

**The Economy Wide Impact of Biofuel Investment in
Ethiopia: A Recursive Dynamic Computable General
Equilibrium Microsimulation Analysis**

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This is to certify that the thesis prepared by Gemechis Mersha Debela, entitled: *The Economy Wide Impact of Biofuel Investment in Ethiopia: A Recursive Dynamic Computable General Equilibrium Microsimulation Analysis* and submitted in partial fulfilment of the requirements for the Degree of Masters of Science in Economics (Economic Policy Analysis) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

The Economy Wide Impact of Biofuel Investment in Ethiopia: A Recursive Dynamic CGE-MS Analysis

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The share of fuel import in total imports of goods for Ethiopia rose from 12% in 2005/06 to 20.1% in 2010/2011. In 2008 the country's oil bill exceeded the total export earnings. The high and often fluctuating fuel prices have frustrated development efforts in the country. This has triggered policy makers to review the energy development strategies and search for mechanisms that minimize dependence on high-cost imported fossil oil. An important mechanism identified in this area is to substitute fossil fuels with domestically produced bio-fuel. Currently, investments in biofuel with the aim of producing ethanol and bio-diesel are underway in different parts of the country.

This study investigates the impact of biofuel investments on growth, poverty and food security in Ethiopia using a dynamic computable general equilibrium (CGE) model linked to micro simulation (MS) model. The CGE model uses the 2005/06 social accounting matrix (SAM) and the MS model uses the 2004/05 Household Income, Consumption and Expenditure (HICE) survey. The results suggest that biofuel investment provide a new opportunity to enhance economic growth and poverty reduction. Our results also show the complementarities between 'biofuel' and 'food' production.

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List of acronyms

AEZs	Agro Ecological Zones
BDCD	Biofuel Development and Coordination Directorate
CGE	Computable General Equilibrium Model
CSA	Central Statistical Agency
DAD	Distributive Analysis/Analyze Distributive
DCGE	Dynamic Computable General Equilibrium Model
EDRI	Ethiopian Development Research Institute
SC	Sugar Corporation
EV	Equivalent Variation
FDI	Foreign Direct Investment
FfE	Forum for Environment
FGT	Foster-Greer-Thorbecke
GHG	Green House Gas
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
HICE	Household Income, Consumption and Expenditure
IMS	Integrated Multiple Households
MoFED	Ministry of Finance and Economic Development
MoME	Ministry of Mine and Energy
MoWE	Ministry of Water and Energy
MS	Microsimulation
NBE	National Bank of Ethiopia
OECD	Organization for Economic Cooperation and Development
RH	Representative Households
SAM	Social Accounting Matrix
SNNPR	Southern Nation Nationalities People Region
TFP	Total Factor Productivity
UNEP	United Nations Environment Programme
USD	United States Dollar
WB	World Bank

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Globally, agrofuel¹ production and use is expected to continue to increase rapidly over the coming two-decades (IEA, 2010). As a substitute for conventional energy source a number of countries are setting huge biofuel consumption mandates. For instance, the European Union has mandated that biofuel account for 10% of the energy used in transportation by 2020 while India plans to meet 20% by 2017 and Brazil is planning to expand its biofuel exports. Ethiopia has entered in to a 10% blend of bio-ethanol. However, biofuel expansion is raising a number of controversies. On the one hand, increase in biofuel production is taken as one of the main reasons for the increase in world food prices (Mitchell, 2008; Heady and Fan, 2008; Baier et al 2009). In addition, environmental benefits (carbon emissions offset) gained from such sources has also been an area of debate, as carbon emissions resulting from deforestation caused by cultivation of biofuel is probably higher (UNEP 2009; OECD, 2008; Dornbosch and Steenblik, 2007). On the other hand, in addition to being considered as important source of clean energy, optimists view biofuel as a potential for growth and development by providing employment opportunity to the rural poor, increasing price of agricultural products and enhancing agricultural productivity through technological spillovers (Hausmann, 2007; Arndt, 2010).

¹ Agrofuel refer to the process of specifically growing crops on a large scale to produce fuels (Agriculture for fuel) (see ABN, 2007). Note also that the terms agrofuel, biofuel and sometimes bioenergy are interchangeably used by the different authors.

Ethiopia has already started investment ventures on biofuel motivated by the desire to reduce the entire dependence on the imported fossil fuel, which significantly exposes the country to external shocks arising from rising fossil fuel prices. The country's dependence on imported fuel is considerable, reached USD 1.7 billion in 2010 largely owing to the continued rise in international oil price and increased volume. Consequently, the share of fuel import in total imports of goods rose to 20.1% in 2011 from 16% in 2009/2010 and 12% in 2005/06. Relative to export earnings the value of oil imports of the country increased from 37 percent in 1995/96 to 85 percent in 2008/2009 (NBE, 2010/2011) and in spring 2008 the country's oil bill exceeded for the first time the total export earnings (WB, 2010). This has aggravated the balance of payments crisis and imposes serious repercussions on macroeconomic stability of the country. The other motives behind the promotion of biofuel expansion are: creating employment opportunities, supporting soil and water conservation programs, and implementing environmental protection programs and measures (MoME, 2007).

1.2. Statement of the Problem

The government of Ethiopia is promoting biofuel investment. The total potential land that is available for the production of feedstock for biodiesel is estimated at about 23.3 million hectare of land (MoWE, 2012). The total land allocated for biofuel to companies in 2007 was about 300,000 hectares, which has increased to more than 600,000 hectares in 2010 (FfE, 2011). The country was able to blend over 13 million litres of ethanol with benzene (E5) in 2011. As a result, it saved over 10 million USD in two years (MoWE, 2012).

Although biofuel production boom seems impressive, its impacts on the economy and the environment are still controversial. It is important to assess the food and energy security, employment and land reclamation issues related with biofuel. On the one hand, the government wants to achieve food self-sufficiency and reduce poverty through employment creation and rising productivity in agriculture. On the other hand, a shift in resource (land, labor and water) use towards biofuel sector and away from cereal and livestock production sectors, poses a major concern.

In Ethiopia very few studies have been going on the economic impact of biofuel investment. The studies on the economy wide impact of biofuel investment conducted so far, however, are not sufficient, not without limitations and no study is conducted by using A Recursive Dynamic Computable General Equilibrium- Micro Simulation Model. Using CGE analysis, Gebreegziabher et.al (2012 forthcoming) examined the distributive effect and food security implication of biofuel investments. Methodologically, they rely on representative household in CGE to analyze the impact on household welfare. The variations in income of representative agents generated with the CGE model are applied to households within their respective group. This means that the intra household income distribution is assumed to be fixed. However, this assumption does not allow analysis of within group (intra-group) poverty and income distribution.

Given the ongoing debates and insufficient study, it is crucial to gain better understanding of the advantages and disadvantages of investment in this area. This study attempts to answer the following questions. What would be the long run impact of biofuel production

on food production? What are the implications of different modes (plantation basis verses out grower scheme) of producing biofuel? Would biofuel investment contribute towards economic growth? Would the biofuel production help reduce poverty and inequality in Ethiopia? It is also good to identify whether biofuel investment is consistent with the poverty reduction and growth plan of the country.

1.3. Objectives of the Study

In light of the above questions the main objective of this study is assess the economic wide impact of biofuel investment. Specifically, it is to investigate the impact of biofuel expansion on economic growth, food security, welfare, and poverty reduction in Ethiopia.

1.4. Significance of the Study

This analysis will help identifying the impact of biofuel investment and consequently draw policy implication. In addition, the study will provide a good basis for further research on economic impact of biofuel investment in Ethiopia.

1.5. Scope of the Study

This study focuses on the growth and poverty impact of biofuel expansion and doesn't take in to account the environmental impact of biofuel investment and the economic impact of other by- products of biofuel feedstocks but biofuel.

1.6. Data and Methodology

The economic-wide impact of biofuel expansion is modeled using DCGE-MS model. The microsimulation model would capture the distributional impact, which is measured by employing a decomposable poverty index. The Ethiopian CGE model/SAM containing

41 agricultural and 5 non-agricultural sectors and 21,594 households from 2004/05 HICE survey by CSA is used in the microsimulation model.

1.7. Organization of the Paper

The remaining part of this paper is organized as follows. The next section presents literature review followed by explanation of current biofuel development status in Ethiopia. Then we described the data and DCGE-MS model that is used in the analysis. This is followed by the simulation scenario and analysis of macro and distributional impact. The finally section concludes by providing policy implications.

CHAPTER TWO

LITERATURE REVIEW

2.1. Theoretical Literature

Neo-classical economic theory regards FDI and international capital flows as a closing equation that fills the savings gap for developing countries (e.g. Chenery and Bruno, 1962). We would expect capital to flow from capital rich to capital poor countries, as is suggested by ideas developed in the Heckscher-Ohlin approach to trade by Mundell (1957), because capital is relatively scarce in developing countries, which should lead to profitable investment opportunities for capital in these countries.

According to Blomstrom and Kokko, (2003) and Borenstein et al (1998), the contributions of FDI to the development of a country are widely recognized as filling the gap between desired investments and domestically mobilized saving, increasing tax revenues, and improving management and technology, as well as labor skills in host countries. These could help the country to fight its way out of poverty. Thus, FDI influences income growth by increasing the amount of capital per person. It spurs long-run growth through such variables as research and development (R&D) and human capital. Through technology transfer to their affiliates and technological spillovers to unaffiliated firms in the host economy, it can speed up the development of new intermediate product varieties, raise product quality, facilitate international collaboration on R&D, and introduce new forms of human capital (Ikara, 2003).

Recently there has been large scale biofuel investment in Africa, which flows mostly from USA and EU. In some countries, like Ethiopia, FDI in biofuel expansion is also accompanied by domestic investors.

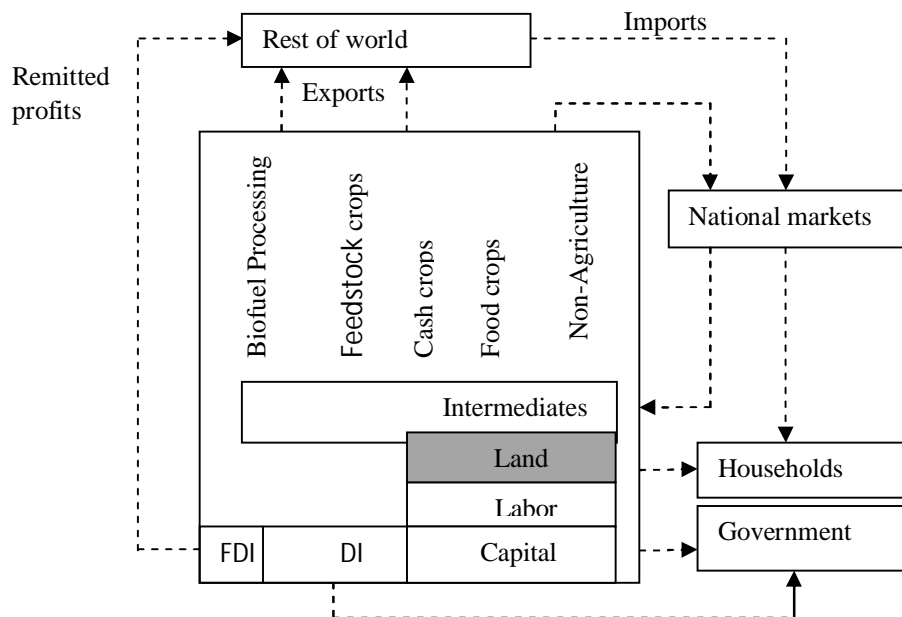
2.1.1. Conceptual Framework

The recent extensive biofuel production caused by large-scale international programs and huge government incentives is expected to have a strong influence on economic variables. Its impact starts from the agricultural sector due to intense resource (land, labor and water) competition between food crops and energy/ biofuel crops. As demand for biofuel crops increases the cultivation of food crops may decrease and hence the prices of these commodities may increase. That's why biofuels are accused of the recent food crisis (see Mitchell, 2008).

Extensive production of biofuel may also have a strong influence on land use, if pastures and forests are replaced by agricultural land, in order to increase the amount of acres used for such activities. The result on farmers' income is a priori positive, since the production of feedstock crops represents another outlet for commodities. But if farmers aren't land owners, the increase in land price can have repercussions on land rents and thus can diminish this positive effect. Finally, biofuel has impacts on consumers' surplus. Consumers dispose of cheaper fuel for transport but have to face higher food prices (Virginie, 2009).

The overall conceptual framework used in this analysis is shown in figure 2.1. In Ethiopia, so far biofuel expansion is assumed to be driven largely by domestic participants/investor's (DI) and FDI participation to some extent. Foreign investors send part of the earned profit abroad (after paying the necessary tax rates) and the other remains domestically (due to domestic employment generation). The decision to invest is thus resolved exogenously by investors, and we assume that the level of investment remains consistent with necessary profitability. Biofuel producers must, however, compete with other sectors for intermediate inputs, land and labor resources. The gray shaded areas in Figure 2.1 represent new cropland resources which cause national production to expand in the simulations. Currently, biofuel expansion is mostly driven by domestic investors.

Figure 2.1 Conceptual framework



Source: Arndt et al., 2010 and own modification

We assume that all most all biofuels will be used domestically. Most of the ethanol produced in Ethiopia has been blended with imported petroleum for domestic use. Biodiesel will be used mainly for cooking as a replacement for kerosene.

2.1.2. Models to Assess the Economic impact of Biofuel and Rationale for using DCGE-MS Approach

We may categorize economic modeling techniques used to model the impact of biofuel into structural and reduced form models. In this section we provide the rationale for using DCGE-MS model for the analysis of the Economic Wide Impact of Biofuel Investment. Structural models are based on economic theory complemented with some technological assumptions. Reduced form models are usually concerned only with statistical properties of time series and do not explicitly take into account the economic or technological factors which generated those time series (Janda.et. al 2011).

1. Reduced form models

The most important representative of reduced form models dealing with the economic impact of biofuel is models of price links between energy and agricultural markets. They usually use time series econometric approach to investigate dependencies among agricultural commodities, biofuels, and fossil fuels. The reduced form models are promising tools for providing the connection to financial market analysis and for investigation of fluctuation and statistical dependences in prices of biofuels and related commodities (see Janda.et. al 2011). They employ models like vector error correction

(VEC), and multivariate generalized autoregressive conditional heteroskedasticity (MGARCH) models.

The econometric analysis of the relations between prices and quantities of foods, biofuel and fossil fuels can be better captured by structural models, which explicitly model underlying economic, technological and behavioral processes (Janda.et. al 2011). Thus, we focus on a review of structural models.

2. Structural models

2.1. Cost accounting and Partial Equilibrium Models

Cost accounting models are static budgeting models used to estimate profitability of an activity for a single price-taking agent, such as an individual farmer. These approaches enable assessing profitability of cultivation of different energy crops. The production function in such models is typically assumed as a fixed-proportion one. Classical representatives of this class of models are crop budget models which have been used to estimate profitability of cultivation of energy crops based on assumptions about yield, output prices, cost of production and other technological and economic parameters (Janda.et. al 2011).

An important advantage of such models is their ability to provide a detailed description of the production chain. The heterogeneity of crops, in terms of production period and harvesting procedures, can be considered in this approach. According to Rajagopal and Zilberman (2007), however, the cost-accounting models are based on accounting rather

than economic principles. Another drawback of these models is that they don't take into account the linkages with the rest of the economy. They ignore general equilibrium effects of large scale intervention or change. Thus, the cost-accounting approach may not be suited to address questions surrounding the biofuel boom.

Partial equilibrium models, also labeled as sector models, analyze part of the overall economy such as a single market (single commodity) or subsets of markets or sectors. Changes in economic conditions such as exogenous shocks on supply, demand or prices lead to a new equilibrium and to a variation of welfare (Virginie, 2009). This is based on the assumption that prices and quantities in other markets remain constant. Partial equilibrium models have an advantage in providing a good indication of short-term response to shocks. They often provide a detailed description of the specific sector of interest but do not account for the impact of expansion in that sector on other sectors of the economy (Janda.et. al 2011).

