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Analysis of Economic Growth, Income Distribution and Poverty in Ethiopia using Computable General Equilibrium Model

By

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A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirement for the Degree of

Master of Science in Economics Policy Analysis

Addis Ababa University
Economics Department

July 2006
Addis Ababa

Addis Ababa University
School of Graduate Studies

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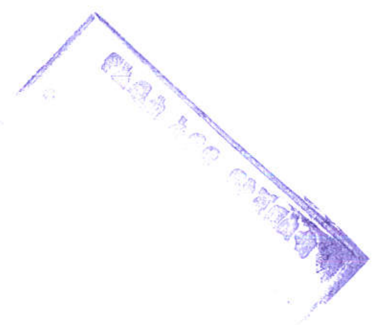

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Acknowledgment

At First, may all the honor and glory be extended to the exalted Heavenly God, for His help and guidance and encouragement which has enabled me to complete my work despite difficulties.

This paper is the result of the cooperation of many individual. I am very grateful to my adviser, Dr. Tekie Alemu for his valuable critiques, helpful comments and constant encouragements through out the study. I would also want to thank my friends, Tadel Ferede, Debel Gemechu, and Kassahun Tadesse for providing me all the necessary data, softwares and reading materials. I am also indebted to all my friends , especially Rahel Shehmole, Nega Meaza, Leulseged Tadesse, Misganu Arega, and Andnet Delelegn. Their moral and material and all sided support helped me a lot to finish the paper. I should also want to thank my sister Hanna Israel, and families for all their care and love through out my academic career. Last but not least, I thank very much all my friends in office and other persons that helped me to succeed my study.

Abstract

This paper presents the nature of the links between economic growth, poverty and income distribution, a central question to the study of economic development. The model adapted was the simple non-dynamic Computable General Equilibrium (CGE) model developed by International Food Policy Research Institute (IFPRI) and those used by Cogneau and Robilliard. CGE model takes into account market interaction, that is, the effects of pricing outcomes of one market in other markets, and its effects, in turn, creating ripples throughout the whole economy, perhaps even to the extent of affecting the price-quantity equilibrium in the original market. The underlying Social Accounting Matrix (SAM), which provides initial values for variables and parameters in the model, is taken from Alemayehu and Tadeles' 1999 SAM. Given the limitations of CGE models, econometric estimations is carried out to handle the households agricultural production function using the Ethiopian Rural Household Survey (ERHS). To explore the impact of an increasing agricultural productivity on poverty and inequality, simulation exercises are performed. Then, the mean income elasticity of the Foster-Greer-Thorbeck (FGT) poverty indices are estimated to examine its poverty impact. Inequality effects are explored by estimating Gini index for rural and urban households by using the Generalized Quadratic (GQ) Lorenz curve.

Key words: computable general equilibrium (CGE), growth, poverty, inequality.

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LIST OF ACRONYMS

ADLI	Agricultural Development Led Industrialization
CD	Cobb-Douglas Production Function
CET	Constant Elasticity of Substitution
CGE	Computable General Equilibrium Model
CPI	Consumer Price Index
CSA	Central Statistic Authority
EPRDF	Ethiopian People Revolutionary Democratic Front
ERHS	Ethiopian Rural Household Survey
FGT	Foster-Greer-Thorbeck
GAMS	Generalized Algebraic Modeling System
HIPC	Highly Indebted Poor Countries
IFPRI	International Food Policy Research Institute
MoFED	Ministry of Finance and Economic Development
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Square Estimation
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PRSP	Poverty Reduction and Strategic Paper
RES	Rest of the World
SAM	Social Accounting Matrix
SDPRP	Sustainable Development and Poverty Reduction Paper

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CHAPTER ONE

INTRODUCTION

1.1 Background

Ethiopia is one of the oldest countries in the world which has been enjoying a long period of independence. Though the country is endowed with diverse cultural heritage and large and ever-increasing population[1] that could ensure effective demand, and available natural endowments, there has been little base for generating growth and enjoying the benefits thereof. To the dismay and tragedy of its people the country has eluded prosperity and wealth and remained poor. A number of reasons, ranging from prolonged war, bad economic management, low productivity, structural bottlenecks, dependence on unreliable rainfall, etc, have been suggested for such an outcome.

Ethiopia is a country characterized by extreme poverty in terms of both assets and income. Several studies show that large proportions of its population lives under abject poverty in both urban and rural areas. The Household Income and Expenditure Survey conducted by the Central Statistical Authority (CSA) in 1999/00 estimates that about 45% and 37% of the rural and urban population, respectively lives under the absolute poverty line (MoFED, 2002). Income poverty is widespread and deep. Some 31 million people live below a poverty line equivalent to 45 US cents per day. Based on 2000 poverty analysis, a 44% head count ratio and between 6 and 13 million people are at a

[1] Central Statistics Authority estimate for July 2006 it at about 75 million peoples.

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risk of starvation each year. There is also extreme vulnerability, with consumption rising and falling dramatically from year to year resulting from drought, ill health, or other family shocks. As a result, many families who are not currently poor are at constant risk of falling into poverty, and can never accumulate enough assets to get out of poverty (MoFED, 2005).

The prolong civil war that lasted until the overthrow of the Derg regime (1991) resulted in intricate economic problems: in the form of, among others, destroyed productive assets. Moreover, the socialist strategy of development exacerbated poverty, particularly in rural areas (Addison, 2003). However, the EPRDF government that came to power in 1991 was committed to economic reforms. Some of the key areas are: tight fiscal and monetary policies, devaluation, price deregulation, financial and trade liberalization, and privatization (ibid.) Moreover, the government introduced Agricultural Development Led Industrialization (ADLI) as it major policy program to achieve higher growth and reduce both rural and urban poverty.

This strategy is upheld with an emphasis on agriculture as the generator of primary surplus, taking advantage of backward and forward linkages, to fuel the transition of a more modern economy. The approach remains basically sound; it places an appropriate emphasis on raising the incomes of the rural population, who constitute 85% of the population, and over 90% of the poor, and who are almost exclusively engaged in agriculture. However, the full potential of agricultural growth has not yet been realized,

and intensification of the strategy seems to be required. More broadly, the overall growth performance has not yielded the hoped-for poverty-reduction results as yet.

1.2 Statement of the Problem

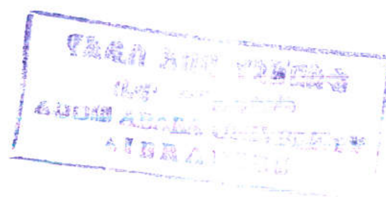
Although poverty reduction has become a central global agenda, there is still an ongoing debate on the policies that would help to attain the objective (Cashin et al, 2001). There is a consensus that the main objective for development efforts is to reduce poverty, which can be accomplished by economic growth and/or by an active policy of income redistribution. However, there may be a trade-off, i.e. if reducing inequalities brings quicker reduction in poverty, then distribution policy will take upper hand; and on the other hand if is it is growth which will bring down poverty fast, it will take the priority. Thus, the relationship between growth and inequality are important from a policy perspective (Bigsten and Levin, 2001).

Kuznets famous hypothesis of an inverted-U pattern - inequality may increase at early stage of development, but as growth continues it declines- has set the main structure for theoretical argument linking growth and inequality (Cogneau and Robilliard, 2000: 3). The empirical literature, however, seems to lead to contradicting conclusions. Among many, Deininger and Squire (1998) and Ravallion and Chen (1997) did not find any systematic relationship between the rate of growth and inequality. On the other hand, Bell and Rich (1994) and Dollar and Kraay (2000) showed a relationship between per capita income growth and poverty reduction. The consensus, however, tends to favor economic policy aimed at rapid growth as a vital ingredient to reduce poverty.

The well structured theoretical argument on the link between growth and inequality has started with Kuznets "analysis of the historical evolution of inequality in the development of Germany and United Kingdom". (Cogneau and Robilliard, 2000: 3). In his finding, growth-inequality links were show as an inverted-U pattern. That is, at early stage of development inequality may increase. But as growth continues to increase and hence per capita income increases, inequality begins to decline. The underpinning cause assumed was "structural change in a dual-economy setting, in which labor was shifted from a poor and relatively undifferentiated traditional sector , to a more productive and more differentiated, modern sector". (Bigsten andLevin, 2001: 9). The empirical literature seems to lead to contradicting conclusions. Deininger and Squire (1998) found no evidence supporting Kuznets popular an inverted-U hypothesis. Similarly, Ravallion and Chen (1997) did not find any systematic relationship between the rate of growth and inequality. On the other hand, there also empirical studies showing a very strong relationship between per capita income growth and poverty reduction.[2] This suggests, in tandem with empirical results, that economic policy aimed at rapid growth is a vital ingredient in a strategy to reduce poverty.

Among the alternative development strategies, there has been an agreement in focusing increasing agricultural productivity as an elixir to reduce poverty (DfID,2005). That is, increasing agricultural productivity will directly increase income of the farm household and as a corollary reduce poverty as households' capability to command over commodities increases. The best experience often mentioned is the Green Revolution in

[2] Other studies supporting positive effects of growth on poverty are Ravallion (1993), Ravallion and Datt (1994), Bell and Rich (1994), and Dollar and Kraay (2000).



the East Asian Countries (Abrar and Mosley, 2006). However, when one takes the indirect effects coming through food grain prices, labor markets, and farm-non-farm linkages into account, the issue gets more complicated i.e. measuring the magnitude of direct and indirect effects separately is not an easy staff (ibid.)

