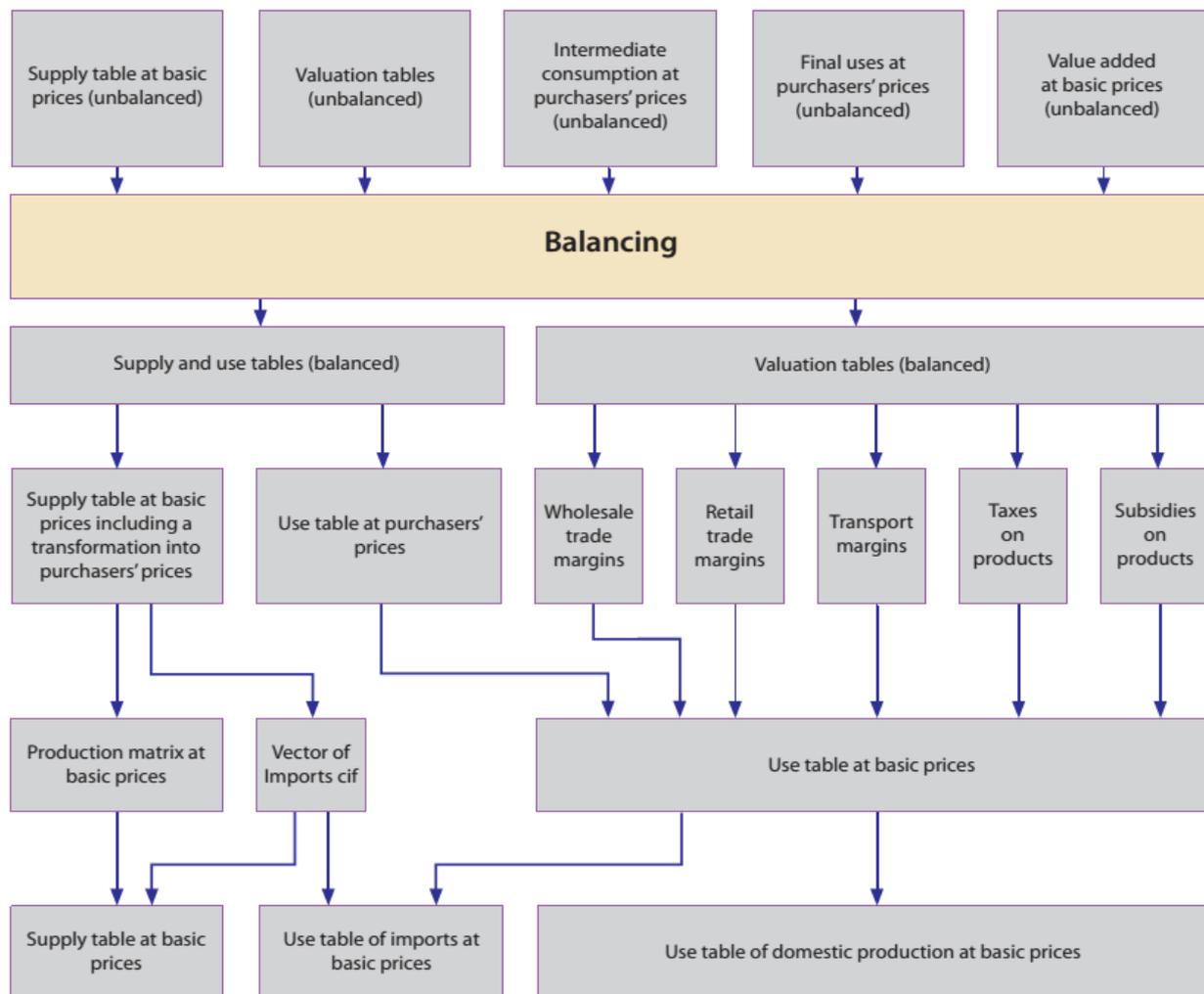
The implied input-output tables from the SUT will also be useful for partial equilibrium analytical work. SUTs are the basis for the construction of symmetric input-output tables. Input-output analysis has become an economic tool since Leontief introduced an assumption of fixed-coefficient linear production functions relating inputs used by an industry along each column to its output flow, i.e., for one unit of every industry's output, a fixed amount of input of each kind is required. They are powerful matrices which can easily be used to assess the implications of change in one activity on all other activities in the economy in a partial equilibrium setting.

4. Supplier User Table Required for the CGE

Methodologies for the compilation of the SUT have been well explained by various authors. The key reference is the “Handbook on Supply and Use Table: Compilation, Application, and Practices Relevant to Africa” whose last version was 2012 and was published by the United Economic Commission for Africa. Other references include the “Handbook of Input-Output Table Compilation and Analysis” published by the Department of Economic and Social Economic Affairs, Statistics department (United Nations) and dated 1999. Both these references contain detailed methodologies on compiling the SUT and its eventual conversion to the Input-Output tables. Therefore the objective of this section is not to repeat what has been well elaborated in these two manuals. Rather we highlight the key processes and steps that will be required and the basic tables required that will be useful in compilation of the SUT that is relevant for the eventual development of the CGE.

Compilation of the supply use table is a comprehensive exercise which is dependent on compilation of various types of tables. The first step in compiling the SUT tables is to compile the separate tables for supply, valuation, intermediate uses and final uses. This process is summarized in figure 4.1 below.

Figure 4.1: Compilation process of the SUT



Source: Eurostat Manual for Supply Use Table and Input-Output Tables (2008).

4.1 Supply Table

The supply table which is compiled at basic prices consists of two sub matrices: first is the table of domestic output and second is the table of imports. The second important table are the valuation tables which would have information on taxes less subsidies on products, trade margins and transport margins. This set of tables are used to adjust production at basic prices to purchase prices. The third table is the one on intermediate consumption at purchaser prices mainly showing the input requirement of goods and services for production of outputs of each industry. The third table to be compiled is the final consumption by households, non-profit institutions, government, gross fixed capital formation, changes in inventories and exports of goods and services. Lastly, we would also need a table on value added at basic prices. The value added table consists of compensation of employees, taxes on production, consumption of fixed capital and net operating surplus. Figure 4.2 below provides samples of tables are required for the compilation process.

Figure 4.2: Samples of tables required for the Supply Table

Supply table at purchasers' prices

INDUSTRIES \ PRODUCTS	INDUSTRIES						VALUATION									
	Agriculture	...	Other service activities	Total output at basic prices	Imports CIF	Total supply at basic prices	Trade margins	Transport margins	Non-deductible VAT	Other taxes on products	Taxes on imports	Subsidies on products	Total supply at purchasers' prices			
No	1	:	6	7	8	9	10	11	12	13	14	15	16			
1	Products of agriculture															
6	Other services															
7	Output at basic prices															

Trade margins

1	Products of agriculture			
6	Other services			
7	Output at basic prices			

Transport margins

1	Products of agriculture			
6	Other services			
7	Output at basic prices			

Use table at purchasers' prices

INDUSTRIES \ PRODUCTS	INDUSTRIES			FINAL USES					
	Agriculture	...	Other service activities	Total	Final consumption	Gross capital formation	Exports	Total	Total uses at purchasers' prices
No	1	:	6	7	8	9	10	11	12
1	Products of agriculture								
6	Other services								
7	Total								
8	Compensation of employees								
9	Other net taxes on production								
10	Consumption of fixed capital								
11	Operating surplus, net								
12	Value added a basic prices								
13	Output at basic prices								

Subsidies on products

1	Products of agriculture								
6	Other services								
7	Total								

Taxes on imports

1	Products of agriculture								
6	Other services								
7	Total								

Other taxes on products

1	Products of agriculture								
6	Other services								
7	Total								

Non-deductible VAT

1	Products of agriculture								
6	Other services								
7	Total								

Transport margins

1	Products of agriculture								
6	Other services								
7	Total								

Trade margins

1	Products of agriculture								
6	Other services								
7	Total								

Source: Eurostat Manual for Supply Use Table and Input-Output Tables (2008).

The process of compilation would also involve the balancing process as the original tables would all be unbalanced. This process is iterative to ensure that the supply after being adjusted to purchases prices is equal to total use and equal to the value added.

Imports under the SUT are valued at FOB prices. But on the other hand imports data is usually valued at CIF prices. An adjustment row is therefore included to reconcile the different valuations of imports. Also an extra row is added to the supply table for direct purchases abroad by residents. Both extra rows are required to derive gross domestic product at market prices from the supply and use system.

The production matrix would largely be derived from survey sources and in this particular case it will be derived from the Enterprise survey for the non-agricultural enterprises and Agriculture survey for the agriculture enterprises. The industries that are producing products would be reported as columns while the products produced are in rows. Note that an industry can potentially be producing many products. This implies that this matrix may not necessarily be a square matrix with entries on the diagonal. Typically industries would have a primary activity and secondary activities. For instance a construction enterprise primary activity might be construction but might as well be involved in quarrying of stones.

To the extent possible it is desirable to have access to a full sized import matrix which comprises of industries mapped into products that they import. The import matrix is critical to know the total amount of goods in the economy and useful for the construction of the input-output data. The two major sources of data for this category will be the customs department of the National Revenue Authority.

The enterprise survey should be designed in such a way that data on trade margins by whole sale and retail level can be adequately captured. In this case the questionnaire for the trade sectors will be designed to capture the trade margins directly. Trade margins are the difference between actual revenues realized on goods and services minus cost of purchased goods for resale.

It is important to separate transportation margins between domestic and imported transport services. The following steps could be followed to estimate the transport margins. Using the trade row, the transportation margins for land transportation services of an industry are estimated by multiplying the national total output of land transportation services with the participation rate of the specific industry and the share of product revenues relevant for transportation services. Transportation margins for other transportation services of an industry are estimated by multiplying the national total output of other transportation services with the participation rate of the specific industry and the share of product revenues relevant for transportation services.

To compile transport margins for imported transportation services, net imports are defined as total imports CIF less total exports FOB. The imported transportation margins for land transportation services of an industry are estimated by multiplying the national total of net imports of land transportation services with the participation rate of the specific industry and the share of product revenues relevant for transportation services. Imported transportation margins for other transportation services of an industry are estimated by multiplying the national total of net imports of other transportation services with the participation rate of the specific industry and the share of product revenues relevant for transportation services.

Information on taxes and subsidies is crucial in the transformation of supply at basic prices to

purchaser's prices. This information will be derived from the data on revenues compiled by the National Revenue Authority. The key taxes to be included in this case are: (i) Non-deductible value added tax (VAT); (ii) Taxes on products, except VAT and import taxes; (iii) Subsidies on products, and; (iv) Taxes and duties on imports excluding VAT.

4.2 Use Table

The use table presents the use of goods and services by products and by type of use for intermediate consumption by industry, final consumption expenditure, gross capital formation and exports. It also shows the components of gross value added by industry for compensation of employees, other taxes less subsidies on production, consumption of fixed capital, and net operating surplus. The type of table and its sources desirable are provided in figure XX. The source of information for this table for intermediate use of goods, gross fixed capital formation and value added will be the enterprise survey complimented and the agriculture census survey. Final consumption by households will be derived from the household survey. The consumption of government will be derived from the detailed fiscal accounts. Finally exports of goods and services will be derived from national accounts data on trade statistics. Figure 4.3 below provides a summary of tables required for the compilation of the USE table.

Figure 4.3: Tables required for compilation of USE table

INDUSTRIES	INPUT OF INDUSTRIES				FINAL USES									Total use at purchasers' prices
	Agriculture	.	Other services	Total	Final consumption by households	Final consumption by non-profit institutions	Final consumption by government	Gross fixed capital formation	Changes in valuables	Changes in inventories	Exports intra EU FOB	Exports extra EU FOB	Total	
PRODUCTS (CPA)	1	.	59	60	61	62	63	64	65	66	67	68	69	70
1 Products of agriculture														
...														
59 Other services														
60 Total														
61 CIF/FOB adjustments exports														
62 Purchases abroad by residents														
63 Dom. purchases by non-residents														
64 Total														
65 Compensation of employees														
66 Other net taxes on production														
67 Consumption of fixed capital														
68 Operating surplus, net														
69 Value added at basic prices														
70 Output at basic prices														

COICOP	CLASSIFICATION OF INDIVIDUAL CONSUMPTION BY PURPOSE											
	Food, beverages and tobacco	Clothing and footwear	Housing, water, electricity	Furnishings, household equipment	Health	Transport	Leisure, entertainment and culture	Education	Hotels, cafes and restaurants	Miscellaneous goods and services	Total	
PRODUCTS (CPA)	1	2	3	4	5	6	7	8	9	10	11	
1 Products of agriculture												
...												
59 Other services												
60 Total												

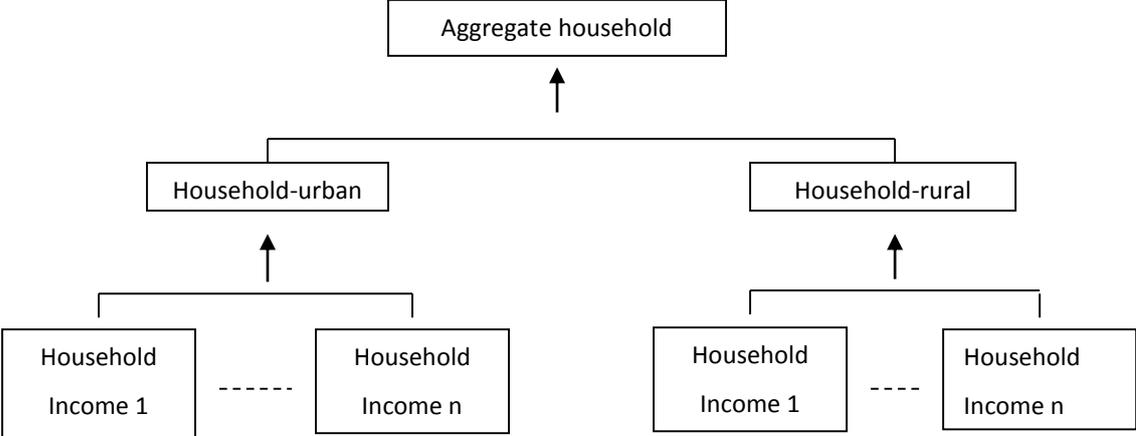
COFOG	CLASSIFICATION OF THE FUNCTIONS OF GOVERNMENT													
	General public service	Defence affairs and services	Public order and safety affairs	Education affairs and services	Health affairs and services	Social security and welfare affairs	Housing and community amenity affairs	Recreational, cultural and religious affairs	.	Other economic affairs and services	Total			
PRODUCTS (CPA)	1	2	3	4	5	6	7	8	.	14	15			
1 Products of agriculture														
...														
59 Other services														
60 Total														

INDUSTRIES (NACE)	INVESTING INDUSTRIES										
	Agriculture, hunting	Forestry, logging	Fishing	Mining of coal and lignite	Extraction of crude oil and natural gas	Mining of uranium	Mining of metal ores	Other mining and quarrying	.	Private households	Total
PRODUCTS (CPA)	1	2	3	4	5	6	7	8	.	59	60
1 Products of agriculture											
...											
59 Other services											
60 Total											

Source: Eurostat Manual for Supply Use Table and Input-Output Tables (2008).