The impacts of the envisaged investment in biofuel, however, are generally economy-wide in nature and may lead to strong downstream implications across the economy. Since partial equilibrium approach can't capture all these impacts, a relevant assessment of biofuel issues requires a modeling framework representing the whole economy. Besides, such a method should take into account the feedback effects between economic variables. In addition, the assessment of biofuel issues needs a model which links production, consumption and trade. Given the drivers of the biofuel boom, it also needs a modeling setting that establishes a tight link between petroleum prices and the demand

for biofuel (Virginie, 2009). This indicates that cost-accounting models and sector models suffer from the inability to take into account the effects of large scale biofuel boom on the overall economy.

2.1.3. Computable General Equilibrium and Microsimulation Models

CGE model can be defined as macroeconomic models that simulate the functioning of a market economy and provide a useful perspective on how it is affected by external shocks that emanate from changes in prices and markets. They lie on a top-down approach using bottom-up information to specify economic behavior. These models use real data to analyze single or several economies in a multi-market model where various institutional and structural characteristics representing the specific nature of the peculiar economy are incorporated to identify the rigidities and constraints that are difficult to capture in a simple analysis (Bibi *et al.*, 2010).

Virginie, 2009, divided CGE setting in to three stages. The first step is a general description of the economy which consists in building a Social Accounting Matrix (SAM). The SAM, which was an outgrowth of input-output models, is a complete, consistent and disaggregated data system that basically quantifies the interdependence of sectors and regions in a square matrix of incomes and expenditures at a single point in time for a certain economy (Sinha and Latigo, 2003). Depending on the availability of data, some parts of macro-balance can be disaggregated into sub-accounts to enhance the studied sector. This disaggregation brings more detail and more realism into the model. The base year is chosen so that the economy is close to a general equilibrium at this

period. Once such a SAM is obtained, it constitutes a benchmarked economy, i.e. a steady-state or a long-run equilibrium (Sue Wing, 2004).

The second stage is to specify an equation system in order to account for the relationship between all variables. This system includes macro-balancing equations, functional forms and behavioral equations. Concerning the latter, it is often assumed that representative consumers and producers maximize utility and profit respectively.² The number of equations must equal the number of endogenous variables so that the model may have a solution. To bring about balance between them, it is necessary to specify macroclosure rules. Indeed, the closure of a CGE model consists in specifying the last element of the model so as all the relationships are compatible. Most of the parameters of the functional forms and behavioral equations are quantified on the basis of existing econometric literature. When such information is not available, some may be chosen idiosyncratically by model builders, who have to estimate a realistic value.

Finally, the model is calibrated so that the initial equilibrium reproduces the values from the SAM. Calibration is the method by which modelers test their parameters. It consists in solving the numerical model backwards to determine parameter values that are consistent with the base year data. These values allow, when the model is run right side up, to find the benchmark equilibrium. In other words, the endogenous solutions calculated by the model for these parameters have to reproduce the values observed during the reference year (for more details, see Schubert 1993 cited in Virginie, 2009). If

² So CGE modeling is based on micro demand and supply language.

this step is satisfied, parameters and thus elasticities are deemed realistic (Virginie, 2009).

CGE modeling technique has a number of features that make it suitable for economy-wide impact analysis of biofuel expansion. First, it simulates the functioning of different markets in the economy, including markets for labor, capital, and commodities. Thus, it provides a useful perspective on how changes in economic conditions will likely be mediated through prices and markets. Secondly, its structure permits a consideration of an expansion of the economy in a new venture. Thirdly, it assures that all economy-wide constraints are respected. For instance, these investments may use large quantity of land, and demand large amount of labor. It is, therefore, pertinent to consider the balance of payments and the supply of useable land and labor. Fourthly, as the model can be fairly disaggregated (compared to macro econometric models), it can provide an economic simulation laboratory to examine how different factors and impacts will affect the performance and structure of the economy, including how they will interact and, most importantly, how to quantify interactive effects of welfare indicators such as GDP growth and income increase (Arndt et al. 2009). Finally, the models provide a theoretically consistent framework for welfare and distributional analysis.

CGE modeling appears as a useful tool to assess the effects of exogenous shocks such as public policies. CGE structural models compute equilibrium by simultaneously taking into account the linkages between all sectors in the economy. Unlike partial equilibrium models, they provides an information of the impact of biofuels on the whole economy by

taking into account all the feedback relations between biofuels and other sectors (Janda et al. 2011). Biofuel interventions have downstream implications across the economy as they affect not only farmers, but also agro-industries, consumers' welfare, the trade balance and public expenditure. Since their induced effects overtake the agricultural sector, it is clear that a partial equilibrium approach can't capture all these impacts (Virginie, 2009).

In CGE models, various ways of substitution possibilities are specified, for instance, substitution between different labor types; capital and labor; imports and domestic goods; and exports and domestic sales occur in response to variations in relative prices. In order to enable a more realistic application of this class of model to developing countries, market imperfections and institutional rigidities are captured by exogenously imposing immobile sector capital stocks, labor market segmentation, and home consumption.

However, this model is not free from problems. An economy-wide approach, like CGE modeling, is not well suited for the analysis of all issues. In striving to develop a comprehensive picture of the entire economy, some detail is necessarily suppressed. If a detail relevant to the analytical question at hand is suppressed, the approach will obviously be poorly suited to the task (Arndt et al. 2009). But, some issues can be adequately addressed with economic frameworks that are less comprehensive. Besides, by linking a CGE model with household surveys, it is possible to capture some suppressed details in CGE, especially household heterogeneity. Since, the impacts of

biofuel investment are generally economy-wide in nature and lead to strong downstream implications for the whole economy; we employed a DCGE-MS model.

In addition, Microsimulation analysis will enable us to take in to account household heterogeneity. It is to communicate/distribute the relevant economywide results of the CGE model to households thereby to measure the level of poverty. These MS models are known for modeling household behavior, consumption pattern, micro-level income distribution etc (Ahmed and Donoghue, 2004). Savard (2003) examined CGE models dealing with poverty and income distribution categorizing CGE Models into three: Those models with representative households (CGE-RH), CGE models with integrated multi-households (CGE-IMH), and CGE models linked with a micro simulation (MS) model (CGE-MS). The last could also be sub-divided into two versions: CGE models that use a uni-directional (top-down/sequential/layered) analysis and CGE models that use a bidirectional analysis.

The CGE-RH approach classifies household into groups based on socio- economic or location criteria, chooses a representative household for each group and uses these representative households in the CGE model. The variations in income of representative agents generated with the CGE model are applied to households within their respective group from household surveys. This means that the intra household income distribution is assumed to be fixed. However, this assumption does not allow analysis of within group (intra-group) poverty and income distribution. Some studies (for instance, Huppi and Ravallion 1991 and Savard 2005) have shown that within group changes can be greater

than between group-inequality changes. Savard (2005) demonstrated that the result of poverty and income distribution analysis can be completely reversed by taking into account within-group distribution effects.

To reduce inefficiencies in analysis as a result of lack of intra-household heterogeneity from the CGE-RH approach, the CGE integrated multi-household approach (CGE-IMH) was proposed by Decluwé, Dumont and Savard (1999) and applied by Cogneau and Robolliard (2000), Gortz et al. (2000) and Cockburn (2001). This method incorporates as many households as possible from household surveys in the CGE model. This approach takes into account within-group distributional effects and has further advantage of providing coherence between the micro and macro parts of the model, but this approach too has its own flaws. First, data reconciliation can be very problematic (Rutherford, Tarr and Shepotylo, 2005). As the size of the model increases, it would become a constraining factor and data reconciliation between the micro and macro levels would be difficult. Second, numerical resolution can be challenging (Chen and Ravallion, 2004). According to Savard (2003), the difficulties arise “as the equation system of the model cannot change as the iteration process moves along.” The problem magnifies if the CGE model uses non-linear equation(s), which is usually the case.

The last approach is CGE micro- simulation sequential method (MS) could be subdivided into two variants. The first, micro-accounting, was formally presented by Chen and

Ravallion (2004) and has been extensively applied in recent years.³ The second variant, proposed by Bourguignon, Robilliard and Robinson (2005), consists of integrating, at an individual level, rich micro behavior observed at a household level such as consumption or labor supply. This version introduces more heterogeneity between households with the application of a microeconomic model. The general idea of the MS approach is that a CGE module feeds market and factor price changes into a micro-simulation of the household model. The main criticism leveled against this approach is that the micro-feedback effect is not fully taken into account; the question has been raised in two literature reviews of macro-micro modeling of poverty analysis (Hertel and Reimer (2005) as well as Bourguignon and Spadaro (2006)). However, Bourguignon and Savard (2008) found that the loss of information associated with using the MS approach can be relatively small and policy conclusions were robust between the two approaches. In this paper we applied the Micro-accounting version of the MS approach.

According to Boccanfuso et al, 2011, both IMS and MS allows for rich analysis of income distribution and poverty because they include a large number of households in the modeling exercise. Granted, the IMH approach is the soundest on a theoretical basis. However, there are two reasons behind our choice to use CGE-MS for our analysis. First, with the IMS approach, it is necessary to construct a balanced sub-matrix for household accounts in a standard SAM. On the other hand, with the CGE-MS approach, the household income and expenditure do not require balancing. This gain in flexibility comes from the fact that the micro module is solved sequentially and that we use price

³ Among early application of this approach are Vos and De Jong (2003) and King and Henda (2003).

percentage changes to link the CGE module to the micro household module.⁴ The second argument for using this approach is that some households will increase their labor supply and land use. This will involve, in some cases, discrete changes or important increases in factor effective endowments. This type of behavior cannot be modeled in the IMH approach that only allows for marginal changes in factor endowments. The Micro model is linked with CGE model for poverty analyses.

2.1.4. Poverty and Distributional Analysis

The indices selected for our distributive analysis are the Foster, Greer and Thorbecke (FGT, 1984) indices for poverty analysis. Ravallion (2004b) indicated three ways in measuring poverty: head count index, poverty gap index and squared poverty gap index. The head count index is the percentage of household population with income per person below the poverty line. The poverty gap index provides the mean distance below the poverty line as a proportion of the poverty line. In squared poverty gap index, the individual poverty gaps are weighted by the gaps themselves to reflect inequality among the poor. This measures not only the deficit that the poor households need to meet the basic need but it also takes into account the inequality among the poor (WB, 2005).

Foster, Greer and Thorbecke (1984) lumped these measures into one formula that incorporates the three consistent and additively decomposable (by income class or region) poverty indices.

The formula for the FGT index is given as:

⁴ We refer to the household sub matrix database as the household module.

$$P_\alpha = \frac{1}{n} \sum_{i=1}^q \left(\frac{z - y_i}{z} \right)^\alpha; \alpha \geq 0, y < z, i = 1, 2, \dots, q; [y_1 < y_2 < \dots < y_q < z < y_{q+1} < \dots \leq y_n]$$

Where z is the poverty line, i is the sub-group of individuals with income below the poverty line, y_i is the value of poverty indicator chosen (consumption expenditure below the poverty line in increasing order)⁵, n is the total population size, q is the total number of poor people in the population, and α is the poverty aversion parameter. By setting the value of α to zero, one and two respectively, the FGT poverty formula delivers a set of poverty indices. Setting α equal to zero, P_0 , gives the head count index (q/n) measuring the incidence (prevalence) of poverty.

Setting α equal to one, P_1 , becomes the poverty gap measuring the depth or intensity of poverty. Setting α equal to two, P_2 , will be the squared poverty gap measuring the severity of poverty (the weighted sum of the poverty gaps themselves)⁶. FGT poverty indices are additively decomposable; as such they are interesting within the framework of this analysis and make it possible to measure the proportion of the poor among the population and also this poverty depth and severity (Boccanfuso et al., 2011). The higher the degree of poverty aversion, the greater the importance granted to the poorest (see Ravallion, 1994).

⁵ If $g_i = Z - Y_i$, then g_i represents income (consumption) short fall of the i th individual (household) and this is assumed to be zero for those above the poverty line (Abebe, 2005).

⁶ “ α ” denotes the weight given to the poorest of the poor and so the higher the value of α , the more is the concern for the poorest (Abebe, 2005).

2.2. Empirical Literature

Debate on the various socio-economic and environmental impact of biofuel growth can be grouped in to three fundamental issues. The first issue is on the implication of biofuel production on food security. Some biofuel feedstocks are in severe competition with some major food crops such as ethanol from maize, wheat, sugar beet, potatoes, cassava, (the staple food for many African nations) and biodiesel from peanuts. Oxfam (2007, 2008) argue that this crop and resources shift (including land, labor and water) for biofuel production would result in food insecurity and aggravate poverty by escalating world food prices. Indeed, this could raise households' reliance on marketed foods for which biofuel may not generate sufficient incomes for poorer households to offset rising food prices.

Others argue that a greater production of biofuel might not necessarily be harmful for the poor as it can improve food security given that the proper production technology is adopted (van Rheenen and Olifinbiyi, 2007). Treguer and Sourie (2006) indicate that production of biofuel crops increase farm jobs and farm income. Farm households may receive high price for their agricultural production due to increased world price resulting from the competition of agricultural based energy production for resources with other agricultural products. But, World Watch Institute, 2007, argues that poor households, dependent on imported food, will become poorer as they would face high food price.

A second issue is about the possible gain from rising biofuel production especially by developing countries. Hausmann (2007), Director of the Center for International Development at Harvard University, view biofuel expansion as a catalyst for growth and development of low-income countries by overcoming their dependence on imported oil and increasing farmers' participation in the growth process. Recent quantitative studies using CGE analysis from Africa sustain this view. Arndt *et al* (2010) showed that investment on biofuel enhances poverty reduction efforts in Tanzania. They indicated that any compromises that do exist between biofuel and food productions are likely to be smaller when feedstocks are produced by high yielding larger-scale farmers.

In Mozambique Arndt et al. 2010 also found that, depending on the production technology, biofuel investments increases annual economic growth by about 0.6 percentage points and reduced the incidence of poverty by about six percentage points, over a 12-year phase-in period. Due to the greater use of unskilled labor and accrual of land rents to smallholders, they see the out-growers approach to producing biofuel to be more pro-poor as it increases their income as compared with the more capital-intensive plantation approach. However, they suggested a carefully designed and managed biofuel policy application in order to insure sustainable potential gains and reflect a caution toward unrestrained biofuel expansion (Arndt *et al*, 2009).

In the case of Ethiopia, using DCGE analysis, Gebreegziabher et.al (2012 forthcoming) examined the distributive effect and food security implication of biofuel investments. Their preliminary findings show that biofuel might have a “win-win” outcome that can

improve smallholder productivity (food security) and increase household welfare. They argue that the benefits of biofuel investment are magnified if such investment is accompanied by technology spillovers to other agricultural crops. Their result, however, is based on the assumption that there is no displacement in smallholders which mean biofuel investments take place in unutilized land and/or land that is not occupied by smallholders.

Methodologically, they rely on representative household in CGE to analyze the impact on household welfare. The variations in income of representative agents generated with the CGE model are applied to households within their respective group. This means that the intra household income distribution is assumed to be fixed. However, this assumption does not allow analysis of within group (intra-group) poverty and income distribution. Some studies (for instance, Huppi and Ravallion (1991) and Savard (2005)) have shown that within group changes can be greater than between group-inequality changes. Savard (2005) demonstrated that the result of poverty and income distribution analysis can be completely reversed by taking into account within-group distribution effects.

The third area of contention is about the environmental impacts of biofuel. Biofuel expansion have been conceived as a means to reduce Green House Gas (GHG) emission as biomass plant grown for biofuel feedstock would offset emission by capturing carbon from air. Cohen et al. (2008) and Coyle (2007) argue that biomass plants reduce greenhouse gases sometimes only minimally. However, unlike fossil fuel the emission release over the entire life cycle of biofuels production is less straightforward. It involves

emissions at the farm level due to land use and cultivation of feedstock and emissions associated with the processing and transportation of biofuel. As feedstock production increases clearing of forest or grassland and the use of fertilizer the indirect emissions caused (due to deforestation and toxin) often surpass the possible environmental benefit of biofuel (Fargione et al. 2008; Searchinger et al. 2009; Melillo et al. 2009).