Although there are still serious problems in measuring impacts of increasing agricultural productivity, the policy has long been adopted by many African governments and supported by the donor communities (ibid.) Ethiopia is not an exception in this regard. Currently, the main focus of research in this areas is either on sources of agricultural productivity (Abrar et al, 2004 and Croppenstedt et al, 2003) or on measuring the extent and profile of poverty (Bigsten et al, 2003, Dercon and Krishnan, 2003) leaving out possible systematic linkage between agricultural productivity increase and poverty. Abrar and Mosley (2006), however, undertook such a study using a multi-market model. Another alternative to measure such a linkage is to use a CGE model which is designed to take both direct and indirect effects of a given policy change (shock).

This paper attempts to assess the impact of increasing agricultural productivity in reducing poverty. It puts in to test the major policy program, i.e. Agricultural Development Led Industrialization (ADLI) policy of the EPRDF government. The standard CGE model developed by International Food Policy Research Institute (IFPRI) has been used to aid our work.

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1.3 Objective of the study

The objectives of the thesis are: -

- ► Reviewing growth, inequality and poverty in Ethiopia since 1991
- ► analyze the impact of Agricultural Development led Industrialization ADLI) strategies on poverty and inequality using CGE model.

1.4 Methodology and Data Source

In this paper, we adapted the simple non-dynamic Computable General Equilibrium (CGE) model developed by International Food Policy Research Institute (IFPRI) and those used by Cogneau and Robilliard. The underlying Social Accounting Matrix (SAM), which provides initial values for variables and parameters in the model, is taken from Alemayehu and Tadeles' 1999 SAM. (Alemayehu and Tadele, 2004). Given the limitations of CGE models (see the literature review) we used econometric estimations to handle the households behavioral equations (combined production and consumption decisions) and reported separately. The Ethiopian Rural Household Survey (ERHS) supplied the basic data for such an exercise (for the detail see chapter 4).

1.5 Significance of the Study

Most of poverty related studies in Ethiopia are based on micro level data drawn from accessible household surveys recently made available including the household expenditure survey conducted by AAU and CSA. Linking macroeconomic policymaking impacts on households' poverty status has gotten a little attention. Some of the attempts,

however, are those done by Abbi (1996), Abebe and Bereket (1995), Mekonen (1996), and Bereket and Abebe (1997). The CGE model employed was the ones developed by the then ONNCP (now MoFED) in collaboration with the University of Oxford and a recently developed 1-2-3 model (one country, two sectors, and three commodities) by the World Bank in 1998.

The first model was based on a SAM that takes year 1987 as its base year and disaggregated only the agricultural sector in a relative detail way while treating the remaining sectors as a single one. No distinction was made between tradable and non-tradable commodities. The latter model is a highly aggregated one and does not allow any study aiming at establishing a macro-micro link. Following this Kassahun (2001), had used the more aggregate SAM developed by Ayele (2000). In this paper, however, we used the CGE calibrated on a more disaggregated SAM developed by Alemayehu and Tadele (1999). This will hopefully serve in improvements for building a full-fledged CGE for Ethiopia. Moreover, it helps to see the impact of growth on poverty reduction (as it was highly upheld in the PRSP) in retrospect by exercising simulations. This, by extension, may contribute to revisit growth impact on poverty reduction as the country embarks on the second round of PRSP renamed as Plan for Accelerated and Sustained Development to End Poverty (PASDEP) for the year 2005/6-2009/0.

1.6 Organization of the paper

The paper is organized as follows. The second chapter is devoted to the brief overview of the country growth, poverty, and inequality since 1991 and a survey of relevant literature. Presentation of the SAM, the CGE applied in the study, and the microeconomic basis of the model are introduced in chapter three. Chapter four discusses results from the calibration and simulations of the research. The last chapter concludes the paper.

CHAPTER TWO

2.1 Brief overview of Growth, Inequality and Poverty in Ethiopia since 1991.

2.1.1 Economic Reform and Performances

The agonizing civil war and the socialist ideology that the country had entertained resulted in an enormous economic damages; i.e, destruction of productive assets, social upheavals, resource diversion from productive sector, capital plight, etc (Daniel, A. et al 2003). During its final days the Derg proclaimed mixed economy as a way out but it availed little. In the end, it had to give way to the Ethiopian Peoples' Revolutionary Democratic Front (EPRDF). The initial conditions of the transfer of power were teemed with maze of problems and confusions of economic, social and political issues. It was summarized as follows:

> The economy had a very low per capita income, and infrastructure that had always been inadequate but had been further damaged by the war and by the depredation of state socialism. This damage certainly included physical infrastructure such as roads, bridges and the like, but it also involved institutional structures such as markets and regular economic migration. Private as well as public investment have been very low, soothe overall productive capacity of the economy was probably deteriorating, even leaving explicit damage aside. (Addison and Bevan. 2003: 230-231).

The new government (EPRDF) that has come to power undertook a number of reforms to tackle these problems. These can seen as a series of phases. The first phase reform, undertaken during 1992/93-1994/95 includes devaluation of birr, introduction of new

interest rate structure, rationalization of public expenditure, new investment, labor and public enterprise laws, decontrolling of internal market, transport, trade, price deregulation, etc (MoFED, 1998). In the second phase (1994/95-1996/1997), focus was given to the creation of fertile environment for labor-intensive growth, confining government roles to selected economic activities, and enhancing private sector activity and investment (ibid). These objectives were aimed to be achieved by implementing the Agricultural Development Led Industrialization (ADLI) and mobilizing both internal and external resources (ibid). In the third phase, in addition to the former once, the government has made a commitment to reduce poverty by engaging in a broad based economic growth within a stable macroeconomic environment. One notes that, during Ethio-Eriteria war: most of the programs (sponsored by donors) were frozen.

In July 2002, the government had finalized its Sustainable Development and Poverty Reduction Paper (SDPRP) which was set as a requirement to draw benefits embedded in the enhanced Highly Indebted Poor Countries (HIPC) initiative. The core program of the government was to reduce poverty while maintaining macroeconomic stability. Starting in 2005 the government has moved into the second phase of SPDRP after revising and renaming it A Plan for Accelerated and Sustainable Development to End Poverty (PASDEP). In all reforms the conventional monetary and fiscal policies were invoked when situations demands (ibid).

The rewards from the aforementioned reforms were not observed quickly. The reasons for such retarded performance could be identified as the Derg's desperate and

irresponsible fiscal policy in the verge of its dooms day cause huge deficits, wars negative residuals impacting on social capital and aggravating investment risks, political confusions, etc (Collier, 1999). As a result the growth rates were small for the first few years of the reform. After 1993, however, growth was high until interrupted by the drought in 1997/98 and the Ethio-Eriteria war from 1998/99-2000.

Although money supply has increased during this period, inflation rate is low. Capital formation has been increasing until it reached 20% immediately before the war. Trade deficit, however, has rose above 10% and remained there. There was a stable exchange rate though it came under pressure after the war (see Table 2.1)

Table 2.1. **Macroeconomic Indicators 1990/91-2004/05**

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05
GDP growth rate(%)	-4.4	-3.7	12.4	1.7	5.4	10.6	5.6	0.5	6.0	5.4	7.4	-0.3	-3.8	11.3	8.9
Inflation rate(%)	20.9	21	10	1.2	13.4	0.9	-6.4	2.3	3.9	4.2	-5.2	-7.2	15.1	9.0	6.8
Gross domestic expenditure as % of GDP at current prices															
Consumption	97	97	94.3	94.9	93.3	93.4	91.4	90.9	98.6	92.1	91.6	91.9	92.5	95.1	94.5
Gross fixed capital formation	10.4	9.2	14.2	15.1	16.4	19.1	19	20.2	16.3	15.3	20.7	23.5	22.7	21.3	21.2
Resource gap	-7.4	-6.2	-8.5	-10	-9.7	-12.5	-10.7	-11.1	-14.9	-12.3	-12.3	-15.4	-15.2	-16.3	-15.7
Fiscal data (as shares of GDP)															
Domestic revenue	14.1	10.6	12.0	13.9	17.5	18.4	19.2	18.5	17.9	15.4	15.6	16.5	16.4	16.6	16.1
External grants	2.4	2.6	1.7	3.5	3.3	2.9	3.6	3.7	3.6	2.4	4.3	3.9	6.7	4.8	4.6
Total expenditure	25.3	20.2	19.5	25.0	24.8	26.9	24.1	23.6	30.0	33.1	25.2	26.5	29.1	24.1	25.4
Recurrent	19.0	15.6	12.9	15.5	15.4	14.7	13.8	12.8	20.9	26.5	19.3	20.9	21.4	18.7	19.8
Capital	6.3	4.6	6.7	9.5	9.3	9.4	10.4	10.1	9.1	6.6	5.9	5.6	7.7	5.4	6.6
M2 growth (%)	18.6	13.1	16.7	10.2	26.9	8.3	5.7	12.7	5.9	14.0	10.5	11.4	10.1	15.2	19.6
Trade balance % of GDP	-8.1	-7.2	-13.1	-13	-11.2	-16.6	-12.5	-12.2	-15.9	-33.9	-6.3	-6.6	-1.9	-5.1	-4.3
Exchange rate (birr/us$)	2.07	2.07	4.27	5.8	8.25	6.32	6.51	6.88	7.53	8.1	8.35	8.5	8.6	8.6	8.7

Source: Bigsten (2003) and MoFED (2002 and 2005).

During the aftermath of the war, things started to change for the good; i.e, the GDP growth rate is increasing, inflation and fiscal deficit are going down, etc. On the other side, the exchange rate seems to be stable over the whole period although it came under pressure following the war with Eritrea (MoFED, 2005).

2.1.2 Poverty and Inequality Trends

The reasons for poverty are either low average incomes, or skewed income distribution, or both. Thus, to reduce poverty one needs to either achieve faster economic growth, or redistribute income in favor of people lower levels of income, or design policies that ensure growth of income of the poor (Addison and Bigsten, 2003).

