ADDIS ABABA UNIVERSITY

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# ETHIOPIA'S ACCESSION TO THE WTO AND ITS IMPLICATION ON POVERTY: A QUANTITATIVE ANALYSIS BASED ON A CGE MODEL

BY

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# "Ethiopia's Accession to the WTO and its implication to Poverty: a Qualitative Analysis Based on a CGE Model."



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| | |
|---|---|
| BRC | BRITISH RETAIL COMMISSION |
| EUREP GAP | EUROPEAN GOOD AGRICULTURAL PRACTICE |
| FDI | FOREIGN DIRECT INVESTMENT |
| GAMS | GENERAL ALGEBRAIC MODELLING SYSTEM |
| HACCP | HAZARD ANALYSIS CRITICAL CONTROL POINTS |
| *LDCS* | *LEAST DEVELOPING COUNTRIES* |
| *SAM* | *SOCIAL ACCOUNTING MATRIX* |
| *SPS* | SANITARY AND PHYTOSANITARY |
| TBT | TECHNICAL BARRIERS TO TRADE |
| WTO | WORLD TRADE ORGANIZATION |

**Abstract**

*Ethiopia is on the process of becoming a member of the WTO. To be accepted as a member, the country has to address the supply side constraints and fulfill a number of preconditions including the upgrading of the existing laboratory infrastructure used for regulating imports and exports, strengthening or creating appropriate national institution that can ensure the implementation of and administration of the TBT Agreement in compliance with the WTO TBT principles, the creation or building of local capacity to respond to a National Enquiry Point for the WTO TBT Agreement and the creation of a national system certification service provider for certifying ISO, HACCP, EUREPGAP, BRC and others required for foreign markets. But, fulfilling these requirements incur high costs. The Thesis tries to analyze the impact of implementing the WTO accession requirements on the national economy and evaluates its implication on poverty using a Computable General Economic Model (CGE) and the 2002 Ethiopian SAM. CGE models can be used to analyze the impact of macroeconomic policy and external shocks on income distribution, employment and poverty. The result of the analysis shows that if Ethiopia tries to implement the membership requirements for accession without further looking for compensating measures, the most disadvantaged group of the society will be adversely affected seriously, at least in the short run, as these groups are exposed to price risks. It was further shown that the increase in government consumption on goods and services induced by the need for fulfilling the accession requirements will have the tendency to increase the prices of goods and services consumed by the poor and to the deterioration of the terms of trade of the sector in which they are employed. The result of the analysis has also shown that an attempt to finance the investment necessary for compliance by diverting resources away from the pro poor expenditure sectors would end up adversely affecting the poor. Although trade liberalization may have a positive effect in the long-run for the poor by stimulating growth, increasing*

*demand for unskilled and semi-skilled workers, and increasing government revenues, the poor may also, at the same time, be at a disadvantage in the short run. The policy implication of this is therefore that the government should take cautious measures in implementing the requirements for WTO accession. These measures may include implementing the requirements sequentially on priority basis and seeking technical and financial supports from the Standards and Trade Development Facility of the WTO for compensating the diverted resources and for injecting additional pro-poor spending. The limitation of this Thesis is that focus was given to the analysis of short-term impacts of shocks. Given the dynamic nature of the global economy and the ever changing modalities of trade relationships among countries, however, a more rigorous analysis involving dynamic CGE model and the incorporation of more disaggregated households in the analysis would have helped to elucidate the impacts of accession on poverty and inequality.*

***Key words**: CGE, SAM, poverty, WTO, SPS measures*

# 1 INTRODUCTION

## 1.1 BACKGROUND

Ethiopia has decided to join the World Trade Organization (WTO) and started implementing the procedures required for the accession. Its first application to enter the WTO was submitted in 2003 and the government decided to submit its Memorandum on Foreign Trade Regime, which is the second stage in the process of accession in November 2006. The working party on the accession of Ethiopia held its first meeting in May 2008 to begin the examination of the legal documents submitted by the country. After examining all aspects of trade and legal regimes the next step will be to enter into multilateral and bilateral negotiations involved in accession. Following this, the organization will evaluate the country's ability to join the WTO. This determines the terms and conditions of entry. (http://www.wto.org).

The process of accession by itself is lengthy and challenging requiring addressing the supply side constraints and the fulfilment of a number of preconditions including, but not limited to:

(i) The upgrading of the existing laboratory infrastructure in a way that could be utilized to regulate import and to support exporting enterprises in meeting technical regulations and market requirements,

(ii) Reorganizing the existing regulatory bodies or creating a new appropriate national institution that can ensure the implementation of and administration of the Technical Barriers to Trade (TBT) Agreement in compliance with the WTO TBT principles

(iii)The creation or building of local capacity to respond to a National Enquiry Point for the WTO TBT Agreement that would be able to provide information to WTO

members on any subject matter falling within the ambit of the WTO TBT Agreement, and

(iv) The creation of a national system certification service provider for certifying ISO 9001, ISO 14001, HACCP, EUREPGAP, BRC and others required for foreign markets.

Once these and other requirements are met and the process of accession is accepted by member countries, Ethiopia will abide by the WTO law to eliminate any quotas on imports and exports, and the "elimination of any restrictive measures which delay or impede trade including TBT and SPS measures". (Pohl Consulting & Associates (2005)

The argument in favour of trade liberalization, in the context of the Doha Development Agenda, launched in 2001 in the Qatari capital, is that free trade and globalization are instruments of accelerated growth, and that the benefits of globalization will trickle down both to the poor and rich, albeit the extent of benefit could vary among groups. However, it is unclear whether the net effects of Doha reforms will help or harm the most vulnerable populations, as the specific reforms and their channels of impacts are numerous and complex. Reforms, in both developed and developing countries may encompass quota/tariff removal/reduction, the elimination of export taxes, the removal of domestic agricultural support and accompanying domestic fiscal reforms to replace lost tariff revenues. The channels of influence are likely, in turn, to simultaneously influence household income (wage rates, returns to capital, remittances, etc.) and consumer prices in contrasting manners.

The main emphasis of this study is therefore to evaluate the possible impact of Ethiopia's accession on various socio economic groups, with particular emphasis given to the

economically disadvantaged groups. To that effect general equilibrium analysis model, known as Computable General Equilibrium Model (CGE) will be employed. This model is widely employed in the literature to evaluate issues of such nature and its main advantage over other models is that it is comprehensive and entertains the impact of price transmission and factor market linkages.

## 1.2 RESEARCH QUESTIONS

The general objective of the thesis is to analyze the impact of Ethiopia's Accession to the WTO on the overall economic growth and measure (quantitatively) the economic impact of meeting the supply side constraints and fulfilling some of the requirements for the accession. Specifically, the following research questions will be addressed:

- What will be the macro and micro effects of accession?
- What will be the effects of implementing the WTO agreement on household income? and,
- What will be the implication for the poor?

## 1.3 SIGNIFICANCE OF THE STUDY

Studies made on WTO show that the current round of WTO negotiations, commonly referred to as the Doha Round, is likely to have profound and far-reaching impacts on developing countries. Furthermore, as these negotiations target especially the agricultural sector, it is the poorest members of these countries who will be most directly affected. This is because the poor, who are located overwhelmingly in rural areas, both consume proportionately more agricultural goods and derive a larger share of their income from the agricultural sector. Therefore, as Ethiopia is in the process of accession, knowing the likely impact of the accessions on the economy in general and the marginalized segment of the society in

particular will help the country to determine what course of action to follow in the negotiation process.

# 2 REVIEW OF LITERATURE

## 2.1 THE CONCEPT OF POVERTY AND ITS MEASUREMENT

Understanding the concept of poverty and its measurement is the primary task of any poverty focused analysis. Therefore in order to make poverty focused assessment of any sort one has to be clear with what is meant by poverty.

There is no single, universally accepted standard definition of poverty. However, it could be assessed indirectly through the analysis of well-being. According to Ravillion (1988), a segment of a society is considered to be 'poor" when they are unable to "attain a level of material well-being deemed to constitute a reasonable minimum by the standards of that society." But well-being by itself is a broad concept which needs to be defined contextually. Two types of approaches are employed in the literature to define well-being. These are the welfarist approach and the non welfarist approach.

The welfarist approach is based on the analysis of the economic well-being or the living standard of the individual and it has got its foundation on the classical micro economic theory. The non welfarist approach, on the other hand, employs both income and non income parameters to measure wellbeing.

When it comes to the process of identification of the poor, the welfarists believe that since, human beings are rational and make their decisions in a way that maximizes their utility given their endowments (including time, land, physical and human capital), the assessment of the poverty status of the individual should be consistent with his/her preference ordering Ravallion (1988). Therefore, according to this approach poverty should not be measured by

pre-determined income and consumption needs since the individual could deliberately work and consume little. Duclos (2002)

The limitations of the welfarist approach emanate basically from its practicality of measurement. The measurement of this approach presupposes that it is possible to observe individual's revealed preferences. Moreover, measuring the actual pleasure derived from experiencing economic wellbeing and its comparison across individuals is very difficult because preferences are diverse; personal characteristics, needs and enjoyment abilities differ; house hold size differ and prices vary across time. To tackle this practicality problem, welfarists use observable proxy variables to utility such as level of consumption or income. But, again, these variables have also their own limitations. First, it is not clear how one can make comparison of wellbeing across individuals by employing these variables because higher/ lower consumption or income may not mean the same as 'better" or '' worse" wellbeing. Secondly, the individual's wellbeing is also influenced by factors like existence and access to public goods, which are not easily measured.

Under the non-welfarist approach, there are two types of approaches: the basic-needs approach and the Capability Approach. The basic need approach defines poverty in more or less similar fashion as the following:

> The sustained inability of a family to meet its basic needs for survival (food and nutrition, water and sanitation, health and clothing), security (income, shelter, peace and security), and empowerment (basic education and functional literacy, psychosocial and family care, and participation in political process (quoted in Duclos (2002))

This definition therefore relies on the multiple specific and separate outcomes, such as the enjoyment of particular type of commodity, consumption, being healthy, literate, well-clothed, well housed, not in shape ,etc (Duclos,2002).

The problem with the above definition is the subjectivity element involved in defining 'basic needs'. For instance, if we take nutrition requirement as one measure of 'basic needs', it differs from individual to individual depending on the gender and age as well as the types and level of activity of the individual.

On the other hand, the capability approach defines poverty on the basis of the person's ability to function well in a society. This approach is pioneered by Sen and emphasizes on the value of freedom of choice Aselin (2002). According to this approach, a person is not judged as poor even if he/she chooses not to achieve certain functioning. Thus, for this school, the "thing" that is lacking refers neither to utility nor to the satisfaction of basic needs, but to human abilities, or capabilities. Hence, the difference between the functioning approach and the capability approach is that while the basic needs is concerned on the measurement of whether an individual gets the things required to fulfill the basic needs or not, the Capability Approach gives emphasis to the capability of the individual on achieving these functionings ASelin (2001).

The above discussion somehow shows that the concept and measurement of poverty is not precise. For this and other reasons focusing on money-metric measures of poverty, based on the assumption that a person's material standard of living largely determines his/her well-being is a practical way of measuring poverty. On the basis of this notion, poverty is defined as "a lack of money—measured either as low income or as inadequate expenditures". In a

similar fashion, the "poverty line" is specified as the income (or level of spending) required to purchase a bundle of essential goods (typically food, clothing, shelter, water, electricity, schooling, and reliable healthcare). Those which fall below this poverty line are categorized as "poor"

In the Ethiopian context, the Sustainable Development and Poverty Reduction Program (SDPRP), the main policy document of the country, defines poverty as a state of material deprivation, low achievement in education and health, malnutrition, low level of security and powerlessness. While this is the general definition of poverty, the document adopts the non-welfarist approach to measure the income side of poverty. Based on this measurement, the expenditure required to cover daily calorie requirement (2200 kcal/day/adult) and essential non-food items in Ethiopia(the poverty line) is 1075 Birr/adult in 1995/96 price Woldehanna (2005).

## 2.2 THE LINK BETWEEN TRADE AND POVERTY

In the developing countries, the poor, i.e., households with income falling below the poverty line, share common broad features: (i) they are generally concentrated in rural (subsistence) agriculture and in urban informal sector; (ii) they have limited assets, the most abundant of which is low-skilled labor; (iii) and food is by far the most important item of their expenditure. Both the direct and indirect effects of trade liberalization on the poor are then to be connected with its impact on this poverty profile.

Trade reform works directly through the transmission of price signals. For instance, if the reform increases the price of something the poor households sell (unskilled labor, goods, services), and/or forces downward the price of something the poor households consume

(goods, services), it will increase the real income (purchasing power) of the poor households and push more poor people from below to above the poverty line, and vice versa.

Economic growth is the indirect channel through which freer trade could contribute to poverty alleviation. Trade openness is believed to reduce the anti-export bias of protection, allow efficient allocation of scarce resources and bring incentive to investment and innovation. In addition, trade reform is usually associated with higher flows of FDI with attendant spillovers of technologies, new business practices and other effects on domestic firms that increase the overall level of productivity and growth. In turn, economic growth is a powerful force for permanent and sustained poverty reduction. The extent to which growth affects poverty, however, depends on how the additional income generated by growth is distributed across the population. The more the income of the bottom segment of the population rises, the more the growth pattern is deemed to be as pro-poor. Dollar and Kraay (2001) find that the incomes of the poorest fifth of the population grew one - for-one with GDP per head in a sample of 80 countries over four decades.

In general, the link between trade reform and poverty may manifest through the price and availability of goods; factor prices, income, and employment; government transfers influenced by changes in revenue from trade taxes; the incentives for investment and innovation, which affect long-run economic growth; and external shocks, in particular, changes in the terms of trade (Reiemer (2002)).

