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**The Impact of Trade on Poverty in Ethiopia: A Sequential Dynamic
Computable General Equilibrium Micro Simulation Analysis**

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This is to certify that the project prepared by Ashenafi Assefa, entitled: The Impact of Trade on Poverty in Ethiopia: A Sequential Dynamic Computable General Equilibrium Micro Simulation Analysis and submitted in partial fulfilment of the requirements for the Degree of Master of Art in Economics (Applied Trade 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

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This study tries to address the impact of trade on poverty by way of agricultural total factor productivity (TFP). In doing so, we employ a Sequential Dynamic Computable General Equilibrium Model linked to a Micro Simulation Model. We also used econometric model to estimate the agricultural TFP of Ethiopia. For these purpose, we utilized the data of the 2005/06 SAM of EDRI (Ethiopian Development Research Institute), the 2004/05 HICE (Household Income Consumption Expenditure) survey conducted by CSA (Central Statistical Agency of Ethiopia), different years of agricultural sample surveys of CSA and the ITC UNCTAD data.

The estimation results of this study shows that trade openness and fertilizer application have positive impact on agricultural TFP. But seeds, irrigation and extension have negative impact on agricultural TFP. We also found that the proposed tariff cut, trade induced agricultural TFP and improved agricultural TFP due the application of fertilizer results in an increment in all macroeconomic variables. However, poverty due to trade openness and tariff reduction exacerbate poverty during the simulation period.

Key words: Trade Openness, Agricultural TFP, Dynamic CGE, Poverty, Ethiopia

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1. INTRODUCTION

The importance of trade openness in the reduction of poverty has been pronounced by different authors (see, for example, Brooks, 2003, WTO (World Trade Organization), 2004, Hameed and Nazir, 2006, Kruger, 2009 and OECD (Organization for Economic Co-operation and Development), 2009). However, assessing the relationship between trade and poverty is highly convoluted (Winters, 2000). Among the channels which are proposed by Winters (2000), total factor productivity could be a link by which trade influences poverty.

One of the major agendas of many developing or poor countries is how to improve living standard and reduce the level of poverty of the majority of their population. In line with this, international institutions such as IMF and WB have provided financial and technical assistance to tackle the problem that these countries face (WB and IMF, 2011). In addition, a lot of studies have been conducted to show the appropriate ways that these poor nations should follow.

The livelihood of most poor nations' population depends on agricultural activities. This sector provides employment opportunity to the rural population, supply production for the domestic as well as for international markets (Dethier and Effenberger, 2011). This implies the advancement of this sector may enable to meet the target that the government of the poor nations have set. Therefore, the policies of these countries should be based on the improvement of the agricultural sector and then the progress of this sector could also enhance the living standard of the poor.

This notion was strongly supported in the 1970s and 1980s with the agricultural development revolution (Green Revolution) in East Asia countries which resulted in the achievement of strong agricultural performance and the decline of poverty. However, this success was not able to recur in Sub-Saharan African (SSA) countries. These countries rather have experienced limited agricultural productivity regardless of many agricultural policy reforms (Christiaensen and Demery, 2007). The lesson from this is that the SSA countries should incorporate the experience of those Asian countries associated with the ground facts in SSA concerning the link between agricultural growth and poverty.

There are studies that show the importance of agricultural sector in poverty reduction process in low-income countries. For example, Christiaensen and Demery (2007) suggested that in designing effective poverty strategy in poor countries, boosting the agricultural productivity must come first. The cross-country empirical analysis of Loayza and Raddatz (2009) also revealed that the more labour intensive sector has a strong tendency to reduce poverty. Similarly, Godoy and Dewbre (2010) concluded that although the sector mix growth is crucial, the agricultural income growth plays an important role in the reduction of poverty. If this is a case, how can then the agricultural productivity be improved in SSA countries? One of the ways is opening up of trade.

Openness of trade would have a positive impact on the TFP of the SSA countries (Akinlo, 2006). The reason behind could be trade may provide a channel that allows the transfer of new technology. This idea is supported by the work of Madsen (2005) that in the OECD countries international technology has an upbeat spill-over effects on TFP via trade. The effect of trade is going beyond improving TFP. Sherman et.al. (2006) found that trade induced productivity gain can have a significant contribution in the diminution of poverty. However, this may not be realized unless the government of the SSA countries create a conducive economic environment and trade reform with poverty mapping analysis that benefit the majority of the population in general and the rural dwellers in particular (Abebe and Alemayehu,2009).

Although trade and poverty relationship is complex (Winter, 2000), trade openness has potential to reduce poverty (Hameed and Nazir, 2006). Some works have been done around the issue of trade and poverty in the case of Ethiopia. For example, Dejene et al. (2007) show that completes trade liberalization might exacerbate poverty in Ethiopia.

Similarly, Bisrat (2009) concluded that complete and instantaneous tariff reduction would worsen poverty in the short run, but in the long run trade liberalization with capital accumulation can reduce poverty. However, both (Dejene et al. and Bisrat) took the assumption of complete tariff cut which is not realistic; no country is willing to apply it and even the requirement of WTO is not a 100% tariff removal for developing countries. On the other hand, Ermias (2009) found that liberalization of the agricultural sector in

Ethiopia would not have a significant impact. Alemayehu and Abebe (2009) attempt to see trade liberalization, poverty and inequality in Ethiopia and suggest that the country should have a trade policy that ensures the sustainability of trade gains and the assimilation of these gains with social objectives in order to meet the objective of poverty reduction. Although this work tries to link trade and poverty, it is not sufficient because the partial equilibrium analysis they used is unable to incorporate trade openness, which is the macroeconomic phenomena, with poverty and inequality which are micro level situations.

Many of the above mentioned and other works used removal of tariff in order to capture openness and thereby change in the poverty status. However, complete tariff cut may not reflect the degree of openness and again the mechanism by which trade influences poverty through the different channels in these works remains scanty. Therefore, this paper tries to link trade and poverty by way of agricultural Total Factor Productivity (TFP). It is among different possible links that first trade influences agricultural TFP and then agricultural TFP influences poverty. This is because the Ethiopian economy highly depends on the agricultural sector, which contains the majority of the poor in the country, and the sector's improvement may have some positive influence on poverty. And also given the fact that the focus of the new plan GTP (Growth and Transformation Plan) is on the transformation of the economy by means of facilitating productivity growth in the agricultural sector, the importance of agriculture as the engine of economic growth in the country is highly valuable. To this extent, examining the impact of trade on poverty through the agricultural total factor productivity is reasonable. So the objective of this paper is to investigate the impact of trade induced agricultural TFP on poverty.