To sum up, most African governments are currently encouraging investment on biofuel by designing different incentive mechanisms and promotion. However, very few quantitative studies exist that consider the true potential for poor countries and the possible downside. Most aspects of the debates outlined above are important concerns to Ethiopia, which makes studies like this invaluable. Among the concerns, the food security and poverty implications of resource (land, labor and water) shift away from agricultural production (particularly food crops production) to biofuel feedstocks production should be carefully analyzed. On the other hand, less dependence on oil imports and trickled down income benefits to households may result in net nutritional benefits.

CHAPTER THREE

CURRENT STATUS OF BIOFUEL DEVELOPMENT IN ETHIOPIA

3.1. General Overview

The sustainable growth of Ethiopian economy depends on the availability and security of energy, of which liquid fuel is an important part. Ethiopia imports its entire petroleum fuel requirement which is rising rapidly due to a growing economy and expanding infrastructure. The annual consumption of petroleum fuels is 2 million tones. The value of oil imports of the country relative to its export earnings increased from 37 percent in 1995/96 to 85 percent in 2008/2009 (NBE, 2010). In fact, in the spring of 2008 the country's oil bill exceeded its total export earnings for the first time (WB, 2010). This indicates that imported petroleum products account for a large share of the total import expenditure and even absorbs total export earnings. High and fluctuating fuel prices have frustrated development efforts and forced the country to review its energy development strategies.

The 'National Biofuel Development and Utilization Strategy' was prepared in 2007. The Strategy argues that the imbalance between the demand for and supply of fossil fuel and its price fluctuation has challenged the sustainability of the economic growth and led to deterioration of its trade balance of the country. For this reason, biofuel development is considered as an alternative energy source to reduce imported fuel demand. The strategy is devised based on principles that development of biofuel should not have unintended consequences on food security, land access, environment, biodiversity, water and cultural values. In this regard, the strategy document states that less fertile, marginal or degraded

lands should be used for cultivation of energy crops (production of biodiesel in particular) without jeopardizing the food production need or livelihoods of the farmers/pastoralists. The strategy emphasizes on the production of ethanol from, sugar cane, and bio-diesel from jatropha, castor bean and palm plants.

The major objectives of the national biofuel strategy include:

- Import substitution to petroleum/ mineral fuel by locally produced biofuels,
- Save foreign currency and provide export earning,
- enhance agricultural development and agro processing; thus play role in creating job in feedstock production, manufacturing, and the transport sectors;
- improve agricultural land productivity by integrating an biofuel development program with its land use plan, and
- decrease environmental pollution and emissions of GHG

The government of Ethiopia is promoting biofuel with the above objectives in mind. According to the GTP (2010), it is planned to produce 1.8 billion litres of liquid biofuel by 2015, consisting of 195 million litres of ethanol and 1.6 billion litres of biodiesel. In Ethiopia, the total potential land that is available for the production of feedstock for biodiesel is estimated at about to 23.3 million hectare of land. Out of this 17.2 million hectare is found in Oromia while the other is found in Benishangul-Gumuz, Gambella, Somali, Amhara, Southern Nations Nationalities and Regional State and Tigray (MoME, 2007). The total land allocated for biofuel to companies in 2007 was about 300,000

hectares, which has increased to more than 600,000 hectares in 2010 (FfE, 2011). This shows that there has been a remarkable increase of land allocated for the production of biofuel crops over the past three years. The total investment capital in biofuel industry is estimated to be around 700 USD. The country was able to blend over 13 million litres of ethanol with benzene (E5). As a result, it saved over 10 million USD in two years (MoWE, 2012).

The Federal Investment Agency and Bureaus of Regional Investment so far issued licenses for 83 investors for development of biofuel in Ethiopia. The investors are local and foreign origins and on a joint venture. According to BDCD of the MoWE, however, excluding those which are growing sugar cane for ethanol purposes and those that are on the verge of starting implementation to date, only 6 foreign companies and 3 domestic non-government companies are operational (MoWE, 2012). Most private companies have not yet started (some even quitted their activities) growing biofuel crops on lands they received, while a few of them are conducting trial operations. Among the challenges the companies face in their implementation include failure to secure loan from banks; low levels of infrastructure development; lack of human resource and clean water; suitability of the land for the biofuel feedstock production (productivity problem); failure experience from pervious similar projects and the risks associated with it; and the border conflicts and livestock intrusions (FfE, 2011).

The technology used in this area involves large scale biofuel plantations; out-growers scheme (growing biofuel crops on smallholder farmers' land through, for example, contract agreement); and community development model. For instance, REST in Tigray,

ORDA in Amhara region are involved in biofuel development using community development model⁷. Other than domestic organizations like ORDA and REST, all most all investment projects on biofuel are large scale plantations.

3.2. Description of Operational Biofuel Projects in Ethiopia

3.2.1. Ethanol Development

Ethanol is produced mainly as a by product of sugarcane (molasses) obtained from sugar factories. Since 2009, the country has been using a 5% ethanol and 95% benzene blended (technically known as E5) for the market. Nile Petrol, a Sudan owned oil company, was a sole agent that was carrying out the blending process and distributing for all local oil stations. Blending of E10 (10% ethanol-blended gasoline) has started in the country since March 2011 after Matahara Sugar Factory started ethanol production. Recently, Oilibya and National Oil Company have joined the blending and distributing processes. So far, ethanol blending is taking place on benzene only, but, according to MoWE, there is a project on the pipeline that aims at producing biodiesel for diesel.

Currently, there are five potential developers of ethanol in the country of which four are government owned sugar factories and one is private company. The three state owned sugar factories Fincha, Metahara and Wonji have been in operation for long time. Fincha has been producing 8 million litres of ethanol every year since 2009. Metahara Sugar Factory started producing some 12.5 million litres of ethanol per year since mid 2011. The fourth factory whose construction is completed this year is the Tendaho Sugar Factory. This will be the biggest and most promising factory expected to produce a large

⁷ REST is an abbreviation for “Relief Society of Tigray” and ORDA an abbreviation for “Organization for Rehabilitation and Development of Amhara” region.

amount of ethanol. The company has plans to produce a total of 22.6 million liters of ethanol this year, 2012. Out of this 15 million litres will be used for blending with gasoline while the remaining will be used by households for house cooking stoves (MoWE, 2012).

According to a survey conducted at national level, regarding water resource and canal development opportunities, it is shown that the country has a potential of more than 500,000 ha of land that is suitable for sugarcane plantation (SC, 2012). In order to raise sugar production, the government is carrying out agricultural expansion projects around existing sugar factories and the Sugar Corporation has plans to build nine new sugar factories within the coming five years (2010-2015). Fincha sugar factory has currently 14,398 ha of sugar plantation, and the agricultural expansion project carried out there will bring the total sugar plantation close to 21,000 ha. Wonji/Shoa Sugar factory will expand its 8,662 ha of sugarcane plantation to 16,000 ha; Matahara Sugar factory is working towards expanding its current 11,180 ha of sugar plantation to 21,000 ha. In addition, the Tendaho Sugar development project aims to expand its cultivation to 50,000 ha from its current level of 4,394 ha. The Kesseem Sugar Development Project, which is planned to be completed by 2013 with a total of 20,000 ha of land earmarked for sugarcane production, out of which on 943 ha is already covered by cane. Similarly, the Tana-Beles Sugar Development project will have two sugar factories with 25,000 ha of sugarcane plantation each. Moreover, the Kuraz Sugar Development Project will have six factories each having 25,000 ha of sugar cane plantation; and the Welkaiyt Sugar Development Project will have one sugar factory with a 25,000 ha of sugarcane plantation. The Al-Habasha Sugar Mill is the only private company growing sugarcane

on 4,000 ha (see Table 3.1). Totally, upon the completion of all sugar factories, including the private one; the country expected to increase its current annual production of 18 million litres per year to 195 million litres per year by 2015.

Table 3.1 Summary of production projection of ethanol from expansion and existing areas of all state owned and private sugar factories

No.	Name of the Sugar Factory/Project	Land under cultivation(ha) ² 011/2012	Land expansion(ha)201 4/2015	Ethanol production capacity(litres annually) in 2015
1	Fincha'a SF	14,398	21,000	20,000,000
2	Wonji/Shoa SF	8,662+(3923 OGs ⁸)	16,000	
3	Metehara SF	11,180	21,000	25,500,000
4	Tendaho SF	4,394	50,000	55,400,000
5	Kessem SF	943	20,000	20,000,000
6	Tana-Beles Sugar DP	Na	50,000	
7	Kuraz Sugar DP	Na	150,000	
8	Welkaiyt Sugar DP	Na	25,000	
9	Al-Habasha Sugar Mill	4,000	28,000	
	Total	47,500	381,000	120,900,000

Source: (Ethiopian Sugar Corporation, 2012)

3.2.2. Biodiesel Development

Biodiesel is a fuel that can be manufactured from non-edible vegetable oil feedstock such as jatropha, castor bean and palm oil. The profiles of currently operational developers in Ethiopia are given below⁹.

⁸ 3923 hectares of land is under cane cultivation by out growers (OGs) around Wonji Sugar Factory which is supplied to the factory.

⁹ Some information on the companies is obtained from the study carried out by FfE to assess biofuel development activities in Ethiopia in 2011, but also updated by recent information gained from MoWE, Ministry of Industry, and Ethiopian Investment Agency.

1. Fri-El Ethiopia Farming and Processing Plc.

Fri-El is an Italian company which has obtained 30,000 ha of land in 2006 for Palm and to some extent Jatropha cultivation and took the land certificate in 2002 E.C. The company operates in an area named Omorate located in Dasenech wereda of South Omo Zone (SNNPR). It has a registered capital of Birr 320 million and grows palm tree that provides seeds in about 5-7 years. It is also engaged in the production of Jatropha to some extent. So far, the company has developed about 800 hectares of land. But, the company is anticipating developing biofuel over the remaining land phase by phase. The company has on the way to import processing machine that can produce 3000 litres per day. The land where biofuel is being developed is an abandoned land covered by bushes. In the past, the land was a cotton plantation owned by joint venture. The ultimate objective of the company is to establish a factory that processes and extract oil for energy purpose.

2. Agro Peace Bio Ethiopia Plc.

Agro Peace Bio Ethiopia Plc is an Israeli owned company that started biofuel development in Ethiopia in 2009. The area for biofuel development is situated in Tad qabale woreda, Shinile Zone of Somali Regional State. The company has already obtained 2000 hectares of land. Currently, it is undertaking its phase I pilot project on 20 hectares of land. It has imported and planted different types of castor seeds imported from different countries (such as Israel and China). It is working on identifying the most suitable plant for production that is environmentally friendly. It also has applied to get about 20,000 ha of land to commence its Phase III. In the future, the company plans to obtain and develop about 50,000 ha of land. The land under development is considered as

degraded land and is located in semi-arid area. The area has potential underground water, which the company is using for its agrofuel development. The main objective of the company is to export (semi processed) castor crude oil to Europe refineries.

3. Africa Power Initiative

It is an Ethiopian owned company, working in Tanku Abergele and Abide of Tigray region. Currently, it plants six million biodiesel feedstock most of which are Jatropha. It also plants Jatropha, Castor seeds and to some extent Curton and Candlenet on 3000 hectares and intends to develop 50,000 ha of land. The company has already planted the processing machine which can produce 2000 liters of biodiesel per day. The land the company is developing is considered by the local people as a communal land, thus, the company is facing border conflicts and intrusion of cattle. In addition to growing feedstocks, the company has plan of purchasing feedstock from the farmers and establishing a processing plant to produce 2000 litres of biodiesel.

4. ATRIF Alternative Energy Plc.

ATRIF Alternative Energy Plc is owned by a group of Ethiopian engineers. The project is located in Gurage Zone of SNNPR at a place known as Cheha Gerenbo. It started implanting its project in 2007/08 with Birr 2,080,200 registered capital. The company grows Jatropha on 80 ha out of the 108 ha that it has received. The development work has been undertaken phase by phase. The land used by the company is rocky and not suitable for crop production. The company is undertaking some research and development trials to identify the most suitable crop type for production in the area while maintaining the

local environment. So far about 2,500 Jatropha plants (trees) have been planted by the company. The company is planning to cover the rest of the land in a similar manner by planting seedlings from the seeds that have been harvested from the ripe trees. Since, it takes time for the plan to develop and get into commercialization it is currently undertaking inter-cropping of other crops. It plans to distribute Jatropha seedling to farmers after raising the seedlings on its own nursery.

The company is operating on degraded land, and being conscious of possible environmental impact, attempts to preserve the ecosystem as much as possible. The objective of the company in general is to provide biofuel benefits to the community in three forms. First it aims to make use of the processed oil as fuel. Second it wants to make use of the husk of the seed for fuel purpose after turning it into briquette form. Third it is to make use of the cake (waste found after oil is processed) for animal feed and fertilizer.

5. S and P Company

S and P is a company, owned by an Indian investor. It is at the phase of preparation to grow Pongamia on 50,000 ha found in Metekal zone of Benshangul-Gumuz province, Dangur district. Pongamia is a plant brought from India which can be used to produce biodiesel. Currently, the company has grown 500 thousand seedlings on 7 ha to plan it over 600 ha.

6. The giving Tree Nursery

The giving Tree Nursery grows castor on 5 ha out of the 200 ha it acquired in Marti District, Werota Dino Kebele, besides the Awash River, an hour northwest of Nazareth where it is engaged in fruit cultivation. It has a plan to ask for more land and to increase castor cultivation. It is on preparation to increase castor development and ask more land for that.

LOCAL ORGANIZATIONS

According to MoWE, planting jatropha, castor seeds and palm trees for biofuel production is being undertaken by the Ministry of Agriculture and Regional Development units in Amhara, Tigray and Somali regions in the form of community development by involving farmers.

ORDA

ORDA has so far planted over 200 million seedlings of Jatropha in 50 woredas in degraded areas in order to secure feedstock supply for a biodiesel processing factory which can produce 300 litres of Jatropha oil per day in Bati Woreda of the Amhara Region. Up to 2012, about 21.23 million jatropha trees (seedling) are being grown on 6232 ha of unused land in 16 Woredas. If we assume that half out of 200 million seedlings grow up it is expected to cover at least 39,597 ha of land. From this 2-3% (8320 quintals) of yield is expected which amounts to about 200 thousand litres of Jatropha oil.

REST

Relief Society of Tigrai has been working in six selected District (Raya Azebo, Samir Sehit, Tanqua Abergele, Kola Tenben, Werayi Lehi and Merbi Lihi). From 2007 till 2011, a total of 49.35 million jatropha plants have been planted on highly degraded areas with an aim of reclaiming soil fertility and 67%(32.85 million) of the seed has been grow sustainably which covers 19,803 ha of land. In five woreda 166,498 plants of jatropha grown on 100.3 ha has started giving yield. From this 6000 kg has been collected this year. Since jatropha cultivation is undertaken on highly degraded mountainous land, the yield gain is expected to be small. In 2012 it is planned to plant 100 quintals of jatropha out of which 70% is on unused land and 30% is on farmers' land and around their houses' fences. This will cover on average 4800 ha of new unused land.

Save the environment Ethiopia

Save the environment Ethiopia works on environmental protection and rehabilitation in Somali region. Given the environmental and energy benefits of biofuel production, the organization sensitizes members of society as they expand or increase production of jatropha and castor/gule. Jatropha is currently growing on 7 ha. They are preparing to grow castor (which can give yield within 4-5 months) on 15 ha and plan to plant jatropha on 12 ha in near future. Totally, 24,600 litres are expected if castor is grown on 15 ha. In addition, the company intends to install a processing plant with capacity of producing 300 litres of oil from jatropha and castor.