For purposes of the CGE model it is important at this stage to highlight some of the key components that will have to feature in this table. First is the household disaggregation, it is critical to identify the types of households desirable for the CGE model. Households could be grouped by income, regions, gender or types of occupations. It is also possible to group have nested groups where for example you start with households in particular region and then disaggregate the households in a particular region by incomes. The figure 4.3 below illustrates the nested household types.

Figure 4.3: Household types



This level of disaggregation for the SUT will enable the authorities to undertake targeted policy interventions.

Also for the consumption by government, we need to have a detailed disaggregation for relevant policy simulations. At the very minimum government consumption should cover the functional roles of government including (i) general public service, (ii) defense and security, (iii) public order and safety, (iii) education disaggregated to primary, secondary and tertiary (in case education national accounts are available), (iv) health services, (v) energy sector, (vi) transport (disaggregated into roads, water, railway and air transport), (viii) social security services, (ix) housing and community development, and (x) other services provided by government. This classification will be very critical for the CGE model and will enable the modelers to avoid the use of assumptions in the shares of government spending in total consumption.

On gross fixed capital formation usually the focus is on the gross fixed capital formation by the various industries. Since we shall be developing a dynamic CGE model and with interest in the roles of government, we also need to capture at this stage the gross fixed capital formation in its various services it provides.

5. Development of Social Accounting Matrix

5.1 Introduction

This section outlines the construction of a 2018 social accounting matrix (SAM) for Sierra Leone. A SAM is a square matrix in which each account is represented by a row and column. Each cell shows the payment from the account of its column to the account of its row – the incomes of an account appear along its row, its expenditures along its column. A SAM is a consistent data framework that captures the information contained in the national income and product accounts and the input-output table, as well as the monetary flows between institutions. Since the required data is not drawn from a single source, information from various sources must be compiled and made consistent. This process is valuable since it identifies inconsistencies among Sierra Leone’s statistical sources and highlights areas where data reliability is weakest. This SAM will entirely be built from the Supply and Use Table (SUT) of the same fiscal year, government accounts and balance of payments.

Section 1 reviews the structure of SAMs for using to computational general-equilibrium (CGE). The first step is construction of a standard SAM through the compilation of information from various sources into a SAM format or framework. The construction of the standard SAM takes place in two stages. A “macro SAM” is first constructed using aggregate information from national accounts and other macroeconomic databases. This SAM is then disaggregated across sectors, factors and households to derive a more detailed ‘micro SAM’. Given the diversity of its data sources, the prior SAM is invariably inconsistent (i.e., there are inequalities between receipts and payments). The second step is construction of SAM for CGE. The construction of the SAM for CGE consists to disaggregated: (i) government account for distinguish types of tax; (ii) institutions transfer for distinguishing domestic and external interest; (iii) savings for distinguishing stocks of capital (private, government, rest of world) and investment (private, government, rest of world).

Section 2 describes the data sources used to construct the standard SAM and SAM for CGE. In this section, we describe methodology of balancing of SAM. This is done in two stages. The reliability of the various data sources is first assessed based on the observed inequalities between row and column accounts. Cross-entropy approach is used to balance the SAM. This approach is described in this section.

5.2 Structure of Social Matrix Account

A SAM is an economy-wide data framework that usually represents the real economy of a single country.¹ More technically, a SAM is a square matrix in which each account is represented by a row and column. Each cell shows the payment from the account of its column to the account of its row – the incomes of an account appear along its row, its expenditures along its column. The underlying principle of double-entry accounting requires that, for each account in the SAM, total revenue (row total) equals total expenditure (column total). Table 1.1 shows an aggregate SAM (with verbal explanations in place of numbers).

¹ For general discussions of SAMs see Pyatt and Round (1985), and Reinert and Roland-Holst (1997); for perspectives on SAM-based modeling see Pyatt (1988), and Robinson and Roland-Holst (1988).

Activities and Commodities

The SAM distinguishes between ‘activities’ (the entities that carry out production) and ‘commodities’ (representing markets for goods and non-factor services). SAM flows are valued at producers’ prices in the activity accounts and at market prices (including indirect commodity taxes and transactions costs) in the commodity accounts. The commodities are activity outputs, either exported or sold domestically, and imports. In the activity columns, payments are made to commodities (intermediate demand), and factors of production (value-added comprising of operating surplus and compensation of employees). In the commodity columns, payments are made to domestic activities, the rest of the world, and various tax accounts (for domestic and import taxes). This treatment provides the data needed to model imports as perfect or imperfect substitutes vis-à-vis domestic production.

Trade and Marketing Margins

Domestic and international trade flows in the SAM are explicitly associated with transactions (trade and transportation) costs, also referred to as marketing margins. For each commodity, the SAM accounts for the costs associated with domestic, import, and export marketing (i.e., each commodity purchases other trade and transport commodities). For domestic marketing of domestic output, the marketing margin represents the cost of moving the commodity from the producer to the domestic consumer. For imports, it represents the cost of moving the commodity from the border to the domestic market, while for exports it shows the cost of moving the commodity from the producer to the border.

Factors of production

The factors of production are composed to the labor and capital. Labor represents employment of each sector and capital represents mix income. For each sector the remuneration of factor (labor and capital) is the difference between production and intermediate consumption.

Government Income and Payments

The income of government in the SAM is composed of the tax on activities, commodities and household; and transfer which are direct payments between the government and other domestic institutions. Finally, payments from the government to factors (for the labor services provided by public sector employees) are captured in the government services activity. Government consumption demand is a purchase of the output from the government services activity, which in turn, pays labor.

Domestic Non-Government Institutions

The domestic non-government institutions consist of households and enterprises. The enterprises earn factor incomes (a reflection of ownership of capital and/or land) and may also receive transfers from other institutions. Their incomes are used for corporate taxes, enterprise savings, and transfers to other institutions. Unlike households, enterprises do not demand commodities. It is possible to disaggregate the enterprise sector in a manner that

captures differences across enterprises in terms of tax rates, savings rates, and the shares of retained earnings that are received by different household types.

Home and Final Household Consumption

The SAM distinguishes between home (own) consumption of activities and marketed consumption of commodities by households. Home consumption, which appears in the SAM as payments from household accounts to activity accounts, is valued at producer prices, i.e., without marketing margins and the sales taxes that may be levied on marketed commodities. Final household consumption of marketed commodities appears as payments from household accounts to commodity accounts, valued at consumer prices that include marketing margins and commodity taxes.

Table 1.1: Basic structure SAM

	Activities	Commodities	Factors	Households	Enterprises	Government	Investment	Rest of the World (Row)	Total
Activities		marketed outputs		home-consumed outputs					activity income
Commodities	intermediate inputs	Marketing margin		Private consumption		government consumption	investment, change in stocks	exports	total demand
Factors	value-added								factor income
Households (HHD)			factor income to HHD		Distributed profits	Subsidies and social security		transfers to HHD from Row	HHD income
Enterprises			factor income to enterprises			transfers to enterprises		transfers to enterprises from Row	enterprise income
Government	Activity/ Production taxes or subsidies	sales taxes, import tariffs	factor income to government	direct HHD taxes	surplus to government, enterprise taxes			transfers to government from Row	government income
Savings				HHD savings	enterprise savings	government savings		foreign savings (Trade balance)	savings
Rest of the World (Row)		imports			surplus to Row	government transfers to Row			foreign exchange outflow
Total	activity expenditures	total supply	factor expenditures	HHD expenditures	enterprise expenditures	government expenditures	investment	foreign exchange inflow	

Table 1.2: Structure of MCGE-SAM

	Activities	Commodities	Factors	Households	Enterprises	Government (Gov)	Production taxes or subsidies	Sales taxes, import tariffs	Direct taxes	Interest domestic	Interest rest of world	Capital household	Capital government	Capital rest of world	Private investment	Government investment	Change in stock (dstk)	Rest of the World (Row)	Total
Activities		marketed outputs		home-consumed outputs															activity income
Commodities	intermediate inputs	Marketing margin		Private consumption		government consumption									Private investment	Government investment	Change in stock	exports	total demand
Factors	value-added																		factor income
Households (HHD)			factor income to		Distributed profits	Subsidies and social				Interest domestic								transfers to HHD from	HHD income
Enterprises			factor income to enterprises			transfers to enterprises				Interest domestic								transfers to enterprises from Row	enterprise income
Government			factor income to Gov		surplus to Gov		Activity/ Production tax or subsidies	sales taxes, import tariffs	direct HHD taxes, enterprise taxes									transfers to government from Row	government income
Production taxes or subsidies	Activity/ Production taxes or																		Production taxes or subsidies
Sales taxes, import tariffs		sales taxes, import tariffs																	Sales taxes, import
Direct taxes				direct HHD taxes	enterprise taxes														Direct taxes
Interest domestic						interest payment Gov to domestic													Interest domestic
Interest rest of world				interest payment HHD to row	interest payment enterprise to row	interest payment Gov to row													Interest rest of world
Capital household				HHD savings	enterprise savings														Private savings
Capital government						Gov savings						domestic financial		External financial					Government savings
Capital rest of world																		Foreign savings	Rest of world saving
Private investment												HHD investment		direct investment row					Private investment
Government investment													Gov investment						Government investment
Change in stock (dstk)												domestic investment							change in stock
Rest of the World (Row)		imports			surplus to Row	Gov transfers to Row					Interest rest of world								foreign exchange outflow
Total	activity expenditures	total supply	factor expenditures	HHD expenditures	enterprise expenditures	government expenditures	Production taxes or subsidies	Sales taxes, import tariffs	Direct taxes	Interest domestic	Interest rest of world	Private capital	Government capital	Rest of world capital	Private investment	Government investment	Change in stock	foreign exchange inflow	

5.3 Structure of Macro-SAM for CGE

The main difference between basic “macro Sam” (table 1.1) and “macro-Sam for CGE” (table 1.2) are the disaggregation of government account into the types of tax, internal (institutions excluding rest of world) transfer to the rest of world into domestic and external interest, and the disaggregation of the institutions saving into capital and investment.

The government is disaggregated into a core government account and different tax collection accounts, one for each tax type. The government transfer is disaggregated to the subsidies and social security, domestic interest and external interest. The institutions savings are disaggregated into capital and investment. For each then, it is distinguished private, government and rest of world. The difference between capital and investment is that the first constitute the stock of resources whereas the second is expenditures to be recovered.

5.4 Methodology for construction of SAM

Activities sectors and commodities block

The structure of Sierra Leone Supply and Use Table (SUT) at 2017 will be used to establish activities sectors and commodities block. All the activities sectors and commodities of SUT will be retained without sectors where productions are zero.

(Activities, Commodities)

The total value of intersection of activities and commodities is the value of total marketed output. Since all output is assumed to be supplied to markets, this value is equivalent to gross output, where gross output is the sum of intermediate demand and GDP at factor cost. The SAM distinguishes between activities and commodities, and thus facilitates interactions between single/multiple activities and single/multiple commodities. Therefore the disaggregation of this cell in the micro SAM is single entries along the main diagonal of the activity-commodity sub-matrix (i.e., a one-to-one mapping).

(Commodities, Activities)

The total value of intersection of commodities and activities is the value of intermediate inputs used in the production process. The aggregate value is derived at the sector-level using GDP estimates described above. The technical coefficients used in the SAM will be derived from the supply-use table, which contains detailed information for a large number of sectors.

(Commodities, Commodities)

The payment by commodities to commodities is a condensed version of the treatment of trade margins in the final micro SAM. In the SAM there are disaggregated margin into three accounts: (i) domestic margin; (ii) export margin; (iii) import margin. Trade margins will be taken from the supply-use table.

(Taxes, Commodities)

These taxes including sales tax, excise tax and import tax. We shall use details of tax as provided in the SUT and complete them with the fiscal national accounts provided by the MOFPED and NRA.

(Rest of World, Commodities)

The total value of intersection of rest of world and commodities is the value of total imports of goods and services was initially taken from national accounts. Goods and service imports will be disaggregated using data from the supply-use table.

(Commodities, Households)

The payment from households to commodities is equal to household consumption of marketed production. The private consumption by commodities is taken from supply-use table and will be distributed to different household groups using information from Sierra Leone household surveys.

(Commodities, Government)

The total value of government consumption spending will be taken from supply-use table. Education sectors and health sector will be disaggregated by using information from specialized surveys on the two sectors. The total of expenditure to the education and health will be broken down into the private and government respectively.

(Commodities, Investment)

The value of investment demand will come from the supply-use table. It is the sum of Gross Fixed Capital Formation (G.F.C.F) and the change in stock of supply-use table.

(Commodities, Rest of World)

The value of total exports of goods and services will be derived from the supply-use table.

Factors of production block

The factors in the SAM are represented by intersection (factors, activities). This is the value of gross domestic product (GDP) at factor cost or alternatively, total value-added generated by labor and capital. Sectoral GDP is drawn from national accounts and is further disaggregated across the various sectors using GDP shares from the supply-use table. Value-added is further divided into the returns to labor; capital and land using the supply-use table.

Labor income is split across three skill or occupational groups: “unskilled” labor includes clerks, service and sales workers, craft and trade workers, and elementary farm laborers; “semi-skilled” is equivalent of “self-employed” labor refers to subsistence farmers and family farm workers; and “skilled” labor includes legislators, senior officials and managers, professionals, technicians and associate professionals. This disaggregation will be guided by information from the Labour Force survey.

(Households, Factors)

The total value of intersection of rest of household and factors is the total labor value-added generated during production. The distribution of these factor incomes across households is determined using household labor income shares derived from the household surveys. The labor value-added is equivalent to the compensation paid to labor and the value of own farm and enterprise profits. Its aggregate value is derived at the sectoral level using the labor-capital shares from the supply-use table.

(Taxes, Households)

The value of direct taxes on households is equivalent to PAYE taxes and is taken from government accounts. Tax payments are distributed across households using information on tax payments from Sierra Leone survey.

(Savings, Households)

This is value of domestic private savings and is calculated as a residual to balance aggregate household income and expenditure accounts.

(Government, Taxes)

The government sector is disaggregated on six counts: (i) current account of government; (ii) sales tax; (iii) commodities tax (excise tax excluded petroleum tax); (iv) import tax (duties imports); (vi) direct tax.

(Savings, Government)

The total value of intersection of saving and government is value of public savings and is estimated to replicate overall fiscal balance including grants according to this equation:

$$S = D + I$$

Where S is the saving, D is government deficit-Overall Fiscal Balance (include Grants) and I is government investment from the Gross Fixed Capital Formation (G.F.C.F). The balance between government income and the expenditure is treated as government transfer to the household.