Given the dismal economic growth rates of the country, sustained economic growth is suggested as a means to alleviate poverty in Ethiopia. However, if this is achievable only at a cost of increased income inequality, then there emerges a policy dilemma (Bigsten, 2003). Another area of contention has been whether the incidence of poverty is higher in rural or urban areas. Study with MoFED suggest the former, 'but estimates using pnel data for 1994-1997 and the poverty line estimates derived by Mekonen Taddesse *et al.* (1998) suggest that urban-poverty incidences are actually higher". Addison and Bigsten, 2003: 110). Given large proportion of the population (85%) living the rural area, it is clear that most poor found there.

The Household Income and Consumption Expenditure Survey conducted by the Central Statistic Authority (CSA) in 1995/96 show that rural and urban poverty rates at 47% and 33.3% respectively. The same survey, undertaken in 1999/00 show poverty rates of 45% for rural and 37% for urban areas: decline of rural poverty by 4.2% and an increase in urban poverty by 11.1%. Nevertheless, the majority of the poor lives in the rural area (see Table 1.2).

Table 1.2. Trends in Poverty Head Count Indices (Po) by Rural and Urban Areas(%)

Location	1995/96	1999/2000	% change over 1995/9
Rural	47.0	45.0	-4.2
Urban	33.3	37.0	11.1
Total	45.5	44.2	-2.9

Source: MoFED 2002

MoFED (2002) indicates that income distribution is less equitable both in urban and rural areas. Gini coefficient estimate for the overall income inequality was 0.28 in 1999/00. But urban inequality swinging at .38 was higher than that of the rural scaling at 0.26. The figures were 0.27 and 0.34 for rural and urban area in 1995/96. This shows slight inequality decline in rural area while the urban increased.

2.2 Review of Relevant Literature

2.2.1. Definition of Poverty

At first instance the concept of poverty seems straight forward, which is not worth to discuss it in detail. However, once one indulges himself in this concept s/he can easily understand that even the term poverty is far from obvious. Defining poverty inevitably entails passing judgment on who is poor and who is not. At the same time, different definitions of poverty can lead to the design of very different policy measures to reduce poverty (Glewwe and Gaag, 1990; Hagenaars and de Vos, 1988). This shows that defining the word poverty has a crucial role in poverty analysis.

In the literature there are three main approaches in analyzing poverty: the welfare approach, the basic needs approach and capability approach. Although each approach adopts different ways to define poverty and to identify the poor, they are both dichotomous and judge a person to be poor whenever he or she is lacking, with respect to a reasonable minimum, the particular thing in question as discussed in Rowntree (1901)and Atkinson (1975) (cited in Ravallioin et al, 1995). The debate about poverty between these approaches is in taking up the nature of that missing thing.

In the welfare approach poverty is associated with economic well-being. Poverty is usually used to mean the situation when one is unable to meet a level of economic welfare deemed to constitute a reasonable minimum, either in absolute or relative sense to a certain standard (Lipton and Ravallion, 1995). Strengmann-Kuhn (2000) formalizes the definition as follows. Given W_i is the welfare attained of individual i, W_{min} is the welfare below which a person is

considered to be poor and P is the set of poor individuals, i is poor if (and only if) i's individual welfare W_i is lower than W_{min}, and is not poor otherwise. That is, $W_i < W\min \Leftrightarrow i \in P$. This approach basically falls back on real income and consumption expenses as indicators of well-being if one assumes that these are the constituents of welfare and hence it is identified as 'the income approach' to poverty. Welfare and public policy decisions comparisons are based on the preference of individuals. It avoids passing subjective judgments that are incompatible with individual behavior.

An alternative to the above is the basic needs approach which considers the things that are lacking in the lives of the poor as a set of goods and services specifically identified and deemed to meet the basic needs of all human beings. The goods in question are called 'basics' in the sense that their satisfaction is seen as a pre-requisite to quality of life; they are not initially perceived as generators of well-being (Kabeers, 1994). The basic goods and services are summarized as: adequate nutrition, shelter, clothing and others like basic education (Streeten et al. 1981; Richards and Leonor, 1982).

This approach argues that the set of basic goods and services needed is different for different individuals depending on age, sex, type of activity, etc. One of the major problems in this approach is the difficulty in identifying what constitutes 'basic needs' (Lipton and Ravallion, 1995). Moreover, measuring the cost of it is also problematic. It is recorded that much of the literature on poverty in developing countries has taken economic welfare to refer to a person's consumption of goods and services, and the 'reasonable minimum' is used to mean predetermined basic consumption needs (ibid).

The other approach, which is closely related to the basic need approach, in motivation, but entailing a more fundamental re-definition of 'poverty', is Sen's 'capabilities' approach. Its roots lie in the rejection of the "welfare" approach in which individual utility is taken to be the sole metric of welfare, and the sole basis for social choice (Sen, 1979, 1985 and 1987). Commodities are viewed not as ends but as means to desire; welfare depends on a host of factors including personal and environmental circumstances of an individual (Sen, 1987). In short, for this school, the thing that is missing is neither utility nor getting the basic needs; it is, however, human abilities or capabilities to achieve a set of functioning.

The relevant set of functioning can vary from such elementary physical ones as being well nourished, being adequately clothed and sheltered, avoiding preventable morbidity, etc to more complex social achievements such as taking part in the life of the community, being able to appear in public without shame and so on. These are rather general and the specific form that their fulfillments may take would tend to vary from society to society (Sen, 1992). This school, thus, considers an individual as poor if that person does not have the possibility to achieve a certain set of functioning.

All the aforementioned definitions take poverty as absolute, relative, and a mixture of both. Following Liu and Wu (1998) and Ravallion (1992), the absolutist approach to defining poverty begins with the concept of "minimum subsistence", i.e., some bundles of goods and services that are regarded as essential to the physical need (minimum caloric intake essential to human existence) of an individual or a household. Poor are those who lack the means

(economic resources) to obtain it. A major critic is its ignorance of the social needs-peoples are not simply individual organisms requiring replenishment of physical energy.

In the relative approach (more important in developed countries), the mean or median value of national income represents the economic indicator which proxies the dominant life style in the population (ibid). An individual or a family whose income is less than that value can be defined poor as s/he has no means to lead that life style.

> "if all income increase by the same proportion then the relative poverty measure would remain totally unchanged-there would be no change in relative inequalities and so the Lorenz curve would not change. And the poverty line would simply increase by the same proportion". (Ravallion, 1992: 30).

Critics are: first, it perpetuates poverty in the sense that some fixed proportion of the population is always regarded as poor. Second, while a relative measure of poverty can give an estimate of the size of the poor, it cannot provide any information on the quality of life of the poor (ibid).

2.2.2. Measurement of Poverty

Measuring poverty is as important and difficult as defining it. It mainly entails enabling poverty comparisons that are needed for the purpose of assessing a country's progress in poverty alleviation and/or evaluating policies and projects (United Nations, 1996). There are a lot of instruments that used to measure the type and extent of poverty in a given society. These instruments are: poverty line and poverty index.

In poverty analysis, the most important issue that has to be addressed first is to determine whether the individual is poor or not. For this purpose, poverty line plays an important role in categorizing the population into poor and non-poor. The argument is that there is a minimum level of consumption of goods i.e. food, cloth, shelter, etc. below which it is difficult to sustain life. So in order to define the poverty line, the level and types of goods must be precisely identified. However, the debate is how to exactly arrive at these levels and types of goods for any given individual/household. Following the different definitions, three alternative approaches (Ravallion, 1992) spotted in building poverty line: absolute, relative, and subjective poverty lines. The most difficult task in poverty analysis is setting the poverty line. Once this line is identified, the next step is to calculate poverty indices, which help us to see the incidence and intensity of poverty. The three most commonly used poverty indices in the literature are: the head count, poverty gap and FGT indices.

The Head Count Index (Po)

It is an index that tells us the proportion of the population for whom consumption (or any other suitable measure of living standard) is less than the predetermined poverty line. Although it is easily understood and communicated, it has serious drawbacks. First, it is totally insensitive to differences in the depth of poverty i.e. once the individual is identified as poor, the index does not reflect the degree of poverty s/he is in. Second, it is completely insensitive to the distribution of income among the poor (Lipton and Ravallion, 1995 and Alemayehu, 1993). It is given by the following ratio

$$P_o = \frac{q}{N}$$

Where:

q = the number of people with consumption expenditure or income below the poverty line

N= total population

The Poverty Gap Index (P_1)

In this approach the degree of misery suffered by a poor person is assumed to be proportional to how far the individual's income falls short from the poverty line. That is, it depends on the distance of the poor's income falling below the poverty line. Hence, compared to the head count index, this one gives a better picture as it is based on the aggregate poverty deficit of the poor relative to the poverty line (or the average proportionate shortfall below the poverty line).

This index is given as:

$$P_1 = \frac{1}{N}\sum_{i=1}^{q}\frac{[Z - Y_i]}{Z}$$

Where:

Yi = consumption expenditure or income of the poor

Z = poverty line

The Foster - Greer - Thorbecke Index

The poverty index used in this particular study is the Foster-Greer-Thorbeck (1984), commonly known as the FGT index. It is a summary of poverty indices. It measures the severity of poverty by squaring and averaging the gap between the consumption expenditure or income of the poor and poverty line. Given a vector of suitable measure of well-being, Y, is arranged in an increasing order, $Y_1, Y_2, Y_3, ..., Y_n$, where n represents the number of households under consideration, the FGT poverty index (P_α) can be given as

$$P_\alpha = \frac{1}{N}\sum_{i=1}^{q}\frac{[Z - Y_i]^\alpha}{Z}, 0 \le \alpha \le 2 \, for Y_i \le Z$$

Where; P_α = the measure of poverty

Where z is poverty line for the household, q is the number of the poor households, Y denotes household income and α is the poverty aversion parameter ($\alpha \ge 0$). It represents the weight attached to a gain by the poorest. Usually α takes the values of 0, 1, and 2. When we set α equal to 0, then P_α will be reduced to the headcount ratio, which measures the incidence of poverty (the proportion of poverty in the total population). When α equals to 1, P_α gives the poverty gap. P_1 shows how far the poor, on average, are below the poverty line (intensity of poverty). Setting α equal to 2 gives the severity of poverty. This particular poverty index gives greater weight to the poorest of the poor, as it is more sensitive to redistribution among the poor.