Farmers Participation

According to MoWE (2012), farmers in some regions are participating in growing energy crops mainly for biodiesel. Jatropha is being produced in 27 arid and semi arid Woredas in SNNPR. A biodiesel development survey undertaken by MoWE in 5 kebeles shows that 5,530 households is grow, on average, 1,804,633 jatropha seedlings around their farm and fences. On average, 45,116 quintals of yield per year is expected to be produced which can be used to manufacture 1.08 million litres of Jatropha oil. Based on this, it is estimated that about 75 million jatropha feedstock, which covers 30,000 ha of land in 27 districts. If they give 5% yield totally 93,700 quintals of jatropha is expected which can be 2.25 million litres of jatropha oil.

In Tigray Region, by organizing farmers through ‘safety net programs’, the Agriculture and Rural Development Office of the region sowed 43.4 million jatropha feedstock (out of which 70% is growing successfully) on 12,000 ha which was unused and degraded mountainous land. In Amhara Region, a study in 2007 by development organization called Tiret showed that 10-11 million trees of jatropha which covers 4200 ha of land exists on farm land and around the house fence in 13 Woredas. From this, on some 250,000-275,000 quintals of yield (9 million litres) per year may be obtained. Jatropha is being cultivated around fences and farmers’ land in 23 Weredas of various zones of the Oromia Regional State (West Hararge, Arsi, Jima, North Showa, East Showa, Wara Guduru, Wellega). In addition in 401 kebales and in 172 kebales farmers are growing castor and palm respectively.

In general, more than 46,000 hectares of land is currently used farmers to grow Jatropha in SNNPR, Amhara and Tigray regions. This is expected to increase since the development organization is growing Jatropha not only for oil purpose but also as a key means of environmental conservation mainly in the form of land reclamation.

Table 3.2 The summary of current operational developers of biodiesel crops

No.	Name of Developers	Type of feedstock	Current land under utilization(ha)	Total Potential land allocated(ha)	Region	AEZs
1	Fri-El Ethiopia	Palm	800	30,000	SNNPR	1
2	Agro peace Bio Ethiopia	Castor	20	2000	Somalia	5
3	Africa Power Initiative	Jatropha, Castor, Curton and Candilnet	3000	13000	Tigray	4
4	Global Energy Ethiopia	Castor	7500 OGs ¹⁰	10,200	South	3
5	S and P Company	Pongamia	7	50,000	Beneshangul	4
6	ATRIF Alternative Energy plc	Jatropha	80	108	SNNPR	3
7	Giving Tree Nursery	Castor	5	200	Oromia	4
8	ORDA	Jatropha	39,597	79,194	Amhara	4,2
9	REST	Jatropha	19,803	29,749	Tigray	4
10	Save the Environment Ethiopia	Jatropha and Castor	7	70	Somalia	5
11	Farmers	Jatropha	46,000	92,000	A,T,S	
	Total		116,819	306,521		

Source: MoWE, 2012

The biodiesel development activity by currently operational developers indicates that more than 100,000 ha of land are currently under biodiesel's crop cultivation; while more than 300,000 ha of potential land are expected to be additionally utilized (See table 3.2).

¹⁰ Out growers started castor cultivation as a contract agreement with Global Energy Ethiopia Company. Even though the company quit the investment we assume the land cultivated by out growers as a potential land for castor bean cultivation.

Although the government has an extensive development plan for biofuel projects, most private companies failed to meet the expectation. However, development by domestic non-government development organization like ORDA and REST is increasing. In addition, as farmers' awareness and market demand for biofuel crops will continue to rise their production of biofuel crops for the market will increase. For instance, out of the total land currently under jatropha cultivation only 2% is developed by private companies while the rest is by domestic non-government development organ and farmers. In addition, most of the operational company has plan of asking more land and expanding their investment. While those not yet operational companies are expected to start their production. Generally, even though the biofuel investment expansion in Ethiopia is not as expected and promoted by the government, it is hoped that the investment will expand. According to the BDCD of MoWE, 2012 the main reason of slow biofuel investment in Ethiopia is the invertors' unwillingness to take degraded/less fertile land.

The overall biofuel development activity in Ethiopia indicates there is farmer participation in various ways. Out-growers are cultivating sugarcane on about 4,000 ha around Wonji Sugar factory to supply for the Sugar factory. Community development is another scheme highly practiced in Amahra and Tigray regions. For example, in 2012 REST planned to grow/sow 100 quintals of jatropha which covers around 4800 ha out of which 70% will be on land not under cultivation and 30% on farmers' land as their farm and houses' fence.

As of the production characteristics, the technology indicates that sugarcane is primarily plantation based and capital intensive while biodiesel crops (jatropha, castor bean and

palm oil) are labour-intensive as it requires more labour per land compared with sugar cane and cultivated mostly by out growers and in the form of community development participation. The data indicate that sugar cane accounted for a larger share of the total land allocated to biofuel crops (Appendix A). In addition, most of the total land allotted to biofuels production is not utilized in 2012. For instance, about half of the total land allotted to jatropha and castor bean are not utilized yet. While more than 85 percent and almost all of the total land allocated to sugar cane and palm oil are not yet utilized respectively (Appendix B). This suggests that there is a huge room for further expansion of production by bringing more land into cultivation until full scale operation without displacing smallholders at least in the short- and medium-term. Moreover, current biofuel development status in Ethiopia indicates that all most all biofuel investment is going on the unutilized land. In this study, we assume that biofuels investments take place in unutilized land, i.e. land that is not occupied by smallholders.

CHAPTER FOUR

DATA AND METHODOLOGY

This study uses DCGE-MS framework to analyze the impact of biofuel investment on growth and poverty. First, we introduce the concept of the SAM which is the base line data for calibration. Then a detailed specification of the dynamic CGE model follows. Lastly, the household model to be linked to the CGE model is brought in.

4.1. The Social Accounting Matrix

Ethiopia's CGE model is calibrated to a 2005 social accounting matrix (SAM), which was modified for this purpose using the EDRI SAM 2005/06 by researchers at the Environmental Economics Policy Forum for Ethiopia (EEPFE). CGE model/SAM contains 60 activities, including 41 agricultural and 5 non-agricultural sectors. One main aspect of the model is that activities are sorted according to agro-ecological zones (AEZs).¹¹ The model identified a total of 14 agricultural and non-agricultural commodities. Five factors of production are identified: three categories of labour (skilled, semiskilled and unskilled labour), agricultural capital and land categorized in five agro-ecological zones, and the non-agricultural capital. Fourteen household types are distinguished. While rural households are classified according to their poverty status (poor and non-poor) and location (AEZs) (ten rural households), urban households are based on urban size and poverty status (four urban households). However, in order to

¹¹ The five AEZs include: Humid lowlands moisture reliable (AEZ1), Moisture sufficient highlands (cereal-based) (AEZ2), Moisture sufficient highlands (enset-based) (AEZ3), Drought prone (Highlands) (AEZ4), and Pastoralist (Arid Lowland Plains) (AEZ5). (see EDRI (2009) for details on AEZs)

reconcile with household data we aggregated the 14 household types into four. If the initial SAM has several household categories, these should be aggregated together to facilitate the reconciliation process, as these household categories will be subsequently replaced by the actual households anyways (Cockburn J. et. al, 2006).

Table 4.1 shows the basic structure of the Ethiopian economy in 2005/06. While agriculture generates a half of the national GDP and three-fourth of total employment, the non-agricultural sectors, especially the contribution of the manufacturing sector to total output is minimal, accounting for only 10% and 7% of total GDP and employment, respectively. The country heavily depends on imported industrial products, accounting for 71% of total imports. Note that fuel imports are quite considerable, accounting for about 12% of total imports and 18% of total industrial imports in 2005/06. The country imports less agricultural products, especially cereals which accounted for 3.5% of total imports over the same period.

The detail in the SAM captures Ethiopia's economic structure and will profoundly influence the model results. For instance, since biofuel are expected to be either exported or used to substitute fuel imports, a substantial increase in biofuel will have implications for trade and hence foreign exchange availability. Availability of foreign exchange enables the country to import more and reduce exports of other products. Specifically, disaggregation of activities into AEZs and existence of different biofuel activities in each AEZs captures some of the diversity in economic structure and potentials across regions.

Table 4.1 Structure of Ethiopia's economy in 2005/06

	Share of total (%)				Export Intensity ^a	Import penetration ^a
	GDP	Employment	Exports	Imports	(%)	(%)
Total	100.00	100.00	100.00	100.00	8.96	21.88
Agriculture	48.14	73.54	42.23	4.69	11.18	3.39
Cereal crops	13.83	23.02	0.00	3.49	0.00	7.23
Cash Crops	7.05	8.83	25.01	0.16	53.77	1.24
Sugar Cane	0.32	0.46	0.00	0.00	0.00	0.00
Jatropha	0.00	0.00	0.00	0.00	0.00	0.00
Castor Bean	0.00	0.00	0.00	0.00	0.00	0.00
Palm Oil	0.00	0.00	0.00	0.00	0.00	0.00
Livestock	14.39	20.08	4.51	0.00	4.99	0.00
Other Agriculture	7.80	12.49	12.71	1.05	16.82	3.73
Forestry and Fisheries	4.75	8.66	0.00	0.00	0.00	0.00
Non-Agriculture	51.86	26.46	57.77	95.31	7.82	28.51
Industry	11.72	7.62	17.56	70.99	6.60	41.25
Electricity	0.92	0.14	0.00	0.00	0.00	0.00
Food processing	2.30	1.66	3.01	2.42	10.53	14.92
Biofuel processing	0.00	0.00	0.00	0.00	0.00	0.00
Ethanol processing	0.00	0.00	0.00	0.00	0.00	0.00
Services	40.14	18.84	40.21	24.32	9.16	14.61

Note: ^a 'Export intensity' is the share of exports in domestic output, 'import penetration' is the share of imports in total domestic demand. Sums of shares in this table and subsequent tables may not equal to 100 due to rounding.

Source: Ethiopia's 2005/06 social accounting matrix (SAM)

For example, sugarcane plantation is undertaken in all most all AEZs with smallholders involvement, whereas palm oil activity is mainly undertaken in humid lowlands moisture reliable (AEZ1) (see Table 3.2). Jatropha and castor bean activities are primarily undertaken in moisture sufficient highlands (enset-based systems), drought prone, and pastoralist zones: AEZ 3 and 4 for jatropha and AEZ 4 and 5 for castor bean.

4.2. The computable general equilibrium Model Specification and Assumptions

The basic structure of macro model used in this paper is a conventional CGE model which imitates the standard IFPRI model.¹² We employ a modified version of the standard CGE model for Ethiopia based on the 2005/2006 SAM of Ethiopia. The IFPRI standard CGE model explains all of the payments recorded in the SAM. The model therefore follows the SAM disaggregation of factors, activities, commodities, and institutions. The model is formulated as a set of simultaneous linear and non-linear equations, which define the behavior of economic agents, as well as the economic environment in which these agents operate. This environment is described by market equilibrium conditions, macroeconomic balances, and dynamic updating equations. For production and consumption decisions, behavior is captured by nonlinear, first-order optimality conditions that is, production and consumption decisions are driven by the maximization of profits and utility, respectively. The equations also include a set of constraints such as markets (for factors and commodities) and macroeconomic aggregates

¹² For a detailed exposition of this type of model, and for the implementation of the “standard” model in the GAMS modeling language, see Lofgren et al. (2001) and (2002).

(balances for Savings-Investment, the government, and the current account of the rest of the world), that have to be satisfied by the system as a whole but are not necessarily considered by any individual actor.

The dynamic model is constructed as a static CGE model that is linked to between periods by exogenous and endogenous variables updating procedures. The model belongs to the recursive dynamic strand of the dynamic CGE literature, which implies that the behavior of its agents is based on adaptive expectations, rather than on the forward looking expectations that underlie alternative inter-temporal optimization models. Since a recursive model is solved one period at a time, it is possible to separate the *within-period* component from the *between-period* component, where the latter governs the dynamics of the model. Although a detailed mathematical description can be found in Appendix A and in Lofgren *et al* (2002), this section presents a detailed overview of the model's structure.

4.2.1. Within-period Specification

The within-period component describes a one-period static CGE model. The following description of the structure of this model is divided into four major blocks: production and trade, price, institutions and system constraint blocks.

Production and Trade Block

It is assumed that each producer (represented by activity) maximizes profits, subject to a production technology. Profit maximization implies that the factors receive income where

marginal revenue equals marginal cost based on endogenous relative prices. In this study, the technology at the top level of the technology nest is a Leontief technology which will yield commodity outputs in the production process. A constant elasticity of substitution (CES) function of primary factors will be used to represent the quantities of value-added. According to Thurlow (2004), the CES specification for value-added enable producer so as to respond to dynamics in factors returns by substituting among available factors. Once determined, these factors are combined with fixed-share intermediates using a Leontief specification. Using a Leontief technology aggregate intermediate input will be represented as composite commodities partially domestic and partially imported (Lofgren et al., 2002).

Each activity produces one or more commodities according to fixed yield coefficients. In addition, a commodity may be produced by more than one activity. The final price of an activity's output is derived from the price of value-added and intermediates, together with any producer taxes or subsidies that may be imposed by the government per unit of output. The revenue of an activity is defined by the level of the activity, yields, and commodity prices at the producer level.

In the Leontief function for the activity production function, both demand for value-added (QVA_a) and aggregate intermediate inputs ($QINTA$) are expressed as a fixed share

of the level of activity (QA_a).¹³ Each activity produces one or more commodities according to fixed yield coefficients. Similarly, a commodity may be produced by more than one activity.

$$QVA_a = iva_a \cdot QA_a \quad a \in ALEO \quad (4.1)$$

$$QINTA_a = int a_a \cdot QA_a \quad a \in ALEO \quad (4.2)$$

Where, a represent a set of activities in the Leontief activity function, iva_a represents quantity of value-added per activity unit, and $int a_a$ represents quantity of aggregate intermediate input per activity unit.

With regard to flows in the commodity market, for domestically produced marketable commodities, each activity in the economy will contribute to an aggregate domestic output using a CES aggregation function with activity-specific prices clearing the disaggregated commodity market. The output is then allocated between exports and domestic sales using a constant elasticity of transformation (CET) function and by doing so captures any time or quality differences between the two products. Profit maximization drives producers to sell in those markets where they can achieve the highest returns. Domestic demand is an aggregate of consumption demands of households and government, investment demand, intermediate input demand and

¹³ As demonstrated by Thurlow (2004) the implication of the use of fixed shares is that, it is technology (rather than the decision making power of the producers) which determine the necessary combination of value-added and intermediate inputs per unit of output. Consequently, the Leontief technology denotes fixed proportion of inputs to outputs.

transaction input demand. Domestic output and imports make up a composite commodity to meet this domestic demand through a CES aggregation function (Lofgren *et al.*, 2002).

The output transformation (CET) function determines allocations of the marketed domestic output, QX_c , to domestic sales, QD_c , and exports, QE_c .

$$QX_c = \alpha_c^t \cdot (\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t})^{\frac{1}{\rho_c^t}} \quad c \in (CE \cap CD) \quad (4.3)$$

Where, α_c^t represents a shift parameter, δ_c^t represents a share parameter, and ρ_c^t represent an elasticity exponent in the CET function. The shift parameter measures the supply shift in the destination of domestic products based on the profitability of the destination. The share parameter, however, represents the share (proportion) of exports or domestic sale from domestically produced output. The exponent shows the elasticity of transformation between the two destinations (Lofgren *et al.*, 2002). In addition, based on the assumption of imperfect transformability between the two destinations, the export-domestic supply ratio is formulated as:

$$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \quad c \in (CE \cap CD) \quad (4.4)$$

This ratio expresses the optimal mix between exports and domestic sales. Accordingly, an increase in the export-domestic price ratio brings about an increase in the export-domestic supply ratio (i.e., a move toward the destination that offers the higher return).