(Government, Rest of World)

Government income from the rest of the world is equivalent to the value of foreign grants as reported in the balance of payments.

(Savings, Rest of World)

The intersection of rest of world and the other account is the foreign saving. This will be the current account deficit of Sierra Leone.

5.5 The balancing procedure for the national SAM

The range of datasets used to construct the prior micro SAM implies that there will inevitably be imbalances (i.e., row and column totals are unequal). Cross-entropy econometrics is used to reconcile SAM accounts (see Robinson *et al.*, 2001). This approach begins with the construction of the prior SAM, which as explained in the previous section, used a variety of data from a number of sources of varying quality. This prior SAM provided the initial ‘best guess’ for the estimation procedure. Additional information is then brought to bear, including knowledge about aggregate values from national accounts and technology coefficients. A balanced Sierra Leone SAM will then be estimated by minimizing the entropy ‘distance’ measure between the final SAM and the initial unbalanced prior SAM, taking into account of all additional information.

Table 3 summarizes the equations defining the SAM estimation procedure. Starting from an initial estimate of the SAM, additional information is imposed in the form of constraints on the estimation. Equation 1 specifies that row sums and corresponding column sums must be equal, which is the defining characteristic for a consistent set of SAM accounts. Equation 2 specifies that sub-accounts of the SAM must equal control totals, and that these totals are assumed to be measured with error (Equation 3). An example would be the estimate of GDP provided by national accounts, which is the total value of the Factor-Activity matrix in the prior SAM. The matrix G is an aggregator matrix, with entries equal to 0 or 1. The index k is general and can include individual cells, column/row sums, and any combination of cells such as macro aggregates. Equation 4 allows for the imposition of information about column coefficients in the SAM rather than cell values, also allowing for error (Equation 5).

The error specification in Equations 2 and 3 describes the errors as a weighted sum of a specified ‘support set’ (the V parameters). The weights (W) are probabilities to be estimated, starting from a prior on the standard error of measurement of aggregates of flows (Equation 8) or coefficients (Equation 9). The number of elements in the error support set (w) determines how many moments of the error distribution are estimated. The probability weights must be non-negative and sum to one (Equations 8 and 9). The objective function is the cross-entropy distance between the estimated probability weights and their prior for the errors in both coefficients and aggregates of SAM flows. It can be shown that this minimand is uniquely appropriate, and that using any other minimand introduces unwarranted assumptions (or information) about the errors.

Table 3. Cross Entropy SAM Estimation Equations

Index	Definition
i, j	row (i) and column (j) entries
K	set of constraints
W	set of weights
Symbol	Definition
$T_{i,j}$	SAM in values
$A_{i,j}$ and $\overline{A}_{i,j}$	SAM in column coefficients
$G_{k,i,j}$	aggregator matrix for each constraint k

γ_k and $\bar{\gamma}_k$	aggregate value for constraint k
e_k	error on each constraint k
$e_{i,j}^A$	error on each cell coefficient
W and \bar{W}	weights and prior on error term for each constraint k or cell coefficient i,j
\bar{V}	error support set indexed over w for each constraint k or cell coefficient i,j

Equations

$$\sum_i T_{i,j} = \sum_j T_{i,j} \quad (1)$$

$$\sum_i \sum_j G_{k,i,j} \cdot T_{i,j} = \gamma_k \quad (2)$$

$$\gamma_k = \bar{\gamma}_k + e_k \quad (3)$$

$$A_{i,j} = \frac{T_{i,j}}{\sum_i T_{i,j}} \quad \text{with} \quad \sum_i A_{i,j} = 1 \quad \forall i \quad (4)$$

$$A_{i,j} = \bar{A}_{i,j} + e_{i,j}^A \quad \text{for some } i, j \quad (5)$$

$$e_k = \sum_w W_{k,w} \cdot \bar{V}_{k,w} \quad (6)$$

$$e_{i,j}^A = \sum_w W_{i,j,w}^A \cdot \bar{V}_{i,j,w}^A \quad (7)$$

$$\sum_w W_{k,w} = 1 \quad \text{with} \quad 0 \leq W_{k,w} \leq 1 \quad (8)$$

$$\sum_w W_{i,j,w}^A = 1 \quad \text{with} \quad 0 \leq W_{i,j,w}^A \leq 1 \quad (9)$$

$$\min \left[\sum_k \sum_w W_{k,w} \cdot (\ln W_{k,w} - \ln \bar{W}_{k,w}) + \sum_i \sum_j \sum_w W_{i,j,w}^A (\ln W_{i,j,w}^A - \ln \bar{W}_{i,j,w}^A) \right] \quad (10)$$

Various constraints are imposed on the model according to the perceived reliability of the Sierra Leone data. Certain values that appeared in national accounts will be maintained in order to remain consistent with the overall macro structure of the Sierra Leone economy. The macroeconomic aggregates that may be maintained in the micro-SAM include: total labor value-added; total capital value-added; household final demand; government spending; investment demand; exports; imports; government borrowing/saving; current account balance; sales taxes; import tariffs; direct taxes on enterprises; government transfers to enterprises; enterprise transfers to the rest of the world; enterprise transfers to government; household transfers to government; government transfers to the rest of the world; and household foreign transfers received.

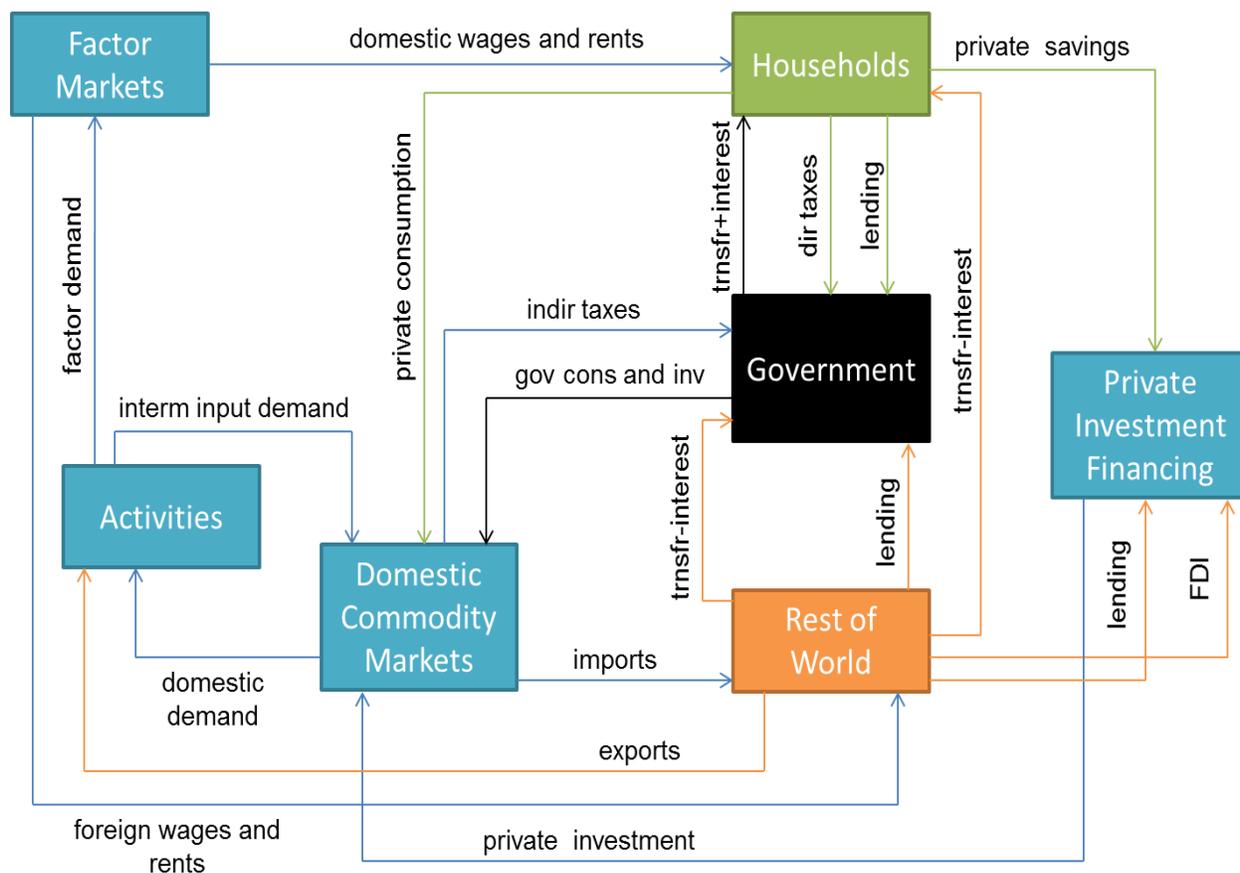
6.0 Computable General Equilibrium Model

6.1 Introduction

Computable general equilibrium (CGE) models are widely used for policy-analysis in many countries. In the past a number of CGE models have been developed for Africa, and used to assess a broad range of policy issues. The pioneering work of practical CGE model was implemented on Cameroon in 197X. However, the perceived complexity of this analytical approach, and the concentration of capacity within a small number of academic or related institutions, have generally led policy-makers, analysts and other researchers to avoid directly using CGE models in their analysis or decision-making. But with advancements in technology CGE models are now being used by policy makers without necessarily dwelling too much on the challenges of numerical implementation and the programming demands. Since CGE modelling provides both an economy-wide assessment of policies and a framework in which the workings of policies can be more easily understood, it is the objective of this paper to present a core model will be implemented on Sierra Leone. The core model can then be adapted according to the interests of policy-makers. Furthermore, since the strength of the model is dependent on its ability to reflect the specific structure and workings of the Sierra Leone economy, it is hoped that the core model will be developed further as more supporting evidence and research becomes available.

The model presented in this paper has at its core the static model used by the International Food Policy Research Institute (IFPRI) as described in Lofgren *et al.* (2002). The model is recursive dynamic and is therefore an extension of the IFPRI model. In the Sierra Leone model, the structure and interactions of the economy within and across time periods is specified in a set of mathematical equations. The Figure XX below demonstrates the financial flows of a typical CGE model. We describes the specification of the Sierra Leone model without the aid of mathematics.

Figure XX: Financial flows in CGE model



6.2 Model Description

The dynamic Sierra Leone model described below has developed from the neoclassical-structuralist modelling tradition originally presented in Dervis *et al* (1982), and has at its core the static CGE model described in Lofgren *et al* (2002) and Thurlow and van Severter (2002). The model is formulated as a set of simultaneous linear and non-linear equations, which define the behaviour of economic agents, as well as the economic environment in which these agents operate. This environment is described by market equilibrium conditions, macroeconomic balances, and dynamic updating equations.

The model belongs to the recursive dynamic strand of the dynamic CGE literature, which implies that the behavior of its agents is based on adaptive expectations, rather than on the forward-looking expectations that underlie alternative inter-temporal optimization models. Since a recursive model is solved one period at a time, it is possible to separate the *within-period* component from the *between-period* component, where the latter governs the dynamics of the model. Although a detailed mathematical description can be found in Appendix A and in Lofgren

et al (2002), this section presents a more discursive overview of the model's structure.

Within-period Specification

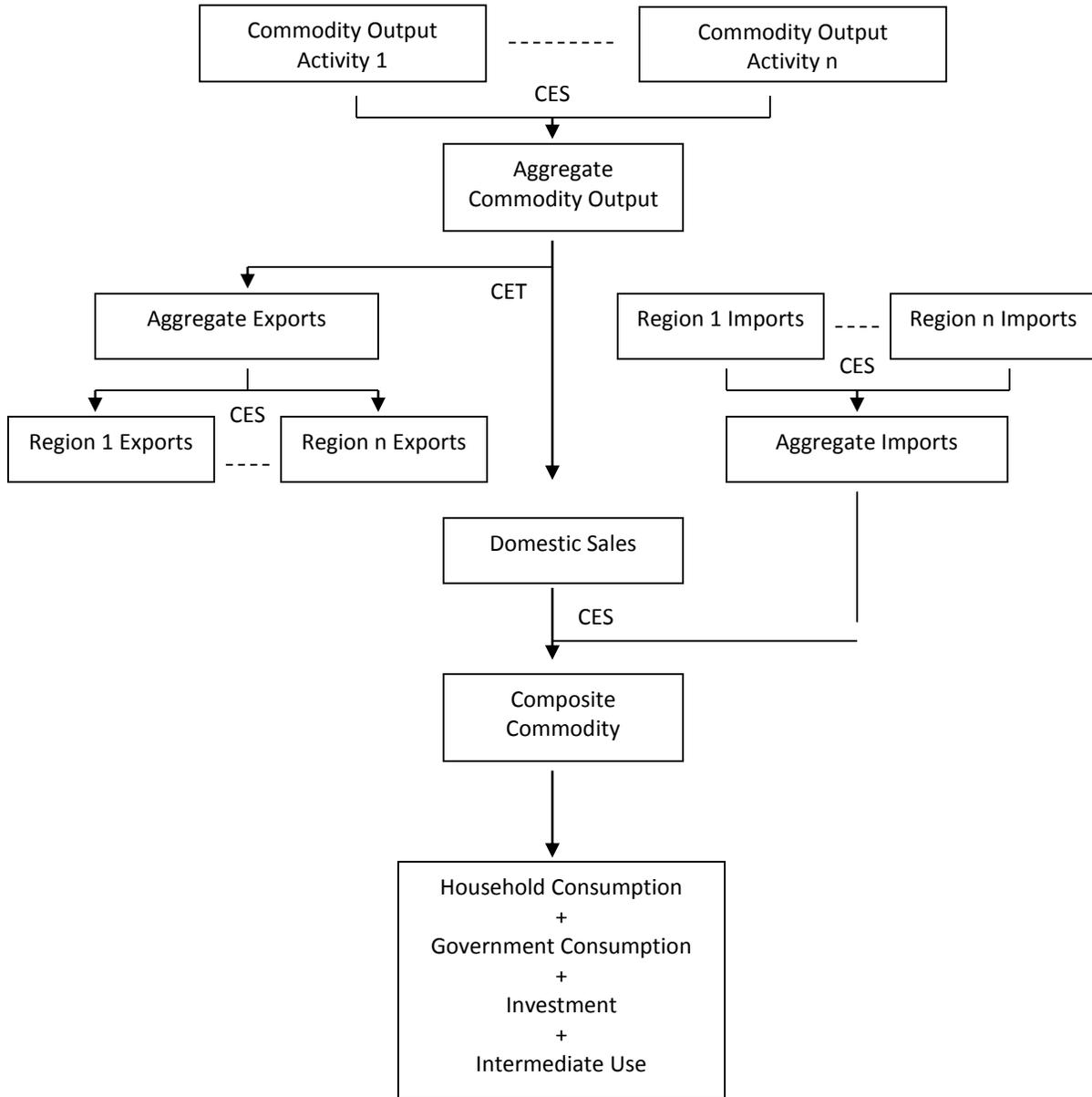
The within-period component describes a one-period static CGE model. The following description of this model is divided into the derivation of production and prices, and the generation of institutional incomes and demand. Equilibrium is maintained through a series of system constraints which are discussed last.