2.2.3 Growth, Inequality, and Poverty

Poverty has always been a tragedy to humanity. Its concepts, causes and possible remedies have been perceived differently in different time periods and across different countries. The view and remedies suggested before the 18th century in Europe and before the 1950's in Africa, Asia, and Latin American countries were moralistic. Poverty was thought as incurable either through economic growth or deliberate public action. So it was approached in four ways: acceptance, palliation, insurance and/or theft (Ravallion and Lipton, 1993).

By acceptance it means "embrace poverty as a sacred vow [or] tolerated (or railed against) as unhappy fact of life". (Himmelfarb cited in Ravallion and Lipton, 1995: 2555). Poverty might be palliated, by private charity; i.e., devoted religious mans' alms giving, which was seen as a pious duty. On the other hand it might also be socially insured against through implicit informal contract among members of a group or tribe. But, formally a lord or chief provides insurance to free or serf laborers in order to maintain their military or productive power and loyalty both in bad and good time (Bardhan and Rudra cited in Ravallion et al 1995: 2555). When both palliation or insurance fails, theft was an ethically accepted cure for life-threatening poverty. A person "in imminent danger [who] cannot be helped in any other way ... may legitimately supply his own wants out of another's property". (Aquinas and Gilby cited in Ravallion et al 1995: 2555).

This approach, however, was challenged by the classical economists who argued that the accumulation of physical and human capitals along with technical progress would be a solution to poverty reduction (Smith cited in Ravallion et al 1995: 2554). Unlike Smith, Malthus (1798)

argued that free market growth and polices such as poor-laws aimed at increasing real wage rates, would self-destruct by inducing early marriage and therefore, larger fertility rates which ultimately increases the price of food up and reduces wage of labor (cited in Ravallion et al 1995: 2554). Ricardo also had a doubt in Smith's view that mechanization or free-market growth might not allow the participation of poor labor because of the implication that it induces high real wage (cited in Ravallion et al 1995: 2557).

Despite these objections, classical economists' view had dominantly been supported and implemented across Europe and other countries as the right approach to reduce poverty. Such thinking toward poverty alleviation has changed not only the ideas as to the root causes of poverty but also emphasized on the importance of assigning responsible bodies/institutions in the society to take care of the poor. It was believed that the existence of responsible public institution along with the efforts of mass education, provision of health services etc. was appropriate to prevent or reduce poverty (ibid).

Although this transition took place between 1750-1850 in Europe, similar transition in developing countries: Africa, Asia, and Latin America took place very lately, in 1950s. Following classical thinking, it was highly believed that industrialization raises the demand for labor and hence enriches the poor. The choice of the strategic sectors is based on their capacity to generate forward linkages (which encourage investment in sectors that require their production as input) or backward linkages (which may encourage investment in sectors producing the inputs that they demand). The measure of these linkages is done from the matrix

of inter industry flows, the "the input-output" matrix. Agricultural sector was neglected on the basis of shortage of such linkages (Sadoulet and De Janvry, 1995).

From mid 1960's to early 1970's, however, counter to such consensus started to emerge. The objections brought significant changes both in terms of thinking and policy, toward poverty and its relation to growth and inequality. The staunch objection and the policy implication of such shift were well reflected on (Chenery et al, 1974). The shift then moved to consider income distribution in the analysis; i.e, "not only is growth necessary for poverty reduction but that growth and equitable distribution of growth can indeed go hand-in-hand- all that is needed is the right policy". (World Bank Report, 1990: chap. 7). Besides, the extension of the concepts of linkages to include income and final consumption using the Social Accounting Matrix (SAM) has refocused attention to the agricultural sector. That is, the agricultural sector was recognized as an important source of household incomes, the expenditure of which can induce industrialization under the pull of effective demand (Sadoulet and De Janvry, 1995).

Despite such an argument, however, the growth-inequality trade-off has been a long lingering unresolved matter. Poverty could be address either through growth or redistribution of income depending on which ever is effective. That is,

> [I]f more rapid reduction in poverty can be achieved through reductions in inequalities, then distributional policy takes on a greater priority; but on the other hand, if greater levels of inequality appear to secure rapid growth leading to faster poverty reduction, then there may well be greater tolerance of inequalities. (Bigsten and Levin, 2001: 5-6).

Thus, the relationship between growth and inequality are important from a policy perspective.

Recent research finds neither systematic pattern of change in income distribution nor any systematic link from fast growth to increasing inequality. In his famous 1955 article, Simon Kuznets investigated the relation-ship between per capita incomes and inequality in a cross-section of countries. He found that there was an inverted-U pattern, that is, inequality first increased, and then decreased, as per capita income increased (cited in Bigsten et al, 2001: 9). The driving force was assumed to be structural change in a dual-economy setting, in which laborer was shifted from a poor and relatively undifferentiated traditional sector, to a more productive and more differentiated, modern sector (Lewis cited in Bigsten and Levin, 2001: 9-10).

Econometric analysis of the Kuznet's inverted-U thus far has been carried out on cross country data (Alhuwalia, 1976; Anand and Kanbur, 1993 and Deininger and Squire, 1998). These empirical studies have provided mixed results. In parallel, many comparative static analyses starting from the dual economy model have been done to assess the impact of growth on inequality (Bourguignon et al, 1990; Baland and Ray, 1991 and Eswaran and Kotwal, 1993). Two common ways emphasized in the studies are: first, labor displacement between the two sectors is the main engine affecting growth and the evolution of the income distribution. Second, income distribution affects equilibrium through variation of the composition of demand for goods between income classes.

Another significant contribution compared to the standard dual economy model is the general equilibrium framework, which allows taking into account redistributive effects through the evolution of the agricultural terms of trade. The magnitude of these effects and thus the equalizing or un-equalizing nature of the growth shock, depends on the characteristics of the demand for the traditional good (agriculture), in particular on the price and income elasticities of the demand for this good (Cogneau and Robilliard, 2000).

There seems a consensus among authors that

> [s]ince Ethiopia is the poorest countries in the world it will not be possible to achieve significant poverty reduction unless there is economic growth. A basis for any strategy will therefore have to be policies that promote growth. For these reasons, growth must remain a top priority. But its structure should be such that the poor benefit as smallholders, micro-entrepreneurs, and wage-employees. The development of agriculture must be emphasized since the majority of the poor make their livelihood in this sector. The design of growth strategies must incorporate appropriate analysis of their distributional impact while at the same time emphasizing policies that are especially pro-poor. (Addison and Bigsten, 2003: 108-109).

2.3 Computable General Equilibrium (CGE) Models

Partial equilibrium, as a name indicates, analyses part of the economy assuming away other thing remaining constant (citrus paribus). However,

> "there exist market interactions and thus market feedbacks. Pricing outcomes in one market have effects in other markets, and these effects, in turn, create ripples throughout the economy, perhaps even to the extent of affecting the price-quantity equilibrium in the

original market. To represent this complex set of economic relationships, it is necessary to go beyond partial equilibrium analysis and construct a model that permits viewing many markets simultaneously" (Koh, Schreiner and Shin, 2001: 1).

To address this concern the general equilibrium model was developed as a framework which analyzing linkages between markets and thus interactions between industries, factors and institutions (Sadoulet and de Janvry, 1995).

As it is put

> [T]he fundamental reason for analyzing and measuring poverty within a general equilibrium framework rather than a partial equilibrium framework is that interaction and interdependence within socioeconomic system matters as does the prevailing structure of the economy. Policy measures and shocks have direct effects on sectors of production, institutions (such as different socioeconomic groups and firms) and factors of production. However, indirect effects of policies and shocks are often as, or more, important than the direct effects. Besides, the model has the ability to produce disaggregated results at the microeconomic level, within a consistent macroeconomic framework (Thorbecke, 2001: 2).

The base data upon which the CGE model relies on the structure of a Social Accounting Matrix (SAM). A SAM is

> "a square matrix in which each transactor or account has its own row and column. The payments (expenditures) are listed in columns and the receipts in rows. As each account must balance, the corresponding row and column totals are equal". (Sadoulet and de Janvry, 1995: 274).

That is, it is a data system, including both social and economic data for an economy. The data sources for a SAM come from input-output tables, national income statistics, and household income and expenditure statistics. It is "a way of logical arrangement of statistical information, concerning income flows in a country's economy within a particular time period, usually a year. It can also provide a conceptual basis to analyze both distributional and growth issues within a single framework" (Chowdhury and Kirkpatrick, 1994: 58). But, this approach is based on some limiting assumptions, such as the existence of excess capacity, unused resources and constant prices (Sadoulet and de Janvry, 1995).

A CGE model, however, is calibrated on an underlying SAM and reflects not only the initial structure of the socioeconomic system but also the behavior of the various agents and institutions. In contrast with the SAM that describes a Keynesian world, the CGE approach

> "attempts to capture a more likely world (and set of conditions) in that, at least, some sectors in the economy operate at full capacity and some factors of production (skilled labor) are fully employed. Under those circumstances, prices can no longer be assumed to remain constant. Producers are profit maximizes and thus choose their levels of production and purchase of inputs on the basis of prices. They also decide to sell on the domestic market or export on the basis of relative prices. Equally, households also maximize utility and thus choose their levels of consumption based on income and prices". (Sadoulet and de Janvry, 1995: 341-342).

In such a model prices are endogenously determined so as to generate the set of prices that is consistent with "equilibrium" in an economy. When an economy is affected by an exogenous shock or a policy change, a new set of prices obtains, which, in turn, determines production, consumption, employment and income (ibid).