Trade liberalization is therefore expected to help the poor, given the positive association between openness and growth and growth and poverty reduction. However, trade reform alone is not a panacea and relying solely on the growth effect of a liberal trade policy is not

sufficient to address the poverty problem. Trade liberalization should be supported by a stable macroeconomic environment and a competitive real exchange rate. Furthermore, it should be supplemented by other pro-poor growth policies, targeted directly towards the vulnerable segments of society. In this regard, government has an important role to play in fostering (rural) development, including through encouraging absorption of new technologies, expanding access to education, providing basic social services to poor people and investing in infrastructure.

## 2.3 EMPIRICAL WORKS

Research into the poverty impacts of trade reform is new, and almost the only consensus it has reached is that countries differ. However, a growing number of research works that focus on the analysis of the impact of international trade and other shocks on poverty have been conducted following the WTO process.

Reimer (2002) has made a detail review of thirty-five studies that focuses on this issue. This section has heavily relied on this work.

According to Reimer the research works done in the last decade could be broadly categorized into two: the bottom-up approach and the top-down approach. The bottom-up approach makes use of detailed household income and expenditure data to analyse poverty while the top-down approach is based on an economy wide data. The former approach recognizes the heterogeneity of households and brings into the picture detailed national income and expenditure surveys. The top-down approach, on the other hand, is based on the microeconomic representative household.

But even with this broad classification, Reimer noted that studies may also differ significantly depending on whether the analysis is made for representative household or

actual household, whether it is static or dynamic, single or multi region, partial or general equilibrium, and so on. Therefore, Reimer found it convenient to classify the studies into the following four categories:

(i) Cross country regression analysis

(ii) Partial –equilibrium and/or cost of living approach

(iii) General equilibrium model, and

(iv) Micro-macro synthesis

The cross country regression involves the application of econometric techniques to aggregate cross-country data and "tests for the existence of correlation among trade, growth, income, poverty, and inequality variables observed at the national level". The work of Dollar and Kraay (2001) are the pioneer on this methodology.

Although this approach is getting attention with time, Kirkpatrick and Thepopularity (2006) have noted that this approach has certain limitations:

> Firstly, there is a standard problem of demonstrating causality. It is relatively simple to show a statistically robust correlation between a change in trade policy and a change in poverty levels: it is more difficult however to 'prove' that the change in trade policy is the cause of the change in poverty. Secondly, the econometric approach lacks precisely the micro detail that characterizes the social assessment approach. Typically, it uses broad aggregate measures of poverty for the macro economy, such as the number of households with an absolute income below the specified poverty line. Thirdly, there are major concerns about the quality of the data and the econometric specifications in this literature (including weak

> theoretical underpinnings), with considerable differences in the results and in the policy conclusions drawn from the findings. (Qtd. in Reimer (2002), p13)

Rodrik has also criticized this approach in a similar fashion:

> Estimating the relationships that exist between trade policy, growth, and poverty depends critically on finding appropriate measures of these variables, and carefully sorting out omitted variable and endogeneity problems, all of which are quite challenging given the very limited data available. (Qtd. in Reimer (2002), p13)

However notwithstanding this limitation, this approach has a number of advantages for understanding the links between trade and poverty:

> First of all, it enables the use of traditional statistical tools for testing results and hypotheses, as opposed to only making predictions. Secondly, cross-country regression results are typically much more general than the country-specific results of many applied simulation models. Thirdly, cross-country regression may be able to account for some of the dynamic aspects of trade reform that are missed by static simulation models. (Reimer (2002), p 8)

The partial equilibrium analysis is the second category. It focuses on one or a limited number of markets, usually on the commodity market. In the context of trade and poverty linkages, this methodology is more appropriate when the researcher is interested in making an analysis

of how trade liberalization affects a limited number of markets and when there is a need to incorporate sectoral details. But when it comes to poverty analysis, this methodology has got its own limitations. In the words of Reimer, if one is interested in making poverty analysis using partial equilibrium/ cost of living analysis, one has to "make some abstract from the income side of the issue, or limit the analysis to consideration of a single factor (typically labor)". However this abstraction will in most cases lead to erroneous results.

The third category in Reimer's classification is Computable General Economic Models which have been developed widely to assess the impact of trade liberalization on welfare and poverty, particularly in the context of WTO. Measuring poverty within a general equilibrium framework rather than a partial equilibrium framework has the advantage of capturing both impact of the interaction and interdependence found within a socioeconomic system and the prevailing structure of the economy. These models have the advantage of capturing both the direct and indirect effects of Policy measures and shocks on sectors of production, institutions (such as different socioeconomic groups and firms) and factors of production.

According to Savard (2003), CGE models are used very widely in LDC's for policy analysis since the 1970's with the view to mitigate the problems of the market-clearing assumption and abstraction from macro problems found in Walrasian CGE models. CGE models that incorporate some macro features have therefore spread and are in widespread use. The works of Adelman and Robinson for South Korea (1978) and Lysy and Taylor for Brazil (1980) are cited as pioneer in employing general equilibrium models for poverty and distribution analysis and the work of Lofgren (1999) is "representative of how applied general equilibrium models are currently used to analyze trade and poverty issues." (Qtd. in Reimer (2002)).

CGE models are theoretically grounded in Walrasian general equilibrium theory, but nonetheless incorporate macro issues. There is a longstanding theoretical debate between Walrasian models, with their usual assumptions of market-clearing price-adjustment mechanisms in product and factor markets, and macro models where there is unemployment and very different notions of equilibrium. However, whether one should incorporate macro models in SAM-based models has become a matter of preference of the researcher because "the debate really concerns the theoretical divide between Walras and Keynes, and the micro foundations of macro models or the lack thereof" (Robinson (2003)).

CGEs have different sects. They are broadly classified into Global (first generation) CGE models and single-country augmented (second generation) CGE models. The first types of CGE models are the conventional CGE models which are characterized by lack of information at household level and fail to distinguish between poor and non poor households. They are therefore not well suited to make poverty analysis. On the other hand, the second types of CGE models (the augmented CGE models) are better suited for making poverty analysis because they try to link the CGE models with the micro simulation model, which is based on household survey data (Kirkpatrick and Scrieciu(2006)).

Within the augmented CGE framework, there are three types of approaches which are used to analyze poverty. These are the Representative Household (RH) Approach, the integrated multi-household and the Top Down/ Bottom-Up Approach.

The augmented representative household model is a technique based on a computable general equilibrium model with representative households that are linked to a household module.

Representative household models can be used to analyze the impact of macroeconomic policy and external shocks on income distribution, employment, and poverty. Representative household models allow for a forecast of welfare measures and poverty outcomes consistent with a set of macroeconomic policies in the context of a general equilibrium model. The key features of the Representative Household Approach are the following.

The Computable General Equilibrium (CGE) model incorporates markets for factors and commodities and their links to the rest of the economy, which generates equilibrium values for employment, wages and commodity prices as well as its "extended" functional distribution (i.e. labour differentiated by skill, education, gender, region, and sector of employment); There is a mapping from the extended functional distribution into the "size" distribution (the distribution of income across different households).

As the name indicates, in the representative household approach a few groups of households are represented in the CGE model and a simulation for income shocks is carried out for these groups and then the result is applied to a disaggregated household survey data to make poverty analysis (Savard 2003). Dervis, de Melo and Robinson (1982), Gunning (1983), and Decaluwé et. al (1999), among others, have used this approach. This approach either assumes that income distribution is uniform within groups, or if there is any, the distribution follows a lognormal distribution. This model is relatively easy to use in a standard CGE model. However, it has also serious limitations: The model does not consider intra group income distribution differences, which makes it less robust for studying poverty impacts; and since the analysis is made for groups, there is also a constraint of selection of groups, i.e., the modelist will be forced to make representative groups which are sometimes arbitrary.

The second approach is the Integrated Multi-household CGE Approach (CGE-IMH). In this approach the entire households obtained in income and expenditure surveys are incorporated in the CGE model directly without making any household groupings. Therefore, this approach offers an ample opportunity for the modeller to make poverty analysis at the required degree of disaggregation but at the same time one has to reconcile the household data with the national data to ensure "consistency between the micro analysis and the CGE model prediction" (Bibi and Chatti (2005)). Therefore it is not hard to see the computational difficulties one may encounter.

The micro-macro synthesis or the Top-Down CGE model is the fourth and final category in Remier's classification. This approach tries to merge micro simulation and CGE in a sequential manner. The model is first developed by Orcutt et al. (1961) and this work has been the basis for the works of Cogneau (1999), Cogneau and Robillard (2001) and Cockburn (2001). The model is best used for the analysis of income distribution (dispersion) and it "provides richness in household behaviour, while remaining extremely flexible in terms of specific behaviours that can be modelled," Savard (2003).

This model works in two stages: first the CGE model is simulated for the given external shocks to get a price vector including wage rates. This output is then fed into the micro simulation model to conduct a detailed analysis of income distribution and poverty at the household level. The steps involved in applying this work are more elaborated in the works of Robilliard, Bourguignon, and Robinson (2003) as follows:

> The macro or CGE model is solved first and communicates with the micro-simulation model through a vector of prices, wages, and aggregate employment variables. Then the micro-simulation model is used to generate

changes in individual wages, self-employment incomes, and employment status in a way that is consistent with the set of macro variables generated by the macro model. When this is done, the full distribution of real household income corresponding to the shock or policy change initially simulated in the macro model may be evaluated.

This approach is costly and involving numerous estimation works since the unit of analysis is done at an actual household level. The robustness of this model depends much more on the degree of coherence achieved between the micro and macro models; however this task is not usually easy to achieve. The transmission mechanism is also unidirectional in the sense that the CGE model does not get feedback from the reaction of the household model.

With the intension of establishing coherence between the CGE model and the household model, a fourth alternative approach, called a Top-Down/ Bottom-Up Approach is developed by Savard(2003). This approach makes use of the advantages of the CGE-IHM and the Micro-CGE models and is believed to allow "the modeller to use the exact incomes and expenditure structure found in the household income and expenditure surveys" while at the same time "introducing a bi-directional link between the CGE and the household model. Savard(2003) further asserts that this approach has the following advantages over CGE-IMH approach: (i) reconciliation of household model and macro model is no more required (ii) production sectors and the households could be disaggregated to the required level of analysis, and (iii) it offers better degree of freedom in choice of functional forms used to reflect micro-economic household behaviour. However, one of the limitations of this approach is that a manipulation of data is needed to reconcile nomenclature employed in the household income and expenditure survey and that used in the SAM.

From the above discussion it is obvious that there is no single 'best' approach to measuring the impact of trade liberalization on poverty. The literature is filled by a number of controversies on the validity of different approaches. This ranges from mico, meso, to macro and economy wide approaches. Within each of the approaches, too, researchers don't seem to be in total agreement. As Kirkpatrick and Scrieciu(2006) have noted, the literature on this issue is "always open to the charge of eclecticism and lack of intellectual rigour" and searching for a best-single approach to measure impact of trade liberalization on poverty is tantamount to the unsuccessful "search for the holy grail".

While the debate on the measurement issues is still unresolved, there is also a continuing debate on the effects of trade liberalization on poverty, welfare and inequality. Cockburn et.al (2008) noted that there had been a long standing belief that trade liberalization will have a positive impact on the rural poor but its effect on the urban poor is adverse. This will be so because initial tariff rates are generally much higher for industrial import, so that trade liberalization leads to an expansion in the agricultural sectors and benefits those who derive their earning out of it. This belief is however being challenged.

Cockburn et.al (2008) have tried to synthesize the lessons drawn from the Computable General Equilibrium (CGE) analysis of the impacts of trade liberalization on poverty conducted by different researchers residing in seven Asian and African countries which undergo trade liberalization to comply with WTO rules. These countries include Bangladesh, Benin, India, Nepal, Pakistan, the Philippines and Senegal. Based on the results of the studies made on these countries Cockburn et.al (2008) concluded that, in general terms, trade liberalization has small, but positive, impacts on welfare and poverty. Moreover, industrial

sectors benefit - relative to agriculture - from trade liberalization as do urban households relative to their rural counterparts. As a result, since the poor are more concentrated in the rural areas, overall inequality generally increases. Likewise, industrial output increases relative to agricultural output as a result of a stronger export response and greater input cost saving. Nominal consumer prices also fall more in industry than agriculture or services by reducing import prices and local competing goods.

However, Cockburn et.al (2008) have also noted that the impact of trade liberalization could differ from country to country depending on the specific characteristics of each country. Factors like initial tariff structure, trade patterns, relative factor endowments, production patterns, income sources and consumption patterns of the poor, etc .may affect the magnitude and direction of influence. For instance, trade liberalization increases welfare marginally in all countries except in Benin and India. However, the result is mixed at the urban-rural levels. In Bangladesh, Benin, India, Nepal, and Pakistan welfare increases and poverty decreases most for urban households. On the other hand, except in Philippines and Senegal welfare decreases and poverty increases in the rural areas of five of the seven countries studied.

From the above discussions, one can discern the fact that there are a number of approaches and definitions of the concept and measurement of poverty. The methodologies employed to measure the impact of WTO accession on poverty are also diverse. Despite these differences, however, researchers seem to agree on the fact that the impact of accession is not the same in all countries and for all socio economic groupings. Different segments of the society could be affected differently as a result of accession depending on the level of development and the initial structure of their economies.