Production and Prices

The model identifies several productive sectors or activities that combine primary factors with intermediate commodities to determine a level of output. The four factors of production identified in the model will include capital, unskilled and semi-skilled, skilled, and highly-skilled labour.² The technology underlying production is depicted for a single producer in Figure 2.1. Producers in the model make decisions in order to maximize profits subject to constant returns to scale, with the choice between factors being governed by a constant elasticity of substitution (CES) function. This specification allows producers to respond to changes in relative factor returns by smoothly substituting between available factors so as to derive a final value-added composite. Profit-maximization implies that the factors receive income where marginal revenue equals marginal cost based on endogenous relative prices. Once determined, these factors are combined with fixed-share intermediates using a Leontief specification. The use of fixed-shares reflects the belief that the required combination of intermediates per unit of output, and the ratio of intermediates to value-added, is determined by technology rather than by the decision-making of producers. The final price of an activity's output is derived from the price of value-added and intermediates, together with any producer taxes or subsidies that may be imposed by the government per unit of output.

² A detailed account of the different factor categories is provided in Section 3.

Figure XX: Commodity Flows¹



¹ 'CES' is a constant elasticity of substitution aggregation function. 'CET' is constant elasticity of transformation function.

In addition to its multi-sector specification, the model also distinguishes between activities and the commodities that these activities produce. This distinction allows individual activities to produce more than a single commodity and conversely, for a single commodity to be produced

by more than one activity.³ Fixed-shares govern the disaggregation of activity output into commodities since it is assumed that technology largely determines the production of secondary products. These commodities are supplied to the market.

Figure 2.2 traces the flow of a single commodity from being supplied to the market to its final demand. The previous figure showed how a single producer could supply more than one identified commodities by the model. In the figure below, the supply of a particular commodity from each producer is combined to derive aggregate commodity output. This aggregation is governed by a CES function which allows demanders to substitute between the different producers supplying a particular commodity, in order to maximize consumption subject to relative supply prices.

Substitution possibilities exist between production for the domestic and the foreign markets. This decision of producers is governed by a constant elasticity of transformation (CET) function, which distinguishes between exported and domestic goods, and by doing so, captures any time or quality differences between the two products. Profit maximization drives producers to sell in those markets where they can achieve the highest returns. These returns are based on domestic and export prices (where the latter is determined by the world price times the exchange rate adjusted for any taxes or subsidies). Under the small-country assumption, Sierra Leone is assumed to face a perfectly elastic world demand at a fixed world price. The final ratio of exports to domestic goods is determined by the endogenous interaction of relative prices for these two commodity types. Commodities that are exported are further disaggregated according to their region of destination under a CES specification. Allowing substitution between regions is preferable to the use of fixed shares, since changes in relative prices across regions should lead to a shift in the geographic composition of exports.

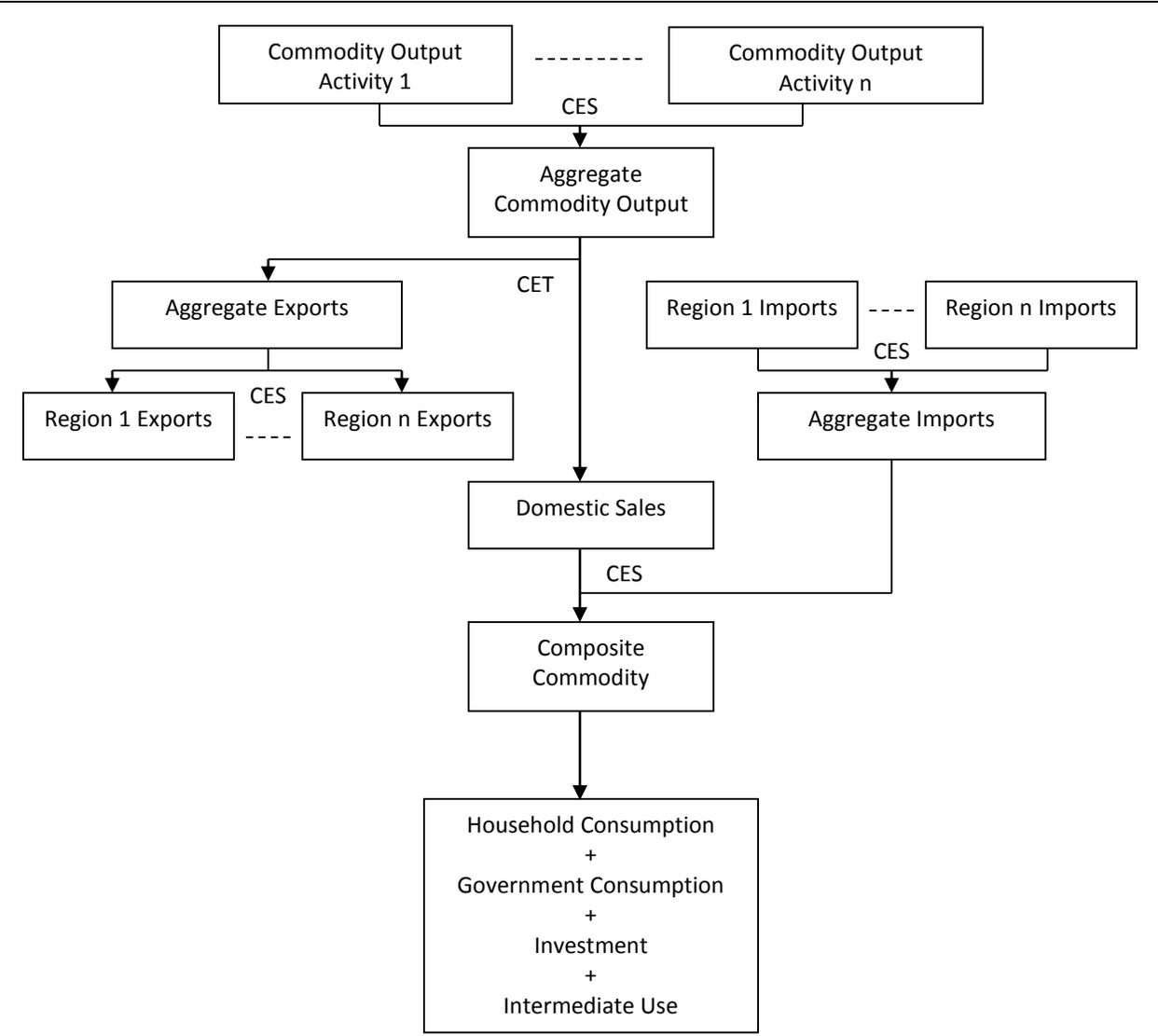
Domestically produced commodities that are not exported are supplied to the domestic market. Substitution possibilities exist between imported and domestic goods under a CES Armington specification (Armington, 1969). Such substitution can take place both in final and intermediates usage. The Armington elasticities vary across sectors, with lower elasticities reflecting greater differences between domestic and imported goods.⁴ Again under the small country assumption, Sierra Leone is assumed to face infinitely elastic world supply at fixed world prices. The final ratio of imports to domestic goods is determined by the cost minimizing decision-making of domestic demanders based on the relative prices of imports and domestic goods (both of which include

³ For example, although the agricultural sector's primary output is agricultural products, this sector might also produce some processed food products. Therefore this single sector or activity can produce more than one product or commodity. Conversely, since food is also produced by the processed food sector, the combination of agricultural and processed food production suggests that some commodities can also be produced by more than one activity.

⁴ The use of an Armington specification is justified by the likely heterogeneity of commodities within broad commodity categories, and by the observed two-way trade between South Africa and its trading partners. See Section 3 and Appendix C for the values of the Armington elasticities used in the model.

relevant taxes). Imports are further disaggregated according to their region of origin using a CES function. This specification allows for regionally specific tariffs, and for substitution between regions following changes in relative import prices.

Figure XX: Commodity Flows¹



¹ ‘CES’ is a constant elasticity of substitution aggregation function. ‘CET’ is constant elasticity of transformation function.

Transaction costs are incurred on exports, imports and domestic sales. These costs are treated as a fixed share per unit of commodity, and generate demand for trade and transportation services. The final composite good, containing a combination of imported and domestic goods, is supplied to both final and intermediate demand. Intermediate demand, as described above, is determined by technology and by the composition of sectoral production. Final demand is dependent on institutional incomes and the composition of aggregate demand.

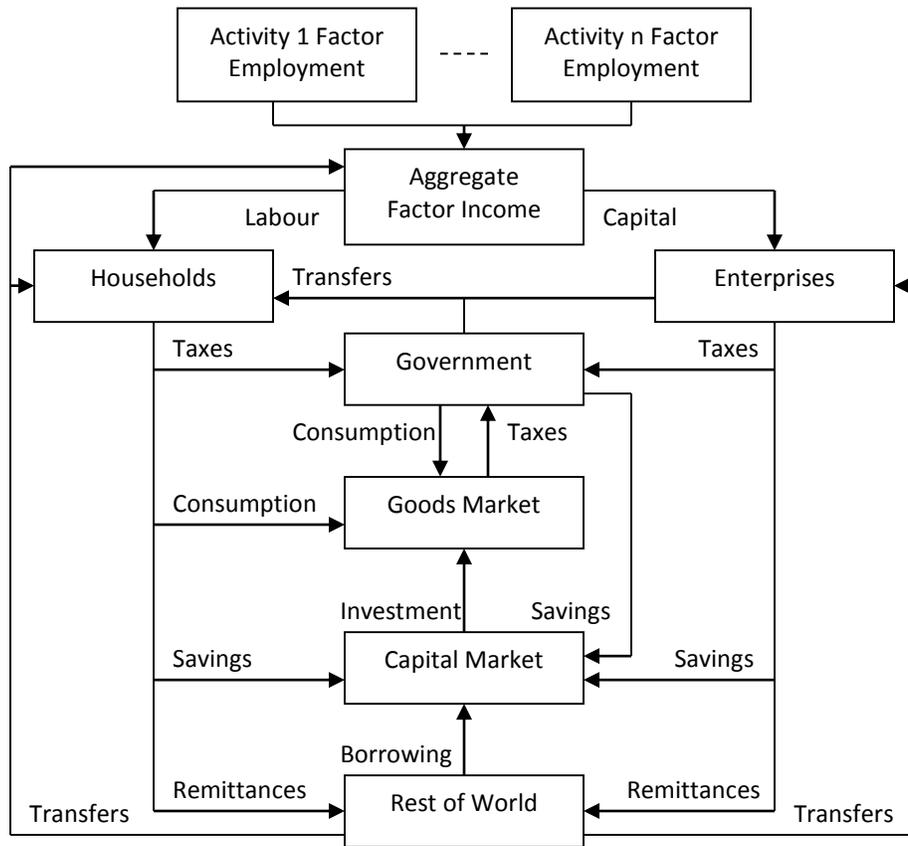
Institutional Incomes and Domestic Demand

The model will distinguish between various institutions within the Sierra Leone economy, including enterprises, the government, and various types of households. The household categories can be disaggregated across income deciles, regions, gender etc. Figure 2.3 summarizes the interaction between institutions in the model.

The primary source of income for households and enterprises are factor returns generated during production. The supply of capital is fixed within a given time-period and is immobile across sectors, thus implying that capital earns sector-specific returns. Unskilled and semi-skilled, and skilled labour supply is assumed to be perfectly elastic at a given real wage. Highly-skilled labour face upward-sloping labour supply curves, with wage elasticities determining adjustments to supply following changes in real wages. Each activity pays an activity-specific wage that is the product of the economy-wide wage and a fixed activity-specific wage distortion term. This specification, in which factor returns are sector-specific, is preferable to the use of simple average wages, since average factor returns in most developing countries are observed to vary both across occupations and sectors. Final factor incomes also include remittances received from and paid to the rest of the world.

Households and enterprises earn factor incomes in proportion to the implied share that they control of each factor stock. Enterprises or firms are the sole recipient of capital income, which they transfer to households after having paid corporate taxes (based on fixed tax rates), saved (based on fixed savings rates), and remitted profits to the rest of the world. Households within each income category are assumed to have identical preferences, and are therefore modelled as 'representative' consumers. In addition to factor returns, which represent the bulk of household incomes, households also receive transfers from the government, other domestic institutions, and the rest of the world. Household disposable income is net of personal income tax (based on fixed rates), savings (based on fixed marginal propensities), and remittances to the rest of the world. Consumer preferences are represented by a linear expenditure system (LES) of demand, which is derived from the maximization of a Stone-Geary utility function subject to a household budget constraint. Given prices and incomes, these demand functions define households' real consumption of each commodity. The LES specification allows for the identification of supernumerary household income that ensures a minimum level of consumption.

Figure XX: Institutional Incomes and Domestic Demand



The government earns most of its income from direct and indirect taxes, and then spends it on consumption and transfers to households. Both of these payments are fixed in real terms. The difference between revenues and expenditures is the budget deficit, which is primarily financed through borrowing (or dis-saving) from the domestic capital market. Although not shown in Figure 2.3, the government also makes payments to the rest of the world. In the current model the government's role as a consumer is treated separately from the production of government services. The latter is specified as an activity producing services for which the government institution is the primary consumer.

Savings by households and enterprises are collected into a savings pool from which investment is financed. This supply of loanable funds is diminished by government borrowing (or dis-saving) and augmented by capital inflows from the rest of the world. There is no explicit modelling of the investment decision or the financial sector within a particular time-period, with savings equaling investment as per the ex post accounting identity. This implicitly assumes that the necessary adjustment in the interest rate takes place to ensure that savings equals investment in equilibrium. The disaggregation of investment into demand for final commodities is done using

fixed shares, with changes in aggregate investment leading to proportional increases in the demand for individual commodities. Therefore there is no real compositional shift in investment following changes in relative commodity prices.

Production is linked to demand through the generation of factor incomes and the payment of these incomes to domestic institutions. Balance between demand and supply for both commodities and factors are necessary in order for the model to reach equilibrium. This balance is imposed on the model through a series of system constraints.

System Constraints and Macroeconomic Closures

Equilibrium in the goods market requires that demand for commodities equal supply. Aggregate demand for each commodity comprises household and government consumption spending, investment spending, and export and transaction services demand. Supply includes both domestic production and imported commodities. Equilibrium is attained through the endogenous interaction of domestic and foreign prices, and the effect that shifts in relative prices have on sectoral production and employment, and hence institutional incomes and demand.