Luc Savard (2003) summarizes the long history of CGE and income distribution as follows. The first attempts using it trace back to the pioneering work by Dervis, de Melo and Robinson (1982) and Gunning (1983). Then it was followed by a second important wave in the early 90's with the OECD sponsored papers such as Thorbecke (1991), Bourguignon et al. (1991), de Janvry et al. (1991). The last impetus to this literature came near the end of the 90's with contribution by Decaluwe et al. (1999a and 1999b), and Cogneau and Robillard (2000) among others. The standard CGE models adapted in each of these authors can be seen in the following categories.

First, the CGE models with a representative household: - is the traditional method whereby poverty analysis is performed by using the variation of income of the representative household generated by the CGE model (output of CGE model) with household survey data to perform ex ante poverty comparison. The main drawback and advantage of this approach are that it supposes that there is no intra-group income distribution change, and requires no specific modeling effort outside what is done in the standard CGE modeling respectively. This is one of the reasons to use the approach in our thesis.

Second, multi-household CGE analysis: - it multiplies the number of representative households compared to the first. Owing to major gains in computing efficiency over the last few years it is simple to add as many households in the model as what is found in income and expenditure household surveys. Its advantage is that is allows for intra-group distribution of changes as well as leaving the modeler free from pre-selecting household grouping or

aggregation. The disadvantage is the limits it imposes in terms of microeconomic household behaviors and the size of the model which make data reconciliation difficult.

Third, micro-simulation approach: - analyzes income distribution (dispersion) using micro-econometrics modeling of household behaviors and price vector generated by a CGE model or even exogenous price vector changes (Bonnet and Mahieu, 2000). Its advantage is that it provides richness in household behavior by relaxing the representative agent assumption. Thus it remains extremely flexible in terms of specific behaviors that can be modeled. The main drawbacks are the coherence between the macro and micro models, which is not always guaranteed, and the fact that the feedback effects of household behaviors are not taken into account in the macro model.

In summary, the SAM models are applicable for an economy exhibiting the Keynesian environment of a fix-price model; i.e., excess production capacity in most sectors and absence of substitutions. This, however, fails to show the characteristics of a market economy in which price adjustments play an important role and where there are substitution possibilities in both production and demand.

> "It thus can not be used at all to study shocks that encompass important structural changes based on major relative price readjustments, like real exchange rate movements, wage repression, or terms of trade effects. To capture such features, a nonlinear model with joint determination of prices and quantities must be used. CGE is one of such type of models. It underscore the main linkages among the different economic and social sectors of the economy and help one to understand the ramifications and trickle-down effects induced by a policy or a shock". (Sadoulet and de Janvry, 1995: 295, 362, and 363).

CGE model is not immune from drawbacks. That is, it should neither be employed in forecasting, as they lack any proper dynamic features, or, for predictions of the impact of very specific policy packages, as they cannot properly model the particularities of any specific policy (ibid).

CHAPTER THREE

3.1 Model Specification

The nature of the links between economic growth, poverty and income distribution is a question that is central to the study of economic development. A number of approaches have been used to analyze such links. This debate has contributed to raising the question of how to construct suitable tools in analyzing the impact of macroeconomic policies on poverty and income distribution. More recently, this led to the development of tools for counterfactual analysis to study the impact of structural adjustment policies. Among the tools, Computable General Equilibrium (CGE) models are widely used because of their ability to produce disaggregated results (Adelman and Robinson, 1988; Dervis et al., 1982; Taylor, 1990; Bourguignon, 1991; de Janvry et al., 1991).

A CGE is usually calibrated using a SAM. A SAM is a comprehensive economy wide data framework representing the economy of an individual country. It is basically the extension of the input-output matrix by including income and consumption. The payments (expenditures) are listed in columns and the receipts in rows. As each account must balance, the corresponding row and column totals are equal.

There are six types of accounts in the standard SAM: the activities/production accounts (producing sector), the commodities accounts (representing the domestic market), factors (of production) accounts, the institutions accounts (households, firms, and the government), the capital account and the rest of the world. (Sadoulet and de Janvry, 1995: 274).

The distinction between activities and commodities is required in cases where a given activity produces multiple commodities or a given commodity is produced by more than one activity (ibid).

In this thesis, we adapted the CGE model developed by International Food Policy Research Institute (IFPRI) and those used by Cogneau and Robilliard (2000). Given the limitations of CGE models, as elucidated in the literature review, we used econometric estimations to handle the households' behavioral equations (combined production and consumption decisions).

3.2 The social Accounting Matrix (SAM)

The SAM provides much of the data needed to implement a CGE model. In our model we used the SAM developed by Alemayehu and Tadel, 1999. It was structured in such a way that there are twelve activities, eight commodities, four factors of production, ten institutions, transaction cost and public investment, and capital account. Given that SAM aggregation or disaggregation is flexible and may depend on data availability and the purposes for which the SAM will be used (Lofgren, Robinson, and El-Said, 2001), we aggregate it-reflect the agricultural sector- in such a way that it could fit into our purpose of analyzing agricultural productivity increase and its sectoral impact. That is, activities and commodities were aggregated into agricultural, informal and formal accounts while factors of production were disaggregated into agricultural family labor, informal labor, formal labor, capital and land. Besides, institutions are lumped into urban and rural and

the rest of the accounts put together in one account named RES. The table below shows details of such classifications.

Table 3.1 Balanced Social Accounting Matrix for Ethiopia 1999 (Million of Birr)

	Agricultural activity	Informal activity	Formal activity	Agricultural commodity	Informal commodity	Formal commodity	Agricultural family labor	Informal labor	Formal labor	capital	Land	Urban households	Rural households	Rest of the world	TOTAL
Agricultural activity	0	0	0	15582	2804	0	0	0	0	0	0	0	0	16127	34513
Informal activity	0	0	0	0	0	3359	0	0	0	0	0	0	0	0	3359
Formal activity	0	0	0	189	24098	16837	0	0	0	0	0	0	0	5440	46564
Agricultural commodity	541	528	779	0	0	0	0	0	0	0	0	2135	13729	1083	18795
Informal commodity	574	427	14002	0	0	0	0	0	0	0	0	2477	4595	8450	30525
Formal commodity	606	309	8191	0	0	0	0	0	0	0	0	13703	7350	8856	39015
Agricultural family labor	17694	873	1401	0	0	0	0	0	0	0	0	0	0	1113	21082
Informal labor	934	186	3557	0	0	0	0	0	0	0	0	0	0	1167	5844
Formal labor	933	185	3557	0	0	0	0	0	0	0	0	0	0	1169	5843
Capital	4991	711	14637	0	0	0	0	0	0	0	0	0	0	6685	27024
Land	8040	0	148	0	0	0	0	0	0	0	0	0	0	0	8188
Urban household	0	0	0	103	361	3138	800	4910	4911	22208	95	11696	7443	0	55664
Rural household	0	0	0	646	2853	12469	20282	934	932	4816	8093	3809	13980	0	68814
Rest of the world	200	140	292	2275	404	3212	0	0	0	0	0	21844	21717	0	50090
TOTAL	34513	3359	46564	18795	30525	39015	21082	5844	5843	27024	8188	55664	68814	50090	

Source: authors computation

3.3 The Model

The model is simplified by aggregating government, formal firms, savings-investment, and the rest of the world accounts into a single account labeled as RES in order to focus on agricultural (producers) technology and resources. Moreover, it is a static model with three sectors: agricultural, informal and formal. The agricultural sector produces two types of goods, a tradable good that is exported and non-tradable good. We use the Armington (Armington cited in Cogneau et al, 2000) assumption of imperfect substitutability between them. The formalization of this assumption is based on the specification of a function with constant elasticity of transformation (CET). Its calibration is based on the production data derived from the household survey but also requires the definition of the substitution elasticity between production for the local market and export (Cogneau et al, 2000). For this parameter, which can not be estimated because of the absence of a long series of data on production and price, a guessed value is chosen whose sensitivity is tested with various simulations. The values of "guesstimated" parameters of the reference simulation are presented in Table 3.2.

Table 3.2: Model Parameters

Parameter	Value
Income elasticity	
of agricultural goods demand	0.60
of informal goods demand	0.97
of formal goods demand	1.20
Price elasticity	
of demand for agricultural demand	-0.40
of demand for informal goods	-0.62
of demand for formal goods	-0.84
Substitution of elasticity of CET	-10.00

Source: Cogneau and Robilliard (2000)

The two other sectors (formal and informal) each produce one type of good. The informal good is a non-tradable good, while the formal good is tradable.

The basic mathematical statements were adapted from the standard model notation used in CGE models developed by IFPRI' (Lofgren, 1999). Moreover, Cogneau and Robilliard's (2000) Growth, Distribution and Poverty application model and Lofgren and Robinson's 1997 Mixed-Complementarity approach to specify Agricultural Supply in the CGE are used for the modifications. The assumptions used in the model are nicely summarized by Lofgren and stated as follows:

> Producers maximize profits subject to production functions, with primary factor as arguments, while households maximize utility subject to budget constraints. Cobb-Douglas functions are used both for producer technology and the utility functions from which household consumption demands are derived. Factors are mobile across activities, available in fixed supplies, and demanded by producers at market-clearing prices(rents). On the basis of fixed shares assumption, factor incomes are passed on in their entirety to the households, providing them their only income. The outputs are demanded by the households at market-clearing prices (Lofgren, 1999: 4).