To meet the objective of this study, econometric and DCGE (Dynamic Computable General Equilibrium)-MS (Micro Simulation) models of analysis will be employed. The econometrics part estimates trade induced agricultural TFP using secondary data. The next step of the analysis uses the estimated parameter of openness and tariff cut to create scenarios in the DCGE-MS model. Regarding to DCGE model, this paper will utilize the IFPRI (International Food Policy Research Institute) DCGE model in line with the

2005/6 SAM (Social Accounting Matrix) of EDRI (Ethiopian Development Research Institute) and the Micro-Simulation will also use the 2004/05 Household Income, Consumption and Expenditure (HICE) survey data of CSA (Central Statistical Agency) of Ethiopia and some variables from the DCGE result.

The paper is organised as follows. Section 2 provides literature review of trade, poverty and their links, specifically TFP. Section 3 describes trade, agricultural growth and poverty in the Ethiopian economy. Section 4 outlines the methodology that the paper will employ. Section 5 presents the empirical results and section 6 sets forth conclusion and policy implications.

2. LITERATURE REVIEW

Openness of trade can play a paramount role in the process of economic development of a country. Trade can provide access to variety of goods and services, market opportunities and thereby increase domestic production, getting better information and transfer of technology that improves productivity, improve resource allocation and reduce inefficiency (Brooks, 2003 and WTO, 2004) and this may lead to the achievement of higher economic growth and reduce poverty.

Model of endogenous technological change explains the long-growth and openness. When the economy is more open, it can access wider market for outputs and wider market for inputs and this in turn increase the rate of technical progress and thereby enhancing productivity (Lucas, 1988). This thought is consolidated by the work of Romer (1990) that more open economy experiences a rapid productivity growth because openness allows getting assortment of capital goods which enables the country to broaden its productive knowledge.

To grasp the above advantages, however, important conditions need to be satisfied. Grossman and Helpman (1991) argued that a country that has research-incentive oriented trade could increase total factor productivity. On the other hand, trade related total factor

productivity growth depends on the country's ability to absorb or to imitate. That is, lower initial stock of knowledge lead to faster imitation of technological progress (Edwards, 1997). Another requirement to enhance productivity through efficient resources allocation consistent with comparative advantage is undistorted price signal from world market. In this regard, the country's trade policies have to allow competitiveness (Hoekman et al., 2001).

Measuring the degree of openness is important to countries to formulate appropriate trade policies. In this aspect, there are two ways of gauging openness, namely 'revealed openness' and 'policy openness' (Dowric-Golley, 2004). The former (is defined as the ratio of total trade to GDP) measures the degree of distortion indirectly using prices and quantities, that is, it is based on outcomes. Although this method is simple to define and to measure, it has disadvantages, for example, it does not give exact answer about why some countries trade more. Whereas policy openness measures policy instruments directly, that is based on incidence. Like the former method, incidence based method has its own drawback, for example, since all sectors are not protected by tariff barriers, we may use subjective judgment which is difficult to quantify the degree of protection and distortion of trade (Dowric-Golley, 2004; Mikic and Gilbert, 2007).

Trade reform or trade policy change may make the poor vulnerable to economic fluctuations because the poor lack physical, financial and/or human capital. Thus, the poor would be sensitive to trade reform (Brooks, 2003). To protect the poor from vulnerability and to increase the beneficial effect of trade, trade reform should centre the poor. That is, there is a need to design policies, targeting those sectors that are of great importance to the poor, good institutional arrangement and investment response. However, these pro-poor trade policies depend up on the definition and the measurement of poverty.

Sen (1976) argued that there are two problems in measuring poverty; the criterion to choose the poverty line and forming poverty index using the information available. The former involves the difficulty of identifying the poor among the population whilst the

later implies the available information may not convey all the necessary information about the poor. Winters (2000) contend that one of the reasons for the existing disagreement about the poor is being poor itself is due to so many reasons and due to this any economic shock can have different effects among the poor.

To cope with the problems, different measurements of poverty have been applied. For example, the head-count ratio (H), it counts the number of the poor in the total population, was formulated to capture the problem of constructing poverty index using available information. However, this method is insensitive of income distribution among the poor (Sen, 1976). Another measurement is the poverty gap index. This measures the aggregate short-fall of income all the poor taken together from the poverty line. Although this measure satisfies the monotonicity axiom (*'Given other things, a reduction in income of a person below the poverty line must increase the poverty measure'* (Sen, 1976, p 219), it fails to satisfy the transfer axiom (*'Given other things, a pure transfer of income from a person below the poverty line to anyone is richer must increase the poverty measure'* (Sen, 1976, p 219). Currently, the FGT-index is considered as a standard measurement of poverty because this measurement is additively decomposable (total poverty is the sum of a weighted average of sub-group of poverty levels), satisfies the monotonicity and transfer axioms; and acceptable by the concept of relative deprivation of poverty. In addition, FGT incorporates inequality measures, the head count ratio and the income-gap ratio (Foster, Greer and Thorbecke, 1984)

In FGT poverty (P) is defined as:

$$P_{\alpha}(y; z) = \frac{1}{n} \sum_{i=1}^q \left(\frac{z - y_i}{z} \right)^{\alpha}$$

or

$$P_{\alpha} = \int_{i=1}^z \left\{ \left(\frac{z - y_i}{z} \right)^{\alpha} f(y) \right\} dy$$

$$\alpha \geq 0, i \geq 1 \text{ and } z > 0$$

Where α is the measures poverty aversion, z is poverty line, y is income, i represents household and n is number of population. Larger α emphasis to the poorest poor, P_0 is the headcount ratio, P_1 is a renormalization of the income-gap measure, P_2 measures the severity of poverty, etc.

Once the relevant measure of poverty index is chosen, the pro-poor trade policy could be framed. However, this is not exhaustive in the sense that the inclusion of an analysis of the link between trade (trade policies) and poverty is crucial as far the framing of this trade policy is concerned.