# 3 METHODOLOGY, CALIBRATION AND DATA

## 3.1 METHODOLOGY

As discussed above there have been numerous attempts to adapt CGE models to the analysis of income distribution and poverty issues. Many authors impose strong assumptions concerning the distribution of income among households in each category. A popular approach is to assume a lognormal distribution of income within each category where the variance is estimated with the base year data (De Janvry, Sadoulet, and Fargeix (1991)). In the spirit of this same approach, Decaluwé et al (2000) argue that a beta distribution is preferable to other distributions because it can be skewed left or right and thus may better represent the types of intra-category income distributions commonly observed. Regardless of the assumed distribution, the CGE model is used to estimate the change in the average income for each household category, while the variance of this income is assumed fixed.

In this Thesis, the analysis will be done using a CGE model while GAMS software will be used to solve the mathematic programming problem.

## 3.2 CALIBRATION AND CLOSURE RULES

Calibration is the process of selecting share parameters, elasticities of substitution, and in the case of LES preferences Frisch parameters. According to Annabi, Cockburn and Decaluwe (2006), calibration is the process of determining the numerical values of parameters used in the various functional forms compatible with the initial SAM. To determine the parameter values needed in the production and utility functions of a CGE model, it is customary to make an assumption that the economy observed is in equilibrium in its base year (that is the year to which the SAM applies). Hence, share parameters can be taken from the SAM, but elasticities and Frisch parameters must come from other sources.

In Walrasian Model specification tradition closure is not an issue because the model yields full-employment equilibrium and market-clearing prices. However, in a non Walrasian CGE model short-run macro models involve wage and price rigidities, partial adjustment mechanisms, and equilibrium without market clearing, including unemployment. Therefore the model requires a rule for how the various macro balances are determined. According to Davis (1992) "... where saving and investment is not treated simply as another good purchased by consumers, or fiscal or trade imbalances are allowed, it is necessary to close the CGE model by specifying how the various macro balances are determined."

Davis (1992) further noted that determining the closure rule is not an easy exercise and making "Assumptions are unavoidably somewhat ad hoc, and there is often a fear that the choice of a particular closure may unduly influence results."(12). To tackle this problem, he advises "to err on the side of assuming a relatively "neutral" or "balanced" closure, in order to avoid extreme results"

The process of calibration boils down to the estimation of elasticity parameters of the various functional forms involved in the CGE model. The choice of behavioral functions, in turn, depends on the values of the various related elasticities.

Elasticities measure the percentage variation in one variable to a variation in another variable. The CGE model makes use of different types of elasticities including price elasticity, income elasticity and elasticity of substitution. The theoretical framework for these elasticities is discussed at length in Annabi, et al (2006). Annabi, et al noted that the functional form of a CGE model should be continuous and homogenous of degree zero and result in a system of demand in conformity with the Walaras Law in order to ensure equilibrium and ease the analysis of variations in the prices resulting from economic policies. The choice of behavioral

functions should also reflect the characteristics of the sectors or products under study and consequently on the values of the various related elasticities. To this effect, therefore, a very few types of functional forms are usually employed in the construction of CGE models. The most common functional forms are the Cobb-Douglas (C-D) function, the constant elasticity of substitution function (CES) or the linear expenditure system (LES). Each of these functional forms has their own distinct features.

With a Cobb-Douglas utility function (U), the consumer's demand is obtained as the solution to the following maximization program:

Max U= $\prod_i^n C_i^{\alpha_i}$ S. t

$$\sum p_i C_i = \text{R and } \sum \alpha_i = 1 \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where

U stands for utility

R stands for total income

$p_i$ Stands for price of good i

$C_i$ Stands for consumption of good i and

$\alpha_i$ stands for the share of commodity i in total consumption

The consumption of each commodity i reads:

$$C_i = \frac{\alpha_i \text{ R}}{p_i} \quad \ldots\ldots\ldots\ldots \quad (2)$$

In a C-D function, the values of the price and income elasticities, as well as the elasticity of substitution between each pair of goods, are all equal to one where as the cross price elasticity is nil. The advantage of this strong assumption is that it can be easily calibrated and

does not require outside estimates of free parameters. Thus, considering the income, the consumption and prices provided by the SAM, the computation of the share of each good in overall consumption income (total expenditure) could be computed by a simple inversion of the demand equation as follows:

$$\alpha_i = \frac{PC_i}{R_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Although C-D function rarely exists in the real world, many authors resort to the C-D function given that it can be easily calibrated and does not require outside estimates of free parameters

An alternative functional form which relaxes the C-D assumption is the constant elasticity of substitution (CES) function. This function allows for non-unitary, but constant, price elasticities and non-nil, but constant, substitution elasticities. The consumer's utility maximization program is as follows:

$$MaxU = \sum \left[ \alpha_i C_i^{\frac{\varepsilon - 1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon - 1}} s.t$$

$$\sum p_i C_i = R \text{ and}$$

$$\sum \alpha_i = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where $\varepsilon$ is elasticity of substitution

The solution of this optimization problem gives the demand function for each commodity. As in the case of the C-D function, the income elasticity is unitary in CES function. The implication of this unit income elasticity is that the budget shares of each good do not vary

with the level of income. The C-D function is a special case of the CES function when elasticity of substitution equals to one.

Another function which relaxes the unit elasticity of income assumption observed in C-D and CES functions is the Stone-Geary function also known as the linear expenditure system or LES. By introducing a term which represents minimal or subsistence consumption in a C-D function, the LES demand function is obtained as the result of the following utility maximization problem:

$$MaxU = \prod \left(C_i^{a_i} - C_{\min\ i}\right)^{\alpha_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$\sum p_i C_i = R \ \ and \ \ \sum \alpha_i = 1$$

The resulting demand for the consumption of commodity i is the sum of the minimal and discretionary components:

$$C_i = C_{\min\ i} + \frac{\alpha_i}{p_i}\left[R - \sum P_j C_{\min\ j}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

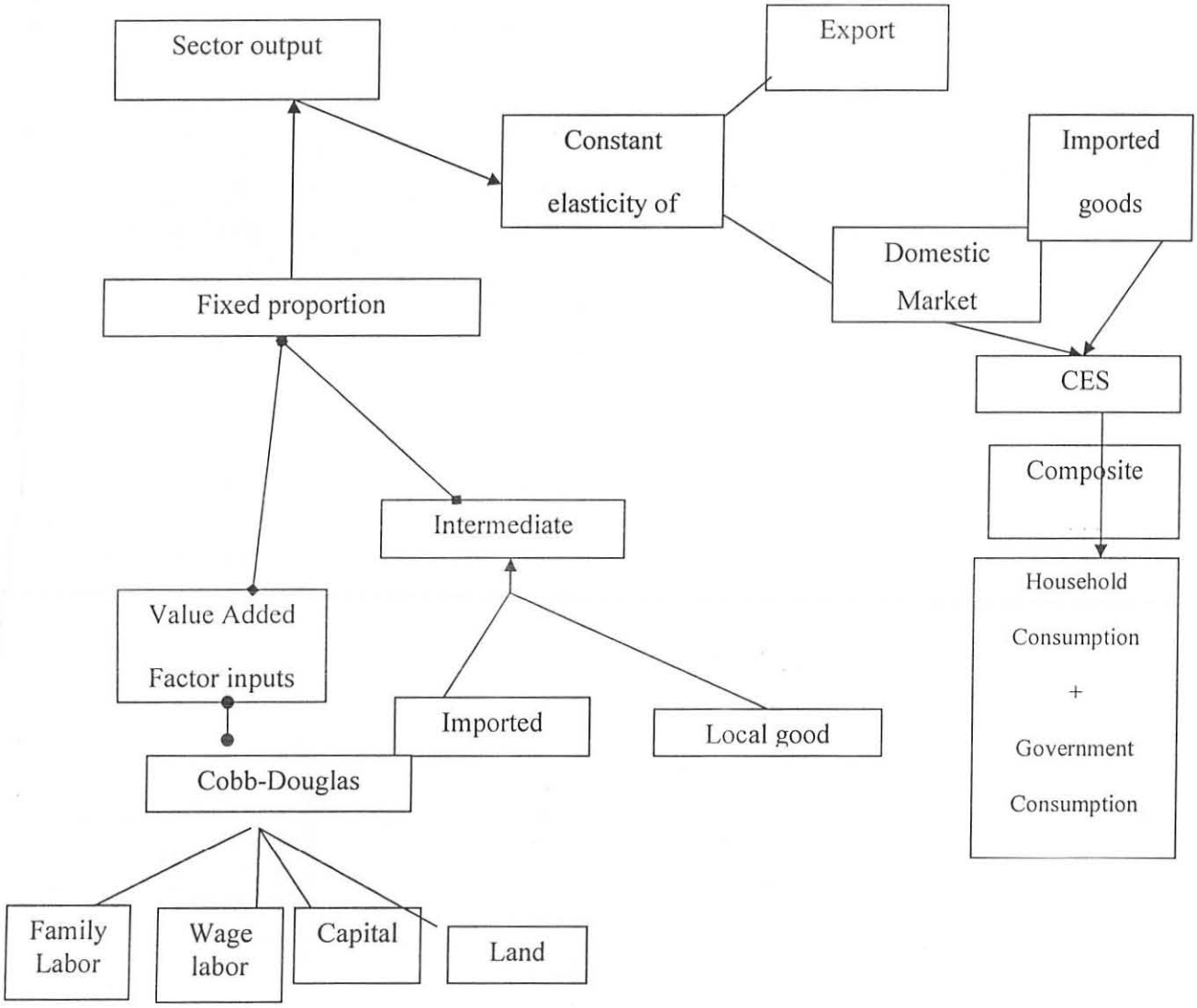
Where $C_{\min i}$ is minimal consumption of good i

The term $R - \sum P_j C_{\min j}$ is known as supernumerary or residual income. It represents the income available after satisfaction of minimal consumption. The calibration of a LES function is not as easy as that of a C-D function or a CES function as minimal consumption levels must also be determined.

Free parameters could be estimated either through econometrics methods or through opinion of experts. The difficulty in gathering data necessary for the econometric estimation of these parameters prompts modelers either to "borrow" these values from other studies conducted on countries with similar characteristics, or to base them on their personal judgment as "guess estimates". In some cases, the choice of the values of these elasticities is made on the basis of a "consensus" reached by researchers.

Figure 3.1 depicts the structure of production and commodity output.

Figure 3-1 Structure of Production and Commodity Output




## 3.3 DATA REQUIREMENT AND SOURCE

### 3.3.1 DATA REQUIREMENT

The starting point for the development of any CGE model is the construction of a micro-consistent benchmark dataset. Such a dataset must specify aggregate factor endowments, outputs by industry, factor usage by production activities, exports, imports, and the input-output structure of the economy. In addition, it may be disaggregated by type of economic agent (households, firms etc.), and detail the factor use, receipts and expenditures of public

and external sectors of the economy. The benchmark dataset needed for a CGE model has generally come to be specified in the form of a "social accounting matrix" or SAM.

Thus, depending on the classification scheme used to record transactions and the extent of disaggregation, the SAM can provide useful information about such key issues as intersectoral linkages (such as between agriculture and industry); the determination of the income distribution by socioeconomic groups given the structure and technology of production and the resource endowments of these groups; and the relationship between a given regional economy and other regional economies within a nation, and with the rest of the world.

The SAM is a comprehensive, disaggregated, consistent and complete data system that captures the interdependence that exists within a socioeconomic system. It is a square matrix with equal number of rows and columns. The columns represent expenditures and the rows show receipts. These expenditures and receipts are made or received by factors, institutions, production activities, and the rest of the world (ROW). Institutions include households, companies, government and a combined capital account.

The SAM has the following major accounts: Activity Account, Commodity Account, Factor Account, Institutional Account, Capital Account, and the Rest of the World (ROW) Account. Figure 3.2 shows a basic structure of a typical SAM.

**Figure 3-2 A Basic Social Accounting Matrix**

| | | Receipt | Expenditure | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Factors of Production | Institutions | | | | Production Activities | Rest of the world | Total |
| | | | | Current account | | | Combined Capital account | | | |
| | | | | Households | Firms | Government | | | | |
| **Factors of production** | | | | | | | | Value added payment to factors | net factor income received from abroad | Income of the domestic factors of production |
| **Institutions** | Current Account | **Households** | Allocation of income to households | current transfers between households | profits distributed to households | current transfer to households | | | net non factor income received from abroad | income of institutions |
| | | **Enterprises** | Allocation of surplus to firms | | | current transfer to firms | | | | |
| | | **Government** | | direct taxes on income and indirect taxes on current expenditures | direct taxes confirms and indirect taxes plus operating surplus of state enterprises | | indirect taxes on capital goods | indirect tax on inputs | | |
| | **Combined Capital Account** | | | Household saving | undistributed profit after tax | Government current account surplus | | | Net capital received from abroad | Aggregate Saving |
| **Production Activities** | | | | household expenditure of domestic goods | | Government current Expenditure | investment expenditure on domestic goods | Raw material purchase of domestic goods | Exports | Aggregate demand-Gross surplus |
| **Rest of the world** | | | | household expenditure of imported goods | | | import of capital goods | import of raw materials | | Import |

Source: Thorbecke (2003)

As could be seen from Figure 3.2, in the activities accounts the production and sales of domestically produced goods and services are reported. The row of this account represents revenue from sales of domestically produced goods while the column account represents payment to intermediates, production factors and indirect taxes. Again here row sum must equal to column sum. In other words the gross output sales should cover total production costs. For the sake of simplicity, it is assumed in this basic SAM structure that a production activity is equivalent to a corresponding commodity. But if one activity could produce different products, a commodity account is introduced to account for this misalignment. Hence, if the SAM incorporates both a production and commodity accounts, the commodity account will represent the commodity market where the row of this account represents revenue from supply of goods and services to various domestic agents while the column account represents payments to domestic and imports of goods and services, including tariff and taxes. Equality between row sum and column sum in this account signifies that demand equals supply in each commodity market.