The composite supply (Armington) function is specified to capture the imperfect substitutability between imports and domestic output sold domestically as a CES function in which the composite commodity for domestic supply is a contribution from both.

$$QQ_c = \alpha_c \cdot (\delta_c \cdot QM_c^{-\rho} + (1 - \delta_c) \cdot QD_c^{-\rho})^{-\frac{1}{\rho}} \quad c \in (CM \cap CD) \quad (4.5)$$

Where, QQ_c denotes composite supply (i.e., the quantity of goods supplied to domestic market), QM_c denotes the quantity of imports of commodity c , α_c denotes a shift parameter, δ_c denotes a share parameter, and ρ denotes an Armington function exponent. The shift parameter measures the shift in demand based on the expensiveness of the quantity supplied to the domestic economy. The share parameter signifies the domestic market share of imports or domestically produced output. The Armington exponent shows the elasticity of substitution between the two types of commodities. For the Armington function, import-domestic demand ratio (expressed as a function of domestic-import price ratio) is formulated as:

$$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c}{1 - \delta_c} \right)^{\frac{1}{1+\rho}} \quad c \in (CM \cap CD) \quad (4.6)$$

This ratio states the optimal mix between imports and domestic output where an increase in the price ratio leads to an increase in the demand ratio implying a shift away from the source that becomes more expensive (Lofgren *et al.*, 2002).

Price Block

This block comprises different equations in which endogenous model prices are linked to other prices (endogenous or exogenous) and to non-price model variables. As specified

below for the import price equation, the domestic import price, PM_c , of commodity c is given by world import price of c , pwm_c , multiplied by the tariff adjustment, $1 + tmc$, and the exchange rate, EXR , plus transaction costs to move the commodity from the border to the domestic demander. The exchange rate is local currency per unit of foreign currency.

$$PM_c = pwm_c \cdot (1 + tmc) \cdot EXR + \sum_{c \in CT} PQ_c \cdot icm_{c,c} \quad c \in CM \quad (4.7)$$

Where, PQ_c is composite commodity price, $icm_{c,c}$ is trade input per imported commodity, CT is a set of domestic trade inputs, CM is a set of imported commodities.

The export price of a commodity in domestic currency, PE_c , on the other hand, is the product of the commodity's world price, pwe_c , and the exchange rate minus the transaction costs of moving the commodity to the border where $ice_{c,c}$ represents the trade input per exported unit of c .¹⁴

$$PE_c = pwe_c \cdot EXR - \sum_{c \in CT} PQ_c \cdot ice_{c,c} \quad c \in CE \quad (4.8)$$

The other price is the demand price for domestically produced non-traded goods (i.e., this includes commodities that are neither imported nor exported) can be represented as follows:

$$PDD_c = PDS_c + \sum_{c \in CT} PQ_c \cdot icd_{c,c} \quad c \in CD \quad (4.9)$$

¹⁴ In Ethiopia there is no imposition of tax on export. Thus, te_c (export tax rate) is removed from export price equation (i.e., te_c is zero for the case of Ethiopia).

It is given by supply prices for commodities produced and sold domestically, PDS_c , plus transaction costs where $icd_{c'c}$ represents the trade inputs per commodity produced domestically. Where, CD is a set of commodities with domestic sales of domestic output. We also have specifications for equations for consumer price index (CPI) and producer price index for non-traded market output (DPI).

$$CPI = \sum_{c \in C} PQ_c \cdot cwt_s_c \quad (4.10)$$

$$\overline{DPI} = \sum_{c \in C} PDS_c \cdot dwt_s_c \quad (4.11)$$

Where; cwt_s_c denotes weight of commodity c in the consumer price index and dwt_s_c denotes weight of commodity c in the producer price index. In our model, the DPI is the numeraire ¹⁵ and hence is fixed whereas the CPI is made flexible. The CPI is made flexible in order to update the expenditures we used in the micro simulation model. Since price is normalized to one in the model, the changes in CPI indicate consumer prices changes that bring about equilibrium.

In addition, absorption represents total domestic spending on commodities domestically produced and imported at domestic demander prices; marketed output value represents the commodities available for the domestic market plus those that are for export; and

¹⁵ In the basic model version CPI is fixed (exogenous variable) and functions as the numeraire, otherwise DPI may be fixed. A numeraire is vital since the model is homogenous of degree zero in prices. Subsequently, a doubling of the value of the numeraire would double all prices but leave all real quantities/real resource allocation unchanged. As a remark, all simulated price and income changes should be interpreted as changes in relation to the numeraire price index (Lofgren et al., 2002).

activity price represents the gross revenue per activity unit. Additional equations are also there for aggregated intermediate input prices and activity revenue and costs.

Institutional Block

This block constitutes the modeling of the incomes and expenditures of the four major institutions: households, government, enterprises and the rest of world. The sources of income for households are factors of production and transfers from other institutions. Transfers from the rest of the world to households are fixed in foreign currency as is the case for all transfers between the rest of the world and domestic institutions and factors. They use the income for consumption, saving, transfers to other institutions and payment of taxes. The direct taxes and transfers to other domestic institutions are defined as fixed shares of household income whereas the savings share is flexible for selected households. Household consumption covers marketed commodities, purchased at market prices that include commodity taxes and transaction costs, and home commodities, which are valued at activity-specific producer prices. Household consumption is allocated across different commodities (both market and home commodities) according to linear expenditure system (LES) demand functions, which is derived from maximization of a Stone-Geary utility function subject to a household budget constraint. Given prices and incomes, these demand functions define households' real consumption of each commodity. Enterprises reveal similar characteristics like that of households in income and expenditure aspects except absence of consumption in their case.

Factor income, YF_f , defines the total income of each factor. It is the sum over all activities of the product of the average factor price, WF_f , the wage distortion factor, \overline{WFDIST}_{fa} , and the quantity demanded of factor f from activity a , QF_{fa} .

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \quad f \in F \quad (4.12)$$

The wage distortion factor measures the deviation from the average wage. It is fixed because for each factor in the model, the deviation is the same.

On the other hand, we have institutional factor income which splits income among domestic institutions in fixed shares after payments are made for direct taxes and transfers to the ROW.

$$YIF_{if} = shif_{if} \cdot [YF_f - trnsfr_{rowf} \cdot EXR] \quad i \in INSD \quad (4.13)$$

Where, i which stands for institutions is an element of INDS (it represents a set of domestic institutions), $shif_{if}$ represents the share of domestic institution i in income of factor f , and $trnsfr_{rowf}$ represents transfer from factor f to institution i .¹⁶

We can also extract a formulation for domestic non-government institutions, $INSDNG$, to find out the sources of their incomes, YI_i . These institutions are mainly households and

¹⁶ Ethiopia does not impose direct tax rate for factor (tf_f). Thus, in the above equation, the direct tax rate for factor f is taken as zero.

enterprises which get the incomes from factors, transfers from other institutions, the government (indexed to the DPI) and ROW.

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG} TRII_{ii'} + trnsfr_{gov} \overline{DPI} + trnsfr_{irow} \cdot EXR \quad i \in INSDNG$$

(4.14)

Where, $trnsfr_{igov}$ denotes transfers from the government to institution i , $trnsfr_{irow}$ denotes transfer from the *ROW* to institution i , and $TRII_{ii'}$ denotes transfers from domestic institution i' to institution i .

Household consumption expenditure, EH_h , is another aspect here that can be divided into spending on marketed commodities and home commodities.

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1 - MPS_h) \cdot (1 - TINS_h) \cdot YI_h \quad h \in H \quad (4.15)$$

Where, h is an element of a set of households H , $shii_{ih}$ represents the share of net income of household h to institution i , MPS_h represents the marginal propensity to save for household h , $TINS_h$ represents direct tax rate for household h , and YI_h represents the income of household h . Accordingly, household consumption expenditure is expressed as a remnant after payments are made for direct taxes, savings and also transfers.

When we come to the revenue of the government, YG , we find that the government collects revenue from many sources including taxes at fixed ad valorem rates, factors, and transfers other institutions.

$$YG = \sum_{i \in INSDNG} TINS_i \cdot YI_i + \sum_{c \in CM} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YIF_{govf} + trnsfr_{govrow} \cdot EXR \quad (4.16)$$

Where, tq_c is for rate of sales tax, $TINS_i$ is direct tax rate for institution i , YI_i is income of institution i , tm_c is import tariffs, pwm_c is world price of import, QM_c quantity of import, tq_c is indirect sales tax, PQ_c is composite commodity price, QQ_c is composite supply, YIF_{govf} is transfer from institution to the government, $trnsfr_{govrow}$ is transfer from the rest of the world to the government, and EXR is exchange rate (local currency per foreign currency). Specifically, sources of government revenue stated in the equation are direct taxes from institutions, import tariff, sales taxes, factor incomes and transfers from ROW in that order.¹⁷

On the expenditure side, total current government expenditure, EG , is the sum of spending on government consumption and government transfers.

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\ gov} \cdot \overline{DPI} \quad (4.17)$$

Government consumption is the sum overall commodities of the product of the price of the composite commodity, PQ_c , and quantity of government consumption, QG_c , of commodity c .

The government transfer, however, is the sum overall *INSDNG* of DPI indexed government transfers to domestic non-government institutions (only households in the

¹⁷ In Ethiopia, there are no direct taxes from factors, “value added taxes” on activities directly, activity taxes, and export taxes. Thus, revenues from these sources are non-existent in Ethiopia (see Dorosh *et al.*, 2009).

SAM). Government consumption is fixed in real (quantity) terms and government savings, i.e., the difference between government income and spending, is a flexible residual.

Finally, the transfer payments between the rest of the world and domestic institutions and factors are all fixed in foreign currency. Foreign savings or the current account deficit is the difference between foreign currency spending and receipts.

System Constraint Block

The notion of closure rule implies equality of equations and endogenous variables which requires fixation of some variables for the model to have a solution. The choices on closures do not have impact on solutions of the base simulation but affect other simulations, and in addition, the choice per closure doesn't constrain the choice for the other closures (Damuri and Perdana, 2003). Here under we select the model closures that are applicable to the Ethiopian economy.

The standard CGE model has closures for factor markets and the macroeconomic system. The first closure is the closure in the factor markets. It imposes equality between quantity demanded and quantity supplied of factor f .

$$\sum_{a \in A} QF_{fa} = \overline{QFS}_f \quad f \in F \quad (4.18)$$

Where, \overline{QFS}_f represents quantity supplied of factor f . This fixed \overline{QFS}_f is dependent on the closure rule. It works if factors are fully employed, otherwise not. Since, in the above

specification, all demand variables are flexible and supply is held fixed, the average price for each factor or the economy-wide wage, WF , plays the market clearing role in a setting with perfect factor mobility across activities. Alternative factor market closures are available in cases of unemployment where supply is flexible while the economy-wide wage is fixed; and in cases of fully segmented factor markets (Lofgren *et al.*, 2002). In this model we assume full employments of factors. Labour is assumed to be mobile across sectors and fully employed. This implies that expanding biofuel production reduces use of labour elsewhere in the economy, which is consistent with widespread evidence that while relatively few people have formal jobs, the large proportion of the working age population engage in productive activities that contribute to GDP. Therefore, employing these working age population in biofuel production has an opportunity cost.

The macroeconomic closures (balances) are centered on the government balance, the external (current account) balance and the saving-investment (S-I) balance. For the government balance, the default closure is fixed direct tax rates and flexible government savings, $GSAV$, which clears the government account. But in the other two alternative closures, government saving is fixed with uniform direct tax rates in the first alternative and scaled direct tax rates for selected institutions in the second case.

$$YG = EG + GSAV \tag{4.19}$$

Government balance is represented by the equality of government revenue and the sum of government expenditure and savings. In this study, we follow the closure in which direct

tax rates are exogenous and it is the changes in government savings that equilibrate the economy.

For the external (ROW) balance, the default closure is fixed foreign savings (trade balance) and flexible real exchange rate, EXR , that clears the current account of the ROW whereas the alternative is the vice versa. This current account balance, in foreign currency, equates the country's spending and its earnings of foreign exchange.

$$\sum_{c \in CM} p w m_c \cdot Q M_c + \sum_{f \in F} t r n s f r_{r o w f} = \sum_{c \in CE} p w e_c \cdot Q E_c + \sum_{i \in INSD} t r n s f r_{i r o w} + \overline{F S A V} \quad (4.20)$$

Where, $\overline{F S A V}$ is for foreign savings (in foreign currency unit). In the equation, import spending plus factor transfers to the ROW must equal the sum of export revenue, institutional transfers from the ROW and foreign savings. In this study, we assume fixed foreign saving, and thus it is the real exchange rate that plays the equilibrating role.

In the S-I balance; we have about five closure rules. The default is a saving-driven closure in which we have flexible capital formation but fixed propensities to save for all non-government domestic institutions. We follow this closure in this model in which investment adjusts to ensure equilibrium. There are four alternative closures, however. The first alternative is investment driven closure in which savings do the adjustment. Uniform saving rates (MPS) adjust for selected institutions to finance the cost of the (exogenous) investment. The second alternative is similar with the first except that the saving rates are scaled or are multiplied by a scalar (not uniform like the above). Apart from these, we have other two variants of investment-driven closures like the second two

closures but the difference here is that an adjustment for government consumption is imposed. Thus, the third and fourth alternative closures are fixed investment and government consumption absorption shares for both with the disparities being uniform MPS for the former and scaled MPS for the latter (Lofgren *et al.*, 2002; Thurlow, 2004).

$$\sum_{i \in INSDNG} MPS_i \cdot (1 - TINS_i) \cdot Y_i + GSAV + EXR \cdot \overline{FSAV} = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c \quad (4.21)$$

Where, $qdst_c$ is the quantity of stock change. The sum of savings from government, domestic non-government institutions and ROW are equated with the sum of fixed investment and stock change. To cater for imbalance, the S-I balance also has an optional addendum in ‘WALRAS’¹⁸ which is valued at zero if the model is in equilibrium (balanced).

¹⁸ According to Varian (1992) the foundations for the Walrasian general equilibrium are the accounting rules (the conservation of value) which reflects the accounting principle of budgetary balance that for each activity in the economy the value of expenditures must be balanced by the value of incomes, and that each unit of expenditure has to purchase some amount of some type of commodity. The author normally stated the walrasian equilibrium as the price and commodity vectors such that there is no good for which there is positive excess demand. As shown by Wing et.al (2007) the Walrasian general equilibrium prevails when the price of commodities equal to their marginal cost of production with firms earning zero profits, there is no excess demand for commodities and factors, and consumers’ income equals their expenditure.

4.2.2. Between-period Specification

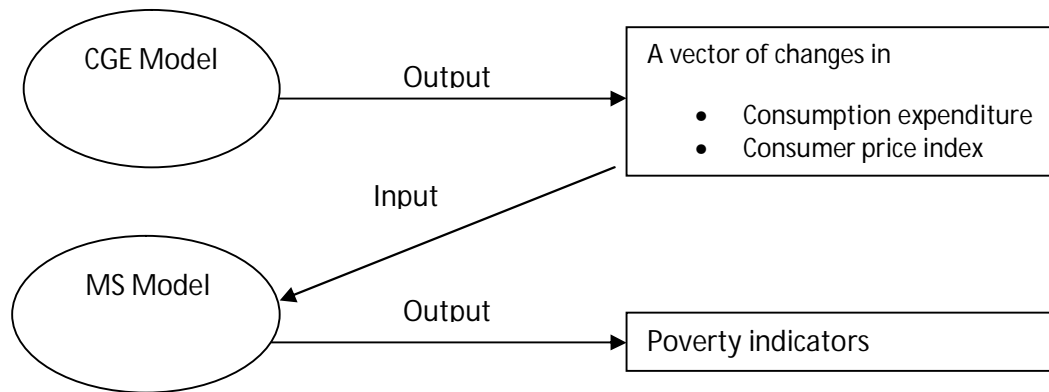
While the static model described above is a representation of an economy within a particular time-period, its inability to account for second-period considerations limits its assessment of the full effect of policy and non-policy changes. However, as investments in biofuel unfold over a dozen of years or more, the static model is extended to a recursive dynamic model in which selected parameters are updated based on the modeling of inter-temporal behavior and results from previous periods. The model is dynamized by building a set of capital accumulation and updating rules for capital stock, labor force growth by skill category and productivity growth. Growth in total supply of each labour category and land is specified exogenously. In addition, growth in land supply by agro-ecological zones to biofuel sectors is specified exogenously.