The theory of absolute advantage implies that a country that loses in pure trade competition might face higher level of poverty because when the country imports, it may get into debt. If this import is unable to create new, productive, and competitive activities, higher deficit would be inevitable and thereby poverty could ensue (Echevria, 2005). On the other hand, the theory of comparative advantage does not show the relationship between trade and poverty. Based on this theory, it is difficult to know degree to which the poor countries affected in terms of benefits and damages as a result of trade (Hassoun, 2008). One of the weaknesses of this theory is that it assumes flexibility of prices and full employment. According to this theory, trade deficit is not importunate due to the flexibility of prices. Consider two nations that have trade relations, one of these countries is deficit running because of trade and the other surplus country. Since the deficit running country has to pay to the surplus country, the out flow of money increases and this reduces the domestic prices of the deficit running country. As a result, in this latter country some producers could be competitive because it is cheap to produce there. However, the reverse would happen in the surplus country. Here the message is prices and exchange rates move fast enough to preclude the persistent deficit and simultaneously specialization appears. With regard to full employment assumption, unemployment does not exist because the employment lost by uncompetitive producers will be absorbed by the competitive producers. In sum, the two assumptions entail that there is no room for poverty to appear (Echevria, 2005).

Another traditional and advanced trade theory is Stolper-Samuelson theory. This advocates that an increase in the relative price of a commodity will increase the real return of the factor used intensively in producing that commodity. Thus, we may conclude that trade openness (liberalization) would rise real wage of unskilled labour of developing countries (Geoffrey et al., 2001). This is because these countries are assumed to produce primary products using unskilled workers. However, the SS theorem is unsatisfactory to predict the relationship between trade and poverty in developing countries. Among other reasons, the theorem relies on the very restrictive assumptions about technologies, labour market, number of products and factors. In addition, the SS theorem concentrated on the functional distribution of income change, but this may not be directly related to the household's income change (Winters, 2001a; Geoffrey et al., 2001).

Winters (2000) identifies different links by which trade and trade policies influence poverty. A static effect of trade on poverty is manifested through enterprise, distributive channel, government and household. Whereas the dynamic effect of trade is via vulnerability to shock, adjustment cost and economic growth.

Bhagwati and Srinivasan (2002) also argued that first trade promotes growth and then growth reduces poverty. Alternatively, total factor productivity can link trade, growth and poverty. However, the response of productivity to trade openness has an ambiguous effect on poverty. On one hand, the trade would improve productivity by way of increased competition, access to new technology, providing intermediate goods and the like. And this may contribute to reduce poverty. On the other way, higher total factor productivity due to trade may reduce input uses by the producers to produce the same level of output as before and this leads to decline employment and thereby intensify poverty (Winters et al., 2004).

When we compare the total factor productivity of different sectors, the total factor productivity of the agricultural sector is higher than the industrial sector (Martin and Mitra, 2001). Here we can understand that agricultural productivity as a result of trade

could play an important role in the process of poverty reduction in developing world at large. Inter alia factors, sustainable economic growth is required to overcome poverty in countries with the majority of the poor living in rural areas. In addition, to achieve effective poverty alleviation, there is a need of opening up the agricultural sector (in doing so improving agricultural productivity) because the sector has higher demand-spill over on localized activities that the poor are highly involved relative to other sectors (Winters, 2000).

We have seen that there are different links through which trade openness influences poverty. Out of these various connections, trade induced agricultural total factor productivity can play a part in poverty reduction. However, as Winter (2000) noted, the growth of productivity have to be less than the growth of output, otherwise agricultural productivity would exacerbate poverty.

To provide policy prescription and understand the connection between trade and poverty in the real world, the exiting theories have to be verified using pragmatic studies. There are many practical studies that assess the poverty impact of trade and the conduits that trade influences poverty. Much of these studies use Computable General Equilibrium-Micro-Simulation analysis. Although CGE models are subjected to some limitation, CGE-MS analysis have advantages over econometric analysis, that is, it has an ability to explain the impact of macroeconomic shocks on microeconomic activities and elucidate the inter linkages of different sectors and economic agents in a given economy.

Based on a CGE micro-simulation model, Chitiga (2004) found that trade liberalization would reduce poverty in Zimbabwe. The study seems to justify the SS theorem. The removal of tariff favours crop agricultural sector which intensively uses unskilled labour, agricultural capital and land. Using Generic Macroeconomic CGE model, Khan (2005) also came across that trade liberalization reduces poverty in South Asian countries. However, he identifies that the extent of trade liberalization to influence poverty is limited and reduction of average tariff beyond 15% has negligible impact on poverty. Thus, trade policies are not the only instruments to reduce poverty, but it is in

conjunction with other policies targeting on poverty lessening. Similarly, the CGE model applied to Ghana by Bhasin and Obeng (2007) explains that trade liberalization would reduce the incidence, depth and severity of poverty. Nevertheless, this could happen if the elimination of import and export duties is compensated by foreign aid. Dollar and Kraay (2001) used the cross-country regression analysis to see the effect of openness on inequality and poverty over the past 20 years. They concluded that those poor countries more open (post-1980 'globalizers') their economy, achieves faster growth and thereby reducing poverty.

On the other hand, Cisse et al. (2005) employed the dynamic CGE model using the 1996 Social Accounting Matrix (SAM) and the 1995 household survey data of Senegal. Their finding demonstrates that in the short-run trade liberalization brings about petite raise in poverty and slimming down of production of those initially protected sectors. However, in the long-run openness decreases poverty because trade could enhance capital accumulation. Bibi and Chatti (2006), as well, assessed the impact of trade openness between Tunisia and EU countries by making use of the layered dynamic CGE model. Their simulation result hints that although trade liberalization reduces poverty in the long-run, it slows down the poverty reduction process in the short-run in the case of Tunisia.

Total factor productivity is one of the streams through which trade influences poverty, that is, first trade enhances TFP growth and TFP growth reduces poverty. Based on 13 OECD countries, Madsen (2005) showed that trade is a significant determinant of TFP growth by facilitating the transfer of technology. Their simulation lays bare that the 200% TFP increment over the past 120 years came from knowledge associated with import. In addition, in this study, those countries which had lowest TFP in 1883 highly benefited from technological spill over of trade. This result seems consistent with Edward's (1997) argument. Using a simple version of Hecksher-Ohlin model, Ferreiray et al. (2010) also found out that the relevance of gains from trade in the measurement of TFP.

Anchored in emerging economies data, Martens (2008) estimated the elasticity of TFP with respect to trade openness. The main finding of the study, in general, is that openness has a positive and statistically significant effect on TFP. But, different indicators of openness provide different elasticity of TFP. For example, the elasticity of TFP with respect to openness which is defined as total export and total import to GDP ratio lies between 0.34 and 0.74. On the other hand, the elasticity of TFP with respect to openness (import divided by GDP) is about 0.31. Although there is a positive and considerable effect of trade on TFP growth of the aggregate economy as investigated by Abizadeh and Pandey (2009), using a panel data of 20 OECD countries between the years 1980 and 2000, no substantial TFP growth resulting from trade is recorded in agriculture and industrial sectors. However, the attribute of higher TFP growth of the given economies which are trade induced emanated from the service sector. Using the global CGE model and econometric estimate of trade induced TFP; Sherman et al. (2006) analyze the preferential trade agreements between Morocco and EU, and those of Egypt and EU. They found that trade induced TFP contributes a lot in the reduction of poverty in Morocco and Egypt.

