

POTENTIAL OPTIMAL TARIFF RATES FOR TANZANIA: A CGE ANALYSIS^a

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ABSTRACT: Computable General Equilibrium (CGE) models are usually presented as a set of simultaneous equations that describe the economic activities of consumers, producers, government, and traders in the markets for factors of production (inputs), and for goods and services (outputs). The supply and demand in each market is equilibrated by a market-clearing price. The model is called computable because simulation is used to find the prices that clear the markets for inputs and outputs. The models allow for the establishment of a direct link between economic structures as embodied in a social accounting matrix and policy changes. In this study a CGE model of Tanzania is used to endogenously determine revenue-neutral tax rates and the corresponding pareto-optimum capital adjustment that are needed to lower intermediate sales tax and import tax rates. The generic CGE model of Tanzania is presented based on the 2001 national social accounting matrix. The objective is to develop a detailed and suitable model for assessing impacts of new and potential macroeconomic policy options available for Tanzania. For illustration purposes, the model is used to endogenously determine revenue-neutral tax rate changes and the corresponding pareto optimum capital adjustment needed to lower intermediate input price by 20%, relative to import prices. The results indicate that lower tax rates will increase production for both domestic and export markets and lower price indices across the

board. However, total investment has to increase by more than 2% so as not to make all households at least as well-off as they were before the new taxes.

Key Words: CGE, Pareto-optimal, Tariff, Tanzania.

JEL Classification: O21, R13, R15

INTRODUCTION

A proper assessment of the impact of various micro and macro level policy options or investment requires a comprehensive framework to analyze interactions and linkages among different sectors of the economy. In this paper a computable general equilibrium model (CGE) of Tanzania was developed using the national social accounting matrix (SAM) as a benchmark dataset. The SAM provides a comprehensive and detailed quantified description of the economic interrelationships in the country. The CGE model based on a SAM describes the flow of the economy, while maintaining accounting and data consistency at the macro and micro levels. The model serves as a useful tool for analyzing the impact of possible policy options or investment alternatives.

A SAM is the baseline data that contain a static account for all economic transactions taking place in a base year between sectors and sub-sectors of the economy. Each account is represented by a row and a column in a square matrix. The rows of the SAM contain receipt accounts of production activities, factors of production, institutions (households, government,

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firms), investment and saving, import and export that account for transactions on inputs for production activities and commodities for consumption. The column elements represent expenditures made by these accounts. The matrix tracks how a nation produces its goods and services and how household income is generated and distributed (Cohen, 1988; Kehoe, 1996)

The CGE modeling transforms a SAM into an economy-wide model without extensive supplementary data while focusing on the demand side of the economy. CGE models simulate the working of a market economy in which prices and quantities adjust to clear all markets (Vargas et al, 1999). The CGE models specify the behavior of optimizing consumers (i.e., households, government, and enterprises), and producers while capturing all transactions and linkages within the economy (Figure 1). In its mathematical form, the CGE model contains a system of simultaneous equations divided into four blocks i.e., price, production and trade, institution, and the system constraint blocks. The price block consists of equations in which endogenous model prices are specified as a function of other prices (endogenous or exogenous) and non-price independent variables.

The production block covers domestic production and input use; allocation of domestic output to household consumption, the rest of domestic market, and export, the aggregation of supply to the domestic market; and the definition of the demand for trade inputs that is generated by the distribution process. The institution block has equations that define distribution of income to factors of production and owners of the factors of production, intra-institutional transfers, household consumption expenditures on both domestically produced and imported commodities, investment demand and savings, and government expenditures. The fourth block contains equations that equilibrate the market for factors of production, the market for goods and services and the government revenue to expenditure (Abbink, Braber and Cohen, 1995).

The CGE model operates by simulating the operation of markets for factors, products and foreign exchange. The equilibrium solution to the model for a given year produces a wealth of detailed information, including market clearing prices, GNP, productivity levels by industry, investment by industry, final consumption levels by commodity, employment by industry, imports and exports by commodity, and many more economic variables. Moreover, the Hicksian equivalent variation can be estimated to provide an exact measure of the welfare impacts of, say, price change or increased government expenditure in one sector. Furthermore, the CGE model incorporates an explicit tax system. This makes it suitable for estimating the change in tax revenue that can be generated by any policy change (Ginsburgh and Keyzer, 2002).

The underlying principle for CGE models is that prices and quantities produced or consumed in both factor and output markets are endogenous, and so is income. At equilibrium, four major market characteristics must be fulfilled. First, the total market demand equals the total market supply for every factor and output markets. Second, prices are set such that the firm's equilibrium profits are zero with all rents accruing to the factors of production such as wages and return on capital. Third, household incomes equal household expenditures including savings. Fourth, government tax revenues equal government expenditures that include subsidy payments. Thus, the CGE model contains a complete specification of the optimization problems facing all actors in the economy. This makes it possible to trace all results of the model to specific agents in the economy.

There are three main advantages of using a CGE model for policy analysis. First, it takes into account the linkages and interactions among all sectors throughout the economy in a theoretically consistent manner. A shock in one sector is likely to induce economic changes in other sectors of the economy. This is automatically taken into account when assessing the total

impact of the shock. Second, CGE models are extensions of Input-Output (IO) models, which have been widely used for decades to measure the effects of public policies. CGE models extend these older models to take into account substitution possibilities in terms of, for example, labor or capital-intensive technology choices as well as the circular flow of income across consuming households and producing industries. Third, CGE models are based on well-developed economic theories (Vargas et al, 1999). Moreover, with the SAM-based CGE models, different economic shocks can be analyzed concomitantly, and it is possible to determine the impacts of economic shocks or investment on indicators of economic growth and development. Techniques of formulating SAM-CGE based models are detailed in Abbink, Braber and Cohen (1995). Löfgren, Harris, and Robinson (2003) present a procedure for constructing an algebraic standard CGE model in General Algebraic Modeling System (GAMS) Software (Brooke et al, 2003). Rutherford presents a simplified implementation of the same model using GAMS/MPSGE (Rutherford, 1998). In summary, CGE models have two main parts. The first part of the model is an input-output matrix showing how production in one sector leads to demands for output from other sectors. The second part of the model shows how producers choose what products to produce and what combination of production resources to use based on output prices and input prices. How production responds to changes in prices is governed by elasticities built into the model. Thus getting good estimates of these elasticities is crucial to the model to generate realistic results. Conducting sensitivity analyses to test the robustness of the models and subsequent results is also important. Another crucial point for CGE models is that static models do not simulate how an economy will respond to a policy-induced shock, but instead show how the economy of the base year would have been different, had the policy change taken place prior

to the base year with enough time for adjustment. The models are more useful when recent data are used. However, for developing economies, a lag of up to five years is usually acceptable.