The new capital will be distributed among sectors based on each sector's initial share of aggregate capital income (Thurlow, 2004). This means the model adopts a 'putty-clay' formulation such that new investments can be directed to any sector in response to differential rates of returns (Arndt *et al*, 2010) while, installed equipments remain immobile. Moreover, in this model a simple adaptive expectation formation is specified whereby investment is allocated according to current relative prices, which implicitly implies that investors expect current price ratios prevail indefinitely. Full specification of each dynamic equation is given in Appendix G.

4.3. The Microsimulation Model

In the literature review, we have discussed the importance and various approaches in linking the CGE model with the MS model. In this study, we link the CGE and the household models in a top-down sequential (MSS) manner as can be seen from figure below. In this top-down approach, the CGE model is linked with 21,594 households in the 2004/05 HICE survey of CSA.¹⁹ The external shocks introduced in the CGE model will result in economy-wide changes in the consumer price index and consumption expenditures of households. These simulation results for the before and after shock period are later fed into the household model using distribution analysis²⁰ (DAD) software that yields the FGT poverty indices.²¹

Figure 4.1 The Top-down Sequential Approach



Source: Colombo (2008); Dejene et al., (2007)

The 1995/96 HICE survey used 11,928 households whereas the 1999/00 HICE survey used 17,332 households (CSA, 2008).

²⁰ The DAD (distribution analysis) software is “designed to facilitate the analysis and the comparisons of social welfare, inequality, poverty and equity across distributions of living standards. Its features include the estimation of a large number of indices and curves that are useful for distributive comparisons as well as the provision of asymptotic standard errors to enable statistical inference. The features also include basic descriptive statistics and provide simple non-parametric estimations of density functions and regressions.” (Duclos *et.al.*, 2010)

²¹ DAD usually provides results for the sequential approach in poverty and income distribution analysis.

The households in the 2004/05 HICE survey were categorized into four groups to comply with the household disaggregation in the SAM where the households are subdivided as rural poor, rural non-poor, urban poor and urban non-poor taking the bottom 40% as poor after the households are arranged in descending expenditure levels. In other words, the bottom two quintiles (4th and 5th) were considered as poor. The consumption expenditure level at the demarcation of the top 60% and bottom 40% households (urban plus rural) is taken as the poverty line in estimating the FGT indices.

CHAPTER FIVE

SIMULATIONS AND RESULTS

5.1. Description of Simulations

In this section, we state the baseline scenario and different biofuel scenarios. In the modelling, we focus on the differential impacts of various forms of biofuel production to that of the baseline, which excludes investments in the biofuel and allows us to observe whether the various biofuel scenarios are reasonable. Examining the differences between the biofuel scenarios and the baseline scenario allows one to isolate the impacts of biofuel investments that enable us to obtain clear and analytically tractable comparisons. The aim of each simulation is to examine the impacts on selected macroeconomic, food production, welfare and poverty indicators. In conducting each simulation, the base values of all other parameters are retained.

Baseline Scenarios

We first produce a baseline growth path that assumes that the economy continues to grow during 2005–2020 in line with its recent economic performance. For each year, we update the model to reflect changes in population, supply of labour and land, and factor productivity (see Table 5.1).

Ethiopia is a relatively land-abundant country, since the country has large potential of cultivable land. As a result we assumed that, on average, land supply grows at 3.2% in all AEZs, which is the same as the rate of cropped area expansion over the past decade.

Population is assumed to grow at 2.5%, which is the same as the average rate of population growth from 1994 to 2007 (CSA, 2008). Rising skill intensities in the labour force is captured by assuming the supply and productivity of skilled and semiskilled labour force to grow faster than unskilled labour. Skilled labour is assumed to grow at a rate of 7.9% per year, which is consistent with expansion of higher education in the country. While semi-skilled labour is assumed to grow at the rate of 5% per year, unskilled labour is assumed to grow at 4.4% per year, a little slower than the rate at which semi-skilled is assumed to grow. According to data from national labour force surveys, labour force grows faster than the rate of population growth. The most recent population Census (CSA, 2007) indicates that the age composition of the population is skewed towards young and adult population, suggesting that labour force grows faster than population growth rate.

It is assumed that there is an unbiased technological change, which shifts the parameter on the production function (total factor productivity (TFP) parameter) to grow at the rate of 2.5% in livestock and sectors that produce cereals and cash crops. Similarly, TFP in all other non-agricultural activities is assumed to grow at the rate of 2.9%. These estimates of TFP are obtained from previous studies on growth accounting in the country (e.g. Prat and Yu, 2008; WB, 2009). The rate of TFP growth in sugarcane activity is assumed to be 5%, which is consistent with the expansion in the sector. Similarly, the TFP growth rates in jatropha, castor bean, and palm are assumed to grow 3.5%, 3%, and 2.5%, respectively. The results of these scenarios are compared with the biofuel scenarios so as to isolate the effects of biofuel investment from the effect of other factors.

Table 5.1 Core macroeconomic assumptions for the dynamic CGE model

	Initial (2005)	Baseline-scenario (growth rates)
Population (in thousands)	70,167	2.5
GDP	100.0	2.54
Labour supply	40,479.4	7.0
Skilled labour	7.9	7.9
Professional labour-rural	5.0	5.0
Administrative labour-urban	5.0	5.0
Unskilled labour-urban	4.4	4.4
Agricultural labour-rural	4.4	4.4
Capital stock	56,455.9	10
Land supply	3.2	3.2

(CSA, 2007 EDRI, 2009 and MoFED, 2010)

Biofuel Scenario

Given the existence of various biofuel development options in Ethiopia, we considered seven biofuel scenarios, which we describe briefly as follows.

Simulation 1, Sugarcane scenario (S1): assumes expansion of sugarcane production using extensive cultivation, i.e. by allocating more land to sugarcane production. Specifically,

we increase land allocated to sugarcane by 13,333.33 hectare per year over the 2020 period.²²

Simulation 2, Jatropha scenario (S2), we keep on increasing jatropha production by bringing more land into cultivation. Land allotted to this crop increases by 13,333.33 hectare per year. Given that a large of proportion of land allocated to this crop is unutilized for other purposes, we assume that expansion of jatropha will not affect smallholders in terms of land displacement.

Simulation 3, Caster bean scenario (S3), caster bean is increased through increasing the quantity of land, which is assumed to increase by about 1,161 hectare per year.

Simulation 4, Palm oil scenario (S4), assumes expansion in palm oil production by increasing land which is assumed to grow by 1,500 hectare per year.

Simulation 5, Jatropha plus slipover effect scenario (S5), this includes S2 with improved productivity of the smallholder crop sector and this scenario intends to capture the spill over effect of biofuel investment on smallholder agriculture. Such effect can arise, for instance, through improved way of farming practices, access to other agricultural inputs (e.g. chemical fertilizer, improved seeds, insecticides, etc). We assume that the productivity growth in the cereals sector increased from 2.5% to 4% per year.

²² We assume the total 200,000ha of Sugarcane and Jatropha each, 17, 414 of Castor and 22,500 ha of Palm will be utilized at the end of 2020 by current operational developers of biofuel crops. In the biofuel scenarios, we evenly distribute yet unutilized land over the 15 period which implies no displacement of smallholders.

Experiences from commercial agriculture investment in Africa suggest the existence of technology spillovers, whereby farmers associated with out grower schemes and their neighbors tend to adopt improved technologies for other crops (Benfica, 2006 and Uaiene, 2008). Biofuel investment in the form of out grower schemes are often thought to be more pro-poor than large scale capital intensive plantations, especially when they result in technology spill-over to other crops such as observed in Mozambique (Arndt, 2010; Ewing and Msangi, 2009). In Ethiopia for instance, study by Martha N. 2012 on the microeconomic evidence on food security impacts of privately organized biofuel out grower schemes indicated that food security and food caloric intake is significantly better for households that participated in producing biofuel crops. These benefits arouse, among others, via increased soil fertility, improved access to agricultural input and flexible access to cash income. Moreover, according to BDCD of MoWE, 2012, the benefits from biofuel investment have started to trickle down to smallholders through soil conservation, income generation from labor employment and selling feedstock and the like.

Simulation 6, Caster bean plus spillover effect scenario (S6), this includes S3 with spillover effect of biofuel technology on smallholder crop agriculture which induces improved productivity of the smallholder crop sector. Productivity growth in the cereals sector is postulated to increase from 2.5 to 4% per year.

Simulation 7, Combined scenario (S7), captures the combined effect of all biofuel interventions on the structure of the economy.

5.2. Results

Impacts on Economic Growth and Food Security

Table 5.2 shows the sectoral impact of biofuel investments. Jatropha and castor bean scenarios involving spillover effect leads to slightly higher agriculture sector and GDP growth rate compared to plantation based sugarcane production. This might be due to large shares of the value-added generated from producing jatropha and castor bean involving spillover goes to farmers. This is, for instance, in the form of increasing farmer's agricultural productivity which in turn leads to higher GDP growth. This result also suggest that the out grower mode of production involving spillover effect might be preferable than plantation based production. The industry sector also benefited under sugarcane scenario, jatropha and castor bean scenarios involving spillover effect and combined scenarios, whilst service sector is negatively affected, though small, under the same scenarios. The negative impact on service sector is possibly explained by competition over scares labor resource. On the other hand, the jatropha, castor bean, and palm oil scenarios are found to have no effect on aggregate sectors and real GDP. In general, biofuel investment increases the national GDP growth rate since the gain outweighs the loss.

We can also infer the impacts on food production from table 5.2. Generally, cereals (food) production sector largely gains from biofuel investment while production of both cash crops and other agricultural activities are slightly increased. Specifically, jatropha and castor bean involving spill over effects and combined scenarios increased cereals, cash crops and other agricultural activities production. This might be due to the existence

Table 5.2 Sectoral result of biofuel investment

	Initial value in billion birr (2005)	Change from (relative to) the baseline growth rate (2005-2020) (%)							
		Baseline growth	Sugarcane Scenario (1)	Jatropha Scenario (2)	Caster bean scenario (3)	Palm oil scenario (4)	Jatropha + spillover effects (5)	Caster bean + spillover effects (6)	Combined scenario (1+5+6)
GDP	122.33	9.33	0.01	0.00	0.00	0.00	0.08	0.06	0.09
Agriculture	58.88	7.85	0.02	0.00	0.00	0.00	0.17	0.14	0.20
Cereal crops	16.88	6.38	0.01	0.00	0.00	0.00	0.64	0.51	0.66
Cash Crops	8.70	6.61	0.01	0.00	0.00	0.00	0.02	0.01	0.03
Sugar Cane	0.38	9.78	1.93	0.00	0.00	0.00	0.06	0.04	2.00
Jatropha	0.00	10.62	0.00	1.60	-0.59	-0.27	1.61	-0.59	0.82
Castor Bean	0.00	8.80	0.00	-0.86	1.47	-0.28	-0.85	1.47	0.38
Palm Oil	0.00	7.99	0.00	-0.84	-0.60	1.68	-0.83	-0.60	0.22
Livestock	17.60	9.12	0.00	0.00	0.00	0.00	0.02	0.02	0.02
Other Agriculture	9.55	7.25	0.01	0.00	0.00	0.00	0.02	0.02	0.03
Industry	14.06	11.92	0.01	0.00	0.00	0.00	0.01	0.01	0.02
Electricity	1.12	11.34	0.02	0.00	0.00	0.00	0.01	0.01	0.02
Food processing	2.80	10.23	0.23	0.00	0.00	0.00	0.09	0.07	0.32
Biofuel processing	0.00	9.46	0.00	0.38	0.23	0.10	0.39	0.23	0.56
Ethanol processing	0.01	8.27	3.43	0.00	0.00	0.00	0.00	0.00	3.46
Other indus'l processing	10.13	12.39	-0.03	0.00	0.00	0.00	-0.01	-0.01	-0.04
Services	49.39	11.39	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01

Source: DCGE simulation result

of strong linkage between cereals production and jatropha and castor bean production involving spill over effect. Biofuel investment involving spill over effect benefits small holders by increasing farm productivity for instance, through wage employment, income earning by supplying biofuel crops for the processing companies, improved farm practices due to access to some agricultural inputs (e.g. chemical fertilizer, improved seeds, insecticides), and soil fertility etc. On the other hand, jatropha, castor bean, and palm oil scenarios have no effect on cereals production whereas the effect of sugarcane scenario is positive but small in magnitude. Cash crops and livestock sectors also benefited from this new investment to some extent. Furthermore, other agricultural activities gain from biofuel scenarios involving spill over effects, sugarcane and combined scenarios, while other scenarios have no effect on it.

Contrary to the ongoing critics that expansion of biofuel investment might exacerbate food insecurity problem of developing countries, our result reveal the opposite. Given the assumption that the ongoing biofuel investments are on the unutilized land (land not occupied by smallholders); our simulation shows the complementarities between 'biofuel' and 'food' production.

We can also observe the impact of biofuels investment on price of cereals (Appendix E). Biofuel investment intervention involving spill over effects decreases cereals prices. This might be due to higher productivity growth in cereals which in turn leads to increase cereals production. In contrast, the other biofuel scenarios have no effect on cereals prices.

Distributional (welfare) effects

Biofuel investment raises national GDP and factor returns which in turn increases both rural and urban households' income. Even though, the overall/combined distributional impacts across household groups have similarity, which is positive, biofuel scenarios have varying effect on household groups. Table 5.3 shows change in households' equivalent variation, which is a welfare measure that controls for changes in prices. That is, EV measures the level of income (in money terms) that the consumer needs to (presumably) pay before the shock to leave him as well off at the equivalent level of utility loss after the price increase²³. Jatropha and castor bean scenarios involving spill over effects have a significant positive effect on welfare of all households. Under sugarcane scenario the welfares of all urban households and half of rural household groups improved. The competition on land and labor can explain the reduction in welfare of some rural households. Palm oil scenario has zero sum effect on rural household found in AEZ 1. On the other hand, jatropha, and castor bean scenarios have no significant effects on the welfare of households. Moreover, the combined scenario records strong welfare improvement of all households which may be attributed to increased productivity caused by jatropha and castor bean production involving spill over effects.

²³ Since the consumer is harmed prior to the policy change by paying the price equivalent in income, negative EV changes represent welfare (utility) loss as a result of the policy shock. The concept of EV informs that price increases from P1 to P2 lead to welfare loss by as much as the loss of income equal to EV if price remained at P1.