Different studies discover that agricultural productivity gain is crucial to reduce poverty. For instance, Christiaesen and Demery (2007) disclose the evidence that agricultural productivity is critical and effective to curbing poverty in low income countries. Hassine et al. (2010) also examine the impact of trade induced agricultural TFP on poverty. To capture agricultural technological change due to trade openness, first they estimated agricultural TFP using the latent Class Stochastic Frontier Model. Then by combining this estimated TFP with static Micro-Simulation CGE model they assessed the poverty impact of trade induced agricultural TFP. Their simulation result revealed that when trade induced productivity is considered, the agricultural and full liberalization would reduce poverty in Tunisia by 19% and 38%, respectively.

Some studies have been under taken to get the picture of the relationship between trade and poverty in Ethiopia. Using a Static CGE Micro-Simulation model, Dejene et al. (2006) identify that although a 100% tariff removal would improve the welfare of farm

households, poverty at national level might step up. On the other hand, Seid (2007) and Bisrat(2009) employed the Dynamic CGE to examine the impact of trade liberalization on poverty in Ethiopia. Their simulation result showed that in the long run trade liberalization could reduce poverty. However, in the short run Seid found that poverty remains unaffected by trade liberalization whilst Bisrat found that trade liberalization would exacerbate poverty in Ethiopia in the short run.

By utilizing econometric analysis of rural household panel data, Adugna (2009) uses the change in price of input and output channel by which trade liberalization affects change in poverty status of rural farm household in Ethiopia. His result depicts that the probability of remaining being poor and falling into poverty would be higher if trade liberalization changes the price of cash crops. But, a combination of relative price change (due to trade liberalization) with access to credit and schools would create a higher probability for the household to be out of the poverty category. However, these pragmatic studies in the case of Ethiopia around the issue of trade and poverty seem to miss the agricultural total factor productivity which could be the link between trade and poverty in Ethiopia. This notion could be consistent with the finding of Mulat et al. (2003) that in order to overcome the severity of poverty in Ethiopia agricultural growth complement with its productivity growth is crucial.

3. TRADE, AGRICULTURAL GROWTH AND POVERTY IN ETHIOPIA

Under this topic we describe the trade, agricultural growth and poverty situation in Ethiopia between 2005 and 2010.

The external sector of the Ethiopian economy includes export and imports of agricultural and industrial items; and trade in service. The export sector has grown by 38.4% between 2009 and 2010, and by 36.7% between 2008 and 2010. Most of the increase in export is attributed by the growth of Coffee and Oilseeds. For example, in 2008 coffee and oilseeds had grown by 35.8% share and 14.9% share of the total export. Similarly, coffee had grown by 26.4% share and the percent share of oilseeds was 17.9 in the year 2010 (NBE, 2010).

The import side of the country has shown increment as the export sector. Although the percentage changes of import are smaller than the percentage change in export, the volume of import much more than the export. In 2008, the volume of import was USD 6,810.5 mil. But, the volume of export was USD 1465.7 mil. Similar difference is also true in the years 2009 and 2010. Such differences which are the mentioned years as well as the country's trade history (from the imperial regime) result the country to exercise negative trade balance.

The agriculture sector of Ethiopia is the main source of food consumption; it is also the livelihood of the majority of the country's farmers and the major source of foreign currencies. Thus, the growth of this sector has many implications on the country's economy as a whole and on poverty situation in particular.

According to the 2010 NBE report, the total value of the agricultural items had grown successively from 2005 to 2010. In 2005 the sectoral GDP of the sector was birr 39,728 mil., this growth continued to increase into 48,225 mil in 2007 and in 2010 reached 59,348 mil. But, whether these increments of the agricultural GDP growth are emanated due to the increased in the total agricultural output or the increased general price level is the issue that should be addressed. When we assess the contribution of the agricultural sector to the GDP growth, its contribution continuously declined and overtook by the service sector. In 2005 the agricultural contribution was 6.4% and turn down to 3.2% in 2010, in the meantime the contribution of the service sector had increased from 5.1% in 2005 to 6% in 2010.

In the case of poverty situation in Ethiopia, we compare the head count index, the poverty gap index and poverty severity index (i.e., a class of decomposable poverty measures, FGT) of 2004/05 and 2010/11 using Household Income Consumption and Expenditure (HICE) surveys of CSA. This is depicted in Table.1 below. Accordingly, HCIE shows that ratio of the poor to the population at national level, in rural and urban have declined in 2010/11 comparing from the year 2004/5. The PGI measure of poverty also shows that the mean consumption shortfall of the poor relative the poverty line across the whole population has depressed in terms national, rural and urban level. However, the inequality

among the poor has widened in 2010/11. At national level, poverty severity has increased from 0.027 in 2004/5 to 0.031 in 2010/11. Similarly, in rural area as well as in urban area of the country the inequality among the poor has inflated. In rural area, it has increased to 0.032 from 0.027 and in urban, the severity has recorded to 0.027 from 0.026.

Table1. National, Rural and Urban poverty indices

	2004/05	2010/11
National		
head count index	0.387	0.296
poverty gap index	0.083	0.078
poverty severity index	0.027	0.031
Rural		
head count index	0.393	0.304
poverty gap index	0.085	0.08
poverty severity index	0.027	0.032
Urban		
head count index	0.351	0.257
poverty gap index	0.077	0.069
poverty severity index	0.026	0.027

Source: the 2004/5 and 2010/11 HICE survey of CSA of Ethiopia

And MoFED's(2012) computation

4. DATA AND METHODOLOGY

To capture the poverty impact of trade, the paper will employ a dynamic CGE (which is developed by IFPRI) and Micro-simulation (MS) models. Besides this, to see how trade influence poverty via agricultural TFP in Ethiopia and to create scenarios, the study estimates agricultural TFP. For these purposes, secondary data is applied. The sources of these data are CSA (The agriculture sample surveys between 2006-2010 and the 2004/2005 Household Income Consumption and Expenditure (HICE) Metadata),

International Trade Center (ITC UN data of import and export between 2006 and 2010) and the 2005/06 SAM of Ethiopian Development Research Institution (EDRI).