The general objectives of the paper are two fold. The first involves presenting a detailed generic CGE model of Tanzania suitable for analyzing different macro-policy adjustments currently taking place in Tanzania. The motivation behind this is that most macro policies instituted in Tanzania lack rigorous and quantitative policy assessment and critique, which is often attributed to limited expertise and/or availability of relevant analytical tools and data. The model and data presented here can be used directly or with adjustments to assess potential impacts of current or future trade and macro-policy scenarios.

The second objective is to stimulate the use of CGE models for fiscal, monetary or commercial policy analyses among Tanzania researchers. These models are useful tools for assessing the potential impacts of available trade and policy options on different indicators such as economic growth, poverty reduction and other issues related to gender, sustainable development and the environment. Readily available CGE tools will encourage graduate students and policy analyst in Tanzania to use and expand the presented model. In North America, Europe and some Asian countries there are several private and public institutions that are commissioned to maintain national CGE models or collect and update data for CGE modeling and policy analyses. It is our anticipation that this work will contribute to the effort of creating a critical mass of Tanzania-based researchers capable of undertaking much needed rigorous macroeconomic policy analysis.

After the introduction and background material, the second section of this paper describes the social accounting matrix of Tanzania that provides the basic data for the CGE modeling. The actual structure of the CGE model is explained in Section 3. For illustration purposes, the model

is simulated to estimate optimal tax rates for Tanzania. Summary and limitations of the model are presented in Section 4. The model in GAMS/MPSGE language is presented in Appendix 1.

A SOCIAL ACCOUNTING MATRIX (SAM) FOR TANZANIA

As stated before, a SAM is an accounting of the flow of activities, commodities and expenditures in the economy, in which every transaction between the actors in the economic system is accounted for. In other words, the SAM is a presentation of the System of National Accounts (SNA). It shows how income is derived from production activities and how it is distributed to the various socio-economic groups (Pyatt and Round, 1979). The matrix integrates the flow of goods and payments between institutions in the economy. A simple SAM contains four sectors, namely activities; commodities; factors of production; and institutions. Production activities (e.g. agriculture, manufacturing, etc) purchase inputs from other industries and pay factors of production such as capital and labor for services rendered. The factors pass this money along to households such as rural and urban households. The households in turn pay the commodity sectors for purchases of food and clothing. The SAM, therefore, provides a comprehensive and detailed quantified description of the macro and micro economic interrelationships in the country (Cohen, 1988)

A generic SAM is presented in Table 1. In the table activities represent domestic production by producers and its disposition between exports and domestic markets. Commodities consist of the disposition of domestic and imported goods to final consumers. The distinction ensures that only domestically produced goods are exported, which include intermediate products for re-export. The distinction also allows more than one activity sector to produce a given commodity. This is useful when there exist different technologies for producing the same goods or services. The rows in the SAM represent the source of income. The commodity

accounts include purchase of intermediate goods, public and private consumption goods, and investment (savings). The household row represents income sources from factors and remittances from government, firms, households, and from the rest of the world. The columns represent expenditure of income by each account. For example, the household column includes purchases of consumption goods, payment of taxes, private savings, and payment to external transfer account. A square SAM is balanced when the sums of respective rows and columns equal, roughly corresponding to the conventional notion of double-entry-book-keeping and satisfying the market clearing conditions.

The International Food Policy Research Institute (IFPRI) under the Macro-Economic Reform and Regional Integration in Southern Africa Project compiled the 2001 SAM for Tanzania. Thurlow and Wobst (2003) present a detailed account on the processes of developing the SAM. The SAM they developed has seven sections: a) activities: agricultural (21 accounts) and non-agricultural (22 accounts); b) commodities: agricultural (21) and non-agricultural (22 accounts); c) marketing margins (3 accounts), d) factors of production (13 accounts); e) institutions: households (12 accounts), government (1 account), and enterprise or corporation (1 account); f) taxes (6 account); g) one account for saving and investment; and h) and the rest of the world account that include activities related to foreign trade.

The household section was divided into urban and rural households. In each category, households are organized into six groups that include households below poverty line, between food and basic needs poverty lines, non-poor-head with no education, non-poor-head not finished primary school, non-poor-head not finished secondary school, and non-poor-head finished secondary school.

Factors of production are divided into a subsistence factor, labor, agricultural capital, non-agricultural capital, and agricultural land. Labor supply is divided into child, female, and male labor sub-groups. Child labor supply is for participant aged 10 to 14. Female and male labor supply is for participant aged above 14 years and grouped into those without formal education, finished primary school not finished secondary school, and finished secondary school or higher education.

Taxes include direct taxes on domestic institutions, import tariff, export taxes, value added or activity taxes, indirect or sale taxes, and factor taxes. The marketing margins section contains export, import and domestic market accounts. Marketing margins include export transaction costs, domestic sales transaction costs, and import transaction costs. Marketing margins combine trade and transport costs. They represent real costs associated with the distribution of products from their point of production or port of importation to the point of purchase. Table 2 presents the aggregated 2001 macro SAM for Tanzania. It is noteworthy that the Tanzania SAM distinguishes between goods produced for home (own) consumption and goods produced for the domestic market. Goods produced for own consumption appear as payment from households to activity account and is valued at households' consumption prices, which does not include marketing margins and sales taxes that may be levied on marketed commodities. In addition, the economy exports commodities instead of activities. See Thurlow and Wobst, 2003 for more details.