In the CGE model, the usual behavioral assumptions are that agents respond to relative prices rather than to the absolute level of any price. "Formally stated, all demand and supply functions of the model are homogeneous of degree zero[3] in all prices". (Sadoulet and de Janvry, 1995: 343). The system will be solved for relative prices only. Besides, it is a standard procedure to set one price or a price index as constant (ibid). That is, to

[3] Multiplying the initial value of *cpi* by some positive factor, compared to the base, should only change the prices of the model solution by the value of the factor, while all quantities should stay unchanged.

assure that only one solution exists, a price normalization equation, in our case fixing the consumer price index (CPI), was made. Given this definition of the price normalization equation, all simulated price changes can be directly interpreted as changes vis-à-vis the CPI (Lofgren, 1999).

In the mathematical statements all endogenous variables are written in uppercase Latin letters, whereas parameters (including variables with fixed or exogenous values) have lower-case Latin or Greek letters. Subscripts refer to set indexes, with one letter per index. Superscripts are part of the parameter name (that is, not an index). In terms of letter choice, variables and parameters for commodity and factor quantities start with the letter q; for commodity and factor prices, the first letters are *p* and *w*, respectively.

Table 3.3 Notations

$a \in A$	Activities	
	AGR	agricultural activities
	INFRML	informal activities
	FRML	formal activities
$c \in C$	Commodities	
	AGR-C	agricultural commodities
	INFRML-C	informal commodities
	FRML-C	formal commodities
$c \in CE(\subset C)$	CE	exported commodities
$c \in CNE(\subset C)$	CNE	nonexported commodities
$f \in F$	Factors	
	LAB-1	agricultural family labor
	LAB-2	informal labor
	LAB-3	formal labor
	CAP	Capital
	LAD	Land
$h \in H$	Households	
	U-HHD	urban households
	R-HHD	rural households

Table 3.4 Parameters

ad_a	efficiency parameter in the production function for activity a
at_c	Shift parameter for output transformation (CET) function
cpi	consumer price index (CPI)
$cwts_c$	weight of commodity c in the CPI
ica_{ca}	quantity of c as intermediate input per unit of output in activity a
mps_h	marginal propensity to save for household h
qfs_f	Supply of factor f
$shry_{hf}$	share of household h in the income of factor f
α_{fa}	share of value-added for factor f in activity a
β_{ch}	share in household h consumption spending of commodity c
$wfdist_{fa}$	wage distortion factor for f in activity a
θ_{ac}	yield of output c per unit of activity a
δ^t_c	share parameter for CET function
ρ^t_c	exponent ($1 < \rho^t_c < \infty$) for CET function
σ^t_c	elasticity of transformation for CET function

Table 3.5 Variables

PA_c	price of agricultural commodity c
PI_a	price of informal a
PVA_a	value-added (or net) price of activity a
Q_c	Output level in commodity c
QA_a	level of activity a
QD_c	domestically sold output
QE_c	quantities of export
QF_{fa}	demand for factor f from activity a
QH_{ch}	consumption of commodity c by household h
$QINT_{ca}$	quantity of commodity c as intermediate input in activity a
QX_c	quantity of domestic output
WF_f	price of factor f
YF_{hf}	income of household h from factor f
YH_h	income of household h

Equations

Production and Commodity Block

Production Function

$$QA_a = ad_a \cdot \prod_{f \in F} QF_{fa}^{\alpha_{fa}} \qquad a \in A \qquad (1)$$

Output transformation (CET) function

$$Qx_c = at_c.(\delta_c^t.QE_c^{\rho_c^t} + (1-\delta_c^t).QD_c^{\rho_c^t})^{\frac{1}{\rho_c^t}} \qquad c \in CE \qquad (2)$$

Output transformation for non-exported commodities

$$Qx_c = QD_c \qquad c \in CNE \qquad (3)$$

Factor Demand

$$WF_f.wfdist_{fa} = \frac{\alpha_{fa}.PVA_a.QA_a}{QF_{fa}} \qquad f \in F, a \in A \qquad (4)$$

Intermediate demand

$$QINT_{ca} = ica_{ca}.QA_a \qquad c \in C, a \in A \qquad (5)$$

Activity price

$$PI_a = \sum_{c \in C} \theta_{ac}.PA_c \qquad a \in A \qquad (6)$$

Value-added price

$$PVA_a = PI_a - \sum_{c \in C} PA_c.ica_{ca} \qquad a \in A \qquad (7)$$

Output function

$$Q_c = \sum_{a \in A} \theta_{ac}.QA_a \qquad c \in C \qquad (8)$$

Institution Block

Factor Income

$$YF_{hf} = shry_{hf} \sum_{a \in A} WF_f.wfdist_{fa}.QF_{fa} \qquad h \in H, f \in F \qquad (9)$$

Household Income

$$YH_{h} = \sum_{f \in F} YF_{hf} \qquad h \in H \qquad (10)$$

Household Demand

$$QH_{ch} = \frac{\beta_{ch}(1 - mps_{h}).YH_{h}}{P_{c}} \qquad c \in C; h \in H \qquad (11)$$

System Constraint Block

Factor Market Equilibrium

$$\sum_{a \in A} QF_{fa} = QFS_{f} \qquad f \in F \qquad (12)$$

Output Market Equilibrium

$$Q_{c} = \sum_{h \in H} QH_{ch} + \sum_{a \in A} QINT_{ca} \qquad c \in C \qquad (13)$$

Price Normalization Equation

$$\sum_{c \in C} cwts_c . PA_c = cpi \qquad (14)$$

The Foster Greer and Thorbeck (FGT) of absolute poverty index and the Gini index for inequality are used in our poverty analysis. There are two approaches to specify the within-group distributions and generating measures of the overall size distribution. These are: the lognormal frequency function and the bottom-up (microeconomic specification). In the first approach, which is used in this thesis, the within group income has an endogenous average (given by the model) and is fixed (Cogneau et al, 2000). Under this approach, the CGE model generates changes in the distribution of mean income (or mean consumption) between groups (ibid.). Together with additional data for poverty line (which was estimated at Birr 1075.00 in 1995/96 prices as derived by Abebe Shimels (Mekonen, T. et al, 1998) and population size, and household survey data of consumption and expenditure (Economics department data in our case), the overall inequality and poverty figures are generated. We used this approach because "less information is lost through assuming that the within-group distribution follows a smooth probability distribution". (Lofgren et al, 2001: 334).

The table below summarizes lists of poverty and inequality measures that are preprogrammed in the household module that is linked to the standard model.

Table 3.6 Poverty and Inequality Measures in the Standard Model

Poverty measures	Inequality measures
Po-head count	Squared coefficient of variations
P1-poverty gap	Variance of logarithms of incomes
P2-squared poverty gap	Gini coefficient Atkinson measure Generalized entropy measure Theil (normalized and non-normalized entropy measures

Source: Lofgren, Robinson and El-Said (2001).

3.4 Production and Labor Allocation

We seek to model the labor allocation of households among various activities. Three sectors are considered: formal, informal, and agricultural. Households can be wage workers or self-employed. Thus, we distinguish three types of activities: i) agricultural activity, ii) informal activity, iii) wage-earning in the formal sector.

3.4.1 Agricultural Households

Farm households and the labor supply of their members are of considerable interest to policy makers in developing countries. The extent to which the benefits of rural investment strategies and technological innovations in agriculture are transmitted through the labor market to landless and poor households depends crucially on how farm households adjust their members' labor supply and their demand for family and hired labor. (Skoufias, 1994: 215).

Labor allocation models, traditionally, are applied in a context where wage activities are dominant. That is, production (labor demand) and consumption(labor supply) decisions are made separately or model equations could be estimated by importing exogenous price

from the existing (one or several) labor markets (Jacoby, 1992 and 1993; Benjamin, 1992; and Skoufias, 1994). The necessary condition for separation is "the existence and operation of the labor market". (Cogneau et al, 2000: 10). That is, if the market exists (and functions perfectly), households make decision recursively-first production (which determines its labor demand) and then consumption (which determines its labor supply). Corollary, marginal productivity of on-farm labor is equal to the market wage and depends neither on the household's endowment of production factors, nor on its consumer preferences. In short

> [T]he issue of separability depends on whether or not there is a difference between market prices of production-consumption goods and the value of those goods within the household-their shadow price". (Lofgren and Robinson, 1999: 663).

Coming to the agricultural households in developing countries, however, there are "two fundamental characteristics which justify the extension of tradition models of the producer and consumer: the dominant use of family work, and the home consumption of an often significant part of their own production". (Cogneau et al, 2000: 9-10). Moreover, rampant market imperfection arising due to transaction cost, imperfect substitutability of different labor (family and hired) and goods produced, etc. could also make the production-consumption separation difficult (ibid).

In the empirical front, many authors agree in the incapability of the two models satisfactorily explaining developing countries markets. Their research indicates the

simultaneous existence of a rural labor market and different marginal productivities among households (Cogneau et al, 2000; Benjamin, 1992; Jacoby, 1992 and 1993).

In our model, we adapted the assumption that Cogneau and Robilliard (2000) have made to Madagascar. This again is on the assumption that both are developing countries and more or less exhibit similar rural labor markets. The authors treat off-farm and hired labor in an asymmetrical way. That is, agricultural households hiring agricultural wage labor can have low marginal productivities of labor, lower than the average agricultural wage. Thus, the assumption that hired labor is complementary to family labor has been made. The validity of this assumption is reinforced by the seasonal character of the use of agricultural wage labor in Ethiopia. Hiring is particularly important at the time of plowing and harvesting. Households call upon paid work or mutual aid during this period.

On the off-farm employment side, agricultural households have several possibilities, including agricultural or informal wage work, or an informal handicraft or commercial activity. Following the authors (mentioned above), we chose to consider households that do not supply work off-farm have a marginal productivity of on-farm labor higher than their potential off-farm wages, adjusted for costs. On the contrary, households that supply off-farm labor have a marginal productivity that is equal to their off-farm wage wages, adjusted for transaction costs. Regarding formal labor, there is a defined wage rate and a functioning market. Thus, any shock in it will have an impact on the time available for agricultural and informal activities and in turn affecting total labor supply.