4.1 The Social Accounting Matrix (SAM)

In order to analyze the economy wide impacts (in general) and poverty impacts (in particular) of different economic policies change, changes in production and trade structure, world's economic and environmental shocks using a CGE model, the CGE model have to be calibrated based on the Social Accounting Matrix because the SAM provides more information about the flow of goods and services associated with payments across the given economy. In the case of this study, the 2005/06 SAM of EDRI will be utilized. This SAM is designed based on the Neo-Classical-Structuralist assumption to fit the IFPR's CGE model. As any standardized SAM, the EDRI's SAM is square matrix and each cell also shows column describes the expenditure while the row shows income received. Thus This SAM is divided into four groups of accounts: activities, commodities, factors of production and institution.

The activity account divided into agricultural and non-agricultural activities and presents the monetary value of goods and services produced by each activity and the expenditure of each activity on intermediate inputs and primary factors to produce the given amount of the commodity. The commodity account, on the other hand, (is divided into marketed, non-marketed and trade and transaction costs) express the total supply and total demand sides. The supply side incorporates the domestic production, imports, indirect taxes (domestic taxes, import duties and taxes) and marketing margins whereas the demand side shows the intermediate input uses, the final consumption, investment demand, government consumption and export.

The third account is factors of production which depicts the source of factor income and the distribution of these factor payments to different households, government and rest of the world. This account also divides factors into agricultural land, agricultural capital-land, non-agricultural land and non-agricultural capital-land. The institutional account records all income, expenditure and transfers among institutions .This account also

comprises household, government and rest of the world. The household is categorized into rural poor, rural non-poor, urban-poor and urban non-poor. In addition, the SAM contains Saving-Investment account to record savings of institutions and investment expenditures.

In aspect of the flow of goods and service and payment across the Ethiopian economy, the EDRI's SAM presents detail analysis. In the activity account both agricultural and non-agricultural activities purchase the intermediate inputs from the marketed commodities and the agricultural activity employs agricultural land, agricultural capital-land, non-agricultural land and non-agricultural capital-land. But the non-agricultural activity uses only non-agricultural land and non-agricultural capital-land. In the commodity account, the marketed spend to agricultural, non-agricultural activities and the rest of the world; and pays domestic indirect taxes and import duties and taxes and the non-marketed spend only to agricultural and non-agricultural activities. While the transaction cost part shows payment to the marketed.

In factors of production section, both rural poor and rural non-poor receive income from selling or renting their agricultural land, agricultural capital-land, non-agricultural land and non-agricultural capital-land. The urban poor and urban non-poor also get their income from non-agricultural land and non-agricultural capital-land. But the public enterprise and the rest of the world earn income only from the non-agricultural capital-land.

The institution account demonstrates that all households spend on marketed and non-marketed commodities and except urban poor other households pay direct tax, but only urban non-poor pays to the rest of the world. In addition, all households save the part of their disposable income in the saving account. The government collects its income from public enterprise and different taxes and expends on marketed commodities, transfers to households and to the rest of the world and saves the residual. For the gross capital formation, investment uses the marketed commodities.

The 2005/06 EDRI's SAM could be aggregated or disaggregated. The aggregated SAM is a 47 by 47 matrix and comprises 14 activities, 15 commodities, 4 factors of production, 7 institutions (with in this account there are 4 households (rural poor, rural non-poor, urban-poor and urban non-poor), a government, an enterprise and the rest of the world), 3 tax accounts, Saving-Investment account and stock changes.

The disaggregate SAM also a 255 by 255 matrix which accommodates 98 activities, 93 commodities, 26 factors of production, 17 institutions, 9 direct taxes, 8 indirect taxes, trade and transport margin, Saving-Investment account, stock change and the rest are included in Total values. And this SAM also includes 5 agro-ecological zones. At last, given time constraint, this study employs the aggregated (47× 47 matrix) SAM of EDRI for the CGE analysis.

4.2 METHODOLOGY

4.2.1 Econometric Model

The objective of estimating of the agricultural TFP in Ethiopia in this paper is to get the value of the parameter of trade openness which help to set the simulation value of the agricultural TFP in Ethiopia.

To estimate the agricultural TFP, the study assume the Cobb-Douglas production function that

$$Q_{it} = A_{it} L_{it}^{\alpha} La_{it}^{\beta} \dots\dots\dots(1)$$

Where Q is total output

A is agricultural total factor productivity (TFP)

L is labor which is proxy by the number of holders

La is area of cultivated land,

α and β are share parameters of L and La, respectively

i represents agricultural commodity, i.e, i= 1,2,3.....n

t is production year

Taking the natural logarithm on both sides of equation (1)

$$\ln Q_{it} = \ln A_{it} + \alpha \ln L_{it} + \beta \ln La_{it} \dots \dots \dots (2)$$

We can generate the agricultural TFP of each item for each year using either equation (1) or equation (2)

$$TFP_{it} = \frac{A_{it}}{L_{it}^{\alpha} La_{it}^{\beta}} \dots \dots \dots (3)$$

Alternatively,

$$\ln A_{it} = \ln Q_{it} - \alpha \ln L_{it} + \beta \ln La_{it} \dots \dots \dots (4)$$

Equation (3) and (4) the “Solow Residual” it means the part output that is not explained by the labor and capital/land. This “Solow Residual” represents the TFP.

Once we get the level of agricultural TFP of each item for each year, it is possible to estimate TFP. But it is necessary to get the possible determinants of agricultural TFP in the given economy. Based on some empirical works, the factors the influence agricultural TFP in Ethiopia would be fertilizer (allfirti), seeds, pesticide, irrigation, extension package (which includes how to use best practice, transfer of technology to farmers and education among others), trade openness (trade) and agro-ecological zone(dummy).

$$TFP_{it} = f(\text{allfirti}, \text{seeds}, \text{pesticide}, \text{irrigation}, \text{extensionp}, \text{trade}, \text{dummy}) \dots \dots \dots (5)$$

$$\ln TFP_{it} = \beta_0 + \beta_1 \ln \text{allfirti}_{it} + \beta_2 \ln \text{seeds}_{it} + \beta_3 \ln \text{pesticide}_{it} + \beta_4 \ln \text{irrigation}_{it} + \beta_5 \ln \text{extension}_{it} + \beta_6 \ln \text{trade}_{it} + \beta_7 \text{dummy} + e_{it} \dots \dots \dots (6)$$