THE CGE MODEL OF TANZANIA

The CGE models work by using SAM data to describe the economy in a benchmark year, and by then varying one or more elements to shock the economy and register changes among macro and micro variables. The CGE models of all countries were developed following Devarajan *et al.*

(1997). Each sector produces a composite commodity that is transformed according to a constant elasticity of transformation (CET) function into a commodity sold on the domestic market, consumed at home and exported. Output is produced according to a constant elasticity of substitution (CES) production function in primary factors and fixed input-output coefficients for intermediate inputs. Commodities produced for home consumption, private consumption, intermediate demand, enterprise, government, and investments are the five components of domestic demand. Consumer demand is based on the Cobb-Douglas utility functions that generate fixed expenditure shares. Households pay income taxes to the government and save a fixed proportion of their income. Real government demand and real investment are fixed exogenously.

There are three macro balances in the model: the government deficit, aggregate investment and savings, and the balance of trade. Government savings is the difference between revenue and spending, with real spending fixed exogenously, and revenue depending on a variety of tax instruments. Taxes include direct taxes on domestic institutions, import tariff, export taxes, value added or activity taxes, indirect or sales taxes, and factor taxes. The government deficit is therefore determined endogenously. Real investment is set exogenously and aggregate private savings is determined residually to achieve the nominal savings-investment balance. The balance of trade foreign savings is set exogenously and valued in world prices. The model solves for the relative domestic prices and factor returns that clear the factor and product markets. In equilibrium, there is exogenous aggregate trade balance in the model, and real exchange rate brings aggregate export supply and import demand into balance. The circular flow of income is captured by tracing the flow from producers to households, government, enterprises, and

investors, and finally back to demand for goods and services in the product markets. The circular flow of these goods and services are presented in Figure 1.

Specifically, the model included seven classes of production activities, eleven classes of prices or cost indexes, and three types of consumers (i.e., households, government, and private firms). Production activities included: total domestic production, production of output to domestic and export markets, production for export market, aggregate supply, transportation and marketing margin, household consumption, and aggregate investment. Price or cost indexes included: output supply price, domestic sales price for marketed output, domestic export price, composite demand price, household consumption price, trade and transport margins for export, factor prices, tax revenue, enterprise or private firm rents, export and export prices in foreign currency, and price of investment

Nested CES (constant-elasticity-of-substitution), Leontief (fixed-coefficient), and Cobb-Douglas functions represent production technology in the model. The domestic production activity has a nested CES cost function with a Leontief aggregation across intermediate input and factor demands at the top level. The reference output quantities are the SAM values of domestic marketed output, household production for own consumption, and value of export. There are two types of inputs to the domestic production function, corresponding to aggregate intermediate input demand and value added. Value added is Cobb-Douglas function of the primary factors, while intermediate input functions are defined by fixed input-output coefficients. In the model, an ad-valorem tax rate is applied to intermediate inputs.

The production sectors produce differentiated goods for domestic market, households' own consumption, and export markets. Allocation between the markets is achieved by using a CET (constant-elasticity-of-transformation) functions. The value of export at producer price and

export marketing margins serves as an input in the export sector. Producer price and trade and transportation margin serves as an input associated with price for domestically marketed output.

The aggregate supply or the Armington aggregation constitutes a composite of imported and domestic goods, which are imperfect substitutes. The activity is presented as a nested CES cost function with elasticity of substitution between imports and domestically produced goods being equal to zero. Indirect taxes are levied on aggregate commodities and import tariff are levied on imported commodities. The marketed output price index serves as an input to the Armington aggregation sectors. There are three types of inputs to the Armington aggregation activity: domestic sales price; trade and transportation costs, and price of foreign exchange. The domestic sale price represents domestic use of locally produced goods, trade and transportation costs represent domestic sales and import transaction costs; and foreign exchange, which represent value of imports at the port, inclusive of cost, insurance and freight (cif). In this activity, vector of second level input nests, each with an elasticity of substitution equal to zero (Leontief technology). Using a Leontief aggregation on the inputs assures that domestic and import margins remain strictly to the base year level.

Final consumption by consumers and producers is characterized as a Cobb-Douglas composite of goods. Price of investment serves as an input to the investment sectors. Aggregate investment equals to savings. The input is the composite demand price index for marketed output, which defines the benchmark quantity of private investment demand. The model statement concludes with a specification of commodity endowments and demand for each institution. Households are endowed with income from primary factors, government transfers, earning from private firms and from rest of the world. As indicated before, households save the proportion of their income and pay income taxes. All remaining household income is allocated to

private consumption. For enterprise, any revenue from factor earnings is allocated to tax payments or transfers to households, government or repatriation to the rest of the world. The government sector is likewise subject to a budget constraint such that government revenue from different sources equals expenditures that include government transfers, savings and debit payments. The data and tools used in the analysis are available on request.

Calibration or benchmarking determines the values of the normalizing parameters to replicate the observed flow values incorporated in the SAM. This process assumes that all equations describing market equilibriums in the CGE model are met in the benchmark period (Vargas et al., 1999). Since CGE modeling deals with flexible functional forms, such as the constant elasticity of substitution (CES) or the constant elasticity of transformation (CET), the calibration process is supplemented with exogenously determined elasticities of substitution. Other parameters obtained from the literature included income elasticities and price elasticities of export and import demand. These parameters are used in the calibration process of the various components of the CGE model.

Because in CGE analysis only relative prices matter, all prices and factor rents are normalized to unity in the initial equilibrium. With prices normalized to one, the flow values in the SAM are physical index of quantity in the commodity (industry) and factor markets. Once all the parameters are specified, the model is solved to reproduce the benchmark data. In addition to providing a check on the accuracy of the calibration, the replication process also shows that there is a complete balance between circular flows of income and expenditures or there is a micro-consistency within the SAM data. Counterfactual equilibrium is obtained by rerunning the model after introducing changes to exogenous variables, in market conditions, or in any policy variable.