An account which reflects the factor markets is the factor accounts. The row of this account shows the earnings of primary factors from the sale of their services and net factor income received from ROW or other accounts. The column of the factor income shows the distribution of the factor income into households as a labor income and institutions as operating surplus or distributed profit.

The enterprises, households and government are represented in the Institution accounts. Institutions include households, firms and the government. The Row of this account signifies receipt of income from factors they own and income transfer from other; while their Column show consumption spending, tax and transfer payments.

The Capital account is a simplified financial market with loanable funds as the only asset. The Row shows the collection of savings from all agents (accounts) while the Column shows the allocation of saving to investment. An internal balance is represented by the equality of Row sum and Column sum.

The international market is represented in the SAM in the Rest of the World (ROW) Account. The row of this account shows how much income is generated from the country's exports and the Column are payment to the country's imports (fob) and shipping cost. Row sum equal column sum means that external macroeconomic balance, i.e., exports plus capital inflows equal imports. The difference between total foreign exchange receipts and imports is by definition net capital received from abroad or the rest of the nation and extra regional and foreign savings.

The SAM incorporates the three macro balances: government deficit, trade deficit, and savings-investment balance. All models in the SAM framework must explain how balance is achieved in the three macro accounts. Given that the SAM is always balanced, determining two of the macro balances necessarily determines the third. The SAM represents a closed system. All economic transactions are included and models in this framework will incorporate Walras Law in some form.

On the other hand, poverty analysis requires detailed treatment of links between activities, factors and households. In order to specify the CGE Model, therefore, there should be an appropriately designed SAM and distributional data describing the representative household groups or a household survey.

### 3.3.2 THE ETHIOPIAN SAM

There is a growing interest recently in Ethiopia to capture the interdependence that exists within a socioeconomic system through the construction of social accounting models. The 2002 Ethiopian SAM constructed by the World Bank is one of such attempts and recently the Ethiopian Development Research Institute (EDRI) is constructing a more comprehensive SAM to support Economywide policy analysis. In this study, the SAM developed by the World Bank (2002) and reproduced here in Appendix 1 is used to caliber the CGE model because the later was not readily available.

The SAM has the following salient features (WB (2004)). It is a 40 X 40 matrix and disaggregated into the following activities:

- Four factors of production including family labor, wage labor, capital, and land
- 12 activities, including
    - five agricultural activities (peasant farming - highland, peasant farming - lowland, peasant livestock production, private commercial farming, and public commercial farming),
    - seven industrial activities (cottage/handicraft and small scale industry, large/medium scale agro-manufacturing - public, large/medium scale agro-manufacturing - private, large/medium scale other manufacturing - public, large/medium scale other manufacturing - private, other industry - public, and other
- Eight commodities including food crops, traditional agricultural exportables (mainly livestock and livestock products, coffee, and chat), non-traditional agricultural exportables (including tea, flowers, and fruits and vegetables), other agricultural products (forest products and fisheries), agro-manufacturing products (processed food and beverages,

textiles, leather and leather products, wood products), other industrial products (chemical products, non-metallic mineral products, metal products, electricity and water, construction, and mining and quarrying), public goods (education, health, public administration, and other related services), and other services (primarily trading services, transport and communications, banking and insurance).

- Eight domestic institutions including
    - three types of households (farm households, wage workers, and entrepreneurs),
    - three types of enterprises (peasant farms, private firms, and public firms),
    - a food-for-work project,
    - the government, and
- A transactions cost account

In principle, the model disaggregation of any CGE model has to follow the SAM disaggregation of factors, activities, commodities, and institutions. Therefore to reconcile the SAM with the CGE model employed in this study, aggregation of some the accounts were made. Accordingly, the modifications made to the 2002 Ethiopian Sam are as follows:

- The factors of production were represented by labour, capital and land;
- Activities are regrouped into three broad categories, namely agriculture, industry and service,
- The commodities account was aggregated into three broad activities( agriculture, industry and Service)

Thus, the standard CGE model used in this study is calibrated based on this modified SAM.

The applied CGE model adopted in this study has strictly followed the standard CGE model manual prepared by Lofgren, et al. (2002). However, following the SAM specification of WB

(2002), some minor modification of equations is made to reconcile the structure of the aforementioned Ethiopian SAM with the standard CGE model. The assumptions of the model are as discussed below.

**Activities, Production, and Commodities**

The producers specified in the model are assumed to maximize profit subject to the specified technology. They earn their income from the sales of goods and services in the domestic market and in the international market.

- The goods supplied to the domestic and international markets are different in quality(Armington assumption) and their allocation is determined based on their relative prices received in domestic and international markets,
- The domestic product market is served both from imports and local production, the amount supplied from each market being determined by their relative prices.
- production technology is a nested function of intermediate inputs and final outputs where
    - value added and intermediate inputs are combined at the top of the technology nest by a Leontief production function;
    - factors of production(labour, capital and land) are combined assuming a Cobb-Douglas production function; and
    - intermediate inputs are a composite of imported and local goods and they are combined by Leontief production function
- Food for work programme is financed by the rest of the world and the dividends obtained from participating in the programme are channelled fully to the highland peasant farming,

- Food aid is part of the transfers made by the rest of the world to households and therefore total household consumption equals the sum of disposable income and food aid.

**Institutions**

- Households receive income from the factor of production they supplied to enterprises, food for work activities, and transfer payments from government, rest of the world and food aid. Transfer from the rest of the world is fixed in foreign currency. Households use their income to pay direct taxes, save, consume and make transfers to other domestic institutions. Household consumption is equal to the sum of household's disposable income, food aid, and food for work
- Enterprises get their income from the sale of goods and services and transfer from the government. This income is allocated to direct taxes, savings, and transfers to other institutions. Enterprises don't consume.
- The government collects taxes and receives transfers from other institution and uses this income to purchase goods and services and for transfer to other institutions. Government consumption is fixed in real terms whereas government transfers to domestic institutions are CPI-indexed.
- The rest of the world transfers made between domestic institutions and factors are all fixed in foreign currency. Foreign saving (or current account deficit) is the difference between foreign currency spending and receipts.

**Commodity Markets**

- Domestic output may be sold in the market or consumed at home. For marketed output, the first stage in the chain consists of generating aggregated domestic output from the output of different activities of a given commodity. These outputs are imperfectly

substitutable as a result of, for example, differences in timing, quality, and distance between the locations of activities. A CES function is used as the aggregation function (Figure.3.2). The demand for the output of each activity is derived from the problem of minimizing the cost of supplying a given quantity of aggregated output subject to this CES function. Activity-specific commodity prices serve to clear the implicit market for each disaggregated commodity.

- Aggregated domestic output is allocated between exports and domestic sales on the assumption that suppliers maximize sales revenue for any given aggregate output level, subject to imperfect transformability between exports and domestic sales, expressed by a constant elasticity of transformation (CET) function. In the international markets, export demands are infinitely elastic at given world prices. The price received by domestic suppliers for exports is expressed in domestic currency and adjusted for the transaction costs (to the border) and export taxes (if any). The supply price for domestic sales is equal to the price paid by domestic demanders minus the transaction costs of domestic marketing (from the supplier to the demander) per unit of domestic sales. If the commodity is not exported, total output is passed to the domestic market.

- Domestic demand is made up of the sum of demands for household consumption, government consumption, investment (the determination of which is discussed below), intermediate inputs, and transactions (trade and transportation) inputs. To the extent that a commodity is imported, all domestic market demands are for a composite commodity made up of imports and domestic output, the demands for which are derived on the assumption that domestic demanders minimize cost subject to imperfect substitutability. This is also captured by a CES aggregation function. The derived demands for imported commodities are met by international supplies that are infinitely elastic at given world prices. The import prices paid by domestic demanders also include import tariffs (at fixed ad valorem rates)

and the cost of a fixed quantity of transactions services per import unit, covering the cost of moving the commodity from the border to the demander. Similarly, the derived demand for domestic output is met by domestic suppliers. The prices paid by the demanders include the cost of transactions services, in this case reflecting that the commodity was moved from the domestic supplier to the domestic demander. The prices received by domestic suppliers are net of these transaction costs. Flexible prices equilibrate demands and supplies of domestically marketed domestic output.

**Macroeconomic Closure**

As noted above the market must clear to ensure a solution, i.e., the demand for and supply of goods must always be equal. The appropriate choice between the different macro-closures depends on the context of the analysis. Given that this is a single-period model, a closure combining fixed foreign savings, fixed real investment, and fixed real government consumption may be preferable for simulations that explore the equilibrium welfare changes of alternative policies. The closure rules adopted in this model for the three macroeconomic balances (the government balance, the external balance and the saving-Investment balance) are as follows:

Government savings (the difference between current government revenues and current government expenditures) is a flexible residual while all tax rates are fixed.

For the external balance, the real exchange rate is flexible while foreign savings (the current account deficit) is fixed. Given that all other items are fixed in the external balance (transfers between the rest of the world and domestic institutions), the trade balance is also fixed.

For the Savings-Investment balance, closures are investment driven (the value of savings adjusts). Real investment quantities are fixed. In order to generate savings that equal the cost

of the investment bundle, the base-year savings rates of selected non-government institutions are adjusted by the same number of percentage points. Implicitly, it is assumed that the government is able to implement policies that generate the necessary private savings to finance the fixed real investment quantities. Based on the above discussions and following Lofgren et al. (2002) CGE tradition of model specification, the mathematical model equations and notations used in this study are described in detail Appendix 2 and Appendix 3, respectively.

### 3.3.3 POVERTY PROFILE OF ETHIPOIA

Ethiopia is one of the poorest countries in the world with a GDP (at current price) of USD11.2 billion and per capita income (at current price) of USD157 (see Table 3.1). According to a World Bank report (WB 2005), 81% of the population earn an income below US$ 2 a day. When compared to other countries, Ethiopia ranks 73$^{rd}$ out of 96 countries when using a 1USD a day poverty line and 84$^{th}$ when using a 2 US$ a day. The report also shows that poverty incidence differs widely across people's livelihoods. Households employed in the non-agricultural sector tend to be less poor than those in agriculture.

**Table 3-1: Some Indicators on the Ethiopian Economy**

| | 2000 | 2004 | 2005 |
|---|---|---|---|
| GNI, Atlas method (current US$) | 8.1 billion | 9.3 billion | 11.1 billion |
| GNI per capita, Atlas method (current US$) | 130.0 | 130.0 | 160.0 |
| GDP (current US$) | 7.8 billion | 9.7 billion | 11.2 billion |
| GDP growth (annual %) | 5.4 | 12.3 | 8.7 |
| Inflation, GDP deflator (annual %) | 6.0 | 9.6 | 6.0 |
| Agriculture, value added (% of GDP) | 47.7 | 46.3 | 47.7 |
| Industry, value added (% of GDP) | 12.4 | 13.5 | 13.3 |
| Services, etc., value added (% of GDP) | 39.9 | 40.2 | 39.0 |
| Exports of goods and services (% of GDP) | 12.5 | 15.4 | 16.4 |
| Imports of goods and services (% of GDP) | 25.0 | 32.6 | 39.1 |
| Gross capital formation (% of GDP) | 20.5 | 21.3 | 26.3 |

**Source: World Development Indicators database, April 2006**

According to a World Bank report (WB 2005), Ethiopia's economy is predominantly agrarian where agriculture accounts for 85 percent of employment, 45 percent of the national income and more than 90 percent of exports. The industry and service sectors account for only 13.3% and 39% of the value added of GDP, respectively. A significant number of poor Ethiopian households live in rural parts of the country, of which 96 percent are employed in agriculture. Rural households continue to rely almost exclusively on low input, low output, subsistence-oriented, rained agriculture and agriculture related activities. Some four to five million people are considered chronically food insecure and annually in need of food aid. An additional six to seven million are transitorily food insecure and in need of food aid when the rains or

harvests fail. Most of them are net cereal buyers, i.e., one in five rural Ethiopian households lives on less than 0.08 ha per person, which yields on average only slightly more than half the daily cereal caloric needs per person, given current cereal production technologies used in Ethiopia.

Ethiopia's rapid population growth coupled with low productivity, heavy dependence on rainfall, structural bottlenecks, and the like are the major factors that cause the population to live in an abject poverty. However in recent years, the good performance of the economy has changed the poverty profile of the nation to certain extent. The economic growth registered in the country since 1992, largely attributed to the contribution of the service sector, has reduced the incidence of poverty slightly from 45.5% to 44.2% over the period from mid-90s to 2000. But the situation in urban areas in this period is, however, disappointing. The headcount ratio has raised from 33% to 37 %.( WB 2005).

**Table 3-2 Consumption and Poverty Incidence by Sector of Employment of Household Head in 1995 and 1999**

| | 1995 | | | 1999 | | |
|---|---|---|---|---|---|---|
| Sectors of employment of household head | Population share (%) | Consumption per adult equivalent | Poverty incidence | Population share (%) | Consumption per adult equivalent | Poverty incidence |
| Agriculture | 85 | 1592 | 40 | 84 | 1600 | 38 |
| Industry | 14 | 1980 | 32 | 6 | 1707 | 43 |
| Service | 1 | 2201 | 28 | 10 | 2113 | 35 |

**Source: WB (2005)**

Foreign trade is an important sector in the Ethiopian economy. As of 2005, Ethiopia's export of goods and services was estimated at 12.4% of GDP while its imports were about 39.1% of GDP. Ethiopia's imports are largely dominated by final consumption goods including petroleum products, wheat, corn and other cereals in grain form, devices for vehicles, electronic devices and medicaments. The share of capital goods in the total imports is very minimal. On the other hand export is dominated by few agricultural products including coffee, vegetable products, leather and recently flower. In 2003, foreign trade taxes represented 9.24% of the GDP, of which customs duties accounted for 4.26 %.( Pohl and Associates (2005)).