The equilibrating of factor demand and supply is dependent on how the relationship between factor supply and wages is defined. As discussed above, capital is fully employed and sector-specific, implying that sector-specific wages adjust to ensure that demand for capital equals total supply. Unemployment amongst unskilled and semi-skilled, and skilled labour is assumed to be sufficiently large such that wages are fixed in real terms and supply passively adjusts to match demand. Highly-skilled labour is neither fully employed nor significantly unemployed to justify either a fixed supply or a fixed wage. Rather the supply of this factor is responsive to changes in real wages, which adjust to ensure that demand and supply are equal in equilibrium.

The model will include three broad macroeconomic accounts: the current account, the government balance, and the savings and investment account. In order to bring about equilibrium in the various macro accounts it is necessary to specify a set of 'macroclosure' rules, which provide a mechanism through which adjustment is assumed to take place.

For the current account it is assumed that a flexible exchange rate adjusts in order to maintain a fixed level of foreign borrowing (or negative savings). In other words, the external balance is held fixed in foreign currency. This closure is appropriate given Sierra Leone's commitment to a flexible exchange rate system, and the belief that foreign borrowing is not inexhaustible. However given movements in Sierra Leone's current account balance, it might be necessary to exogenously adjust foreign savings based on observed trends and let the exchange rate adjust

accordingly.

In the government account the level of direct and indirect tax rates, as well as real government consumption, are held constant. As such the balance on the government budget is assumed to adjust to ensure that public expenditures equal receipts. This closure is chosen since it is assumed that changes in direct and indirect tax rates are politically motivated and thus are adopted in isolation of changes in other policies or the economic environment.

Although the government and current account closures can be selected based on current government policies, the choice of a savings-investment closure is less obvious. According to Nell (2003), the relationship between saving and investment remains one of the most debated and controversial issues in macroeconomics. On the one hand, neoclassical and recent endogenous growth theory maintains that it is prior savings that is most important when determining an economy's level of investment and output. This view suggests that savings is exogenous, and that investment adjusts passively to maintain the savings-investment balance. By contrast, a more Keynesian view reverses the causality found in neoclassical theory by arguing that investment is exogenous and that it is savings that adjusts. Finally, there might exist, as in the case of some developed countries, a two-way causality between savings and investment. In such cases both the level of savings and investment are endogenously determined and may both adjust in response to policy-changes.

The choice of which direction of causality is appropriate for Sierra Leone might have implications for the outcomes of policies. For example, under the more neoclassical approach and in the case trade liberalization, a reduction in tariff revenue will decrease the level of government savings and thereby crowd-out private investment. Under the exogenous investment paradigm, maintaining the level of investment would require that savings would have to increase through increases in domestic savings rates. In such a case, the level of disposable income is reduced with 'crowding-out' effects on private consumption. It will be important to establish the long-run savings-investment relationship in Sierra Leone in order to adopt the right closure rule

Finally, the consumer price index is chosen as the numéraire such that all prices in the model are relative to the weighted unit price of households' initial consumption bundle. The model is also homogenous of degree zero in prices, implying that a doubling of all prices does not alter the real allocation of resources.

6.3 Between-period Specification

While the static model described above is detailed in its representation of the Sierra Leone economy within a particular time-period, its inability to account for second-period considerations

limits its assessment of the full effect of policy and non-policy changes. For example, the model is unable to account for the second-period effect that changes in current investment have on the subsequent availability of capital. In attempting to overcome these limitations, the static model is extended to a recursive dynamic model in which selected parameters are updated based on the modelling of inter-temporal behavior and results from previous periods. Current economic conditions, such as the availability of capital, are thus endogenously dependent on past outcomes, but remain unaffected by forward-looking expectations. The dynamic model is also exogenously updated to reflect demographic and technological changes that are based on observed or separately calculated projected trends.

The process of capital accumulation is modelled endogenously, with previous-period investment generating new capital stock for the subsequent period. Although the allocation of new capital across sectors is influenced by each sector's initial share of aggregate capital income, the final sectoral allocation of capital in the current period is dependent on the capital depreciation rate and on sectoral profit-rate differentials from the previous period. Sectors with above-average capital returns receive a larger share of investible funds than their share in capital income. The converse is true for sectors where capital returns are below-average.⁵

Population growth is exogenously imposed on the model based on separately calculated growth projections. It is assumed that a growing population generates a higher level of consumption demand and therefore raises the supernumerary income level of household consumption. There is assumed to be no change in the marginal rate of consumption for commodities, implying that new consumers have the same preferences as existing consumers.

Highly-skilled labour supply adjusts endogenously across periods in response to continuing changes in real wages. Between periods there may be an exogenous adjustment to the supply of this labour category as is typical in most recursive dynamic models. This treatment of the model's labour supply dynamics assumes that for the highly-skilled labour category there is neither a binding supply-constraint nor involuntary unemployment. Rather labour supply is seen as being driven by changes in real wages, thus suggesting the existence of an effective reservation wage.

Unskilled and semi-skilled, and skilled labour supply within a particular time period is infinitely elastic at a fixed real wage. As such it is the real wage, rather than labour supply, that adjusts between periods. In the dynamic model it is assumed that real wage changes for unskilled and skilled workers are relative to previous period changes in the real wage of highly skilled workers. This specification allows for the endogenous determination of wages for lower skilled workers, as well as the exogenous determination of skilled-unskilled wage convergence rates.

⁵ See Dervis *et al* (1982) for a more detailed discussion of this and other approaches to modelling capital accumulation in CGE models.

Factor-specific productivity growth is imposed exogenously on the model based on observed trends for labour and capital. Growth in real government consumption and transfer spending is also exogenously determined between periods, since within-period government spending is fixed in real terms. Furthermore, projected changes in the current account balance are exogenously accounted for. Finally, mining production is assumed to be predominantly driven by a combination of changes in world demand and prices, and other factors external to the model. One such external factor might be the gradual exhaustion of non-renewable natural resources. Accordingly, the value-added growth of these sectors and the world price of exports are updated exogenously between periods based on observed long-term trends.⁶

The Sierra Leone dynamic model will be solved as a series of equilibriums, each one representing a single year. By imposing the above policy-independent dynamic adjustments, the model produces a projected or counterfactual growth path. Policy changes can then be expressed in terms of changes in relevant exogenous parameters and the model is re-solved for a new series of equilibriums. Differences between the policy-influenced growth path and that of the counterfactual can then be interpreted as the economy-wide impact of the simulated policy.

Static and Dynamic Equilibrium

Perhaps the main criticism of the static model is that its core formulation is closely tied to the Walrasian ideal of equilibrium (Dervis *et al*, 1982). In a pure neoclassical setting, producers and consumers react passively to prices in order to determine their demand and supply schedules. Markets are therefore assumed to clear through the interaction of relative prices, such that equilibrium is achieved in both goods and factor markets. However, it might be argued that certain institutional and structural rigidities within the Sierra Leone economy result in cases of persistent disequilibrium or deviations from neoclassical theory.

The Sierra Leone model does attempt to incorporate some the perceived rigidities in the economy's factor markets. For example, capital is assumed to be immobile across sectors, and unskilled and semi-skilled, and skilled labour supply is unemployed at a fixed real wage. Furthermore, factor returns are assumed to vary across sectors based on observed and persistent sectoral deviations from economy-wide averages. These rigidities allow for a 'constrained' general equilibrium that, while remaining close to the Walrasian model, accounts for some of the observed structural characteristics of the economy. However, Dervis *et al*. (1982) note that the

⁶ Exogenously imposing a factor growth rate on a sector requires adjusting the capital accumulation process. For example, reducing mining output when capital is sectorally fixed leads to increases in mining capital's profit-rate. Since new capital allocation is driven by sectoral profit-rate differentials, a mining high profit-rate will therefore attract new investment. The mining sector therefore is excluded from the capital allocation decision after adjusting the stock of new capital to account for depreciation and fixed capital changes taking place within the mining sector.

adoption of a more Walrasian approach leads to problems in both factor *and* product markets. In the case of the latter, the Sierra Leone model will retain a neoclassical specification, and ignore such considerations as the existence of imperfect competition and monopoly-pricing.

The use of a numéraire and the lack of an explicitly modelled monetary sector imply that the model is essentially one of a barter economy in which money is neutral. Taylor (1983), in outlining the structuralist approach, discounts money-neutrality by arguing that nominal changes can influence the real economy, particularly within the short-run and in respect to the demand for money balances. Dervis *et al.* (1982) suggest however that, while separability is not always possible to preserve, the overall strength of the CGE approach lies in its ability to address questions of medium to long-term resource allocation.

The specification of capital accumulation and allocation within the dynamic model also represents a deviation from the perfect neoclassical inter-temporal equilibrium. Within the neoclassical framework, market and production prices of capital are identical, within-period sectoral profit-rates are equalised, and the economy moves along an inter-temporally efficient path characterised by perfect foresight (Dervis *et al.*, 1982). However, in the adaptive dynamic Sierra Leone model, capital is immobile across sectors and the allocation of new capital is partly determined by the distribution of previous-period capital incomes. Together these rigidities prevent both a within- and between-period equalisation of sectoral profit-rates. By not determining the inter-temporally efficient allocation of capital the model greatly simplifies the investment allocation decision, and avoids having to explicitly model expectations. This specification can be justified on the grounds that agents within the Sierra Leone economy are unlikely to possess perfect foresight, and as such, the inter-temporal efficient growth path is unlikely to be achieved.

Given the institutional and structural rigidities of the Sierra Leone economy, the use of a more neoclassical market-clearing mechanism suggests that caution be exercised in interpreting the model's results. Most importantly, the model is not able to provide short-term predictions, but rather highlights the direction and relative magnitude of adjustments to the economy following changes in policies, technology, and other external factors.

Production and Factor Demand

Production within the Sierra Leone model will be governed by neoclassical production functions, which may not reflect the specific workings of individual sectors. The model will assume constant returns to scale, and models 'representative' sectors such that all producers within each sector are assumed to share the same behaviour. Capital and labour are treated as equally substitutable for one another, thus implying, for example, that unskilled labour is as substitutable for capital

as is highly-skilled labour. Finally, all producers are assumed to be on their factor demand curve. This last assumption rules out the possibility of excess capacity and the hoarding of labour during economic downturns. Although it is possible to adopt more flexible specifications of production, such as translog or nested-CES functions, these formulations require considerably more parameter estimates than are currently available for Sierra Leone. Furthermore, the relatively high sectoral and factor aggregation of the model, and its medium to long-term focus, are likely to lessen the severity of the above limitations. For example, higher sectoral aggregation reduces the likelihood of monopoly-power within an individual sector.

Final Demand

Final household, government, and investment demand for each commodity is assumed to be a fixed share of aggregate institutional spending. Therefore expenditure shares for each commodity are fixed and do not adjust in response to changes in relative prices. While this is unlikely to reflect actual institutional behaviour, the use of fixed shares is preferable to the use of a more flexible functional form since short and medium-term substitution possibilities are likely to be limited.

This specification also does not allow household consumption patterns to adjust following changes in household incomes. The assumption that there is no income effect on final demand, or that the income elasticity of demand is unity, is unlikely to reflect reality. However, there is little reason to suspect that consumption patterns will adjust significantly as long as the time-period over which the model is used remains relatively short and income changes are small.

Foreign Trade

The model will assume that imports, exports, and domestic goods are imperfect substitutes. This assumption is more realistic than a 'perfect substitutes' specification, since the high sectoral aggregation of the model increases the likelihood of within-sector cross-hauling. However, in the case of imports, the allowance for differentiated products leads to the construction of a composite good containing both imported and domestic commodities. This marketed composite good is then supplied to all components of demand, thus assuming that all consumers of an individual commodity have the same import-intensity of consumption. For example, the import-share of the food composite is the same for low-income and high-income households. This is likely to overstate the import-intensity of low-income household food consumption, and understate high-income households' import-intensity.

7.0 Status of Data Sources

The mandate of compiling National Accounts lies with Statistics Sierra Leone. The National Accounts are compiled using the 1993 system of national accounts. There are several challenges that have been identified and well outlined in the strategic plan of the SSL (2016-2020). Key among them is that fact that the current National Account remain inadequate to account for all economic activities as recommended in the system of National Accounts. Based on this fact, it is also difficult to move straight into the development of a CGE without comprehensively addressing data concerns. SSL has already recognized this need largely motivated by the need to rebase their national accounts which are currently using 2006 as the base year. Specific challenges that SSL has identified include: (i) lack of resources and weak capacity to carry out household and business surveys and censuses; (ii) obsolete business or economic census which was conducted in 2005 which can potentially lead to under estimation of GDP; (iii) partial coverage as a result of using the 1993 System of National Accounts compilation platform, and ISIC rev 3.1 as well as CPC 1 which could lead to biased estimates of GDP; (iv) a large informal sector with unrecorded activities; scanty agriculture statistics data

With all these challenges SSL recognizes the need to address them by collecting various data sets before the end of 2017 with the objective of using them for rebasing. In the process of rebasing their GDP SSL will also develop a SUT which will also be very useful for the development of the first Social Accounting Matrix for Sierra Leone and eventual development of the CGE. The SUT will also greatly improve the coverage and inconsistencies of data collected from the different sources.

As part of its strategic objective to compile the SUT, SSL intends to undertake various surveys during the period 2016-2017. Key among them include:

- Economic Census/detailed survey of establishments and products
- Sierra Leone Integrated Household Survey (SLIHS)-to collection data on household expenditures by COICOP
- Labour Force Survey (LFS)-provide compensation of employees,
- Agriculture Census/Survey of crops and livestock-provide output and input usage estimates

In addition, these surveys will also be complimented by other specialized surveys like for education national accounts, health national accounts, construction and civil engineering, machinery and equipment survey, dwelling and rent services Survey, compensation of government employee's assessment, tourist expenditures assessments, and water, electricity and waste management tariff assessments. All these specialized surveys will be a major source of information for the compilation of the SUT. The sections that follow discuss the current status of the major surveys.

7.1 Enterprise survey methodology

Sierra Leone last conducted a business enterprise survey in 2014 and the results were reported in the 2014 Annual Economic survey (AES). The main purpose this survey was to collect information on employment, expenditure by enterprises, revenue, capital expenditure and changes in stocks. This survey covered eleven industries including: accommodation and food service activities; administration and support service activities; construction; financial and insurance activities; information and communication; manufacturing; mining and quarrying; other service activities; professional, scientific and technical activities; transportation and storage, and wholesale and retail trade. The survey was also restricted in four regional cities of Freetown, Bo, Kenema and Makeni which are estimated to cover more than 65 percent of the business operations in the country. Sectors that were not included in this survey include agriculture, mining and quarrying and formal commercial banks, electricity, water and gas industries. The survey is also based on an old sampling frame compiled in 2005 which is considered to be obsolete and could lead to complete biased estimations of economic activity in Sierra Leone. Out of the 9100 establishments operating in the country, 492 establishments were statistically selected for the survey.