RESULTS AND DISCUSSION

Table 1 presents the aggregated 2001 macro SAM for Tanzania. It is noteworthy that the Tanzania SAM distinguishes between goods produced for home (own) consumption and goods produced for the domestic market. Goods produced for own consumption appear as payment from households to activity account and is valued at households' consumption prices, which does not include marketing margins and sales taxes that may be levied on marketed commodities. In addition, the economy exports commodities instead of activities

As shown in Table 1, a square SAM is balanced when the sum of rows equal the sum of columns to satisfy the zero profit and market clearing conditions. In Table 1, the activity column (A) represents expenditure by production activities, which shows that about 6 trillion Tshs was spent on intermediate inputs, 8 trillion Tshs was spent on factors of production, and the activities paid 21 billion in value added tax. The commodity column (C) shows that goods valued at 12 trillion Tshs were marketed in the domestic market, and the retail and marketing cost was about 356 billion Tshs. The indirect tax on marketed output was 436 billion Tshs, and the value of import at CIF was about 2 trillion Tshs. The factor column (F) shows how the factor income was distributed to households (i.e., 2 trillion to enterprises, 5 trillion to households, 18 billion to government as factor income tax, and 25 billion as dividends to factors owned by foreigners). The enterprise income (column E) was distributed to households (2 trillion Tshs), 1 billion Tshs was paid to the government as dividend, and 96 billion Tshs was paid in form of enterprise or corporate taxes.

Column H, which represents household expenditures, shows that goods valued at about 2 trillion Tshs were produced and consumed at home by households. Private household consumption was valued at about 5 trillion. The households paid 94 billion Tshs in income tax and households saving were 903 billion Tshs. The government column (G) indicates that the

government paid for goods and services valued at 514 billion Tshs, distributed 61 billion as direct support to households, and saved about 91 billion Tshs. The government collected 666 billion Tshs in tax revenue (column TA). The trade column (TR) shows that commodities valued more than 1.3 trillion Tshs were exported. Households received 403 billion Tshs in the form of remittances from abroad. Foreign investment was about 324 billion Tshs. About 1.3 trillion Tshs were invested in the production of commodities (Column I).

As indicated before, the model simulation experiment adjusts sales tax on intermediate inputs and the trade related import tariff on all imports. In addition, investment demand is scaled to determine required capital adjustment to maintain government revenue. Table 3 presents the effects of the experiment on tax reduction. As indicated in Table 3 sales tax on intermediate inputs ranged between 8% on real estate to 71% on Sugar. The average was 33%. The new sales tax rates range from 6% to 56% with an average of 20% reduction in sales tax. There are no significant changes in the imports take rates. This may be because, comparatively, import tax rates were lower than sales tax rates.

Table 4 presents the results on quantity and price indexes changes. On average the quantity index will increase by about 1.70% and relative price will fall by 2.28%. From the results in Tables 3 and 4 it can be concluded that sales tax rates are unnecessarily high. The Tanzania government can cut these tax rates by about 20% and still maintain the same level of revenue. However, total investment has to increase by more than 2% so as to maintain Pareto optimality. In other words, a policy geared towards reducing tax rates in Tanzania should go hand in hand with policies aimed at increasing investment.

Another limitation of the CGE models is the dependency on the closure rule. The CGE models are actually numerical representation of the basic relationships of the Walrasian general

equilibrium system, as formulated within the Arrow-Debreu general equilibrium theorem. The mechanisms that achieve consistency of transactions at the macroeconomic level, called often macro-framework, is particularly important for appraising the model's properties, and this is independent of the way markets clear. The macro-framework mechanism may be represented by four simultaneous identities: the national income identity, the balance of payment, the public budget balance and the savings-investment identity. In traditional CGE models, the savings-investment identity is usually adopted as the "closure rule" and it is often used for evaluating investment. Such a restrictive assumption is necessary because there is no financial-monetary sector. However, it is possible to integrate the real and the monetary/financial sectors of the economy in the model and overcome the closure rule limitation. The strict equality of savings and investments, can be expanded in a way that any difference between them is financed through changes in money supply, private domestic borrowing of government, net foreign assets and private lending from banks. The new set of accounting identities can be expanded to cover a large spectrum of financial market conditions and institutional characteristics.

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Figure 1: Basic Structure of the Tanzania CGE Model