4.2.2 The Recursive Dynamic Computable General Equilibrium (DCGE) Model

In examining of the poverty impact of trade, applying Computable General Equilibrium Model is more convenient. In fact, there are other methods are available to analyze the impact of trade and trade policies change on economy-wide in general and on poverty in particular, but some of these models concentrate on micro-level analysis by ignoring the broader market and macroeconomic effects and/or excluding the decision making individual agents and/or disregarding factor markets are among others (Thurlow et.al, 2011). The advantage of CGE over such models is that its ability to reflect a country’s

economic structure and linkage because the model incorporates the interactions between different economic decision agents and its ability to be linked with micro-simulation modules to capture the effect of any change in the economy on households. Likewise, this model has a capacity to treat the growth-poverty relationship and to provide more information about different policy options that developing countries could face (Thurlow et al., 2011). To meet the objective of this study, therefore, we will employ the recursive dynamic CGE model. This DCGE model is separated into two: “within-period” and “between-period”. The within-period part, developed by Lofgren et al. (2002), is static and solves the maximization problem of the consumers and the producers based on the prevailing prices. The between-period section, on the other hand, updating some of the exogenous variables is either externally-determined or based on the previous period result (Thurlow et al., 2011).

4.2.2.1 Within-Period CGE Model (static part)

This standard DCGE model has four blocks: prices, production and trade, institutions and system constraints. Now first let us describe some equations in these blocks based on the static version, then followed by the dynamic one. The full descriptions of the model equations will be found in the appendix part.

PRICE BLOCK

This block is a price system model that shows how endogenous prices are connected with other prices (it could be endogenous or exogenous) and non-price model variables based on the assumption of the existence of quality differences among commodities of different origins and destinations.

Import price equation

This equation consists of import price (PM_c) in local currency unit (LCU), import price in foreign currency unit (FCU), (p_{wm_c}), tariff adjustment ($1+tm_c$), exchange rate in local currency unit per foreign currency unit (EXR) and cost of trade inputs per import unit (summation of $PQ_{c'}$ times $icm_{c'}$). The equation is:

$$PM_c = pwm_c (1+tm_c) \times EXR + \sum_{c \in CT} PQ_{c'} \cdot icm_{c'} \quad , c \in CM \dots\dots\dots (1)$$

Where;

$c \in CM$ = a set of commodities (also referred to as c' and C')

$c \in CM (\subset C)$ = a set of imported commodities, $\subset C$ = a set of imported commodities,

$c \in CM (\subset C)$ = a set of domestic trade inputs (distribution commodities)

Export price equation

This equation is constituted by export price in LUC (PE_c), export price in FCU (pwe_c), tariff adjustment ($1 - te_c$), EXR in LCU per FCU, and cost of trade inputs per export unit (summation of $PQ_{c'}$ times $ice_{c'}$)

$$PE_c = pwe_c (1 - te_c) \times EXR - \sum_{c' \in CT} (PQ_{c'} \times ice_{c'}) \quad , c \in CE \dots\dots\dots (2)$$

Where;

$c \in CE (\subset C)$ = a set of exported commodities (with domestic production)

Note that since there is no export tariff in the case of Ethiopia, $te_c = 0$. Therefore, equation (2) is reduced to

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

Absorption

In this system, the total domestic spending on a commodity at domestic demander price is shown. It includes absorption at demand prices net of sales tax ($PQ_c (1 - tq_c) QQ_c$), domestic demand price (PDD_c), domestic sales quantity (QD_c), import price (PM_c) and import quantity (QM_c)

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c \dots\dots\dots (3)$$

but $c \in (CD \cup CM)$

Marketed output value

Here the value of the marketed quantity of domestic output is determined. In this system aggregated producer price for commodity (PX_c), aggregated marketed quantity of

domestic output of commodity (QX_c), quantity of export (QE_c), export price (PE_c), domestic supply price (PDD_c) and domestic sales quantity (QD_c) are included.

$$PX_c \cdot QX_c = PDD_c \cdot QD_c + PE_c \cdot QE_c \dots\dots\dots(4)$$

$c \in CX (\subset C)$, it is a set of commodities with domestic output.

Consumer price index

This equation describes consumer price index (CPI) is calculated by the product of price of aggregated commodity c (PQ_c) and weight of commodity c in the CPI ($cwts_c$). For the purpose of this study, which will make use of micro-simulation analysis of poverty, CPI is flexible so as to adjust the consumption expenditure and to determine equilibrium.

The equation is:

$$CPI = \sum_{c \in C} PQ_c \cdot cwts_c \dots\dots\dots(5)$$

Producer price index for non-traded market output (DPI)

This section of equation shows how the DPI is determined by the domestic supply price and the weight of commodity c in the DPI (dwt_s). However, once CPI is made supply, DPI is set as numeraire because the model is homogenous of degree zero in price.

$$\overline{DPI} = \sum_{c \in C} PDS_c \cdot dwt_s \dots\dots\dots(6)$$

PRODUCTION AND TRADE BLOCK

It comprises domestic production and input uses; the allocation of domestic output to home consumption, the domestic market and export; the aggregation of supply to the domestic market (this also contain import and output sold domestically); and the distribution process which define the demand for trade inputs.

Production block

The activity production function utilizes both quantity of aggregate value-added and quantity of aggregate intermediate input. The maximization problem of the producer in

the economy is solved by maximizing profit subject to the given technology and prices. The specification of technology nest at the top-level of activity could be either a CES or a Leontief function of the quantity of aggregate value-added and quantity of aggregate intermediate input use. The CES technology (activity production function) includes activity level (QA_a), quantity of aggregate value-added (QVA_a) and quantity of aggregate intermediate input ($QINTA_a$).

$$QA_a = \alpha_a^a \left(\delta_a^a \cdot QVA_a^{-\rho_a^a} + (1 - \delta_a^a) \cdot QINTA_a^{-\rho_a^a} \right)^{-\frac{1}{\rho_a^a}} \dots \dots \dots (7)$$

Where

$a \in ACES (\subset A)$ = a set of activities with a CES function at the top of the technology nest,

α_a^a = efficiency parameter in the CES activity function,

δ_a^a = CES activity function share parameter, and

ρ_a^a = CES activity function exponent.

Allocation of domestic output

It is an output transformation function showing that how domestically produced output (QX_c) is allocated between domestic sales (QD_c) and exports (QE_c). Equation (8), below, assumes that there is an imperfect transformation between exports and domestic sales,

i.e., there is a CET. $QX_c = \alpha_c^t \cdot \left(\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \dots \dots \dots (8)$

Where

$$c \in (CE \cap CD)$$

α_c^t = a CET function shift parameter,

δ_c^t = a CET function shift parameter, and

ρ_c^t = a CET function exponent.