# 4 POLICY SIMULATION, RESULTS AND DISCUSSIONS

## 4.1 POLICY SIMULATION

Policy reforms can be expected to have an impact on various stakeholders through five main transmission channels outlined below: employment; prices (production, consumption, and wages); access to goods and services; assets; and transfers and taxes. Each policy reform is likely to have impacts through more than one channel. For example, utility reforms might result in changes in prices and access, but might also have an impact on the fiscal stance of a country, and hence on transfers and taxes. Further, different stakeholders are likely to be affected differently through these channels. For example, relative price changes will affect net consumers and net producers differently, and even among these groups the impact may vary. For example, consumers will be affected differently depending on their consumption patterns or their ability to substitute goods.

If Ethiopia decides to join the WTO, one of the immediate tasks she would be required is to prepare itself to fulfill the necessary infrastructures required for the implementation of the SPS measures which are at present non- existent or at best not available in adequate quantity and quality. The requirements and guidelines of the SPS Agreement entail the application of three sets of international standards, set by the so-called "three sister organizations". These organizations are the Codex Alimentarius Commission, International Plant Protection Convention (IPPC) and the Office of International des Epizooties (OIE). They provide technical regulations for a vast number of activities in the supply chain of exports of agricultural products which include input, production and harvesting, storage, transport, processing, packing and labeling, port facilities and international transport. The application of these standards requires various scientific, technical and legal skills and capacities. In the

case of plants alone, they include about 50 different activities and measures. The requirements for food products and animal health are also similarly diverse and complicated.

This in turn requires making a huge investment on the part of the governments. According to studies made on this issue countries are usually required to make an investment worth about USD 9 million(see Table 4-1). In the Ethiopian case, this may mean that translates into doubling the current government consumption of goods and services.

**Table 4-1 Cost of various initial activities necessary for the compliance with SPS Agreement in an African Country(2003 prices)**

| **Activity** | **'000 USD** |
|---|---|
| To strengthen the institutional framework | 56 |
| To update the legal and regulatory framework | 76 |
| To upgrade and rationalize inspection services | 604 |
| To upgrade the scientific and technical capabilities of labs | 1505 |
| To train quality control managers in the implementation of food quality assurance system including HACCP | 120 |
| Total at country level | 2,361.00 |
| Additional cost of Regional activities | 6245 |
| | 8,606.00 |

***Source: CTA (2003), Study of the Consequences of the Application of Sanitary and Phytosanitary (SPS) measures on ACP Countries(CTA, Brussels) quoted in Shafaeddin(2007)***

In this paper, the impact of increasing government consumption on the national economy and its implication to poverty would be tested.

## 4.2 RESULTS AND DISCUSSIONS

### 4.2.1 SECTORAL EFFECTS

One of the primary effects of the accession process is its effect on resource allocation. As could be observed from Table 4.1 and Table 4.2, output of the agricultural sector and the service sectors has declined while that of industry has increased, with a corresponding price increases in all sectors. This decline in outputs of the two sectors and the corresponding rise of prices would mean that the poor would be adversely affected, as most of them are earning their livings from the employment in these two sectors and spend most of their income in food items generated from the agricultural sector. Volume of domestic sales has also witnessed similar patterns.

Looking at the performance of the external sector, the volume of imports of the industrial and the service sectors has surged, despite the rise in prices. The volume of export has also increased from all sectors, with a corresponding marked rise in export prices of the agricultural and industrial sectors. But export price of the service sector and import by the agricultural sector has declined.

**Table 4-2 Effects on Volume of imports and exports, sectoral output and domestic Sales ( percentage change)**

| S.N | Sector | volume Changes | | | |
|---|---|---|---|---|---|
| | | Imports | Domestic Sales | Exports | Output |
| 1 | Agriculture | (99) | -0.5 | 61.4 | -1.2 |
| 2 | Industry | 38,570,740 | 23.2 | 26.3 | 10.8 |
| 3 | Service | 43 | -5.2 | 3.2 | -6.2 |

**Source: Own Computation**

The high increase in volume of import coupled with a relatively high prices would exert further pressure on the current account balance, and hence on the foreign exchange reserve of the country. The magnitude and direction of influence on poverty, however, will depend on which items of industrial products are more affected by the adverse price increases. i.e., if the increase in prices affects the goods consumed by the poor, poverty may further worsen off. Furthermore, the pressure on foreign exchange could also exert another burden to the poor, if the government tries to finance the growing import by reducing pro- poor expenditures.

**Table 4-3 Effects on Prices of imports and exports, sectoral output and domestic Sales**

| S.N | Sector | Price Changes (Percentage change) | | | |
|---|---|---|---|---|---|
| | | Imports | Domestic Sales | Exports | Output |
| 1 | Agriculture | 6,400 | 58.5 | 3100.0 | 4733.3 |
| 2 | Industry | 6,450 | -17.9 | -84.9 | 200.0 |
| 3 | Service | 6,400 | -304.2 | 4000.0 | 5433.3 |

**Source: Own Computation**

### 4.2.2 MACRO EFFECTS

A direct manifestation of the pattern of sectoral resource allocation discussed above is its effects on the income of the representative household. The deteriorating terms of trade in agriculture and the service sectors and the high level of import prices of the industrial sector would mean that households have to raise their level of income to maintain the initial level of welfare while government revenue should also grow to finance its increased expenditure (Table 5.3). However, although government consumption was made to increase in the simulation exercise, it witnessed a sharp decline at the equilibrium level (post simulation) and this in turn has resulted in sharp decline in nominal GDP.

**Table 4-4 Effects on Household Income, Government Revenue and GDP (Marginal Change)**

| | | BASE | increase in Government Consumption(million Birr) |
|---|---|---|---|
| 1 | GDP | 817 | -1234 |
| 2 | Private Consumption | 82 | 536 |
| 3 | Government Consumption | 695 | -1485 |
| 4 | Investment | 39 | -292 |
| 5 | Export | -1 | -3 |
| 6 | Import | 2 | 10 |
| 7 | Income of household | 239 | 403 |
| 8 | Government Revenue | -42 | 263 |

**Source: Own Computation**

## 5 CONCLUSION AND POLICY IMPLICATIONS

If Ethiopia is going to be a member of the WTO, it is required to fulfil the membership requirements and address the supply side constraints. These requirements include, among others, the upgrading of the existing laboratory infrastructure, reorganizing the existing regulatory bodies or creating a new appropriate national institution that can ensure the implementation of and administration of the TBT Agreement in compliance with the WTO TBT principles, the creation or building of local capacity to respond to a National Enquiry Point for the WTO TBT Agreement that would be able to provide information to WTO members on any subject matter falling within the ambit of the WTO TBT Agreement, and the creation of a national system certification service provider for certifying ISO 9001, ISO 14001, HACCP, EUREPGAP, BRC and others required for foreign markets.

The paper tried to analyze, in particular, the impact of implementing SPS measures in Ethiopia, using a CGE model. The analysis was made with the aid of a General Algebraic Modeling System (GAMS), a software which provides a high-level language for the compact representation of large and complex models. The result of the analysis shows that if Ethiopia tries to implement the membership requirements for accession without further looking for compensating measures, the most disadvantaged group of the society will be adversely affected seriously, at least in the short run, as these groups are exposed to price risks. It was further shown that the increase in government consumption on goods and services induced by the need for complying with the accession requirements will have the tendency to increase the prices of goods and services consumed by the poor and to the deterioration of the terms of trade of the sector in which they are employed. The result of the analysis has also shown that an attempt to finance the investment necessary for the implementation of accession

requirements by diverting resources away from the pro poor expenditure sectors would end-up adversely affecting the poor.

Therefore, although trade liberalization may have a positive effect in the long-run for the poor by stimulating growth, increasing demand for unskilled and semi-skilled workers, and increasing government revenues, the poor may also, at the same time, be at a disadvantage in the short run. The policy implication of this is therefore that the government should take cautious measures in implementing the requirements for the fulfillment of the accession process. These measures may include implementing the SPS measures sequentially on priority basis, seeking technical and financial supports from the Standards and Trade Development Facility of the WTO for compensating the diverted resources and for injecting additional pro-poor spending.

The limitation of this Thesis is that focus was given to the analysis of short-term impacts of shocks. Given the dynamic nature of the global economy and the ever changing modalities of trade relationships among countries, however, a more rigorous analysis involving dynamic CGE model and the incorporation of more disaggregated households in the analysis would have helped to elucidate the impacts of accession on poverty and inequality.

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# APPENDIX : 1

## The 2002 Ethiopian SAM

(in million Birr)

| | | | Factors of production | | | | Institutions | | | | | | | | | | Taxes | | | Activities | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | F1 | F2 | F3 | F4 | I1 | I2 | I3 | I4 | I5 | I6 | FWR | FAID | GOV | ROW | D-TAX | E-TAX | I-Tax | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 |
| Pd° Factors | Family labour | F1 | | | | | | | | | | | | | | | | | | 10833.4 | 3125.9 | 3734.8 | 873.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Wage labour | F2 | | | | | | | | | | | | | | | | | | 305.0 | 169.6 | 1867.4 | 65.9 | 231.4 | 117.8 | 159.0 | 93.8 |
| | Capital | F3 | | | | | | | | | | | | | | | | | | 1012.1 | 388.6 | 3686.7 | 710.8 | 951.0 | 126.4 | 348.3 | 300.2 |
| | Land | F4 | | | | | | | | | | | | | | | | | | 6247.5 | 1940.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Institutions | Farm Hs | I1 | 20282.2 | 1867.4 | | | | 787.6 | 332.7 | 2001.7 | | 13083.4 | | 169.7 | 43.4 | 827.3 | | | | | | | | | | | |
| | Wage earners | I2 | | 9821.3 | | | | | | | 349.8 | | | 152.6 | | 744.1 | | | | | | | | | | | |
| | Entrepr. | I3 | 800.3 | | | | 680.6 | 141.2 | | 5878.9 | | | | 317.1 | | 1545.9 | | | | | | | | | | | |
| | Private firms | I4 | | | 15389.2 | 23.8 | | | | | | | | | | | | | | | | | | | | | |
| | Public firms | I5 | | | 6819.2 | 71.0 | | | | | | | | | | | | | | | | | | | | | |
| | Peasant Hs F | I6 | | | 4990.6 | 8092.8 | | | | | | | | | | | | | | | | | | | | | |
| | Food for work project | FWR | | | | | | | | | | | | | | 305.0 | | | | | | | | | | | |
| | Food Aid program | FAID | | | | | | | | | | | | | | 639.3 | | | | | | | | | | | |
| | GOV | GOV | | | | | | | | | | | | | | 1714.5 | 5555.6 | 168.5 | 3600.9 | | | | 61.0 | | | | |
| | RWO | ROW | | | | | | | 94.5 | | | | | | 548.4 | | | | | | | | | | | | |
| Taxes | Direct taxes | D-TAX | | | | | 229.3 | 584.2 | 1546.4 | | 3195.7 | | | | | | | | | | | | | | | | |
| | Export taxes | E-TAX | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Import taxes | I-Tax | | | | | | | | | | | | | | | | | | | | | | | | | |
| Activities | APFHLM | A1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APFLLM | A2 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APLVSP | A3 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | AHndMa | A4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APubAgInd | A5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APvAgIND | A6 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APubOtInd | A7 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APvOtInd | A8 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APubNEInd | A9 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APvNEInd | A10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APubServ | A11 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | APvServ | A12 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Commodities | CFCrop | C1 | | | | | 13729.4 | 1282.0 | 852.9 | | | | | | 0.0 | 0.0 | | | | 252.3 | 38.5 | 145.6 | 505.6 | 230.3 | 146.5 | 0.0 | 0.0 |
| | CTdAgEx | C2 | | | | | 8696.8 | 1326.6 | 882.6 | | | | | | 0.0 | 3388.4 | | | | 33.5 | 11.7 | 30.9 | 88.7 | 118.6 | 75.4 | 3.6 | 7.3 |
| | CNTdAgEx | C3 | | | | | 1976.9 | 362.8 | 241.3 | | | | | | 0.0 | 44.3 | | | | 26.6 | 5.2 | 15.3 | 28.4 | 11.5 | 7.3 | 0.0 | 0.0 |
| | COtrAgPd | C4 | | | | | 2273.5 | 117.8 | 78.4 | | | | | | 0.0 | 0.0 | | | | 46.7 | 11.5 | 30.7 | 0.0 | 100.7 | 64.0 | 0.0 | 0.0 |
| | CAgrIndPd | C5 | | | | | 3153.1 | 2205.3 | 1467.1 | | | | | | 0.0 | 62.2 | | | | 40.3 | 18.2 | 26.5 | 167.7 | 402.6 | 256.1 | 64.7 | 129.5 |
| | COtrIndPd | C6 | | | | | 4196.6 | 1692.9 | 1126.3 | | | | | | 0.0 | 463.0 | | | | 278.5 | 47.7 | 160.0 | 191.9 | 266.1 | 145.1 | 520.5 | 787.8 |
| | CPbServ | C7 | | | | | 0.0 | 0.0 | 0.0 | | | | | | 7202.9 | 0.0 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | COtrServ | C8 | | | | | 2347.6 | 1372.1 | 908.9 | | | | | | 0.0 | 4059.8 | | | | 228.6 | 47.9 | 132.7 | 421.5 | 501.8 | 314.7 | 250.5 | 438.6 |
| Transactions Costs | | TR-CST | | | | | | | | | | | | | | | | | | | | | | | | | |
| Public investement | | Pub Inv | | | | | | | | | | | 305.0 | | 2895.0 | | | | | | | | | | | | |
| Capital account | | CAP | | | | | 2111.6 | 1195.3 | 1832.9 | 7532.3 | 3694.5 | | | | | 2818.5 | | | | | | | | | | | |
| Total | | TOT | 21082.4 | 11688.7 | 27199.0 | 8187.6 | 39395.3 | 11067.8 | 9363.9 | 15413.0 | 6890.2 | 13083.4 | 305.0 | 639.3 | 11039.5 | 16612.2 | 5555.6 | 168.5 | 3600.9 | 19324.4 | 5804.9 | 9830.5 | 3054.0 | 2813.9 | 1253.3 | 1346.6 | 1757.1 |