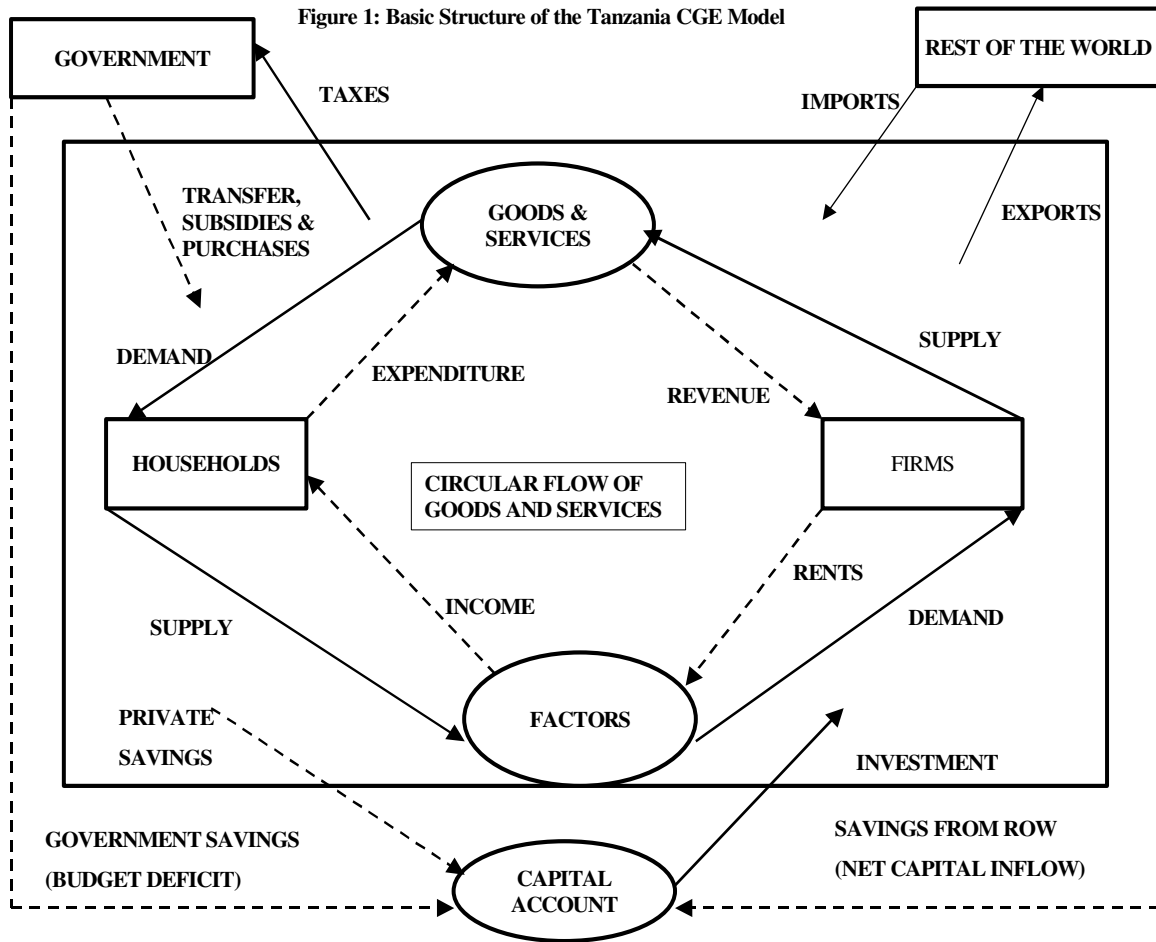


Table 1: The Structure of Social Accounting Matrix for Tanzania

Receipts	Expenditure									
	Activities	Commodities	Margins	Factors	Enterprise	Household	Government	Taxes	Trade	Investment
Activities		Domestic	Sales			Household	Own			
		(ac)				Consumption (ha)				
Commodities	Intermediate		Marketing			Private	Consumption	Government	Value	of Private
	Inputs (ca)		Margins			(ch)	Commodity		Export (er)	Investment
			(cm)				Demand (gd)			Demand (cs)
Margins		Marketing	Margins							
		(mc)								
Factors	Value	Added								
	(fa)									
Enterprise				Factor	Income	to				
				Enterprise (ef)						
Household				Factor	Income	to Enterprise	Payment to	Government		Household
				Households (hf)		households (he)		Transfer to		Income
							households			from Rest of
							(hg)			the World
										(hr)
Government				Factor	Income	to Enterprise	Dividend		Government	Tax
				Government (gf)		Payment	to		Revenue (tr)	
						Government (ge)				
Taxes	Value	Added	Indirect Taxes(tc)	Factor	Taxes (tf)	Enterprise	Direct	Income Tax	Payment by	
	Tax (ta)					Taxes (te)		households (tp)		

Trade	Value of Imports (rc)	Factor Remittance to Rest of the World (rf)			
Investment		Depreciation (dp)	Household Savings (psv)	Private Government Savings (gsv)	Foreign Savings (fsv)

Table 2: Aggregate Macro SAM for Tanzania (2001 Billion Tshs)

Receipts	Expenditures										Total
	A	C	M	F	E	H	G	T	T	I	
Activity		12,098.0				1,949.5					14,047.4
Commodity	6,449.8		355.7			4,953.7	513.9		1,305.7	1,318.7	14,897.5
Margins		355.7									355.7
Factors	7,576.3										7,576.3
Enterprise				2,268.5							2,268.5
Household				5,264.8	2,171.5		61.4		402.6		7,900.3
Government					1.0			665.6			666.6
Taxes	21.3	436.3		18.1	96.0	93.9					665.6
Trade		2,007.5		25.0							2,032.5
Investment						903.2	91.3		324.3		1,318.7
Total	14,047.4	14,897.5	355.7	7,576.3	2,268.5	7,900.3	666.6	665.6	2,032.5	1,318.7	

Table 4: Relative changes in quantity and price indexes for new tax rate

Item	Description	% Change
Quantity Index	Total output	1.25
	Total export	2.21
	Aggregate supply	1.73
	Household consumption	1.77
	Investment	2.00
Price/Cost Index	Farm level price	-2.44
	Market price	-2.41
	Export price	-2.20
	Consumer price index	-1.64
	Household consumption price	-2.40
	Exchange rate	-2.20
	Primary factor prices	-2.66

Appendix 1: The Tanzania CGE Model in GAMS/MPSGE Language

\$title A Generic Computable General Equilibrium Model of Tanzania
set i Row and Columns on the Sam /1*124/;
alias (i,j);

SET s List of activities and commodities/
MAIZE Growing of maize,
PADDY Growing of paddy,
SORGH Growing of sorghum and millet,
WHEAT Growing of wheat,
BEANS Growing of beans,
CASSA Growing of cassava,
CEREA Growing of other cereals,
OILSE Growing of oil seeds,
ROOTS Growing of other roots and tubers,
COTTO Growing of cotton,
COFFE Growing of coffee,
TOBAC Growing of Tobacco,
TEAGR Growing of tea,
CASHE Growing of cashew nuts,
SISAL Growing of sisal fiber,
SUGAR Growing of sugar cane ,
OFRVE Growing of fruits and vegetables,
OCROP Growing of other crops,
LIVES Operation of poultry and livestock,
FISHI Fishing and fish farms,
HUFOR Hunting and forestry,
MININ Mining and quarrying,
MEATD Processing of meat and dairy products,
GRAIN Grain milling,
PFOOD Processed food,