Export-Domestic supply ratio

This identifies how the domestically produced output is optimally distributed between export and domestic sales. For example, if the relative price of export (against domestic

price) is higher, the relative supply of export (against domestic supply) would be higher. The equation is as follow

$$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^e}{\delta_c^e} \right)^{\frac{1}{\rho_c^e}} \dots\dots\dots (9)$$

Composite supply (Armington) function

This function, is a part of trade block, illustrates the supply of the composite commodity (QQ_c) in the economy is the combination of domestically produced and domestically sold (QD_c) and imported commodities (QM_c). When the supply of the composite commodity in the domestic market depends on both imported and domestically produced, the composite supply function is considered as “Armington Function”. This function captures the imperfect substitution between import and domestic output sold domestically

by the CES aggregation function. $QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + (1 - \delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}} \dots\dots\dots (10)$

Where $c \in (CM \cap CD)$

- α_c^q = an Armington function share parameter,
- δ_c^q = an Armington function share parameter, and
- ρ_c^q = an Armington function exponent.

Import-Domestic demand ratio

This ratio provides the optimal combination of imports and domestically produced (that is sold domestically) in the economy. When the relative price of domestic output increases, the country would have a tendency to import more. However, the substitution between import and domestic output is based on the Armington assumption.

$$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q} \right)^{\frac{1}{1 + \rho_c^q}} \dots\dots\dots (11)$$

INSTITUTIONAL BLOCK

This block is constituted by households, enterprises, the government and the rest of the world. There are 11 equations are under this block, however, we present some of them which are relevant to this study.

Factor income equation

It shows the sum or the total income of each factor payment (YF_f) in the economy.

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \dots\dots\dots (12)$$

Where

$$f \in F$$

YF_f = income of factor f,

WF_f = average price of factor f,

\overline{WFDIST}_{fa} = wage distortion factor for factor f in activity a, and

QF_{fa} = quantity demand of factor f form activity a.

Household consumption expenditure equation

This equation describes how the household income disposable for consumption (HE_h) is determined. It is the share of net income of h to I ($shii_{ih}$), the marginal propensity to save for household (MPS_h , exogenous variable), direct tax rate for household h ($TINS_h$) and income of household (YI_h) are included.

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1 - MPS_h) \cdot (1 - TINS_h) \cdot YI_h \dots\dots\dots (13)$$

Where

$i \in H (\subset INSDNG)$, $INSDNG$ is a set of domestic non-government institutions.

Household consumption spending on marketed commodity

This equation represents how household consumption spending on marketed commodity is determined.

$$PO_c \cdot QH_{ch} = PQ_c \cdot \gamma_{c h}^m + \beta_{c h}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c' h}^h - \sum_{a \in A} \sum_{c' \in C} PXAC_{ah} \cdot \gamma_{a c' h}^h \right) \dots\dots\dots (14)$$

Where, $c \in C$, $h \in H$,

$\gamma_{c h}^m$ = subsistence consumption of marketed commodity c for household h,

$\beta_{c h}^h$ = marginal share of consumption spending on marketed commodity c

for household h, and

$\gamma_{ac'h}^h$ = subsistence consumption of home commodity c from activity a for household h.

Investment demand equation

This equation calculates the fixed investment demand ($QINV_c$) using the base-year of the quantity of fixed investment demand (\overline{qinv}_c) adjusted by the exogenous investment factor

(\overline{IADJ}). However, the total amount of investible funds could be flexible when we choose the saving-driven macro-closure.

$$QINV_c = \overline{IADJ} \cdot \overline{qinv}_c \dots\dots\dots (15)$$

Government revenue and expenditure

The government revenue is constituted by direct tax from institutions, direct tax from factors; value added tax, activity tax, import tariff, export tax, sales tax, factor income and transfer from the rest of the world. However, export taxes, value added taxes on activities directly; activity taxes are not the source of government in Ethiopia. The government expenditure (EG), on the other hand, is divided into government consumption ($PQ_c \cdot QG_c$) and government transfer ($trnsfr_{i_{gov}}$).

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i_{gov}} \cdot \overline{DPI} \dots\dots\dots (16)$$

MACRO-SYSTEM CONSTRAINT BLOCK

In order to get the solution of the general equilibrium, the number of equations and the number of variables have to be equal. To satisfy this, the CGE model introduced three macroeconomic balances: the current government balance, the current account balance and the Savings-Investment balance. To get these balances, again, there are different alternative closures and the user can choose the appropriate closures that reflect the objective of his/her study. The choice of any of the available closure does not sway the solution to the base simulation but it changes the results of other simulation (Lofgren et.al, 2002).

The constraint block includes equation of factor market, composite commodity market, CA balance for the RoW (Rest of the World) in FCU, government balance, direct institutional tax rates, institutional savings rates, saving-investment balance, total absorption ratio of investment to absorption and ratio of government consumption to absorption. Now let us present some of the selected which are relevant for this study.

Factor and commodity markets

The equilibrium conditions require the equality between the total quantity demanded for each factor (commodity) and the total quantity for each factor (commodity).

$$\sum_{a \in A} QF_{fa} = \overline{QFS}_f \dots\dots\dots (17)$$

Where,

$$f \in F$$

QF_{fa} = quantity demanded for factor f (endogenous variable)

\overline{QFS}_f = quantity supplied for factor f (exogenous variable)

Note that the economy-wide of factor wage (WF_f) is flexible to equilibrate equation (17).

But in the case of the existence of unemployment assumption \overline{WF}_f is fixed while QFS_f .