Source: World Bank, "Ethiopia-A Strategy to Balance and Stimulate Growth", A Country Economic Memorandum, Report No. 29383-ET, Green Cover, the World Bank January 2005).

| | | | | Commodities | | | | | | | | TR-CST | Pub Inv | CAP | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A9 | A10 | A11 | A12 | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | | | | |
| 0.0 | 1113.1 | 0.0 | 1402.0 | | | | | | | | | | | | 21082.4 |
| 585.2 | 1752.9 | 3281.9 | 3058.8 | | | | | | | | | | | | 11688.7 |
| 915.2 | 5943.2 | 4532.2 | 8284.3 | | | | | | | | | | | | 27199.0 |
| 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | | | | | | 8187.6 |
| | | | | | | | | | | | | | | | 39395.3 |
| | | | | | | | | | | | | | | | 11067.8 |
| | | | | | | | | | | | | | | | 9363.9 |
| | | | | | | | | | | | | | | | 15413.0 |
| | | | | | | | | | | | | | | | 6890.2 |
| | | | | | | | | | | | | | | | 13083.4 |
| | | | | | | | | | | | | | | | 305.0 |
| | | | | | | | | | | | | | | | 639.3 |
| | | | | | | | | | | | | | | | 11039.5 |
| | | | | 646.3 | 0.0 | 0.0 | 0.0 | 779.1 | 11690.5 | 0.0 | 2853.4 | | | | 16612.2 |
| | | | | | | | | | | | | | | | 5555.6 |
| | | | | 0.0 | 168.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 168.5 |
| | | | | 102.4 | 0.0 | 0.0 | 0.0 | 1061.6 | 2076.2 | 0.0 | 360.7 | | | | 3600.9 |
| | | | | 12798.0 | 3624.6 | 1253.8 | 1647.9 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 19324.4 |
| | | | | 2974.0 | 1353.6 | 321.2 | 1156.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 5804.9 |
| | | | | 0.0 | 8847.4 | 983.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 9830.5 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 2670.1 | 383.9 | 0.0 | 0.0 | | | | 3054.0 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 2813.9 | 0.0 | 0.0 | 0.0 | | | | 2813.9 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 1253.3 | 0.0 | 0.0 | 0.0 | | | | 1253.3 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1346.6 | 0.0 | 0.0 | | | | 1346.6 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1757.1 | 0.0 | 0.0 | | | | 1757.1 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1882.8 | 0.0 | 0.0 | | | | 1882.8 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10474.4 | 0.0 | 0.0 | | | | 10474.4 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6590.8 | 4844.4 | | | | 11435.2 |
| | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 612.1 | 19253.9 | | | | 19866.0 |
| 0.0 | 0.0 | 197.8 | 0.0 | | | | | | | | | 0.0 | 355.6 | 1059.4 | 18795.7 |
| 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | | | 0.0 | 177.8 | 1126.7 | 15988.5 |
| 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | | | 0.0 | 0.0 | 207.6 | 2927.1 |
| 26.9 | 312.0 | 0.0 | 0.0 | | | | | | | | | 0.0 | 0.0 | 146.2 | 3208.4 |
| 0.0 | 0.0 | 570.4 | 0.0 | | | | | | | | | 0.0 | 0.0 | 986.3 | 9549.8 |
| 209.2 | 770.2 | 1249.8 | 3065.8 | | | | | | | | | 0.0 | 1066.7 | 15659.0 | 31897.1 |
| 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | | | 0.0 | 0.0 | 0.0 | 7202.9 |
| 146.3 | 583.1 | 1603.1 | 4055.1 | | | | | | | | | 8300.1 | 1600.0 | 0.0 | 27312.4 |
| | | | | 2275.0 | 1994.3 | 369.0 | 404.5 | 971.8 | 2285.5 | 0.0 | 0.0 | | | | 8300.1 |
| | | | | | | | | | | | | | | | 3200.0 |
| | | | | | | | | | | | | | | | 19185.1 |
| 1882.8 | 10474.4 | 11435.2 | 19866.0 | 18795.7 | 15988.5 | 2927.1 | 3208.4 | 9549.8 | 31897.1 | 7202.9 | 27312.4 | 8300.1 | 3200.0 | 19185.1 | |

Activities

| | | |
|---|---|---|
| APFHLM | : | Peasant farming - Highland mixed |
| APFLLM | : | Peasant farming - Lowland mixed |
| APLVSP | : | Peasant livestock production - Pastoralists |
| AHndMa | : | Cottage/handicraft and small-scale manufacturing/processing |
| APubAgInd | : | Large/medium Agro- manufacturing - public |
| APvAgIND | : | Large/medium Agro-manufacturing - private |
| APubOtInd | : | Large/medium Other manufacturing - public |
| APvOtInd | : | Large/medium Other manufacturing - private |
| APubNEInd | : | Other industry n.e.c. -public |
| APvNEInd | : | Other industry n.e.c. -private |
| APubServ | : | Service - public |
| APvServ | : | Services - private |

Commodities

| | | |
|---|---|---|
| CFCrop | : | Food crops |
| CTdAgEx | : | Traditional agricultural exportables |
| CNTdAgEx | : | Non-traditional agricultural exportables |
| COtrAgPd | : | Other agricultural products |
| CAgrIndPd | : | Agro-industrial products |
| COtrIndPd | : | Other industrial products |
| CPbServ | : | Public goods services |
| COtrServ | : | Other services |

## APPENDIX 2: MATHEMATICAL DESIGNATION OF THE CGE MODEL

The mathematical equations are presented in four blocks: prices, production and trade, institutions, and system constraints. Furthermore, parameter and variable names are chosen to facilitate interpretation so that commodity and factor quantities start with q, commodity prices with p, and factor prices with w.

**Price Block**

The price block consists of equations in which endogenous model prices are linked to other prices (endogenous or exogenous) and to non price model variables.

.Import Price

$$PMc = pwmc.\ (1+tmc).EXR + \sum PQc.icm \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(A1)}$$

$$\begin{bmatrix}\text{import}\\ \text{price}\\ \text{(LCU)}\end{bmatrix} = \begin{bmatrix}\text{Im } port\\ price\\ (fcu)\end{bmatrix}\begin{bmatrix}tariff\\ adjust-\\ ment\end{bmatrix}.\begin{bmatrix}exchnge\ rate\\ adjustment\\ (LCU \text{ per FCU}\end{bmatrix} + \begin{bmatrix}\text{cos}t \text{ of trade}\\ \text{inputs per}\\ \text{import unit}\end{bmatrix}$$

.....Export Price

$$PEc = pwe_c.\ (1+te_c).EXR - \sum_{c' \in CT} PQc.ice \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(A2)}$$

$$\begin{bmatrix}\text{export}\\ \text{price}\\ \text{(LCU)}\end{bmatrix} = \begin{bmatrix}\text{exp}ort\\ price\\ (fcu)\end{bmatrix}\begin{bmatrix}tariff\\ adjust-\\ ment\end{bmatrix}.\begin{bmatrix}exchnge\ rate\\ adjustment\\ (LCU \text{ per FCU}\end{bmatrix} - \begin{bmatrix}\text{cos}t \text{ of trade}\\ \text{inputs per}\\ \text{import unit}\end{bmatrix}$$

..... Demand Price of Domestic Non traded Goods

$$PDDc = PDS_c + \sum_{c' \in CT} PQ_{c'} . icd_{c'} \qquad \text{..... (A3)}$$

$$\begin{bmatrix} \text{Domestic} \\ \text{demand price} \end{bmatrix} = \begin{bmatrix} \text{domestic} \\ \text{supply} \\ \text{price} \end{bmatrix} + \begin{bmatrix} \text{cost of trade} \\ \text{inputs per} \\ \text{unit of domestic} \\ \text{sales} \end{bmatrix}$$

..... **Absorption**

$$PQc \,.(1 - tqc\,).QQc = PDDc.QDc + PMc\,.QMc \qquad \text{..... (A4)}$$

$$\begin{bmatrix} \text{absorption} \\ \text{(at demand} \\ \text{prices net of} \\ \text{sales tax} \end{bmatrix} = \begin{bmatrix} \text{domestic demand pric} \\ \text{times} \\ \text{domestic sales quantity} \end{bmatrix} + \begin{bmatrix} \text{import price} \\ \text{times} \\ \text{import quantiity} \end{bmatrix}$$

.....Marketed output Value

$$PXc\,.QXc = PDSc\,.QDc + PEc\,.QEc \qquad \text{..... (A5)}$$

$$\begin{bmatrix} \text{Producer price} \\ \text{times marketed} \\ \text{output quantity} \end{bmatrix} = \begin{bmatrix} \text{domestic demand price} \\ \text{times} \\ \text{domestic sales quantity} \end{bmatrix} + \begin{bmatrix} \text{export price} \\ \text{times} \\ \text{export quantiity} \end{bmatrix}$$

....Activity price

$$PAa = \sum_{c \in C} PXA_{ac} \cdot \theta_{ca} \qquad a \in A \text{.....(A6)}$$

$$\begin{bmatrix} \text{activity} \\ \text{price} \end{bmatrix} = \begin{bmatrix} \text{producer prices} \\ \text{times yields} \end{bmatrix}$$

.....Aggregate intermediate Input Price

$$PAa = \sum_{c \in C} PQ_c \cdot ica_{ca} \qquad a \in A \ldots\ldots\ldots (A7)$$

$$\begin{bmatrix}\text{aggregate}\\ \text{intermedia te}\\ \text{input price}\end{bmatrix} = \begin{bmatrix}\text{intermedia te input cost}\\ \text{per unit of aggregate}\\ \text{intermedia te intput}\end{bmatrix}$$

.....Activity Revenue and Costs

$$PAa \cdot (1 - ta_a).QA_a = PVA_a \cdot QV_a + PINTAa \cdot Q\,UINTAa \qquad a \in A \ldots\ldots\ldots (A8)$$

$$\begin{bmatrix}\text{activity price}\\ \text{(net of taxes)}\\ \text{times}\\ \text{activity level}\end{bmatrix} = \begin{bmatrix}\text{vaue - added}\\ \text{price times}\\ \text{quantity}\end{bmatrix} + \begin{bmatrix}\text{aggregate}\\ \text{int } ermediate\\ \text{input}\\ \text{pricet imes quantity}\end{bmatrix}$$

**.....Consumer Price index**

$$\overline{\text{CPI}} = \sum_{c \in C} PQ_c \cdot cwts_c \qquad \ldots\ldots\ldots\ldots (A9)$$

$$\begin{bmatrix}\text{consumer}\\ \text{price index}\end{bmatrix} = \begin{bmatrix}\text{price times}\\ \text{weights}\end{bmatrix}$$

Producer price index for non traded market output

$$\overline{\text{DPI}} = \sum_{c \in C} PDS_c \cdot dwts_c \qquad \ldots\ldots\ldots\ldots (A10)$$

$$\begin{bmatrix}\text{producer}\\ \text{price index}\end{bmatrix} = \begin{bmatrix}\text{price times}\\ \text{weights}\end{bmatrix}$$

**Production and trade block**

The production and trade block covers four categories: domestic production and input use; the allocation of domestic output to home consumption, the domestic market, and exports; the aggregation of supply to the domestic market (from imports and domestic output sold

domestically); and the definition of the demand for trade inputs that is generated by the distribution process.