BEVER	Beverage and tobacco products,
CLOTH	Textile and leather products,
WOODP	Wood paper printing,
CHEMI	Manufacture of basic and industrial chemicals,
FERTI	Manufacturer of fertilizer and pesticides,
PETRO	Petroleum refineries,
RUPLA	Rubber plastic and other manufacturing,
GLASS	Glass and cement,
METAL	Iron steel and metal products,
EQUIP	Manufacture all equipment,
UTILI	Utilities,
CONST	Construction,
TRADE	Wholesale and retail trade'
HOTEL	Hotels and restaurant,
TRANS	Transport and communication,
ESTAT	Real estate,
ADMIN	Public administration health and education,
PRIVS	Business and other services /,

M Retail and Marketing Margins /

CTDTP-E Export transactions costs,
CTDTP-D Domestic sales transactions costs,
CTDTP-M Import transactions costs /,

F Factors of production /

FSUB	Subsistence factor,
LCHILD	Child labor age 10 to 14,
LNONF	Female labor with no formal education,
LNFPF	Female labor nonfinished primary school,
LNFSF	Female labor nonfinished secondary school,
LSECF	Female labor secondary or higher education,
LNONM	Male labor with no formal education,
LNFPM	Male labor nonfinished primary school,
LNFSM	Male labor nonfinished secondary school,

LSECM Male labor secondary or higher education,
 CAPAG Agricultural capital,
 CAPNAG Non-agricultural capital,
 LAND Agricultural land /,

H Household Groups /

HRBFPL Rural below food poverty line,
 HRFBPL Rural between basic needs poverty line,
 HRNOED Rural non-poor head with non-education,
 HRNFPS Rural non-poor head not finished primary school,
 HRNFSS Rural non-poor head not finished secondary school,
 HRSECP Rural non-poor head finished secondary school,
 HUBFPL Urban below food poverty line,
 HUFBPL Urban between basic needs poverty line,
 HUNOED Urban non-poor head with non-education,
 HUNFPS Urban non-poor head not finished primary school,
 HUNFSS Urban non-poor head not finished secondary school,
 HUSECP Urban non-poor head finished secondary school/ ,

T Different Taxes /

DIRTAX Direct taxes on domestic products,
 IMPTAX Import tariff,
 EXPTAX Export taxes,
 VATAX Value added or activity taxes,
 IND TAX Indirect or sales taxes,
 FACTAX Factor taxes /;

alias (g,s);

parameter

sam(i,j) Balanced social accounting matrix
 ca(g,s) Intermediate inputs demand,
 fa(f,s) Factor demand or value added,

ta(t,s)	Total value added taxes,
ha(s,h)	Household consumption of own production,
ac(s,g)	Marketed output
mc(m,g)	Marketing and transportation costs
tc(t,g)	Indirect taxes
rc(g)	Value of imports at (cif)
cm(g,m)	Wholesale and retail cost
gd(g)	Government Demand
er(g)	Export (fob),
cs(g)	Private investment demand,
ch(g,h)	Private consumption,
hf(h,f)	Factor income to households
ef(f)	Factor income to enterprise
gf(f)	Factor income to government
tf(t,f)	Factor taxes to government
rf(f)	Factor remittance to rest of RoW
dp(f)	Depreciation,
tp(t,h)	Income tax payment by households,
he(h)	Enterprise payment to households,
hg(h)	Government transfer to households,
hr(h)	Household income from RoW,
psv(h)	Private savings,
te(t)	Enterprise direct taxes,
ge	Enterprise dividend payment to government,
gsv	Government savings
fsv	Foreign savings,
tr(t)	Total tax revenue;

* Read the data (SAM):

\$gdxin 'kalibasam.gdx'

\$load ca fa ta ha ac mc tc rc cm gd er cs ch hf ef gf tf rf dp tp he hg hr psv te ge gsv fsv tr

parameter t_y(s) Value-added tax rates (here levied as a tax on output),

t_d(s) Value-added tax rate (here levied as a tax on intermediate inputs

t_d0(s)	Base year value-added tax rate (here levied as a tax on intermediate inputs
t_f(f)	Factor taxes rate
py0(s)	Reference output price
pd0(s)	Reference intermediate input price
pf0(f)	Reference factor taxes
ya(g)	Aggregate output from all sectors
as(g)	Aggregate supply
t_m(g)	Import tariff rate
t_m0(g)	Import tariff rate base year
pm0(g)	Reference import price
t_i(g)	Indirect tax rate
t_i0(g)	Base year indirect tax rate
ex(g)	Exports at producer prices
dm(g)	Domestic use
xi(g)	Adjustment to account for negative implicit supply
gd0(g)	Government Commodity demand on the base year (2001);

$t_y(s) = \text{sum}(t, ta(t,s)) / \text{sum}(g, ac(s,g));$

$py0(s) = 1 - t_y(s);$

$t_f(f) = \text{sum}(t, tf(t,f)) / \text{sum}(s, fa(f,s));$

$pf0(f) = 1 - t_f(f);$

$t_d(s) = \text{sum}(t, ta(t,s)) / \text{sum}(g, ca(g,s));$

$t_d0(s) = t_d(s);$

$pd0(s) = 1 + t_d(s);$

$ex(g) = er(g) - mc("CTDTP-E",g);$

$ya(g) = \max(\text{sum}(s, ac(s,g)), ex(g));$

$xi(g) = ya(g) - \text{sum}(s, ac(s,g));$

display xi;

$dm(g) = ya(g) - ex(g);$

$as(g) = rc(g) + \text{sum}(t, tc(t,g)) + mc("ctdtp-d",g) + mc("ctdtp-m",g) + dm(g);$

$t_m(g)\$rc(g) = tc("imptax",g) / rc(g);$

$t_m0(g) = t_m(g);$

```

pm0(g) = 1 + t_m(g);
t_i(g)$as(g) = tc("indtax",g) / as(g);
t_i0(g)=t_i(g);