Table 5.3 Effects of biofuel investment on household welfare (income) (in%)

	Initial spending (2005)	Base case	Sugarcane (1)	Jatropha (2)	Castor bean (3)	Palm oil (4)	Jatropha + spillover (5)	Castor bean + spillover (6)	Combined (1+5+6) (7)
hhd-pz1-r	425.51	1.38	-0.03	0.01	0.00	0.01	0.75	0.59	0.73
hhd-pz2-r	8338.51	26.68	-0.05	0.00	0.00	0.00	1.05	0.82	1.01
hhd-pz3-r	3903.95	12.46	0.07	0.00	0.00	0.00	1.50	0.52	1.58
hhd-pz4-r	7116.15	22.23	0.06	0.00	0.00	0.00	2.36	2.16	2.44
hhd-pz5-r	1289.63	3.32	0.16	0.00	0.00	0.00	1.65	1.87	2.39
hhd-npz1-r	609.58	2.00	0.04	0.00	0.00	-0.01	0.59	0.47	0.63
hhd-npz2-r	28659.16	93.73	-0.04	0.00	0.00	0.00	0.30	0.22	0.26
hhd-npz3-r	11557.35	38.83	-0.08	0.00	0.00	0.00	1.33	0.34	1.24
hhd-npz4-r	21770.55	68.94	-0.06	0.00	0.00	0.00	2.50	2.42	2.44
hhd-npz5-r	3099.80	8.68	0.15	0.00	0.00	0.00	1.39	1.22	1.68
hhd-sp-u	2593.69	16.04	0.40	0.00	0.00	0.00	1.34	1.05	1.78
hhd-bp-u	1732.45	7.18	0.60	0.00	0.00	0.00	1.11	0.87	1.75
hhd-snp-u	12676.00	60.14	0.32	0.00	0.00	0.00	0.70	0.55	1.04
hhd-bnp-u	11096.52	38.04	0.53	0.00	0.00	0.00	0.50	0.39	1.04

Source: DCGE simulation result

Impacts on Poverty

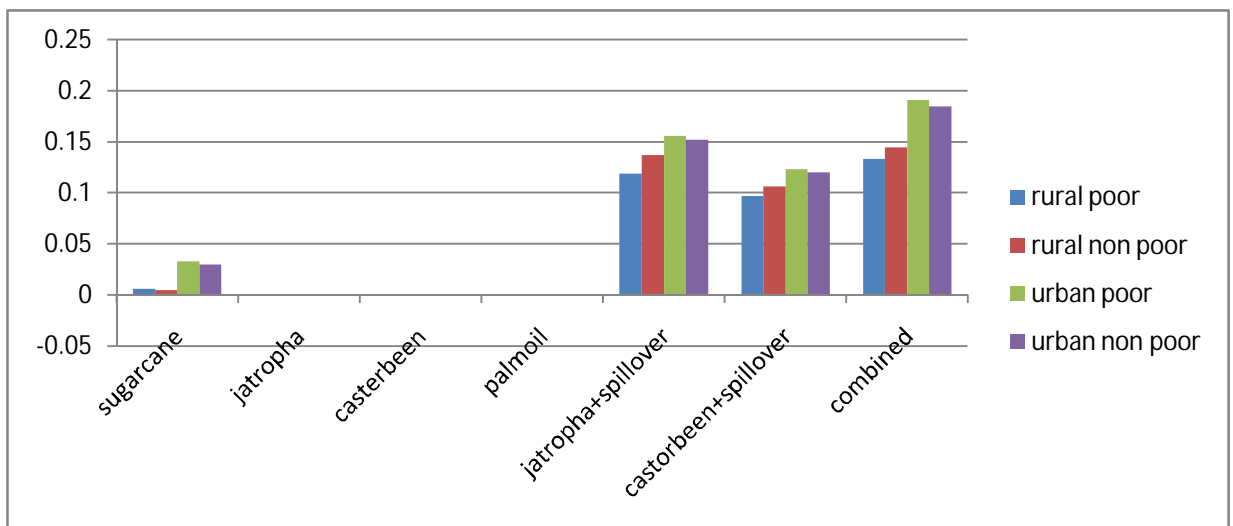
To analyze the poverty changes, we employed the DAD distribution analysis software that allows a microsimulation analysis of the FGT decomposable poverty indices using the 2004/05 HICE survey. In so doing, we used the percentage changes in consumption expenditure of household groups that are taken from the CGE model and linked it with the MS model in conducting the poverty analysis using the three poverty indicators.

Figure 5.1 presents simulation result from CGE which indicates changes in consumption growth from base line for all household groups. In the combined scenario, for instance, we found greater percentage increment than the others simulations where consumption grew by 0.13%, 0.14%, 0.19% and 0.18% for rural poor, rural non-poor, urban poor and urban non-poor, respectively. An almost similar trend is recorded in jatropha and castor bean scenarios involving spillover effects, while the sugarcane scenario improves consumption expenditure even though the magnitude is small. On the other hand, the jatropha, castor bean and palm oil scenarios have almost a null effect on all household groups' expenditure.

To examine the impacts of this consumption expenditure changes on poverty, the FGT poverty estimates are generated for households at national, rural and urban levels. Among the 21,594 households at national level; we found that 9,493 were rural and 12,101 were

urban²⁴. Since the SAM has delineated poor and non-poor households based on levels of consumption expenditure with the bottom 40% as poor, we needed to separate the poor and non-poor in rural and urban areas in the same manner. Rural and urban households were each divided into two categories taking the bottom 40% as poor and the top 60% as non-poor.

Figure 5.1 Household Consumption Expenditure (% change from baseline)



Source: CGE simulation result

As shown in figure 5.1, since consumption expenditures change for these four household categories differently, we made necessary adjustments on the consumption expenditures in the 2004/05 HICE survey using the CGE results for each policy simulation. That is, based on additional information on adult equivalent household size for the 2004/05 survey from CSA, we changed the consumption expenditures in the survey to consumption expenditure per adult equivalent. After this, we took approximate levels of

²⁴ Though the number of rural households is smaller in the survey, one point of note is that the number of people each sample rural household represents (weights) is very large compared to urban households.

consumption expenditure at the demarcation of the bottom 40% (two quintiles) to represent cut points for the national, rural and urban poor and non-poor households. So among rural households, we got 3,861 as poor and 5,632 as non-poor whereas among urban households, we got 4,751 as poor and 7,350 as non-poor. We then introduced the consumption changes on the base values of the four households after simulations from the CGE model. The new values we calculated are the ones we used in DAD to compute the FGT indices.

An important point to be noted here is the disparity that may be created in the poverty results when we compare it with the official levels of the poverty measures gathered from the 2004/05 HICE of CSA. The main reason is that the CSA used 1075.03 as poverty line that is CPI indexed to compute the FGT indices. But in this study, we are guided by the mechanism followed in the SAM that is to arrange the households based on expenditure in descending order and take the bottom 40% as poor. The consumption expenditure level at the demarcation of total households in the survey, 1782.98, is taken as the poverty line. This national poverty line is adjusted for the CPI in each simulation based on CPI values generated from the CGE model. Then, we came up with the results for the poverty measures.

Table 5.4 presents the results for the head count index. The head count index (poverty incidence) represents the proportion of poor households from total population. At the base run, we have 34.1%, 35.5% and 27.1% of poor at the national, rural and urban level respectively. Our analysis shows that poverty incidence is reduced at each level by

similar percentages in all scenarios except scenarios involving spillover effect and combined scenario.

In the sugarcane, jatropha, castor been and palm oil scenarios the national, rural and urban head counts declined by 2.89%, 2.97% and 2.51%, respectively. This could be explained by the increase in households' purchasing power due to the decline in the general prices (CPI). However, the decline in poverty indices in jatropha and castor been scenarios involving spillover effects and combined scenario is slightly less than that of other scenarios. For instance, at national level poverty decreased by 2.56%, 2.61% and 2.54% in jatropha and castor been involving spillover and combined scenarios in that order. This might be due to the slight decline in benefit that goes to the households as a result of lower agricultural (cereal) price. The initial increase in agricultural production due to spillover effects reduces price which in turn lowers return.

Table 5:4 Effects of simulations on poverty head count index (P_0) (% changes)

	base	sugarcane	jatropha	castor been	Palm oil	jatropha+	castor been+	combined
		scenario	scenario	scenario	scenario	spillover	spillover	
National	0.341	-2.89	-2.89	-2.89	-2.89	-2.56	-2.61	-2.54
Rural	0.355	-2.97	-2.97	-2.97	-2.97	-2.62	-2.68	-2.61
Urban	0.271	-2.51	-2.51	-2.51	-2.51	-2.23	-2.28	-2.22

Source: Micro simulation result

Table 5.5 shows the results for the poverty gap index. This index represents the mean aggregate consumption shortfall across the households relative to the poverty line. In other words, it denotes the mean distance separating the poor from the poverty line. The results imply similar changes like the head count index in the sense that the index decreases in all scenarios from the base and still a slightly lower decline is recorded in scenarios that involves spillover effects.

Table 5:5 Effects of simulations on poverty head count index (P_I) (% changes)

	base	sugarcane	jatropha	castorbeen	palmoil	jatropha+	castorbeen+	combined
		scenario	scenario	scenario	scenario	spillover	spillover	
National	0.089	-1.44	-1.44	-1.44	-1.44	-1.24	-1.29	-1.24
Rural	0.092	-1.50	-1.50	-1.50	-1.50	-1.29	-1.34	-1.29
Urban	0.070	-1.14	-1.14	-1.14	-1.14	-0.99	-1.02	-0.99

Source: Micro simulation result

Table 5.6 depicts the results for the poverty severity (squared poverty gap) index. This index takes into account not only the poverty gap but also the inequality among the poor as the poor also have differences in status. Hence, this poverty measure imposes higher weight on households that are found far below the poverty line. The table shows that poverty severity declines for all scenarios. We can also see from the results that, under all scenarios, inequality is reduced and this is more pronounced among the rural poor.

Table 5:6 Effects of simulations on poverty head count index (P_2) (% changes)

	base	sugarcane	jatropha	castorbeen	palmoil	jatropha+	castorbeen+	combined
		scenario	scenario	scenario	scenario	spillover	spillover	
National	0.031	-0.63	-0.63	-0.63	-0.63	-0.55	-0.57	-0.55
Rural	0.032	-0.66	-0.66	-0.66	-0.66	-0.57	-0.59	-0.57
Urban	0.024	-0.50	-0.50	-0.50	-0.50	-0.44	-0.45	-0.44

Source: Micro simulation result

In general, poverty analysis indicates that biofuel investment is largely pro-poor. Rural households are more beneficiaries from this investment. In all scenarios poverty head count, gap and severity at national, rural and urban level declines. However, important indication one has to note is that, poverty reduction in scenarios involving spillover effects is a bit lower than other scenarios without spillover effects. This might have been due to a reduction in return from agricultural (cereal) production caused by lower market prices. The spillover effect initially increases cereal production which in turn leads to lower price. In addition, contrary to welfare analysis results (using representative households) that jatropha, castor been and palm oil scenarios has no impact on households, the intra (within group) distribution analysis shows welfare improvement (poverty reduction) under the same scenarios. This could be due to the general decreases in prices under these scenarios. Savard (2005) demonstrated that in the extreme case, the result of poverty and income distribution analysis can be completely reversed by taking into account within-group distribution effects.

CHAPTER SIX

CONCLUSIONS AND POLICY IMPLICATIONS

6.1. Conclusions

This study investigates the economy wide impact of biofuel investment in Ethiopia using dynamic economic wide CGE model linked to MS model. The dynamic CGE model used the 2005/06 SAM and the MS model used the 2004/05 HICE survey. The dynamic CGE model is developed so as to capture the impact of biofuel investment by agro-ecological zones.

The descriptive analysis about current status of biofuel investment in Ethiopia indicates that there is huge expansion of ethanol development which is primary undertaken by the government. Out of the 83 investors that received license mainly to develop biodiesel only 6 foreign and 3 domestic private companies are operational. The main challenges of the investors are less suitability of the land for the biofuel feedstock production (productivity problem) and low levels of infrastructure development. Another important observation is increase of small-farmers' participation in growing biofuel feedstock in the way that doesn't risk food security. This participation could be beneficiary if there is a well functioning market for biofuel feedstocks.

Model results indicate that biofuel investment can provide Ethiopia with an opportunity to enhance economic growth and reduce poverty. Biofuel accelerate agricultural growth and improve food security. Specifically, the sugarcane scenario, jatropha and castor bean scenarios with spillover effects as well as the combined scenario increase overall

agriculture production and food security. Contrary to the ongoing critics that expansion of biofuel investment might exacerbate food insecurity our simulation shows the complementarities between ‘biofuel’ and ‘food’ (agricultural) production. In addition, biofuels’ production also improves households’ welfare. Furthermore, the benefits of biofuel investment are further increased if it results in technology spill over to other agricultural crops.

Our findings suggest that all biofuel production scenarios improve poverty status of all households. This investment is pro-poor and benefits the rural households more. In particular, biofuel production scenarios with spillover effects and the combined scenario have slightly lower impact on poverty than other scenarios. This result shows the decrease in the return from spillover effects due to decline in agricultural (cereal) price. Although, jatropha, castor bean and palm oil production scenarios have no impact on the households welfare (using EV result from CGE) our poverty analysis reveals poverty reduction under the same scenarios. This might be attributed to the general decreases in consumption prices.

6.2. Implications

The result suggests that biofuel investment is a good opportunity to enhance economic growth, food security, improve welfare and reduce poverty. Biofuels’ expansion also play vital role in stabilizing the macro economy by minimizing the dependence on oil import. This implies that, so as to further increase the gains from biofuel investment, it is important to expand biofuel investment on the land that is not occupied by smallholders

for cultivation. This can be achieved by expanding infrastructure developments and attracting investors by providing different incentives. It is also important to flourish biofuel feedstocks and products' market in order to increase biofuel developers' participation in producing and supplying biofuel feedstocks, processing and distributing biofuel.

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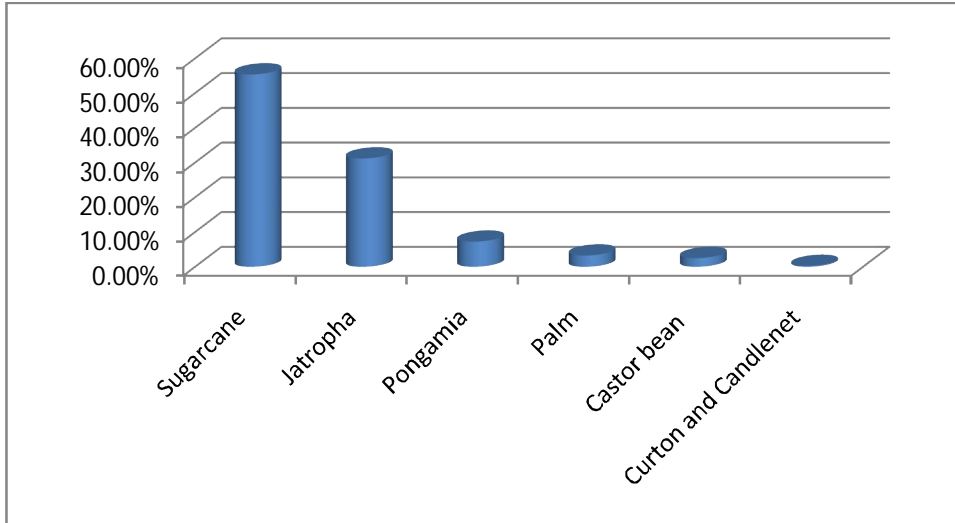
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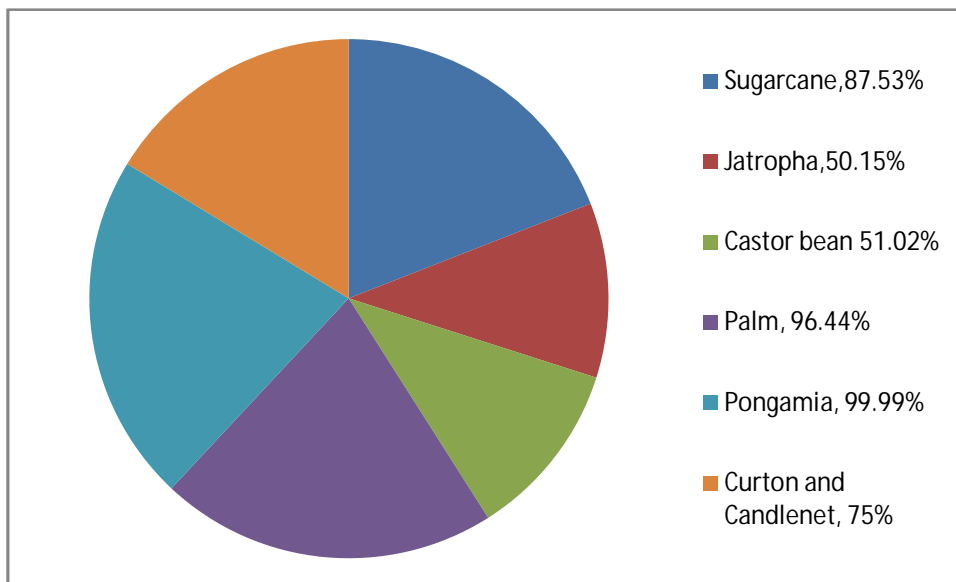
Appendices