Activity Production Function

$$QA = \alpha_a^a \cdot \left( \sigma_a^a \cdot QVA_a^{-\rho_a^a} + (1-\sigma_a^a) \cdot QUINTAa^{-\rho_a^a} \right)^{-\frac{1}{1+\rho_a^a}} \quad \text{..... (A11)}$$

$$\begin{bmatrix} \text{Activity} \\ \text{level} \end{bmatrix} = CES \begin{bmatrix} \text{quantiity of aggregate valu added,} \\ \text{quantity of aggregate intermedia te input} \end{bmatrix}$$

Value-added-intermediate-input ratio

$$\frac{QVAa}{QUINTAa} = \left[ \frac{PINTAa}{PVa} \cdot \frac{\sigma_a^a}{1-\sigma_a^a} \right]^{\frac{1}{1+\rho_a^a}} \quad \text{..... (A12)}$$

$$\begin{bmatrix} \text{value} - \text{dadded} - \\ \text{intermedia te} \\ \text{input quantity} \\ \textit{ratio} \end{bmatrix} = f \begin{bmatrix} \text{intermedia te input} : \\ \text{value} - \text{added} \\ \text{price ratio} \end{bmatrix}$$

Demand for aggregate value added

$$QVA = iva_a \cdot QA_a \qquad a \in ALEO \text{ ..... (A13)}$$

$$\begin{bmatrix} \text{demand for} \\ \text{value} - \text{dadded} \end{bmatrix} = f[\text{activity level}]$$

Demand for aggregate intermediate input

$$QINTA_a = \text{int}_a \cdot QA_a \qquad \text{.....(A14)}$$

$$\begin{bmatrix}\text{demand for}\\ \text{value - added}\end{bmatrix} = f\,[\text{activity level}]$$

Value added and factor demands

$$QVA_a = \alpha^{va}_a \cdot \left( \sum_{f \in F} \delta^{va}_{fa} \cdot QF_{fa}^{-\sigma^{va}_a} \right)^{-\frac{1}{\sigma^{va}_a}} \qquad a \in ALEO \text{ ..... (A15)}$$

$$\begin{bmatrix}\text{quantiity of aggregate}\\ \text{value added}\end{bmatrix} = CES\,[\text{factor inputs}]$$

**Factor Demand**

$$WFf \cdot \overline{WFDISTf_a} = PVAa \cdot (1 - tva).QVA \cdot \left( \sum_{f \in F} \delta^{va}_{fa} \cdot QFfa^{-\sigma^{va}_a} \right)^{-1}$$

$$.\delta^{va}_{fa} \cdot QFa^{-\rho^{va}_a - 1}$$

.....(A16)

**Disaggregated Intermediate Input Demand**

$$QINT_{ca} = ica_{ca}.QINTA_a \qquad \begin{matrix} a \in A \\ c \in C \end{matrix} \qquad \text{..... (A17)}$$

$$\begin{bmatrix}\textit{intermediate demand}\\ \textit{for commodity c}\\ \textit{from activity a}\end{bmatrix} = f \begin{bmatrix}\textit{aggregate intermediate}\\ \textit{input quantity}\\ \textit{for activitiy a}\end{bmatrix}$$

**Commodity Production and Allocation**

$$QXAC_{ac} + \sum_{h \in H} QHA_{ach} = \theta_{ac}.QA_a \qquad \text{..... (A18)}$$

$$\begin{bmatrix}\text{marketed quantity}\\ \text{of commodity c}\\ \text{from activity a}\end{bmatrix}+\begin{bmatrix}\textit{household home}\\ \textit{consumption}\\ \textit{of commodity c}\\ \textit{from activity a}\end{bmatrix}=\begin{bmatrix}\text{production}\\ \text{of commodity c}\\ \text{from activitiy a}\end{bmatrix} \qquad \begin{matrix}a \in A\\ c \in CX\end{matrix}$$

**Output Aggregation Function**

$$QX_c = a_c^{ac}.\left(\sum_{a\in A}\delta_{ac}^{ac}.QXAC_{ac}^{-p_c^{ac}}\right)^{\frac{1}{p_c^{ac}-1}} \qquad \text{..... (A19)}$$

$$\begin{bmatrix}\text{aggregate}\\ \text{marketed}\\ \text{production of}\\ \text{commodity c}\end{bmatrix}=\text{CES}\begin{bmatrix}\textit{activity}-\textit{specific}\\ \textit{marketed}\\ \textit{production of}\\ \text{commodity c}\end{bmatrix} \qquad c \in CX$$

**First-Order Condition for Output Aggregation Function**

$$PXAX_{ac} = PX_c.QX_c\left(\sum_{a\in A}\delta_{ac}^{ac}.\text{QXAC}_{ac}^{-p_c^{ac}}\right)^{-1}.\delta_{ac}^{ac}.\text{QXAC}_{ac}^{-p_c^{ac}-1} \qquad \begin{matrix}a \in A\\ c \in CX\end{matrix} \text{..... (A20)}$$

$$\begin{bmatrix}\text{marginal cost of com -}\\ \text{modity c from activity a}\end{bmatrix}=\begin{bmatrix}\text{marginal revenue product of}\\ \text{commodity c from activity a}\end{bmatrix}$$

**Output Transformation (CET) Function**

$$QX_c = \alpha_c^1.\left(\delta_c^t.\text{QE}_c^{p_c^t}+(1-\delta_c^t).\text{QD}_c^{p_c^t}\right)^{\frac{1}{\rho_c^t}} \qquad \text{..... (A21)}$$

$c \in (\text{CE} \cap \text{CD})$ (21)

$$\begin{bmatrix}\text{aggregate marketed}\\ \text{domestic output}\end{bmatrix}=\text{CET}\begin{bmatrix}\text{export quantity, domestic}\\ \text{sales of domestic output}\end{bmatrix}$$

**Export-Domestic Supply Ratio**

$$\frac{QE_c}{QD_c} = \left( \frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\delta_c^t - 1}} \qquad c \in (CE \cap CD) \ \ldots\ldots\ldots\ldots (A22)$$

$$\begin{bmatrix} \text{export - domestic} \\ \text{supply ratio} \end{bmatrix} = f \begin{bmatrix} \text{export - domestic} \\ \text{price ratio} \end{bmatrix}$$

**Output Transformation for Domestically Sold Outputs without Exports and for Exports without Domestic Sales**

$$QX_c = QD_c \, QE_c \qquad c \in (CD \cap CEN) \cup (CE \cap CDN) \ \ldots\ldots\ldots\ldots (A23)$$

$$\begin{bmatrix} \text{aggregate} \\ \text{marketed} \\ \text{domestic output} \end{bmatrix} = \begin{bmatrix} \text{domestic market} \\ \text{sales of domestic} \\ \text{output [for} \\ c \in (C \in \cap CDN)] \end{bmatrix} + \begin{bmatrix} \text{exports t [for} \\ c \in (CE \cap CDN)] \end{bmatrix}$$

**Composite Supply (Armington) Function**

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

$$c \in (CM \cap CD) \ \ldots (A24)$$

$$\begin{bmatrix} \text{Composite} \\ \text{supply} \end{bmatrix} = f \begin{bmatrix} \text{import quantity, domestic} \\ \text{use of domestic output} \end{bmatrix}$$

**Import-Domestic Demand Ratio**

$$\frac{QM_c}{QD_c} = \left( \frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q} \right)^{\frac{1}{1 + \rho_c^q}} \qquad c \in (CM \cap CD) \ \ldots\ldots\ldots\ldots (A25)$$

$$\begin{bmatrix} \text{import - domestic} \\ \text{demand ratio} \end{bmatrix} = f \begin{bmatrix} \text{domestic - import} \\ \text{price ratio} \end{bmatrix}$$

**Composite Supply for Non-imported Outputs and Nonproduced Imports**

$$QQ_c = QD_c + QM_c$$

$c \in (CD \cap CMN) \cup (CM \cap CDN)$ ..... (A26)

$$\begin{bmatrix} composite \\ supply \end{bmatrix} = \begin{bmatrix} domestic\ use\ of \\ marketed\ domestic \\ output\ [for \\ c \in (CM \cap CDN)] \end{bmatrix} + \begin{bmatrix} imports\ [for \\ c \in (CM \cap CDN)] \end{bmatrix}$$

**Demand for Transactions Services**

$$QT_c = \sum_{c' \in cC'} (icm_{cc'} + ice_{cc'} QE_{c'} + icd_{cc'} . QD_{c'})$$

$c \in CT$ ..... (A27)

$$\begin{bmatrix} demand\ for \\ transactions \\ services \end{bmatrix} = \begin{bmatrix} sum\ of\ demands \\ for\ imports, exports, \\ and\ domestic\ sales \end{bmatrix}$$

**INSTITUTION BLOCK**

**Factor Income**

$$YF_f = \sum_{a \in A} WF_f . \overline{WFDIST_{fa}} . QF_{fa} \qquad f \in F \text{ ..... (A28)}$$

$$\begin{bmatrix} income\ of \\ factor\ f \end{bmatrix} = \begin{bmatrix} sum\ of\ activity\ payments \\ (activity - specific\ wages \\ times\ employment\ levels) \end{bmatrix}$$

**Institutional Factor Incomes**

$$YIF_{if} = shif_{if} . \left[ (1 - tf_f) . YF_f - trnsfr_{row\,f} . EXR \right]$$

$i \in INSE$
$f \in F$ ..... (A29)

$$\begin{bmatrix} income\ of \\ institution\ i \\ from\ factor\ f \end{bmatrix} = \begin{bmatrix} share\ of\ income \\ of\ factor\ f\ to \\ institution\ i \end{bmatrix} . \begin{bmatrix} income\ of\ factor\ f \\ (net\ of\ tax\ and \\ transfer\ to\ RoW \end{bmatrix}$$

**Income of domestic, Nongovernment Institutions**

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDING'} TRII_{ii'} + trnsfr_{i\,gov} . \overline{CPI} + trnsfr_{i\,row} . EXR$$

$$i \in INSDNG \quad \ldots\ldots \text{(A30)}$$

$$\begin{bmatrix} income\ of \\ institution\ i \end{bmatrix} = \begin{bmatrix} factor \\ income \end{bmatrix} + \begin{bmatrix} transfers \\ from\ other\ domestic \\ non-government \\ institutions \end{bmatrix} + \begin{bmatrix} transfers \\ from \\ government \end{bmatrix} + \begin{bmatrix} transfers \\ from \\ RoW \end{bmatrix}$$

**Intra-Institutional Transfers**

$$TRII_{i\,i'} = shii_{ii'} . (1 - MPS_{i'}) . (1 - TINS_{i'}) . YI_{i'}$$

$$\begin{matrix} i \in INSDNG \\ i' \in INSDNG' \end{matrix} \quad \ldots\ldots\ldots \text{(A31)}$$

$$\begin{bmatrix} transfer\ from \\ institution\ i\ to\ i' \end{bmatrix} = \begin{bmatrix} share\ of\ net\ income \\ of\ institution\ i' \\ transfered\ to\ i \end{bmatrix} . \begin{bmatrix} income\ of\ instiurion \\ i', net\ of\ savings\ and \\ direct\ taxes \end{bmatrix}$$

**Household Consumption Expenditures**

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih}\right) . (1 - MPS_h) . (1 - TINS_h) . YI_h + \gamma_h \cdot FID +$$

$$h \in H \quad \ldots\ldots\ldots \text{(A32)}$$

$$\begin{bmatrix} household\ income \\ disposable\ for \\ consumption \end{bmatrix} = \begin{bmatrix} household\ income,\ net\ of\ direct \\ taxes,\ savings,\ and\ transfers\ to \\ other\ non-government\ ionstitutions \end{bmatrix} + \text{Food Aid}$$

**Household Consumption Spending on Marketed Commodities**

$$PQ_c \cdot QH_{ch} = PQ_c \cdot r^m_{ch} + \beta^m_{ch} \cdot \left( EH_h - \sum_{c' \in C} PQ_{c'} \cdot r^m_{c'h} - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \, r^h_{ac'h} \right)$$

$$\begin{matrix} c \in C \\ h \in H \end{matrix} \quad \text{..... (A33)}$$

$$\begin{bmatrix} household\ consumption \\ spending\ on\ market \\ commodity\ c \end{bmatrix} = f \begin{bmatrix} total\ household\ consumption \\ spending, market\ price\ of\ c, and\ other \\ commodity\ prices\ (market\ and\ home) \end{bmatrix}$$

**Household Consumption Spending on Home Commodities**

$$PXAC_{ac} \cdot QHA_{ach} = PXAC_{ac} \cdot r^h_{ach} + \beta^h_{ach}$$

$$\cdot \left( EH_h - \sum_{c' \in C} PQ_{c'} \cdot r^m_{c'h} - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot r^h_{ac'h} \right) \qquad \begin{matrix} a \in A \\ c \in C \\ h \in H \end{matrix} \quad \begin{matrix} c \in C \\ h \in H \end{matrix} \quad \text{..... (A34)}$$

$$\begin{bmatrix} household\ consumption \\ spending\ on\ home\ commodity \\ c\ from\ activity\ a \end{bmatrix} = f \begin{bmatrix} total\ household\ consumption\ spending, \\ producer\ price, and\ other \\ commodity\ prices\ (market\ and\ home) \end{bmatrix}$$

**Investment Demand**

$$QINV_c = \overline{IADJ} \cdot \overline{qinv_c}$$

$$\begin{bmatrix} fixed\ investment \\ demand\ for \\ commodity\ c \end{bmatrix} = \begin{bmatrix} adjustment\ factor \\ times \\ base - year\ fixed \\ investment \end{bmatrix} \qquad c \in C \quad \begin{matrix} c \in C \\ h \in H \end{matrix} \quad \text{..... (A35)}$$

**Government Consumption Demand**

$$QG_c = \overline{GADJ} \cdot \overline{qg_c} \qquad c \in C \quad \text{..... (A36)}$$

$$\begin{bmatrix} government \\ consumption \\ demendfor \\ commodityc \end{bmatrix} = \begin{bmatrix} adjustmen\ factor \\ times \\ base - year\ govenment \\ consumption \end{bmatrix}$$

**Government Revenue**

$$YG = \sum_{i \in INSDNG} TINS_i \cdot YI_i + \sum_{f \in F} tf_f \cdot YF_f + \sum_{a \in A} tva_a \cdot PVA_a \cdot PVA_a \cdot QVA_a$$

$$+ \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CM} tm_c \cdot pwm_c QM_c \cdot EXR + \sum_{c \in CE} te_c \cdot pwe_c \cdot QE_c \cdot EXR$$

$$+ \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YIF_{gov\,f} + trnsfr_{\ gov\,row} \cdot EXR \qquad \text{.... (A36)}$$

$$\begin{bmatrix} government \\ revenue \end{bmatrix} = \begin{bmatrix} direct\ taxes \\ from \\ institutions \end{bmatrix} + \begin{bmatrix} direct\ taxes \\ from \\ factors \end{bmatrix} + \begin{bmatrix} value- \\ added \\ tax \end{bmatrix} + \begin{bmatrix} activity \\ tax \end{bmatrix} + \begin{bmatrix} imports \\ tariffs \end{bmatrix} +$$

$$\begin{bmatrix} export \\ taxes \end{bmatrix} + \begin{bmatrix} sales \\ tax \end{bmatrix} + \begin{bmatrix} factor \\ income \end{bmatrix} + \begin{bmatrix} transfers \\ from \\ RoW \end{bmatrix}$$