```

```

parameter chk, tax, taxrate;
chk(g,"ya") = ya(g);
chk(g,"ex") = ex(g);
chk(g,"ya-ex") = ya(g) - ex(g);
chk(g,"RC")=RC(g);
tax("inptax")=sum((t,s), ta(t,s));
tax("indtax")=sum(g, tc("indtax",g));
tax("imptax")=sum(g, tc("imptax",g));
tax("factax")=sum((t,f), tf(t,f));

```

```

taxrate(s,"T_D")=100*t_y(s);
taxrate(s,"T-M")=100*t_m(s);
*taxrate(s,"t_I")=100*t_I(s);

```

```

option taxrate:3;

```

```

display tax, taxrate;

```

```

parameters margins Transactions costs margins on a gross basis (%)

```

```

qmargins Total transportation and marketing margins ;

```

```

margins(g,"Export")$er(g) = 100 * mc("CTDTP-E",g)/er(g);
margins(g,"Domestic")$(mc("CTDTP-D",g)+dm(g)) = 100 * mc("CTDTP-D",g)/(mc("CTDTP-D",g)+dm(g));
margins(g,"Import")$(mc("CTDTP-m",g)+rc(g)*pm0(g))
= 100 * mc("CTDTP-m",g)/(mc("CTDTP-m",g)+rc(g)*pm0(g));

```

```

qmargins(g,"Export")$er(g) = mc("CTDTP-E",g);
qmargins(g,"Domestic")$(mc("CTDTP-D",g)+dm(g)) = mc("CTDTP-D",g);
qmargins(g,"Import")$(mc("CTDTP-m",g)+rc(g)*pm0(g))= mc("CTDTP-m",g);
gd0(g)=gd(g);
option margins:2,qmargins:2;
display margins, qmargins, ta, gd0;

```

```

set ti Tax adjustment Rate on intermediate inputs and imports /tid, tim/;
$ontext
$model:TZAMODEL
$sectors:
    y(s)          ! Sectoral output (domestic production)
    x(g)          ! Allocation of output to domestic and export markets
    e(g)$er(g)    ! Export activity (applies margins)
    a(s)          ! Aggregate supply (Armington aggregate)
    mg            ! Transport margins
    c(h)          ! Household consumption
    invest        ! Aggregate investment
$commodities:
    py(g)         ! Output price
    pd(g)$dm(g)   ! Domestic sales price
    px(g)$ex(g)   ! Export price
    pa(g)         ! Composite demand price for marketed output
    pc(h)         ! Household consumption price
    pt            ! Trade and transport margins
    pf(f)         ! Factor prices
    pg            ! Lump-sum tax revenue
    pe            ! Enterprise rents
    pfx           ! Price of foreign exchange
    pinv          ! Investment
$consumers:
    ra(h)         ! Private households
    govt          ! Government
    entr          ! Private firms
$auxiliary:
    tau(ti)       ! Tax adjustment parameter
    KSTOCK        ! Capital adjustment parameter
$prod:y(s) s:0 t:4 va:1
    o:py(g)       q:ac(s,g)

```

```

    o:pc(h)          q:ha(s,h)
    i:pa(g)          q:ca(g,s)  a:govt t:t_d(s) p:pd0(s)$pd0(s)
+ n:tau("tid")$t_d0(s) m:(0.8*t_d0(s))$t_d0(s)
    i:pf(f)          q:fa(f,s) va:
$prod:x(g) t:2
    o:pd(g)          q:(ya(g)-ex(g))
    o:px(g)          q:ex(g)
    i:py(g)          q:ya(g)
$prod:e(g)$er(g)
    o:px(g)          q:ex(g)
    i:px(g)          q:ex(g)
    i:pt            q:mc("CTDTP-E",g)
*   Trade margins:
$prod:mg s:0
    o:pt            q:(sum((m,g), mc(m,g)))
    i:pa(g)          q:(sum(m,cm(g,m)))
*   Armington aggregation of domestic and imported goods:
$prod:a(g) dm:2 d(dm):0 m(dm):0
    o:pa(g) q:as(g)      a:govt t:t_i(g)
    i:pd(g) q:dm(g)      d:
    i:pt    q:mc("CTDTP-D",g) d:
    i:px(g) q:rc(g)      m: a:govt t:t_m(g) p:pm0(g)$pm0(g)
+ n:tau("tim")$t_m0(g) m:t_m0(g)$t_m0(g)
    i:pt    q:mc("CTDTP-M",g) m:
*   Investment:
$prod:invest
    o:pinv          q:(sum(g,cs(g)))
    i:pa(g)          q:cs(g)
*   Private household consumption of goods:
$prod:c(h) s:1
    o:pc(h) q:(sum(g,ch(g,h)))
    i:pa(g) q:ch(g,h)
*   Household demand with exogenously fixed investment, taxes and transfers:

```

```

$demand:ra(h)
  d:pc(h)
  e:pinv      q:(-psv(h))      r:kstock
  e:pfx      q:(hg(h)+hr(h)-sum(t,tp(t,h)))
  e:pe      q:he(h)
  e:pf(f)    q:hf(h,f)      r:kstock
$demand:entr
  d:pe
  e:pf(f)    q:ef(f)      r:kstock
  e:pfx      q:(-sum(t,te(t)))
  e:pa(g)    q:(-gd(g))
  e:pg      q:(sum(g,gd(g)))
$demand:govt s:0
  d:pg
  e:py(g)    q:xi(g)
  e:pa(g)    q:(-xi(g))
  e:pinv     q:(-gsv-fsv) r:kstock
  e:pe      q:ge
  e:pf(f)    q:(gf(f)+rf(f)+sum(t,tf(t,f))) r:kstock
  e:pfx      q:(sum(t, te(t))-sum(h,hg(h))+fsv-sum(f,rf(f))+sum((t,h),tp(t,h)))
$constraint:tau(ti)
  govt =e= sum(g, pa(g) * gd0(g));
$constraint:kstock
  pinv =e= (pf("capag")+pf("capnag"))/2;
$offtext
$sysinclude mpsgeset TZAMODEL
TZAMODEL.iterlim = 0;
tau.l(ti)=0;
kstock.l=1;
$include TZAMODEL.gen
solve TZAMODEL using mcp;

parameter EV1      Welfare impact (% change)