3.4.2 Agricultural Production Function

In the literature, the most commonly used agricultural production functions are the Leontief and the Cobb-Douglas functions. Searching a function which takes the simultaneous decisions of production and consumption into account "and the discontinuous technical alternatives entails one to consider estimating a quadratic function embedded in a Cobb-Douglas function". (Cogneau and Robilliard, 2000: 16). For the CGE calibration, a Leontief technology and inequality constraints should be formulated as mixed-complementarity problems (Lofgren and Robinson, 1997). However, we abandon these approaches because the functions are much less handy analytically (Congneau et al, 2000 and ibid) and beyond the scope of this paper. Instead we did the estimation using a Cobb-Douglas(CD) production function because of its assumptions: the contribution of production factors is strongly separable, and the marginal rate of substitution between factors is equal to 1 and does not depend on the other factors. The CD production function is specified as:

$$\ln Y(h) = \sum_{h} \beta_L \ln X(h) + v(h)$$

Where: Y(h) denotes the total value of agricultural crops produced by farm household h, β_L's are parameters. X(h) are inputs used household h, and v(h) in an error term summarizing the influence of other omitted variables.

CHAPTER FOUR

Results and analysis

After specification, the next step is the estimation of model parameters from the given SAM. Although most of the model parameters are derived from the underlying SAM, the agricultural production function, for reasons stated in the preceding chapter, were estimated econometrically. We used OLS for the estimation and the results are presented as follows. Our data source is the Ethiopian Rural Household Survey (ERHS)[4].

ERHS covers a large number of households in 18 Peasant Associations (a cluster of villages which make up a survey site) spanning in 15 Woredas (districts) in six regions. The survey provides a nation-wide data set with wide agro-economic variations and standard of living strata of rural Ethiopia. Our data, used in this thesis consists of 1,315 households drawn from the fifth round (1999) of the ERHS. This was because the static Social Accounting Matrix (SAM) of Tadele and Alemayehu, which is used in our model was prepared in the same year (1999). Otherwise, it requires reconciliation of the microeconomic data with the macroeconomic data using the program of recalibration of the statistical weights (Robilliard and Robinson, 1999) which is out of the scope of this paper.

Following Jacoby (1993), agricultural outputs were derived by aggregating the 'belg' and 'meher' outputs. Also added in is livestock output, measured as the sales of dairy and other animal products and other related off-farm incomes (like incomes from making

[4] The panel survey has been conducted since 1994 by the Department of Economics, Addis Ababa University, in collaboration with the Centre for the Study of African Economics, Oxford.

'tela' from corn or wheat, working as a daily laborer, etc). The input of land is measured as the amount at the household's disposal (in hectares) in the survey year, whether owned, rented or sharecropped.[5] Land in hectares, total hours of work, and other inputs, are all assumed exogenous to the one-year planning horizon. In addition, age and schooling of the household head entered as proxies for the different quality of the management of inputs. Furthermore, regional dummies were included to control for region specific factors.

Table 4.1. Description, Mean, and Standard Deviation of Variables used in the Estimation of the Agricultural Production Function.

Variables	Description	Mean	Std. Dev.
Y	Total income form crop (meher plus belg) and related off-farm activities.	2606.50	2827.86
Labor	Sum of total hours of labor used in plowing, land preparation, and weeding by male, female, and child labor at meher and belg time	123.00	254.51
Ox	Total value of oxen plus bulls used	812.66	1513.70
Land	Land in hectares, owned and worked by household, or rented or sharecropped	2.08	1.75
Age	Age of household head	50.07	15.99
Age Square	Square of the household age		
Sex	Sex of he household head		
Primary education	Dummy: 1 if the household had primary education (0 otherwise)	0.148	0.355
Secondary education	Dummy: 1 if the household had secondary education (0 otherwise)	0.060	0.238
Tertiary education	Dummy: 1 if the household had tertiary education (0 otherwise)	0.002	0.048
Region 3	Region dummy = 1 if region 3 (0 otherwise)	0.293	0.455
Region 4	Region dummy = 1 if region 4 (0 otherwise)	0.231	0.421
Region 7	Region dummy = 1 if region 7 (0 otherwise)	0.085	0.279
Region 8	Region dummy = 1 if region 8 (0 otherwise)	0.087	0.281
Region 9	Region dummy = 1 if region 9 (0 otherwise)	0.093	0.291

Source: Author

[5] It is the sum of the following types of land in hectares: own cultivable (pay tax and not pay tax), fallow, rented, shared-cropped, gift/lent out, grazing and garden .

Then, OLS is used to estimated the coefficients. We used cross-sectional data to fit into our static CGE. "One limitation is that it is not possible to purge from the production function disturbance the fixed effect (e.g. managerial ability) that may correlate with the inputs". (Jacoby, 1993: 908). On the other side, given the presence of zero values in some inputs, the logarithmic transformation was carried out by adding one to all input levels i.e., $\ln X(h) = \ln(X(h)+1)$ (Skoufias, 1994). But, there is cautious in substituting a number instead of zero; i.e., using different arbitrary constants which could result in different coefficient estimates for some variables. However, "Johnson and Rausser (1991) find that bias in parameter estimates increases with the size of the constant added, but modifying only the sub-sample of zero values results in less bias than modifying the entire sample". (Skoufias, 1994: 220). Thus, the degree of bias associated with the choice of one as a scalar for this data is small.

The name of the variables are labeled as: lalabor = ln of Labor; lnox = ln of ox; lnland = ln of land; age = age; sex = sex; primedu = primary education; secedu = secondary education; teredu = tertiary education; reg3 = region 3; reg4 = region 4; reg7 = region 7; reg8 = region 8; and re9 = region 9.

Table 4.2. Results of estimation of the Cobb-Douglas production function

	OLS	Standard errors
Lnlabor	0.335	0.035
Lnox	0.036	0.012
Lnland	0.188	0.034
Age	-0.001	0.002
Sex	0.004	0.091
Primedu	-0.032	0.108
Secedu	0.162	0.166
Teredu	-1.149	1.202
Reg3	0.911	0.122
Reg4	1.091	0.122
Reg7	0.722	0.152
Reg8	1.747	0.145
Reg9	0.208	0.139
Constant	4.045	0.214
R^2	0.344	
Number of observation	1315	

. As stated before, the estimation is needed to handle the behavioral response of agricultural household, particularly the labor supply to policy shocks. In the standard practice, getting labor elasticity for the simulation exercise could be done either by importing figures from other people's estimation or do own estimation or both. Then sensitivity analysis will be done (see Table 4. 4). In our case we opted for own estimation for labor elasticity and imported variable for income and price elasticity (see Table 3. 2). Low labor elasticity means the response of the household (labor supply) to policy shocks is lower; i.e., the policy impact is not significant and vice versa (Lofgren and Robinson, 1997). From the above regression, one can see that factors of productions have all positive sign and are significant. Elasticity of labor, our concern, stands at 0.335. This is a fairly high figure, not different from those used in the standard CGE models.

The model in this paper is formulated as a set of nonlinear mixed-complementarity problems[6]. CGE models are only calibrated, not estimated, using a software program called Generalized Algebraic Modeling System (GAMS). The calibration is facilitated using data from SAM. That is, on the basis of a data set for a base period, the parameters of the model are estimated-parameter values and initial variable levels[7] are defined- in a manner that enables the model solution to precisely replicate the base-year economy in equilibrium. Moreover, it also assumes that base-year factor and output prices are at unity and assign parameter and variable quantities on this basis. A value of unity for all factor and commodity prices (that were initialized at this level) "is a reliable indicator that the initial model solution replicates the initial equilibrium as captured by the initial SAM" (Lofgren, 1999: 18). Then the simulation exercise proceeds.

In addition to model statement and base solution, the GAMS input file with the suggested answer includes a LOOP where simulations are carried out. For the simulation exercise any percentage number can be taken, but should be attested with various sensitivity analysis. In our case[8], however, we took an increasing agricultural productivity ascribed to 10% increase in capital (increase fertilizers and pesticides usage). A set of report parameters are created. The outcomes from the simulation are reported in Table 4.5.

[6] In the general case, a mixed-complementarity problem consists of a set of simultaneous equations that are a mixture of strict equalities and inequalities, with the latter linked to bounded variables. The current model is a special case since all equations are strict equalities.
[7] Initial variable levels give the GAMS solver a good starting point, facilitating its search for solution.
[8] We took the highest growth rate in the agricultural sector as stated in the Poverty Reduction and Strategic Paper (PRSP) document of the Ministry of Finance and Economic Development (MoFED).