Based on these limitations, SSL has embarked on completely revamping the business sampling from to be nationally representative and cover beyond the four regional surveys to all 14 districts. A new business register is now in place and comprise of 19,000 businesses. With funding made available, SSL is to embark on collection of the survey data which will broaden the scope of industries from the current 11 to 21 industries. Indicative costs of this survey as highlighted in the SSL strategic plan are estimated at USD 750,000 dollars.

The Economic Census of business establishments (SBES) will be the first of its kind and it will serve various purposes. Key among them is that it will collect invaluable information on the state of business in the country—the number and nature of enterprises, where they are located, who they are employing—and all this information is useful for both the public and private sectors. Undertaking the survey will enable Sierra Leone to achieve the following:

- (i) Develop the Supply User Table which will be used for developing a SAM and CGE of which the two tools are critical for long-term planning.
- (ii) Using the SBES results to develop the SUT will enable the authorities to rebase their GDP which is long overdue given that it was last done in 2006.
- (iii) The data will also be used to check the consistency of GDP data collected from other sources.

7.1.1 Coverage (Geographic, Establishment and Content)

SSL is committed to improve on the current Enterprise survey by extending its coverage in terms of the area covered as well as the products. The aspiration is to improve the compilation of National Accounts according to the updated 2008 System of National Accounts. With that in mind the SSL will extend the coverage of the survey from the current four regional cities (Freetown,

Bo, Kenema and Makeni) to the entire country covering all the 14 districts in the country covering both the urban and rural areas.

The scope of industries to be covered has also been widened. The list consists of 20 industries which will include: Agriculture, forestry and fishing; Mining and quarrying; Manufacturing; Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities; Construction; Wholesale and retail trade and repair of motor vehicles and motorcycles; Transport and storage; Accommodation and food service activities; Information and communication; Financial and insurance activities; Real estate activities; Professional, scientific and technical activities; Administrative and support service activities; Public administration and defense; Education; Human health and social work activities; Arts, entertainment and recreation; Other service activities, and; Activities of extraterritorial organizations and bodies. A complete detailed list of the industries is provided in Appendix XX.

For purposes of compiling the SUT, the coverage of the information to be collected should include the following aspects: (i) total output/receipts of the various industries; (ii) employment (iii) value added by industry (broken into wage income and net operating surplus); (iv) detailed operating expenses or intermediate use of inputs; (v) gross fixed capital formation, and; (vi) value of fixed assets.

7.1.2 Sampling Frame

SSL has already completed compiling business census register with 19,000 businesses country wide. Typical of any economy, some enterprises are very large in terms of their contribution to GDP. The size or scale of operations of establishments is likely to vary, such as in the number of people employed, capital investment and output. In that regard, such enterprises cannot be left out as a result of sampling. The survey will therefore rely on a dual frame approach to data collection to improve the precision of estimates. From the Business census, a list of large enterprises will be drawn based on number of workers employed and output levels/turnover. All other small and medium enterprises will be subjected to a sampling survey. In the past the criteria that has been used to be included on the list of large enterprises was 50 and above employees (including proprietors and working partners).

7.1.3 Sample Design for Enterprises with less than 50 Employees

The rest of the enterprises with less than 50 employees were subjected to a simple random sampling process. While this might be appropriate to fully capture appropriate representation for all industries by regions it will be prudent to modify the sampling procedure for the enterprises with less than 50 employees. This would involve the choice of the enumeration areas from the district at the first stage and the second stage would involve the choice of enterprises from the chosen enumeration areas.

(i) Probability Proportional to Size Sampling at First Stage

At the first stage, villages/towns in a chosen district will be Enumerator Areas (EA) within the domain. Each EA has a given size preferably the number of enterprises within the EA. A random sample of n EAs will be selected with probability proportional to size (PPS) sampling, which means that the bigger EAs will have a higher probability of selection than the smaller ones. All the EAs will be listed together with their measure of size in terms of number of enterprises and their cumulative size will be shown in a separate column. Then a random start r will be selected, say, from a random number table, between 1 and N where N is the total size of all the EAs in the district. Having calculated a sampling interval k equal to the nearest integer to N/n , then the chosen sample of size n will be obtained in a circular manner as the observations corresponding to $r, r+k, r+2k, \dots, r+(n-1)k$ in such a way that if the j -th of these numbers exceed N then the EA whose cumulative size corresponds to $\{r+(j-1)k - N\}$ will be selected and the process will continue until exactly n enumerator areas are selected.

(ii) Stratified Sampling at Second Stage

Having selected the n EA at the first stage randomly in the above manner, then an equal number, say, m enterprises will be chosen through stratified sampling from each of the selected EAs. For enterprise surveys stratification of the sample makes sense if we are to capture all the industries of interest as shown in Appendix 2. There are three criteria that could be used: (i) firm size; (ii) sector of activity, and; (iii) location of activity.

Since the large enterprises have already been taken care of, the focus here is on enterprises with less than 50 employees. We can adopt the following classifications previously used by SSL namely: (i) Petty enterprise with 1-4 employees; (ii) Small scale Establishment with 5-19 employees and medium enterprises with 20-49 employees. The stratification by sector will be done at a broad level with the following strata's: (i) agriculture sector, (ii) mining and manufacturing, and; (iii) services. To a large extent only this level of stratification will ensure that enterprises of various sizes in the different sectors will be fully captured. This to a large extent would be more reliable sampling criteria compared to random sampling.

It is important to note that some enterprises are very few in the economy and employ few people yet their contribution to GDP is big. Such industries may include financial institutions, insurance companies and ICT companies. In this case as previously done by the SSL, the purposive sampling technique would be used to ensure that these enterprises are included in the survey.

7.1.4 Sample Size

Previous enterprise surveys had limited coverage and the given that they were only focused on four major towns. Out of the total of 9100 establishments operating in the country, 492 establishments were statistically selected for the survey. These were distributed among the 11 industries based on their respective shares of total number of people employed as recorded in the business register. Since the business register has completely been revamped to 19,000 establishments and the number of industries to be covered has also been increased to 20, the sample size will also be increased in that consideration. At this stage SSL has not made a decision on the size of the sample size of enterprises to be included in the survey. In the determination of sample size we can use the following considerations, namely:

- (i) For a specified level of precision, determine sample size n ; or
- (ii) For a given fixed budget C^* , determine the largest sample size, n .

For the forthcoming Sierra Leone Business Enterprise survey, the issues relating to sample size will include among others: Estimation domains; available budget, as well as allowing for non-response.

Level of Precision

The desirable sample size would largely depend on the level of precision that is desired by the authorities.

Cost of Survey

The survey budget will be not ignored in sample size determination knowing that survey costs may differ across domains. When we calculate the initial sample size and find it is larger than what the budget can support we shall discuss with the client to seek additional funds or we shall agree with the client to adjust measurement objectives and go through sample size calculation again and again as may be necessary.

A simple cost function is of the form:

$$C = C_0 + nC_1$$

where C = total cost of survey, C_0 is fixed cost; C_1 is cost per sample unit and n is sample size.

For a fixed total budget C^* the optimum sample size is:

$$n = \frac{C^* - C_0}{C_1}$$

7.1.2 Questionnaire

7.2 Agriculture census survey

7.3 Living Standards Household Survey

7.4 Other Specialized surveys

8.0 Capacity development needs

Practical experience in the use of the model will be required for the team to be very conversant with the model. Therefore, in between the weekly practical sessions will be organized at the Ministry of Finance with the objective of equipping the team with more hands on experience and building further confidence in use of the model.

EPRU will also be undertaking various research activities as requested by top management within the MoFED. Research activities may include issues like: (i) global external shocks, (ii) public choice questions, (iii) long-term planning. This will require EPRU team to quickly adjust the model to suit the questions at hand.

Implementing the CGE and sustaining it within government will require a committed team with the requisite capacity to run the model and interpret the result. For the regular update of the model, the team should comprise members from the following departments:

- (i) Economic Policy Research Unit (MOFED)
- (ii) Economic Statistics Division (Statistics Sierra Leone)
- (iii) Macroeconomic division—Research Department (Bank of Sierra Leone)
- (iv) National Revenue Authority
- (v) Economic Policy Research Think Tank
- (vi) Faculty of Economics, University of Sierra Leone.

To fully appreciate how the model works, it would require each member to possess at least a Master's degree in Economics or Statistics.

The various stages of developing the CGE will require the following training:

8.1 Construction of the Social Accounting Matrix from SUT

The Social Accounting Matrix is the underlying database for the CGE model. Authorities will be introduced to some basic methods of compiling the SAM. This will involve merging of data sets from various sources and ensuring that the SAM is balanced using cross entropy methods. Besides the use of the SAM for CGE analysis, it can also be used for partial equilibrium analysis. For instance, the authorities might be interested to know the multiplier effects of change in production of one sector on other activities in the production sector. The SAM can be independently used to undertake this analysis using the set of multipliers embedded in the matrix. Authorities will be introduced to these methods.

8.2 Computable General Equilibrium modelling training.

Computable General equilibrium models have a rich literature that will be introduced to the team. This literature spans from simple static CGE models to more complex CGE models. CGE models have also been extended to handle social sectors particularly in the areas of education and health. In particular the MAMS model has been widely used on for MDG and SDG planning. Authorities will therefore be introduced to the various sets of models with the objective of equipping them with choice depending on their needs.

8.3 GAMS Programming

CGE models are fairly large non-linear models with many equations and variables to be solved simultaneously. To solve these models the user has to work in a programming environment with access to non-linear solvers or optimization routines. The two most widely used programs for CGE models include GAMS and GEMPACK. Capacity Development in programming using GAMS language and applied to simple and more advanced general equilibrium models will be undertaken.

8.4 User Interfaces

The use of GAMS for large scale models can be a daunting task especially for the policy maker faced with other competing needs. It is for that reason that various user interfaces have been developed to simplify the use of CGEs and also make the model accessible to members who might be with limited interest in detailed modelling. Among the user interfaces include ISIM which runs the Maquette for MDG Simulations (MAMS) program. ISIM-MAMS allows the user to define and run MAMS simulations interactively in the Excel 2007/2010 environment, without directly running GAMS – the software in which MAMS is coded. In this case there is no previous knowledge of the GAMS language or programming skill is necessary to use the program. There are also other simpler user interfaces that have been developed and the user needs some basic knowledge of GAMS and excel. The purpose of this training will be to bring the models closer to the users without necessary running the risk of turning them off owing to the complexity of the models.

8.5 Micro-simulation CGE Analysis

CGE models usually have a set of representative agents. For instance for households they can be disaggregated into various types. However, increasing the level of disaggregation comes with data challenges and huge computational burden. Therefore the practice has been to link the CGE models results to actual household data sets. For instance the changes in prices or wages can be directly linked to expenditure functions or wage functions at the household level and therefore making into possible to assess the impact of policy changes on individual households. That is to say, we take the CGE simulation results – for all conducted scenarios – and apply them to the full distribution as given by a micro data set. Authorities will be introduced to micro-simulation analysis using CGE models.

9.0 Road map with key implementing agencies and time frame.

10.0 Conclusion

Appendix A: 2016/17 Business Establishments Census (BEC) Product Coverage

SECTION A: Agriculture, forestry and fishing

- 0111 Growing of cereals (except rice), leguminous crops and oil seeds (such as wheat, maize, sorghum, millet)
- 0112 Growing of rice
- 0113 Growing of vegetables and melons, roots and tubers (cabbages, lettuce, cucumbers, tomatoes, carrots, onions)
- 0114 Growing of sugar cane
- 0115 Growing of tobacco
- 0116 Growing of fibre crops (cotton, jute, textile bast fibres)
- 0119 Growing of other non-perennial crops
- 0121 Growing of grapes
- 0122 Growing of tropical and subtropical fruits
- 0123 Growing of citrus fruits
- 0124 Growing of pome fruits and stone fruits
- 0125 Growing of other tree and bush fruits and nuts
- 0126 Growing of oleaginous fruits
- 0127 Growing of beverage crops
- 0128 Growing of spices, aromatic, drug and pharmaceutical crops
- 0129 Growing of other perennial crops
- 0130 Plant propagation
- 0141 Raising of cattle and buffaloes
- 0142 Raising of horses and other equines
- 0143 Raising of camels and camelids
- 0144 Raising of sheep and goats
- 0145 Raising of swine/pigs
- 0146 Raising of poultry
- 0149 Raising of other animals
- 0150 Mixed farming
- 0161 Support activities for crop production
- 0162 Support activities for animal production
- 0163 Post-harvest crop activities
- 0164 Seed processing for propagation
- 0170 Hunting, trapping and related service activities
- 0210 Silviculture and other forestry activities
- 0220 Logging
- 0230 Gathering of non-wood forest products
- 0240 Support services to forestry
- 0311 Marine fishing
- 0312 Freshwater fishing
- 0321 Marine aquaculture
- 0322 Freshwater aquaculture

SECTION B: Mining and quarrying

- 0510 Mining of hard coal
- 0520 Mining of lignite
- 0610 Extraction of crude petroleum
- 0620 Extraction of natural gas
- 0710 Mining of iron ores
- 0721 Mining of uranium and thorium ores
- 0729 Mining of non-ferrous metal ores
- 0810 Quarrying of stone, sand and clay
- 0891 Mining of chemical and fertilizer minerals
- 0892 Extraction of peat