Appendix A: Share in total biofuel crop land by biofuel crop type (%)



Source: MoWE, 2012 and SC, 2012

Appendix B: Ratio of unutilized land to total land allocated to each biofuel crop (%)



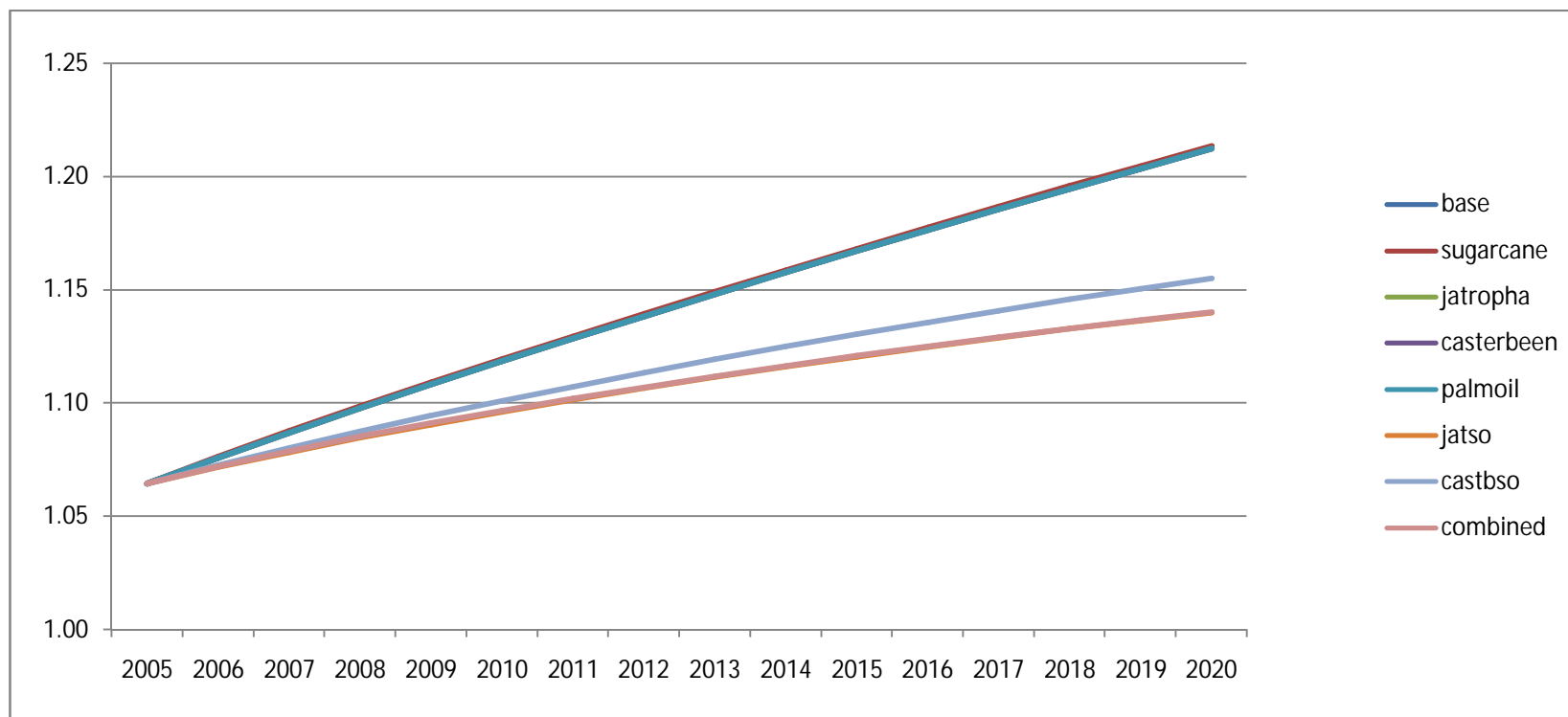
Source: MoWE, 2012 and SC, 2012

Appendix C: Land allocation per biofuel crops to operational developers

No.	biofuel Crops	Land under cultivation(ha)	Potential land(ha)	Total land(ha)	AEZs
1	Sugarcane	47,500	333,500	381,000	1, 2, 4,5
2	Jatropha	106,983	107,617	214,600	3,4
3	Castor bean	8,529	8885	17,414	4,5
4	Palm	800	21700	22, 500	1
5	Pongamia	7	49,993	50,000	4
6	Curton and Candlenet	500	1500	2,000	4
	Total	164,319	523,195	687,514	

Source: MoWE and own calculation

Appendix D: Impact on prices of cereals



Source: DCGE result

Appendix E: CGE Static Part “Within” Model

In this appendix the full formulation of the “within” or static CGE model and between (dynamic) is specified.

Sets, Parameters and Variables in the model

Sets

$\alpha \in A$ - Activities

$\alpha \in ALEO(\subset A)$ - 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

$c \in CM(\subset C)$ - 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)

$i \in INSD(\subset INS)$ - domestic institutions

$i \in INSDNG(\subset INSD)$ - domestic nongovernment institutions

$h \in H(\subset INSDNG)$ - households

Parameters (Latin Letters)

$cwts_c$ - weight of commodity c in the CPI

$dwts_c$ - weight of commodity c in the producer price index

ica_{ca} - quantity of c as intermediate input per unit of activity a

$icd_{cc'}$ - quantity of commodity c as trade input per unit c' produced and sold domestically

$ice_{cc'}$ - quantity of commodity c as trade input per exported unit of c'

$icm_{cc'}$ - quantity of commodity c as trade input per imported unit of c'

$int a_a$ - quantity of aggregate intermediate input per activity unit

iva_a - quantity of value-added per activity unit

\overline{mps}_i - base saving rate for domestic institution i

$mps01_c$ - 0-1 parameter with 1 for institutions with potentially flexed direct tax rates

pwe_c - export price (foreign currency)

pwm_c - import price (foreign price)

$qdst_c$ - quantity of stock change

$\overline{qg_c}$ - base – year quantity of government demand

$\overline{qinv_c}$ - base – year quantity of private investment demand

$shif_{if}$ - share for domestic institution i in income of factor f

$shii_{ii'}$ - share of net income of i' to i ($i' \in INSDNG$; $i \in INSDNG$)

$\overline{tins_i}$ - exogenous direct tax rate for domestic institution i

$tins01_i$ - 0 - 1 parameter with 1 for institutions with potentially flexed direct tax rates tm_c

- import tariff rate

tq_c - rate of sales tax

$trnsfr_{if}$ - transfer from factor f to institution i

Continued

Parameters (Greek Letters)

α^{va}_a - efficiency parameter in the CES value – added function

α^{ac}_a - shift parameter for domestic commodity aggregation function

α^q_c - Armington function shift parameter

α^t_c - CET function shift parameter

β^h_{ach} - marginal share of consumption spending on home commodity c from activity a
for household h

β^m_{ch} - marginal share of consumption spending on marketed commodity c for household
 h

δ_{ac}^{ac} - share parameter for domestic commodity aggregation function

δ_c^a - Armington function share parameter

δ_c^t - CET function share parameter

δ_{fa}^{va} - CES value –added function share parameter for factor f in activity a

γ_{ch}^n - subsistence consumption of marketed commodity c for household h

γ_{ach}^h - subsistence consumption of home commodity c from activity a for household h

θ_{ac} - yield of output c per unit of activity a

ρ_a^{va} - CES value – added function exponent

ρ_a^{ac} - domestic commodity aggregation function exponent

ρ_c^a - Armington function exponent

ρ_c^t - CET function exponent

Exogenous Variables

\overline{DPI} - producer price index for domestically marketed output

\overline{DTINS} - change in domestic institution tax share (= 0 for base; exogenous variable)

\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{WFDIST}_{fa} - wage distortion factor for factor f in activity a

Endogenous Variables

CPI - consumer price index

$DMPS$ - change in domestic institution saving rates (= 0 for base; exogenous variable)

EH_h - consumption spending for household

EXR - exchange rate (LCU per unit of FCU)

$GOVSHR$ - government consumption share in nominal absorption

$GSAV$ - government savings

$INVSHR$ - investment share in nominal absorption

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 price)

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 import 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

$QXAC_{ac}$ - quantity of marketed output of commodity c from activity a

$TABS$ - total nominal absorption

$TINS_i$ - direct tax rate for institution i ($i \in INSDNG$)

$TRII_{ii'}$ - transfer from institution i' to i (both in the rest $INSDNG$)

WF_f - average price of factor f

YF_f - income of factor f

YG - government revenue

YI_i - income of domestic non-government institution

YIF_{if} - income to domestic institution i from factor f

Model Equation

Price Block

[1] Import price

$$PM_c = pwm_c.(1 + tm_c).EXR + \sum_{c \in CT} PQ_c.icm_{c,c} \quad c \in CM$$

[2] Export price

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

[3] Demand price of domestic non-traded goods

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

[4] Absorption

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c \quad c \in (CD \cup CM)$$

[5] Marketed output value

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c \quad c \in CX$$

[6] Activity price

$$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac} \quad a \in A$$

[7] Aggregate intermediate input price

$$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca} \quad a \in A$$

[8] Activity revenue and costs

$$PA_a \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \quad a \in A$$

[9] Consumer price index

$$CPI = \sum_{c \in C} PQ_c \cdot cwtsc$$

[10] Producer price index for non-traded market output

$$\overline{DPI} = \sum_{c \in C} PDS_c \cdot dwts_c$$

Production and Trade Block

[11] Leontief technology: Demand for aggregate value-added

$$QVA_a = iva_a \cdot QA_a \quad a \in ALEO$$

[12] Leontief technology: Demand for aggregate intermediate input

$$QINTA_a = int_a \cdot QA_a \quad a \in ALEO$$

[13] Value-added and factor demands

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

[14] Factor Demand

$$WF_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot QF_{fa}^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot QF_{fa}^{-\rho_a^{va}-1} \quad a \in A \quad f \in F$$

[15] Disaggregated intermediate input demand

$$QINT_{ca} = ica_{ca} \cdot QINTA_a \quad a \in A; \quad c \in C$$

[16] Commodity production and allocation

$$QXAC_{ac} + \sum_{h \in H} QHA_{ach} = \theta_{ac} \cdot QA_a \quad a \in A; \quad a \in CX$$

[17] Output aggregation function

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

[18] First-order condition for output aggregation function

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

[19] Output transformation (CET) function

$$QX_c = \alpha_c^t \cdot (\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t})^{\frac{1}{\rho_c^t}} \quad c \in (CE \cap CD)$$

[20] Export-domestic supply ratio

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

[21] Output transformation for non-exported commodities

$$QX_c = QD_c + QE_c \quad c \in (CD \cap CEN) \cup (CE \cup CDN)$$

[22] Composite supply (Armington) function

$$QQ_c = \alpha_c \cdot (\delta_c \cdot QM_c^{-\rho} + (1 - \delta_c) \cdot QD_c^{-\rho})^{\frac{1}{\rho}} \quad c \in (CM \cap CD)$$

[23] Import-domestic demand ratio

$$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c}{1 - \delta_c} \right)^{\frac{1}{1 + \rho}} \quad c \in (CM \cap CD)$$

[24] Composite supply for non-imported outputs and non-produced imports

$$QQ_c = QD_c + QM_c \quad c \in (CD \cap CMN) \cup (CM \cup CDN)$$

[25] Demand for transaction service

$$QT_c = \sum_{c' \in C'} (icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'}) \quad c \in CT$$

Institutional Block

[26] Factor income

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \quad f \in F$$

[27] Institutional factor incomes

$$YIF_{if} = shif_{if} \cdot [YF_f - trnsfr_{rowf} \cdot EXR] \quad i \in INSD; f \in F$$

[28] Income of domestic, non-government institutions

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{gov} \cdot \overline{DPI} + trnsfr_{irow} \cdot EXR \quad i \in INSDNG$$

[29] Intra-institutional transfers

$$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - TINS_{i'}) \cdot YI_{i'} \quad i \in INSDNG; i' \in INSDNG'$$

[30] Household consumption expenditure

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1 - MPS_h) \cdot (1 - TINS_h) \cdot YI_h \quad h \in H$$

[31] Household consumption demand for marketed commodities

$$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma_{ac'h}^h \right) \quad c \in C; h \in H$$

[32] Household consumption demand for home commodities

$$PXAC_{ac} \cdot QHA_{ach} = PXAC_{ac} \cdot \gamma^h_{ach} + \beta^h_{ach} \cdot \left(EH_h - \sum_{c \in C} PQ_c \cdot \gamma^m_{c'h} - \sum_{a \in A} \sum_{c \in C} PXAC_{ac} \cdot \gamma^h_{ac'h} \right)$$

$a \in A ; c \in C \quad h \in H$

[33] Investment demand

$$QINV_c = \overline{IADJ} \cdot \overline{qinv}_c \quad c \in CINV$$

[34] Government consumption demand

$$QG_c = \overline{GADJ} \cdot \overline{qg}_c \quad c \in C$$

[35] Government revenue

$$YG = \sum_{i \in INSDNG} TINS_i \cdot YI_i + \sum_{c \in CM} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c$$

$$+ \sum_{f \in F} YIF_{govf} + transfr_{govrow} \cdot EXR$$

[36] Government expenditure

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} transfr_{i\ gov} \cdot \overline{DPI}$$

System Constraint Block

[37] Factor market

$$\sum_{a \in A} QF_{fa} = \overline{QFS}_f \quad f \in F$$

[38] Composite commodity markets

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

[39] Current account balance for the rest of the world (in foreign currency)

$$\sum_{c \in CM} pwm_c \cdot QM_c + \sum_{f \in F} transfr_{rowf} = \sum_{c \in CE} pwe_c \cdot QE_c + \sum_{i \in INSD} transfr_{irow} + \overline{FSAV}$$

[40] Government balance

$$YG = EG + GSAV$$

[41] Direct institutional tax rates

$$TINS_i = \overline{tins}_i \cdot (1 + \overline{TINSADJ} \cdot tins01_i) + \overline{DTINS} \cdot tins01_i \quad i \in INSDNG$$

[42] Institutional savings rates

$$MPS_i = \overline{mps}_i \cdot (1 + \overline{MPSADJ} \cdot mps01_i) + \overline{DMPS} \cdot mps01_i \quad i \in INSDNG$$

[43] Saving-investment balance

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

[44] Total absorption

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

$$+ \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$$

[45] Ratio of investment to absorption

$$INVSHR.TABS = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$$

[46] Ratio of government consumption to absorption

$$GOVSHR.TABS = \sum_{c \in C} PQ_c \cdot QG_c$$

Appendix F: The ‘Between’ Model

[1] Average capital rental rate

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

[2] Share of New Capital

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

[3] Quantity of new capital by sector

$$\Delta K^a_{fat} = \eta^a_{fat} \cdot \left(\frac{\sum_a PQ_{ct} \cdot QINV_{ct}}{PK_{ft}} \right)$$

[4] Unit price of capital

$$PK_{ft} = \sum_c PQ_{ct} \frac{QINV_{ct}}{\sum_{c'} QINV_{c't}}$$

[5] Average capital rental rate

$$QF_{fat+1} = QF_{fat} \cdot \left(1 + \frac{\Delta K^a_{fat}}{QF_{fat}} - v_f \right)$$

[6] Average capital rental rate

$$QFS_{ft+1} = QFS_{ft} \cdot \left(1 + \frac{\sum_a \Delta K_{fat}}{QFS_{ft}} - v_f \right)$$