List of the variable to be reported

PA	Price of Agricultural Commodity
PI	Price of Informal Commodity
PVA	Value-added Price of Activity a
WF	Price of Factor f
QAAGR	Total Agricultural Activity
QFRML	Total Formal Activity
QINFRML	Total Informal Activity
QDAGR	Domestically Sold Agricultural Output
QDFRML	Total Sell of Formal Output
QDINFRML	Total Sell of Informal Output
QEAGR	Agricultural Exported Output
QSS/DDLAB	Quantity Supplied/demanded of Labor
QHAGR	Total Consumption of Commodity c by agricultural sector
QHFRML	Total Consumption by the Formal
QHINFRML	Total Consumption by the Informal
YHUH	Income of Urban Household
YHRH	Income of Rural Household

Table 4.3. Simulation in capital increase by 10% (Base in Millions of Birr)

Variable	Base level	10% increase in capital (% change from the base)
Price of agricultural commodity	1.0	-4.3
Price of informal commodity	1.0	-1.3
Value-added price of activity a	1.0	1.78
Price of factor f	48976	6.7
Total agricultural activity	34513	10.1
Total formal activity	3359	0.0
Total informal activity	46564	4.9
Domestically sold agricultural output	56290	0.57
Total sell of formal output	19239	0.12
Total sell of informal output	24389	1.20
Agricultural exported output	28145	12.7
Quantity supply/demand of labor	53789	8.6
Total consumption of commodity c by agricultural sector	32456	1.8
Total consumption by formal sector	27245	0.66
Total consumption by informal sector	34129	1.04
Income of urban household	55664	1.9
Income of rural household	68814	3.5

Source: Author

Simulation of agricultural sector leads to an increase in production and agricultural income (see QAAGR). The effect on production corresponds to the productivity shock (+10%), but the income effect is much weaker (see YHRH). This result can be explained by the specification of the household labor allocation model. That is, increase in agricultural productivity may induce an increase in agricultural labor demand for the agricultural household. This increase leads households to decrease their supply of informal work, because the total number of hours worked does not change. Thus for the households that allocate work towards the agricultural activity, monetary income can increase. However, the reduction in the agricultural goods price by -4.3% (see PA) induced by the increase in production reduces the direct effect on monetary income for

agricultural household. The reduction in the relative prices of informal goods -1.3% (see PI) leads nevertheless to a strong increase in real income for all households and the increase in agricultural productivity results in an increase of household consumption by 3.5% (1.8 + 0.66 + 1.04). On the other side, one can also see that the reduction in the price of the agricultural good signals reallocation of labor toward informal activities, leading to an increase in informal production and, consequently, to a reduction in the price of informal good. Had one use dynamic CGE, this impacts would have been reflected in the following year.

The income of the urban and the rural households increase by 1.9% and 3.5 % respectively. The former get an indirect advantage of increases in agricultural production which is reflected in relative prices of commodities market (-4.3%). The latter directly benefits from increase production by increasing marketing surplus. The reasons are the improvement in agricultural inputs (usages of extension packages).

Before proceeding to see the impact of the policy shock on poverty and inequality we made a sensitivity analysis. The base parameter (labeled as S0) are those indicated in Table 3.2. Other parameters are also introduce under the name S1, S2, and S3 by adopting form Cogneau et al (2000). Besides, for the labor elasticity our OLS estimation is used for the base, and for the other, imported parameters from the same source.

Table 4.4 Sensitivity Analysis: simulation parameters

	S0	S1	S2	S3
Income elasticity	0.6	0.3	0.8	0.4
Price elasticity	-0.4	-0.2	-0.5	-0.6
Substitution elasticity of CET	-10.0	-7.0	-13.0	-20.0
Labor elasticity (OLS estimation	0.335	0.10	0.40	0.25

Source: Cogneau and Robilliard (2000) and Author for labor elasticity base value.

The macroeconomic impact of agricultural productivity on selected variables is given in the following table.

Table 4.5 Sensitivity Analysis for Increasing Agricultural Productivity

	Base	SO	S1	S2	S3
Price of agricultural commodity	1.0	1.0	1.0	0.9	1.0
Price of informal commodity	1.0	1.0	0.9	0.9	0.9
Quantity supply/demand of labor	53789	8.6	2.5	9.2	7.9
Total consumption of commodity c by agricultural sector	32456	1.8	1.6	2.4	1.8

Source: Author

The sensitivity analysis shows little change in the estimation result implying that the parameters used are correct. One exception goes to the labor elasticity. That is, when it takes lower number like 0.10, the impact of the policy shock reduces significantly (from 8.6 to 2.5. This comply (as stated before) with the theory that as labor elasticity reduces, so do the impact of policy shock (increasing agricultural productivity)

After making simulation exercises on the impact of agricultural productivity on the incomes of both urban and rural households, the mean income elasticity of the FGT poverty indices are estimated. This is done on household consumption and expenditure

survey of round of The Ethiopian Rural Household Survey (ERHS) conducted during a similar period to that of the base year of the social accounting matrix employed in the CGE model. The computer program used is DAD's (Distributive Analysis/Analyse Distributive). Table 4.6 and 4.7 give the elasticity of the various poverty indices with respect to the mean consumption and Gini index for rural and urban households by using the Generalized Quadratic (GQ) Lorenz curve. Regarding inequality, the consensus is that income inequality and poverty are positively related. The underpinning assumption is that growth is distributionally neutral.

Table 4.6. Elasticity of Poverty Indices with respect to Mean Income and the Gini Index

Rural Household		
Poverty Indices	Mean Consumption	Gini Index
Head Count Ratio	-1.4	0.34
Poverty Gap	-1.7	0.93
FGT-2	-2.2	1.89
Urban Household		
Poverty Indices	-0.4	.34
Poverty Gap	-0.7	1.23
FGT-2	-0.9	3.42

Source: Author

The head count ratio in rural areas declines by around 1.4% when the mean consumption of the distribution function increases by 1%. Similarly the poverty gap (the intensity of poverty) and the FGT-2 (the severity of poverty) decline by 1.7% and 2.2% when the mean income of the population rises by one percent.

The magnitude of reduction of poverty indices are lower for the urban household which might result from the initial higher level of poverty (inequality) in the urban household. That is, a 1% increase in mean income for urban household would reduce the head count and poverty gap by less than one percent while it is above one for the rural household.

Table 4.7. Poverty impact of an increase in agricultural productivity

Rural Household			
Policy undertaken	Head Count Ratio	Poverty Gap	FGT-2
Agricultural productivity increase(10%)	-1.913	-2.456	-2.934
Urban household			
Agricultural productivity increase(10%)	-0.628	-1.028	-1.220

Source: Author

Increasing agricultural productivity reduces the head count ratio, the poverty gap, and severity of poverty of the rural household by 1.9%, 2.5%, and 2.9% respectively. For the urban household, the figures lies at 0.6%, 1%, and 1.2% respectively. The major finding supports the hypothesis that focusing on increasing agricultural productivity will reduce poverty-more in the rural than the urban areas. Thus, with complementary policies such as infrastructure provision, the impact would have been stronger as farmers could get outlet for the excess supply and make more money.

CHAPTER FIVE

CONCLUSION

In their history, human beings have survived and are still surviving the multifaceted and intricate problems inflicted by poverty. Although various solutions were suggested to curb the problem, there is still rampant poverty mainly in the developing countries. Among the panaceas, in the economic front, growth promoting and thereby reducing poverty macroeconomic policies have been under test. Today poverty alleviation has become a top priority. Nevertheless, the disagreement in the selection of the proper policy to tackle the problem is still there. Some of the reasons could be the diverse and complicated impact of the macroeconomic policies, the timing, failure to tailor the solutions to countries specific problems, lack of institutional capacity, etc.

Currently, Ethiopia has set Agricultural Development Led Industrialization (ADLI) as its top priority. This was on the perception that most of the population and (the poor) live in rural areas and hence increasing the income of such groups would contribute a lot to poverty reduction. In this paper, a modest attempt is made to see the impact of increasing agricultural productivity on both urban and rural poverty. That is, the effect of increasing agricultural productivity by 10% on poverty was investigated. In order to take into account the inter-sectoral linkages-forward and backward and/or direct and indirect-we used the model called Computable General Equilibrium (CGE) model. By estimating

income distribution function from survey data and adopting poverty line from Abebe's work, the poverty impact of the policy was explored.

As elucidated in the ADLI policy, our results show that increasing agricultural productivity would reduce both rural and urban poverty though the former would benefit more. The rural household gets direct benefits through increasing in income. As poverty reduction is directly related with increasing income, the former has also reduced. The reductions in poverty, however, appears relatively small. The explanation could be the negative indirect impact reflected in the reduction of agricultural products. That is, there is surplus product which induces price reduction following supply law. The recommendation therefore, is that problem of product (surplus output) outlet should not be ignored. That is, the government has to put more efforts in enhancing its proactive policies; i.e., improving rural infrastructure(construction of main and feeder roads), giving access to education and credit. To the urban households, the benefits are transmitted indirectly through the drop of agricultural commodity price. But, strong degradation of the agricultural terms of trade can have negative impact on the welfare of the rural households.

Although the paper has made a modest contribution to the approaches in analyzing the impact of growth shocks on poverty and inequality, it suffers from the following limitation. First, for the CGE model we used the standard one which assumes the smooth functioning of the economy following the neo-classical well-behaving economic agents' behavior. This is idealistic and barely explains the reality particularly in the developing

countries like Ethiopia. It would better fit to the countries reality had the Mixed-Complimentarity model been used. This is an area open for further research. Second, the aggregation of commodities and sectors does not give a complete working of the economy. Finally, we chose the household data from the same year that the SAM was prepared simply by assuming that the similarity of the time will entail having similar information. But, to be more realistic the information from the two sources have to be reconciled through the program called recalibration of statistical weights.

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Declaration

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

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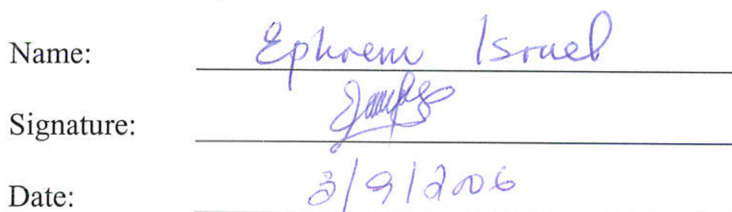

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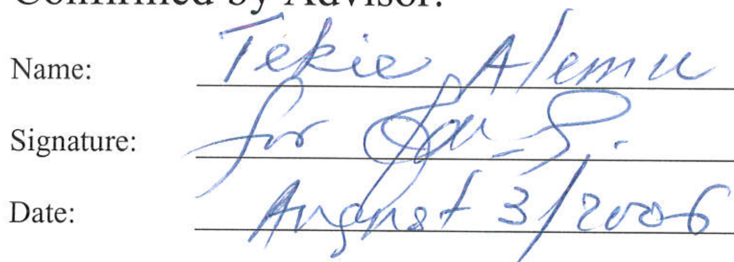

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