**Government Expenditure**

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI} \qquad \text{.... (A37)}$$

$$\begin{bmatrix} government \\ spending \end{bmatrix} = \begin{bmatrix} government \\ consumption \end{bmatrix} + \begin{bmatrix} transfers\ to\ domestic \\ non-government \\ institutions \end{bmatrix}$$

**SYSTEM CONSTRAINT BLOCK**

**Factor Markets**

$$\sum_{a \in A} QF_{f\,a} = \overline{QFS}_f \qquad \text{.... (A38)}$$

$$\begin{bmatrix} demand\ for \\ factor\ f \end{bmatrix} = \begin{bmatrix} supply\ of \\ factor\ f \end{bmatrix} \qquad f \in F$$

**Composite Commodity Markets**

$$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c \qquad c \in C \qquad \text{..... (A39)}$$

$$\begin{bmatrix} composite \\ supply \end{bmatrix} = \begin{bmatrix} \text{int}ermediate \\ use \end{bmatrix} + \begin{bmatrix} household \\ consumption \end{bmatrix} + \begin{bmatrix} government \\ consumption \end{bmatrix}$$

$$+ \begin{bmatrix} fixed \\ investment \end{bmatrix} + \begin{bmatrix} stock \\ change \end{bmatrix} + \begin{bmatrix} trade \\ input\ use \end{bmatrix}$$

**Current-Account Balance for the Rest of the World, in Foreign Currency**

$$\sum_{c \in CM} pwm_c \cdot QM_c + \sum_{f \in F} trnsfr_{row\,f} = \sum_{c \in CE} pwe_c \cdot QE_c + \sum_{i \in INSD} trnsfr_{i\,row} + \overline{FSAV} \qquad \text{..... (A40)}$$

$$\begin{bmatrix} import \\ spending \end{bmatrix} + \begin{bmatrix} factor \\ transfers \\ to\ RoW \end{bmatrix} = \begin{bmatrix} \text{exp}ort \\ revenue \end{bmatrix} + \begin{bmatrix} institutional \\ transfers \\ from\ RoW \end{bmatrix} + \begin{bmatrix} foreign \\ savings \end{bmatrix}$$

**Government Balance**

$$YG = EG + GSAV \qquad \text{..... (A42)}$$

$$\begin{bmatrix} government \\ revenue \end{bmatrix} = \begin{bmatrix} government \\ \text{exp}enditures \end{bmatrix} + \begin{bmatrix} government \\ savings \end{bmatrix}$$

**Direct Institutional Tax Rates**

$$TINS_i = \overline{tinsi} \cdot (1 + \overline{TINSADJ} \cdot tins01_i) + \overline{DTINS} \cdot t_i \qquad \text{..... (A43)}$$

$$\begin{bmatrix} direct\ tax \\ rate\ for \\ institution\ i \end{bmatrix} = \begin{bmatrix} base\ rate\ adjusted \\ for\ scaling\ for \\ selected\ institutions \end{bmatrix} + \begin{bmatrix} point\ change \\ for\ selected \\ institutions \end{bmatrix} \qquad i \in INSDNG$$

**Institutional Savings Rates**

$$MPS_i = \overline{mps_i} \cdot (1 + \overline{MPSADJ}.mps01_i) + DMPS.mps01_i$$

$$i \in INASNG\ ) \text{..... (A44)}$$

$$\begin{bmatrix} savings \\ rate\ for \\ institution\ i \end{bmatrix} = \begin{bmatrix} base\ rate\ adjusted \\ for\ scaling\ for \\ selected\ institutions \end{bmatrix} + \begin{bmatrix} point\ change \\ for\ selected \\ institutions \end{bmatrix}$$

**Savings–Investment Balance**

$$\sum_{i \in INSDNG} MPS_i \,.\, (1 - TINS_i) \,.\, YI_i + GSAV + EXR$$

$$. \; \overline{FSAV} = \sum_{c \in C} PQ_c \,.\, QINV_c + \sum_{c \in C} PQ_c \,.qdst_c \qquad \ldots\ldots\ldots \qquad (A45)$$

$$\begin{bmatrix} non-govern- \\ ment\ savings \end{bmatrix} + \begin{bmatrix} government \\ savings \end{bmatrix} + \begin{bmatrix} foreign \\ savings \end{bmatrix} = \begin{bmatrix} fixed \\ investment \end{bmatrix} + \begin{bmatrix} stock \\ changes \end{bmatrix}$$

**Total Absorption**

$$TABS = \sum_{h \in H} \sum_{c \in C} PQ_c \,.\, QH_{ch} + \sum_{a \in A} \sum_{c \in C} \sum_{h \in H} PXAC_{ac} \,.\, QHA_{ach}$$

$$+ \sum_{c \in C} PQ_c \,.\, QG_c + \sum_{c \in C} PQ_c . QINV_c + \sum_{c \in C} PQ_c \,.\, qdst_c \qquad \ldots\ldots (A46)$$

$$\begin{bmatrix} total \\ absorption \end{bmatrix} = \begin{bmatrix} household \\ market \\ consumption \end{bmatrix} + \begin{bmatrix} household \\ home \\ consumption \end{bmatrix} + \begin{bmatrix} government \\ consumption \end{bmatrix} + \begin{bmatrix} fixed \\ investment \end{bmatrix} + \begin{bmatrix} stock \\ changes \end{bmatrix}$$

**Ratio of Investment to Absorption**

$$INVSHR \,.\, TABS = \sum_{c \in C} PQ_c . QINV_c + \sum_{c \in} PQ_c . qdst_c \qquad \ldots\ldots (A47)$$

$$\begin{bmatrix} investment \\ absorption \\ ratio \end{bmatrix} . \begin{bmatrix} total \\ absorption \end{bmatrix} = \begin{bmatrix} fixed \\ investment \end{bmatrix} + \begin{bmatrix} stock \\ change \end{bmatrix}$$

**Ratio of Government Consumption to Absorption**

$$GOVSHR \,.\, TABS = \sum_{c \in C} PQ_c \,.\, QG_c \qquad \ldots\ldots \qquad (A48)$$

$$\begin{bmatrix} government \\ consumption \\ absorption \\ ratio \end{bmatrix} . \begin{bmatrix} total \\ absorption \end{bmatrix} = \begin{bmatrix} government \\ consumption \end{bmatrix}$$

## APPENDIX 3: NOTATIONAL PRINCIPLES AND NOTATIONS USED IN THE MATHEMATICAL MODEL

| Item | Notation |
|---|---|
| Endogenous variables | Upper-case Latin letters without a bar |
| Exogenous variables | Upper-case Latin letters with a bar |
| Parameters | Lower-case Latin letters (with or without a bar) or lower-case Greek letters (with or without superscripts |
| Set indices | Lower-case Latin letters as subscripts to variables and parameters |
| $a \in A$ | activities |
| $a \in ACES(\subset A)$ | activities with a CES function at the top of the technology nest |
| $a \in ALEO(\subset A)$ | activities with a Leontief function at the top of the technology nest |
| $c \in C$ | commodities |
| $c \in CD(\subset C)$ | commodities with domestic sales of domestic output |
| $c \in CDN(\subset C)$ | commodities not in CD |
| $c \in CE(\subset C)$ | exported commodities |
| $c \in CEN(\subset C)$ | commodities not in CE |
| $c\ CM(\subset C)$ | imported commodities |
| $c \in CMN(\subset C)$ | commodities not in CM |
| $c \in CT(\subset C)$ | transactions service commodities |
| $c \in CX(\subset C)$ | commodities with domestic production |
| $f \in F$ | factors |
| $i \in INS$ | institutions (domestic and rest of the world) |

| | |
|---|---|
| $ta_a$ | tax rate for activity a |
| $te_c$ | export tax rate |
| $tf_f$ | direct tax rate for factor f |
| $\overline{tins_i}$ | exogenous direct tax rate for domestic institution i |
| $tins01_i$ | 0-1 parameter with 1 for institutions with potentially fixed direct tax rates |
| $tm_c$ | import tariff rate |
| $tq_c$ | rate of sales tax |
| $trnsfr_{if}$ | transfer from factor f to institution i |
| $tva_a$ | rate of value-added tax for activity a |
| $\alpha_a^a$ | efficiency parameter in the CES activity function |
| $\alpha_a^{va}$ | efficiency parameter in the CES value-added function |
| $\alpha_a^{ac}$ | shift parameter for domestic commodity aggregation function |
| $\alpha_c^q$ | Armington function shift parameter |
| $\alpha_c^t$ | CET function shift parameter |
| $\beta_{ach}^h$ | marginal share of consumption spending on home Commodity c from activity a for household h |
| $\beta_{ch}^m$ | marginal share of consumption spending on home Commodity c for household h |
| $\alpha_a^s$ | CES activity function share parameter |
| $\alpha_{ac}^{ac}$ | share parameter for domestic commodity aggregation function |

| | |
|---|---|
| $\alpha_c^q$ | Armington function share parameter |
| $\alpha_c^t$ | CET function share parameter |
| $\alpha_{fa}^{va}$ | CES value-added function share parameter for factor f In activity a |
| $r_{ch}^m$ | subsistence consumption of marketed commodity c for Household h |
| $r_{ach}^h$ | subsistence consumption of home commodity c from Activity a for household h |
| $\theta_{ac}$ | yield of output c per unit of activity a |
| $\rho_a^a$ | CES production function exponent |
| $\rho_a^{va}$ | CES value-added function exponent |
| $\rho_c^{ac}$ | domestic commodity aggregation function exponent |
| $\rho_c^q$ | Armington function exponent |
| $\rho_c^t$ | CET function exponent |
| $\overline{CPI}$ | consumer price index |
| $\overline{DTINS}$ | change in domestic institution tax share (- 0 for Base; exogenous (FCU) |
| $\overline{FID}$ | Food Aid |
| $\overline{FSAV}$ | foreign savings (FCU) |
| $\overline{GADJ}$ | government consumption adjustment factor |
| $\overline{IADJ}$ | investment adjustment factor |
| $\overline{MPSADJ}$ | savings rate scaling factor (= 0 for base) |

| | |
|---|---|
| $\overline{QFS}\ f$ | quantity supplied of factor |
| $\overline{TINSADJ}$ | direct tax scaling factor (= 0 for base; exogenous variable) |
| $\overline{SFDIST}\ f\ a$ | wage distortion factor for factor f in activity a |
| $DMPS$ | change in domestic institution savings rates (= 0 forBase; exogenous variable |
| $DPI$ | producer price index for domestically marketed output |
| $EG$ | government expenditures |
| $EH_h$ | consumption spending for household |
| $EXR$ | exchange rate (LCU per unit of FCU) |
| $GOVSHR$ | government consumption share in nominal absorption |
| $GSAV$ | government savings |
| FID | Food Aid |
| $INVSHR$ | investment share in nominal absorption |
| $MPS_i$ | marginal propensity to save for domestic non-government institution (exogenous variable) |
| $PA_a$ | activity price (unit gross revenue) |
| $PDD_c$ | demand price for commodity produced and sold domestically |
| $PDS_c$ | supply price for commodity produced and sold domestically |
| $PE_c$ | export price (domestic currency) |
| $PINTA_a$ | aggregate intermediate input price for activity a |
| $PM_c$ | import price (domestic currency) |
| $PQ_c$ | composite commodity price |
| $PVA_a$ | value-added price (factor income per unit of activity) |

| | |
|---|---|
| $PX_c$ | aggregate producer price for commodity |
| $PXAC_{ac}$ | producer price of commodity c for activity a |
| $QA_a$ | quantity (level) of activity |
| $QD_c$ | quantity sold domestically of domestic output |
| $QE_c$ | quantity of exports |
| $QF_{fa}$ | quantity demanded of factor f from activity a |
| $QG_c$ | government consumption demand for commodity |
| $QH_{ch}$ | quantity consumed of commodity c by household h |
| $QHA_{ach}$ | quantity of household home consumption of Commodity c from activity a for household h |
| $QINTA_a$ | quantity of aggregate intermediate input |
| $QINT_{ca}$ | quantity of commodity c as intermediate input to activity a |
| $QINV_c$ | quantity of investment demand for commodity |
| $QM_c$ | quantity of imports of commodity |
| $QQ_c$ | quantity of goods supplied to domestic market (composite supply) |
| $QT_c$ | quantity of commodity demanded as trade input |
| $QVA_a$ | quantity of (aggregate) value-added |
| $QX_c$ | aggregated marketed quantity of domestic output of commodity |
| $QXAC_{ac}$ | aggregated marketed output of commodity c from activity a |
| $TABS$ | total nominal absorption |
| $TINS_i$ | direct tax rate for institution $i(i \in INSDNG)$ |

| | |
|---|---|
| $TRII_{ii'}$ | transfers from institution i' to I (both in the set INSDNG) |
| $WF_f$ | average price of factor f |
| $YF_f$ | income of factor f |
| $YG$ | government revenue |
| $YI_i$ | income of domestic nongovernmental institution |
| $YIF_{if}$ | income to domestic institution i from factor f |

# Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all source of materials used for the thesis have been duly acknowledged.

The examiners' comments have been dully incorporated.

## Declared by:

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Date: 30 April 2009

Place and date of submission: _____.