```

```

parameter ra0(h)    Reference income level;
ra0(h) = ra.l(h);
TZAMODEL.iterlim = 100000;
*    Examine the welfare impact of instituting equal yield tax on inputs and imports
    t_d(g)=0;
    t_m(g)=0;
    tau.lo(ti)=0;
    tau.up(ti)=+inf;
$include TZAMODEL.gen
Solve TZAMODEL using mcp;
ev1(h) = round(100 * (ra.l(h)/(pc.l(h)*ra0(h)) - 1), 2);
parameter welfare    Welfare impact;
Welfare(h,"ev1")=ev1(h);
display welfare;
parameter Newtaxrate New optimal tax rate on intermediate inputs and imports;
newtaxrate(s,"T_D")=tau.l("tid")*0.8*taxrate(s,"T_D");
newtaxrate(s,"T-M")=tau.l("tid")*taxrate(s,"T-M");
option newtaxrate:3;
display newtaxrate;

```

Appendix 2: Model Description

The MPSGE description of the model in Appendix 1 starts with the GAMS commands that read the data from the Social Accounting Matrix table provided in the tools and declarations of the MPSGE model (\$MODEL:TZAMODEL). The following statements indicate that the model involves seven classes of production activities (i.e., sectors $y(s)$, $x(g)$, $e(g)$, $a(s)$, mg , $c(h)$, and $invest$), eleven classes of commodities or price indices (i.e., $py(g)$, $pd(g)$, $px(g)$, $pa(g)$, $pc(h)$, pt , $pf(f)$, pg , pe , px , and $pinv$), three classes of consumers (i.e., $ra(h)$, $govt$, and $entr$), and an auxiliary variable TAU. The \$PROD: blocks describe classes of production activities, and \$DEMAND: blocks characterize endowments and preferences for the classes of consumers. Consider the records associated with production sector $y(S)$. The entries on the first line of a \$PROD: blocks are elasticity values. The "s:0" field indicates that the top-level elasticity of substitution between inputs is zero (Leontief). The entry "va:1 indicates that primary factors $fa(f,s)$ are entering in the model as aggregates with elasticity of substitution equal to one. Transformation of output to marketed and output consumed at home is represented with a nested transformation function with elasticity of transformation being equal to four (i.e., entry t:4).

Records that begin with O: or I: respectively, indicate an output and an input. In both types of records, Q: is a quantity field indicating a reference input or output level. A P: signifies a reference price field. This price is measured as a user cost, gross of applicable taxes. The default values for reference price and reference quantity are both unity (i.e., a value of 1 is installed if a P: or Q: field is missing). The A: and T: fields in a \$PROD: block indicate tax agent and ad-valorem tax rate, respectively. The tax agent is specified before the tax rate. A single input or output coefficient may have two or more taxes applied. Consumers are treated symmetrically- there is no restriction on who should collect the tax.

The \$DEMAND block also contains fields (e.g., s:, a:, b: etc.) which represent elasticities of substitution. The subsequent records may begin with either an E: field or a D: field. These, respectively, represent commodity endowments and demands. In the demand fields, the P: and Q: entries are interpreted as reference price and reference quantity, analogous to the input fields in a \$PROD block. Ad-valorem taxes may not be applied on final demands, so that if consumption taxes are to be applied in a model they must be

levied on production activities upstream of the final demand. The benchmark values for all activity levels and prices are equal to the default value of unity, and therefore we are able to specify values in the Q: fields directly from the benchmark data (the social accounting matrix). In the model government transfers to households are accomplished through the use of an artificial commodity (PT). The government is identified as the agent who receives all tax revenue (see the A:GOVT entry in both of the \$PROD: blocks). Commodity PT is the only commodity on which GOVT spends its income, hence government tax revenue is divided among households in proportion to their endowments of the artificial good.

In order to simulate the impact of tax policy options, it is necessary to accommodate the endogenous determination of tax rates as part of the equilibrium computation. This is achieved by introducing the auxiliary variables TAU. Auxiliary variables can either represent price-adjustment instrument (endogenous tax) or can represent quantity-adjustment instruments (endowment ration). In the counterfactual model, TAU is used to proportionally scale input and import taxes in order to achieve a target level of government revenue. The auxiliary variable first appears in the \$PROD:y(S) and a(s) blocks, following the declaration of a tax agent. There are two fields associated with an endogenous tax. The first field (N:) gives the name of the auxiliary variable, which will scale the tax rate. The second field (M:) specifies the multiplier. If the M: field is omitted, the multiplier assumes a default value of unity. If the value in the M: field is zero, the tax does not apply. The auxiliary variable TAU also appears at the bottom of the file where it labels an associated inequality constraint. This constraint exhibits complementary slackness with the associated non-negative auxiliary variable (i.e., if TAU is positive, the constraint must hold with an equality, whereas if the constraint is non-binding TAU must be zero). An auxiliary variable may or may not appear in its associated constraint.

A major drawback of static analysis is the presence of a fixed stock, which does not align with investment. The static CGE models usually fail to address the possible changes to investment and the counterfactual capital stock. This can be remedied using the steady-state option, by allowing capital and investment to change in response to policy directives, as would happen in a long-run analysis. The scale parameter (r:kstock), is complementary to the steady-state investment equation. When capital rises relative to private investment, the model scales up government and private investment so that total investment is consistent with the return to

agricultural and nonagricultural capital (Rutherford and Light, 2001). Simulation is conducted by setting existing intermediate inputs and imports tax rates to zero and allowing the model to endogenously determine optimal tax multiplier (TAU:) and capital adjustment scalar (r), which are then used to estimate new tax rates.