0893 Extraction of salt

0899 Other mining and quarrying n.e.c.

0910 Support activities for petroleum and natural gas extraction

0990 Support activities for other mining and quarrying

SECTION C: Manufacturing

1010 Processing and preserving of meat

1020 Processing and preserving of fish, crustaceans and molluscs

1030 Processing of fruits and vegetables

1040 Manufacture of vegetable and animal oils and fats

1050 Manufacture of dairy products

1061 Manufacture of grain mill products

1062 Manufacture of starches and starch products

1071 Manufacture of bakery products

1072 Manufacture of sugar

1073 Manufacture of cocoa, chocolate and sugar confectionery

1074 Manufacture of macaroni, noodles, couscous and similar farinaceous products

1075 Manufacture of prepared meals and dishes

1079 Manufacture of other food products

1080 Manufacture of prepared animal feeds

1101 Distilling, rectifying and blending of spirits

1102 Manufacture of wines

1103 Manufacture of malt liquors and malt

1104 Manufacture of soft drinks; production of mineral and other bottled waters

1200 Manufacture of tobacco products

1311 Preparation and spinning of textile fibre

1312 Weaving of textiles

1313 Finishing of textiles

1391 Manufacture of knitted and crocheted fabrics

1392 Manufacture of made-up textile articles, except apparel

1393 Manufacture of carpets and rugs

1394 Manufacture of cordage, rope, twine and netting

1399 Manufacture of other textile n.e.c.

1410 Manufacture of wearing apparel, except fur apparel

1420 Manufacture of articles of fur

1430 Manufacture of knitted and crocheted apparel

1511 Tanning and dressing of leather, dressing and dyeing of fur

1512 Manufacture of luggage, handbags and the like, saddlery and harness

1520 Manufacture of footwear

1610 Sawmilling and planing of wood

1621 Manufacture of veneer sheets and wood-based panels

1622 Manufacture of builders' carpentry and joinery

1623 Manufacture of wooden containers

1629 Manufacture of other products of wood, articles of cork, straw and plaiting materials

1701 Manufacture of pulp, paper and paperboard

1702 Manufacture of corrugated paper and paperboard and of containers of paper and paperboard

1709 Manufacture of other articles of paper and paperboard

1811 Printing

1812 Service activities related to printing

1820 Reproduction of recorded media

1910 Manufacture of coke oven products

1920 Manufacture of refined petroleum products

2011 Manufacture of basic chemicals

2012 Manufacture of fertilizers and nitrogen compounds

2013 Manufacture of plastics and synthetic rubber in primary forms

2021 Manufacture of pesticides and other agrochemical products
 2022 Manufacture of paints, varnishes and similar coatings, printing ink and mastics
 2023 Manufacture of soap & detergents, cleaning & polishing preparations, perfumes & toiletries
 2029 Manufacture of other chemical products n.e.c.
 2030 Manufacture of man-made fibres
 2100 Manufacture of pharmaceuticals, medicinal, chemical and botanical products
 2211 Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres
 2219 Manufacture of other rubber products
 2220 Manufacture of plastics products
 2310 Manufacture of glass and glass products
 2391 Manufacture of clay building materials
 2393 Manufacture of other porcelain and ceramic products
 2394 Manufacture of cement, lime and plaster
 2395 Manufacture of articles of concrete, cement and plaster
 2396 Cutting, shaping and finishing of stone
 2399 Manufacture of other non-metallic mineral products n.e.c.
 2410 Manufacture of basic iron and steel
 2420 Manufacture of basic precious and other non-ferrous metals
 2431 Casting of iron and steel
 2432 Casting of non-ferrous metals
 2511 Manufacture of structural metal products
 2512 Manufacture of tanks, reservoirs and containers of metal
 2513 Manufacture of steam generators, except central heating hot water boilers
 2520 Manufacture of weapons and ammunition
 2591 Forging, pressing, stamping and roll-forming of metal; powder metallurgy
 2592 Treatment and coating of metals; machining
 2593 Manufacture of cutlery, hand tools and general hardware
 2599 Manufacture of other fabricated metal products n.e.c.
 2610 Manufacture of electronic components and board
 2620 Manufacture of computers and peripheral equipment
 2630 Manufacture of communication equipment
 2640 Manufacture of consumer electronics
 2651 Manufacture of measuring, testing, navigating and control equipment
 2652 Manufacture of watches and clocks
 2660 Manufacture of irradiation, electromedical and electrotherapeutic equipment
 2670 Manufacture of optical instruments and photographic equipment
 2680 Manufacture of magnetic and optical media
 2710 Manufacture of electric motors, generators, transformers and electricity apparatus
 2720 Manufacture of batteries and accumulators
 2731 Manufacture of fibre optic cables
 2732 Manufacture of other electronic and electric wires and cables
 2733 Manufacture of wiring devices
 2740 Manufacture of electric lighting equipment
 2750 Manufacture of domestic appliances
 2790 Manufacture of other electrical equipment
 2811 Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
 2812 Manufacture of fluid power equipment
 2813 Manufacture of other pumps, compressors, taps and valves
 2814 Manufacture of bearings, gears, gearing and driving elements
 2815 Manufacture of ovens, furnaces and furnace burners
 2816 Manufacture of lifting and handling equipment
 2817 Manufacture of office machinery and equipment except computers and peripheral
 2818 Manufacture of power driven hand tools
 2819 Manufacture of other general purpose machinery

- 2821 Manufacture of agricultural and forestry machinery
- 2822 Manufacture of metal-forming machinery and machine tools
- 2823 Manufacture of machinery for metallurgy
- 2824 Manufacture of machinery for mining, quarrying and construction
- 2825 Manufacture of machinery for food, beverage and tobacco processing
- 2826 Manufacture of machinery for textile, apparel and leather production
- 2829 Manufacture of other special-purpose machinery
- 2910 Manufacture of motor vehicles
- 2920 Manufacture of bodies for motor vehicles, trailers and semi-trailers
- 2930 Manufacture of parts and accessories for motor vehicles
- 3011 Building of ships and floating structures
- 3012 Building of pleasure and sporting boats
- 3020 Manufacture of railway locomotives and rolling stock
- 3030 Manufacture of air and spacecraft and related machinery
- 3040 Manufacture of military fighting vehicles
- 3091 Manufacture of motorcycles
- 3092 Manufacture of bicycles and invalid carriages
- 3099 Manufacture of other transport equipment n.e.c.
- 3100 Manufacture of furniture
- 3211 Manufacture of jewellery and related articles
- 3212 Manufacture of imitation jewellery and related articles
- 3220 Manufacture of musical instruments
- 3230 Manufacture of sport goods
- 3240 Manufacture of games and toys
- 3250 Manufacture of medical and dental instruments and supplies
- 3290 Other manufacturing n.e.c.
- 3311 Repair of fabricated metal products
- 3312 Repair of machinery
- 3313 Repair of electronic and optical equipment
- 3314 Repair of electrical equipment
- 3315 Repair of transport equipment, except motor vehicles
- 3319 Repair of other equipment
- 3320 Installation of industrial machinery and equipment
- SECTION D: Electricity, gas, steam and air conditioning supply**
- 3510 Electric power generation, transmission and distribution
- 3520 Manufacture of gas; distribution of gaseous fuels through mains
- 3530 Steam and air conditioning
- SECTION E: Water supply; sewerage, waste management and remediation activities**
- 3600 Water collection, treatment and supply
- 3700 Sewerage
- 3811 Collection of non-hazardous waste
- 3812 Collection of hazardous waste
- 3821 Treatment and disposal of non-hazardous waste
- 3822 Treatment and disposal of hazardous waste
- 3830 Material recovery
- 3900 Remediation activities and other waste management services
- SECTION F: Construction**
- 4100 Construction of buildings
- 4210 Construction of roads and railways
- 4220 Construction of utility projects
- 4290 Construction of other civil engineering projects
- 4311 Demolition
- 4312 Site preparation
- 4321 Electrical installation

- 4322 Plumbing, heat and air-conditioning installation
- 4329 Other construction installation
- 4330 Building completion and finishing
- 4390 Other specialized construction activities

SECTION G: Wholesale and retail trade; repair of motor vehicles and motorcycles

- 4510 Sale of motor vehicles
- 4520 Maintenance and repair of motor vehicles
- 4530 Sale of motor vehicle parts and accessories
- 4540 Sale, maintenance and repair of motorcycles and related parts and accessories
- 4610 Wholesale on a fee or contract basis
- 4620 Wholesale of agricultural raw materials and live animals
- 4630 Wholesale of food, beverage and tobacco
- 4641 Wholesale of textiles, clothing and footwear
- 4649 Wholesale of other household goods
- 4651 Wholesale of computers, computer peripheral equipment and software
- 4652 Wholesale of electronic and telecommunication equipment and parts
- 4653 Wholesale of agricultural machinery, equipment and supplies
- 4659 Wholesale of other machinery and equipment
- 4661 Wholesale of solid, liquid and gaseous fuels and related products
- 4662 Wholesale of metals and metal ores
- 4663 Wholesale of construction materials, hardware, plumbing and heating equipment and supplies
- 4669 Wholesale of waste and scrap and other products n.e.c.
- 4690 Non-specialized wholesale trade
- 4711 Retail sale in non-specialized stores with food, beverages or tobacco predominating
- 4719 Other retail sale in non-specialized stores
- 4721 Retail sale of food in specialized stores
- 4722 Retail sale of beverages in specialized stores
- 4723 Retail sale of tobacco products in specialized stores
- 4730 Retail sale of automotive fuel in specialized stores
- 4741 Retail sale of computers, peripheral units, software and telecommunications equipment
- 4742 Retail sale of audio and video equipment in specialized stores
- 4751 Retail sale of textiles in specialized stores
- 4752 Retail sale of hardware, paints and glass in specialized stores
- 4753 Retail sale of carpets, rugs, wall and floor coverings in specialized stores
- 4759 Retail sale of electrical household appliances, furniture, lighting equipment and other articles
- 4761 Retail sale of books, newspapers and stationary in specialized stores
- 4762 Retail sale of music and video recordings in specialized stores
- 4763 Retail sale of sporting equipment in specialized stores
- 4764 Retail sale of games and toys in specialized stores
- 4771 Retail sale clothing, footwear and leather articles in specialized stores
- 4772 Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles in specialized stores
- 4773 Other retail sale of new goods in specialized stores
- 4774 Retail sale of second-hand goods
- 4781 Retail sale via stalls and markets of food, beverages and tobacco products
- 4782 Retail sale via stalls and markets of textiles, clothing and footwear
- 4789 Retail sale via stalls and markets of other goods
- 4791 Retail sale via mail order houses or via internet
- 4799 Other retail sale not in stores, stalls or markets

SECTION H: Transport and storage

- 4911 Passenger rail transport, interurban
- 4912 Freight rail transport
- 4921 Urban and suburban passenger land transport
- 4922 Other passenger land transport
- 4923 Freight transport by road

4930 Transport via pipeline
5011 Sea and coastal passenger water transport
5012 Sea and coastal freight water transport
5021 Inland passenger water transport
5022 Inland freight water transport
5110 Passenger air transport
5120 Freight air transport
5210 Warehousing and storage
5221 Service activities incidental to land transportation
5222 Service activities incidental to water transport
5223 Service activities incidental to air transport
5224 Cargo handling
5229 Other transportation support activities
5310 Postal activities
5320 Courier activities

SECTION I: Accommodation and food service activities

5510 Short term accommodation activities
5520 Camping grounds, recreational vehicle parks and trailer parks
5590 Other accommodation
5610 Restaurants and mobile food service activities
5621 Event catering
5629 Other food service activities
5630 Beverage serving activities

SECTION J: Information and communication

5811 Book publishing
5812 Publishing of directories and mailing lists
5813 Publishing of newspapers, journals and periodicals
5819 Other publishing activities
5820 Software publishing
5911 Motion picture, video and television programme production activities
5912 Motion picture, video and television programme post-production activities
5913 Motion picture, video and television programme distribution activities
5914 Motion picture projection activities
5920 Sound recording and music publishing activities
6010 Radio broadcasting
6020 Television programming and broadcasting activities
6110 Wired telecommunications activities
6120 Wireless telecommunications activities
6130 Satellite telecommunications activities
6190 Other telecommunications activities
6201 Computer programming activities
6202 Computer consultancy and computer facilities management activities
6209 Other information technology and computer service activities
6311 Data processing, hosting and related activities
6312 Web portals
6391 News agency activities
6399 Other information service activities n.e.c.

SECTION K: Financial and insurance activities

6411 Central banking
6419 Other monetary intermediation
6420 Activities of holding companies
6430 Trusts, funds and similar financial entities
6491 Financial leasing
6492 Other credit granting

6499 Other financial service activities, except insurance and pension funding activities, n.e.c.
6511 Life insurance
6512 Non-life insurance
6520 Reinsurance
6530 Pension funding
6611 Administration of financial markets
6612 Security and commodity contracts brokerage
6619 Other activities auxiliary to financial service activities
6621 Risk and damage evaluation
6622 Activities of insurance agents and brokers
6629 Other activities auxiliary to insurance and pension funding
6630 Fund management activities

SECTION L: Real estate activities

6810 Real estate activities with own or leased property
6820 Real estate activities on a fee or contract basis

SECTION M: Professional, scientific and technical activities

6910 Legal activities
6920 Accounting, bookkeeping and auditing activities; tax consultancy
7010 Activities of head offices
7020 Management consultancy activities
7110 Architectural and engineering activities and related technical consultancy
7120 Technical testing and analysis
7210 Research and experimental development on natural sciences and engineering
7220 Research and experimental development on social sciences and humanities
7310 Advertising
7320 Market research and public opinion polling
7410 Specialized design activities
7420 Photographic activities
7490 Other professional, scientific and technical activities n.e.c.
7500 Veterinary activities

SECTION N: Administrative and support service activities

7710 Renting and leasing of motor vehicles
7721 Renting and leasing of recreational and sports goods
7722 Renting of video tapes and disks
7729 Renting and leasing of other personal and household goods
7730 Renting and leasing of other machinery, equipment and tangible goods
7740 Leasing of intellectual property and similar products, except copyrighted works
7810 Activities of employment placement agencies
7820 Temporary employment agency activities
7830 Other human resources provision
7911 Travel agency activities
7912 Tour operator activities
7990 Other reservation service and related activities
8010 Private security activities
8020 Security systems service activities
8030 Investigation activities
8110 Combined facilities support activities
8121 General cleaning of buildings
8129 Other building and industrial cleaning activities
8130 Landscape care and maintenance service activities
8211 Combined office administrative service activities
8219 Photocopying, document preparation and other specialized office support activities
8220 Activities of call centres
8230 Organization of conventions and trade shows

- 8291 Activities of collection agencies and credit bureaus
- 8292 Packaging activities
- 8299 Other business support service activities n.e.c.
- SECTION O: Public administration and defence; compulsory social security**
- 8411 General public administration activities
- 8412 Regulation of the activities of health care, education, cultural and other social services
- 8413 Regulation of and contributing to more efficient operation of businesses
- 8421 Foreign affairs
- 8422 Defence activities
- 8423 Public order and safety activities
- 8430 Compulsory social security activities
- SECTION P: Education**
- 8510 Pre-primary and primary education
- 8521 General secondary education
- 8522 Technical and vocational secondary education
- 8530 Higher education
- 8541 Sports and recreation education
- 8542 Cultural education
- 8549 Other education
- 8550 Educational support activities
- SECTION Q: Human health and social work activities**
- 8610 Hospital activities
- 8620 Medical and dental practice activities
- 8690 Other human health activities
- 8710 Residential nursing care facilities
- 8720 Residential care activities for mental retardation, mental health and substance abuse
- 8730 Residential care activities for the elderly and disabled
- 8790 Other residential care activities
- 8810 Social work activities without accommodation for the elderly and disabled
- 8890 Other social work activities without accommodation
- SECTION R: Arts, entertainment and recreation**
- 9000 Creative, arts and entertainment activities
- 9101 Library and archives activities
- 9102 Museums activities and operation of historical sites and buildings
- 9103 Botanical and zoological gardens and nature reserves activities
- 9200 Gambling and betting activities
- 9311 Operation of sport facilities
- 9312 Activities of sports clubs
- 9319 Other sports activities
- 9321 Activities of amusement parks and theme parks
- 9329 Other amusement and recreation activities n.e.c.
- SECTION S: Other service activities**
- 9411 Activities of business and employers membership organizations
- 9412 Activities of professional membership organizations
- 9420 Activities of trade unions
- 9491 Activities of religious organizations
- 9492 Activities of political organizations
- 9499 Activities of other membership organizations n.e.c.
- 9511 Repair of computers and peripheral equipment
- 9512 Repair of communication equipment
- 9521 Repair of consumer electronics
- 9522 Repair of household appliances and home and garden equipment
- 9523 Repair of footwear and leather goods
- 9524 Repair of furniture and home furnishings

- 9529 Repair of other personal and household goods
- 9601 Washing and dry-cleaning of textile and fur products
- 9602 Hairdressing and other beauty treatment
- 9603 Funeral and related activities
- 9609 Other personal service activities n.e.c.
- SECTION U: Activities of extraterritorial organizations and bodies**
- 9900 Activities of extraterritorial organizations and bodies

Appendix B: Indicative Questionnaire for the Business Establishments Survey

Appendix C: Model Specification

The following tables provide a complete listing of the model's variables, parameters and equations. It is largely based on the equation listing found in Lofgren *et al* (2002).

Table A1: Model Sets, Parameters, and Variables

<i>Symbol</i>	Explanation	Symbol	Explanation
<i>Sets</i>			
$a \in A$	Activities	$c \in CMR(\subset C)$	Regionally imported commodities
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CMNR(\subset C)$	Non-regionally imported commodities
$c \in C$	Commodities	$c \in CT(\subset C)$	Transaction service commodities
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$c \in CX(\subset C)$	Commodities with domestic production
$c \in CDN(\subset C)$	Commodities not in CD	$f \in F$	Factors
$c \in CE(\subset C)$	Exported commodities	$i \in INS$	Institutions (domestic and rest of world)
$c \in CEN(\subset C)$	Commodities not in CE	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CM(\subset C)$	Aggregate imported commodities	$i \in INSDNG(\subset INSD)$	Domestic non-government institutions
$c \in CMN(\subset C)$	Commodities not in CM	$h \in H(\subset INSDNG)$	Households
Parameters			
$cwts_c$	Weight of commodity c in the CPI	pwm_c	Import price (foreign currency)
$dwts_c$	Weight of commodity c in the producer price index	$pwmr_{cr}$	Import price by region (foreign currency)
ica_{ca}	Quantity of c as intermediate input per unit of activity a	$qdst_c$	Quantity of stock change
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	qg_c	Base-year quantity of government demand
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	$qinv_c$	Base-year quantity of private investment demand
$icer_{cc'r}$	Quantity of commodity c as trade input per exported unit of c' from region r	$shif_{if}$	Share for domestic institution i in income of factor f
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	$shii_{ii'}$	Share of net income of i' to i ($i' \in INSDNG'$; $i \in INSDNG$)

$icmr_{cc'r}$	Quantity of commodity c as trade input per imported unit of c' from region r	ta_a	Tax rate for activity a
$inta_a$	Quantity of aggregate intermediate input per activity unit	\overline{tins}_i	Exogenous direct tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tinsOI_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
\overline{mps}_i	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mpsOI_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tmr_{cr}	Regional import tariff
pwe_c	Export price (foreign currency)	tq_c	Rate of sales tax
$pwer_{cr}$	Export price by region (foreign currency)	$trnsfr_{if}$	Transfer from factor f to institution i

Source: Lofgren *et al* (2002).

Table A1 continued: Model Sets, Parameters, and Variables

<i>Symbol</i>	Explanation	<i>Symbol</i>	Explanation
Greek Symbols			
α_a^a	Efficiency parameter in the CES activity function	δ_c^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor f in activity a
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity a
α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
α_c^m	Shift parameter in the CES regional import function	ρ_a^{va}	CES value-added function exponent
α_c^e	Shift parameter in the CES regional export function	ρ_c^{ac}	Domestic commodity aggregation function exponent
β^a	Capital sectoral mobility factor	ρ_c^q	Armington function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^t	CET function exponent
δ_a^a	CES activity function share parameter	ρ_c^m	Regional imports aggregation function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^e	Regional exports aggregation function exponent
δ_c^q	Armington function share parameter	η_{fat}^a	Sector share of new capital
ν_f	Capital depreciation rate		
Exogenous Variables			
\overline{CPI}	Consumer price index	\overline{MPSADJ}	Savings rate scaling factor (= 0 for base)
\overline{DTINS}	Change in domestic institution tax share (= 0 for base;	\overline{QFS}_f	Quantity supplied of factor

	exogenous variable)		
\overline{FSAV}	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
\overline{GADJ}	Government consumption adjustment factor	\overline{WFDIST}_{fa}	Wage distortion factor for factor f in activity a
\overline{IADJ}	Investment adjustment factor		
Endogenous Variables			
AWF_{ft}^a	Average capital rental rate in time period t	QF_{fa}	Quantity demanded of factor f from activity a
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QG_c	Government consumption demand for commodity
DPI	Producer price index for domestically marketed output	QH_{ch}	Quantity consumed of commodity c by household h
EG	Government expenditures	QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h
EH_h	Consumption spending for household	$QINTA_a$	Quantity of aggregate intermediate input
EXR	Exchange rate (LCU per unit of FCU)	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
$GOVSHR$	Government consumption share in nominal absorption	$QINV_c$	Quantity of investment demand for commodity
$GSAV$	Government savings	QM_c	Quantity of imports of commodity c
$INVSHR$	Investment share in nominal absorption	QMR_{cr}	Quantity of imports of commodity c by region r

Source: Lofgren *et al* (2002).

Table A1 concluded: Model Sets, Parameters, and Variables

Symbol	Explanation	Symbol	Explanation
Endogenous Variables Continued			
MPS_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	QER_{cr}	Quantity of exports of commodity c to region r
PA_a	Activity price (unit gross revenue)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PDD_c	Demand price for commodity produced and sold domestically	QT_c	Quantity of commodity demanded as trade input
PDS_c	Supply price for commodity produced and sold domestically	QVA_a	Quantity of (aggregate) value-added
PE_c	Export price (domestic currency)	QX_c	Aggregated quantity of domestic output of commodity
PER_{cr}	Export price by region (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a
$PINTA_a$	Aggregate intermediate input price for activity a	RWF_f	Real average factor price
PK_{ft}	Unit price of capital in time period t	$TABS$	Total nominal absorption
PM_c	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution i ($i \in INSDNG$)
PMR_{cr}	Import price by region (domestic currency)	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PQ_c	Composite commodity price	WF_f	Average price of factor
PVA_a	Value-added price (factor income per unit of activity)	YF_f	Income of factor f

PX_c	Aggregate producer price for commodity	YG	Government revenue
$PXAC_{ac}$	Producer price of commodity c for activity a	YI_i	Income of domestic non-government institution
QA_a	Quantity (level) of activity	YIF_{if}	Income to domestic institution i from factor f
QD_c	Quantity sold domestically of domestic output	ΔK_{fat}^a	Quantity of new capital by activity a for time period t
QE_c	Quantity of exports		

Source: Lofgren *et al* (2002).

Table A2: Model Equations

Production and Price Equations

$$QINT_{ca} = ica_{ca} \cdot QINTA_a \quad (1)$$

$$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca} \quad (2)$$

$$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot (\alpha_{fa}^{vaf} \cdot QF_{fa})^{-\rho_a^{va}} \right)^{\frac{1}{\rho_a^{va}}} \quad (3)$$

$$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot (\alpha_{fa}^{vaf} \cdot QF_{fa})^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot (\alpha_{fa}^{vaf} \cdot QF_{fa})^{-\rho_a^{va} - 1} \quad (4)$$

$$QVA_a = iva_a \cdot QA_a \quad (5)$$

$$QINTA_a = inta_a \cdot QA_a \quad (6)$$

$$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \quad (7)$$

$$QXAC_{ac} = \theta_{ac} \cdot QA_a \quad (8)$$

$$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac} \quad (9)$$

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{\frac{1}{\rho_c^{ac} - 1}} \quad (10)$$

$$PXAC_{ac} = PX_c \cdot QX_c \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac} - 1} \quad (11)$$

$$PER_{cr} = pwer_{cr} \cdot EXR - \sum_{c' \in CT} PQ_{c'} \cdot icer_{c'cr} \quad (12)$$

$$QE_c = \alpha_c^e \cdot \left(\sum_{r \in R} \delta_{cr}^e \cdot (QER_{cr})^{-\rho_c^e} \right)^{\frac{1}{\rho_c^e}} \quad (13)$$

$$\frac{PER_{cr}}{PE_c} = QER_{cr} \cdot \left(\sum_{r' \in R} \delta_{cr'}^e \cdot (QER_{cr'})^{-\rho_c^e} \right)^{-1} \cdot \delta_{cr}^e \cdot (QER_{cr})^{-\rho_c^e - 1} \quad (14)$$

$$PE_c = pwe_c \cdot EXR - \sum_{c' \in CT} PQ_{c'} \cdot ice_{c'c} \quad (15)$$

$$QX_c = \alpha_c^t \cdot \left(\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \quad (16)$$

$$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \quad (17)$$

$$QX_c = QD_c + QE_c \quad (18)$$

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c \quad (19)$$

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c} \quad (20)$$

Source: Lofgren *et al* (2002).

Table A2 continued: Model Equations

Production and Price Equations Continued

$$PMR_{cr} = pwmr_{cr} \cdot (1 + tmr_{cr}) \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icmr_{c'cr} \quad (21)$$

$$QM_c = \alpha_c^m \cdot \left(\sum_{r \in R} \delta_{cr}^m \cdot (QMR_{cr})^{-\rho_c^m} \right)^{\frac{1}{\rho_c^m}} \quad (22)$$

$$\frac{PMR_{cr}}{PM_c} = QMR_{cr} \cdot \left(\sum_{r' \in R'} \delta_{cr'}^m \cdot (QMR_{cr'})^{-\rho_c^m} \right)^{-1} \cdot \delta_{cr}^m \cdot (QMR_{cr})^{-\rho_c^m - 1} \quad (23)$$

$$PM_c = pwm_c \cdot (1 + tm_c) \cdot EXR + \sum_{c' \in CT} PQ_c \cdot icm_{c'c} \quad (24)$$

$$QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + (1 - \delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{\frac{1}{\rho_c^q}} \quad (25)$$

$$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q} \right)^{\frac{1}{1 + \rho_c^q}} \quad (26)$$

$$QQ_c = QD_c + QM_c \quad (27)$$

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c \quad (28)$$

$$QT_c = \sum_{c' \in C'} (icm_{cc'} \cdot QM_{c'} + icmr_{cc'} \cdot QMR_{c'} + ice_{cc'} \cdot QE_{c'} + icer_{cc'} \cdot QER_{c'} + icd_{cc'} \cdot QD_{c'}) \quad (29)$$

$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c \quad (30)$$

$$\overline{DPI} = \sum_{c \in C} PDS_c \cdot dwts_c \quad (31)$$

Institutional Incomes and Domestic Demand Equations

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \quad (32)$$

$$YIF_{if} = shif_{if} \cdot [YF_f - trnsfr_{rowf} \cdot EXR] \quad (33)$$

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\text{gov}} \cdot \overline{CPI} + trnsfr_{i\text{row}} \cdot EXR \quad (34)$$

$$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'} \quad (35)$$

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{i,h} \right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins_h}) \cdot YI_h \quad (36)$$

$$PQ_c \cdot QH_{c,h} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right) \quad (37)$$

$$QINV_c = IADJ \cdot \overline{qinv_c} \quad (38)$$

$$QG_c = \overline{GADJ} \cdot \overline{qg_c} \quad (39)$$

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i,gov} \cdot \overline{CPI} \quad (40)$$

Source:Lofgren *et al* (2002).

Table A2 concluded: Model Equations

Institutional Incomes and Domestic Demand Equations Continued

$$\begin{aligned}
 YG = & \sum_{i \in \text{INSDNG}} \overline{tins}_i \cdot YI_i + \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in \text{CMNR}} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \\
 & \sum_{r \in R} \sum_{c \in \text{CMR}} tmr_{cr} \cdot pwmr_{cr} \cdot QMR_{cr} \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov f} + \text{trnsfr}_{gov row} \cdot EXR
 \end{aligned} \tag{41}$$

System Constraints and Macroeconomic Closures

$$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + QG_c + QINV_c + qdst_c + QT_c \tag{42}$$

$$\sum_{a \in A} QF_{fa} = QFS_f \tag{43}$$

$$\frac{QFS_f}{QFS_f^0} = \left(\frac{RWF_f}{RWF_f^0} \right)^{etals_f} \tag{44}$$

$$RWF_f = \left(\frac{YF_f}{QFS_f} \right) \left/ \left(\frac{CPI}{CPI^0} \right) \right. \tag{45}$$

$$YG = EG + GSAV \tag{46}$$

$$\begin{aligned}
 & \sum_{c \in \text{CMNR}} pwm_c \cdot QM_c + \sum_{r \in R} \sum_{c \in \text{CMR}} pwmr_{cr} \cdot QMR_{cr} \cdot \sum_{f \in F} \text{trnsfr}_{row f} \\
 = & \sum_{c \in \text{CENR}} pwe_c \cdot QE_c + \sum_{r \in R} \sum_{c \in \text{CER}} pwer_{cr} \cdot QER_{cr} + \sum_{i \in \text{INSD}} \text{trnsfr}_{i row} + FSAV
 \end{aligned} \tag{47}$$

$$\sum_{i \in \text{INSDNG}} MPS_i \cdot (1 - \overline{tins}_i) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c \tag{48}$$

$$MPS_i = \overline{mps}_i \cdot (1 + MPSADJ) \tag{49}$$

Capital Accumulation and Allocation Equations

$$AWF_{ft}^a = \sum_a \left[\left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot WF_{ft} \cdot WFDIST_{fat} \right] \tag{50}$$

$$\eta_{fat}^a = \left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{ft} \cdot WFDIST_{fat}}{AWF_{ft}^a} - 1 \right) + 1 \right) \tag{51}$$

$$\Delta K_{fat}^a = \eta_{fat}^a \cdot \left(\frac{\sum_c PQ_{ct} \cdot QINV_{ct}}{PK_{ft}} \right) \quad (52)$$

$$PK_{ft} = \sum_c PQ_{ct} \cdot \frac{QINV_{ct}}{\sum_{c'} QINV_{c't}} \quad (53)$$

$$QF_{fat+1} = QF_{fat} \cdot \left(1 + \frac{\Delta K_{fat}^a}{QF_{fat}} - \nu_f \right) \quad (54)$$

$$QFS_{ft+1} = QFS_{ft} \cdot \left(1 + \frac{\sum \Delta K_{fat}}{QFS_{ft}} - \nu_f \right) \quad (55)$$

Source: Lofgren *et al* (2002).

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