Government balance

This balance is assured when the government revenue (YG) is equal to the sum of government expenditures (EG) and government savings (GSAV).

$$YG = EG + GSAV \dots\dots\dots (18)$$

Current account balance

In this balance, the sum of import spending ($\sum p_{wm_c} \cdot QM_c$) and factor transfers to RoW ($\sum trnsfr_{row_f}$) must equals to the sum of export revenue ($\sum p_{we_c} \cdot QE_c$), institutional transfers from RoW ($\sum trnsfr_{irow}$) and foreign savings (\overline{FSAV}). The equation is:

$$\sum_{c \in CM} p w m_c \cdot Q M_c + \sum_{f \in F} t r n s f r_{r o w f} = \sum_{c \in CM} p w e_c \cdot Q E_c + \sum_{i \in INSD} t r n s f r_{i r o w} + \overline{F S A V} \dots\dots\dots (19)$$

Saving-Investment balance

This balance also requires the equality of total national saving and total investment.

$$\sum_{i \in INSDNG} M P S_i \cdot (1 - T I N S_i) \cdot Y I_i + G S A V + E X R \cdot \overline{F S A V} = \sum_{c \in C} P Q_c \cdot Q I N V_c + \sum_{c \in C} P Q_c \cdot q d s t_c \quad (20)$$

Where; $\sum_{i \in INSDNG} M P S_i \cdot (1 - T I N S_i) \cdot Y I_i =$ non-government saving

$G S A V =$ government saving

$E X R \cdot \overline{F S A V} =$ foreign savings

$\sum_{c \in C} P Q_c \cdot Q I N V_c =$ fixed investment

$\sum_{c \in C} P Q_c \cdot q d s t_c =$ stock change

To maintain the three macro-balances, this paper uses three default closures of the IFPRI’s CGE model for Ethiopia. For the government balance, tax rates are fixed and government saving is flexible; for the current account balance, foreign saving is fixed while real exchange rate is flexible; and for Saving-Investment balance, saving is fixed and investment is endogenous, i.e., saving-driving closure.

Although we introduce closures to fulfill the three macro-balances, the number of equations exceeds the number of equations by one; this shows the model is not square. But, this model satisfies the Walras’ law and we can drop or add one equation. Thus, the IFPRI’s CGE model adds the “WALRAS” variable (which has zero solution) into Saving-Investment equation. All equations that we have described above are based on the within-period, i.e., static.

4.2.2.2 Between-Period CGE Model (Dynamic part)

Now let us present the general description the between-period part of the recursive dynamic CGE model. In the static part factor supply and TFP are exogenous. These

variables are updated in the between-period part. In this model, labor supply is determined by population growth exogenously. But capital accumulation is determined by the previous period capital stock and investment spending, that is, capital accumulation is determined endogenously. The distribution of the new capital is derived from the initial share of the sector's the aggregate capital income.

The current quantity of factor supply and the present TFP are determined by the previous year's quantity of factor supply and the present TFP, respectively. Similarly, the recent government consumption expenditure is updated based on the preceding year's consumption. Sectoral capital accumulation is also updated on the basis of the previous period level of investment. There are two ways to capture this depending on the assumption we set. Finally, it is important to note that population growth is captured by the model by way of changes in labor supply (the model's equations are depicted on Appendix B.2).

4.2.3. The Micro Simulation Model

To capture the economy-wide impact of changes in trade and trade policies, different authors applied different ways of linking the CGE results to poverty and income distribution. In general these methods are classified into three: CGE model with representative household agent (CGE-HR), layered CGE micro-simulation (CGE-MS), and integrated CGE model with bi-directional micro-simulation (CGE-IH).

The CGE model with representative household agent model was developed by Adelman and Robinson (1978) which classifies different representative household groups on the basis of income, location or occupation. This approach assumes that there is no intra-group inequality and the variance of income within group is fixed. Then, the model compares the variation of the average income among representative groups. The second approach is layered CGE micro-simulation which uses two sequences (top-down approach). First, the CGE model is simulated to generate different results and into which these results are fed into micro-simulation model, particularly consumption expenditure and prices (CPI). Although this approach considers the intra-group difference, there may not be consistency between the micro-simulation data and that of the CGE model and which is unidirectional. The integrated micro-simulation, on the other hand, considers the

intra-group income variation and it provides a bi-directional analysis of CGE micro-simulation model (see Savard, 2003; and Bibi and Chtti, 2006).

In the present study, we use the layered CGE-micro-simulation model to assess the poverty impact of trade and trade policies and in the micro-simulation model we will apply the household consumption expenditure per adult equivalent to capture the households' ability to meet the basic needs. Thus, to get household consumption expenditure per adult equivalent (Exp/adult) we use the 2004/2005 HICS data of CSA. After this, we will adjust the Exp/adult for the percentage change in the private consumption of the simulation result of the DCGE. In similar manner we will also adjust the poverty line for CPI changes of each simulation from the DCGE model. The last task is taking the adjusted Exp/adult and adjusted poverty line into the Software for Distributive Analysis (DAD) to address the poverty impacts of our simulations.

5. ECONOMETRIC AND SIMULATION RESULTS

In this section we begin with the presentation of the estimation result of agricultural TFP and following this, the economy-wide and the poverty impact of simulation of tariff reduction and an increase in agricultural TFP will be described.

5.1. Econometric result

We performed appropriate statistical tests to test the employed panel data, the parameters of estimates and the specification of the model. Breusch and Pagan LM test suggests that the model should be Random Effect Model (REF). Accordingly, the result is given in Table 2.

The result shows that fertilizer, seeds, irrigation, extension package and trade openness are statistically significant while pesticide and agro-ecological dummy fail to explain agricultural TFP statistically. The negative sign of the coefficients of seeds and irrigation may signify that their application on the given cultivated land could be beyond the optimal level, but the negative coefficient of the extension package might be indicative

of the fact that an extension package provides knowledge and information to farmers on how improving TFP would reduce the price of their produced items, as a result of which the farmers may not be willing to increase their productivity and they may allocate their resources sub-optimally which contributes to TFP decline.

The positive coefficient of fertilizer and trade openness could be explained by the fact that an increase in the application of fertilizer use by one unit would induce the agricultural TFP to increase by 1.063, on average. In the same way, an increase in trade openness by one unit, on average, would trigger the agricultural TFP to respond by 0.144.

Table.2 Random-Effect GLS regression results for agricultural TFP

Intfp	Coef.	Std. Err.	z	P> z
_cons	14.0894	2.238	6.30	0.000
lnallfirtr	1.0633	0.2848	3.73	0.000
lnseed	-1.2522	0.1761	-7.11	0.000
lnpesticide	-.13788	0.1095	-1.26	0.208
lnirrigatn	-0.4574	0.1196	-3.82	0.000
lnextensie	-0.5134	0.1861	-2.76	0.006
lntrade	0.1442	0.0631	2.29	0.022
Dummy2	0.3063	0.2041	1.50	0.133

R-sq: within = 0.3532 overall = 0.9190 Wald chi2(7) = 192.83 sigma_e = 0.14538502
between = 0.9558 Prob > chi2 = 0.0000 rho = 0

Source: estimation result of STATA 11 software.

5.2 Simulations

Baseline scenario

The model which we introduced, DCGE, is calibrated to reflect what would happen to the economy when there is no policy change and external shocks; and to generate the growth path over time. Here the assumption is that the economy exhibits changes which arise

from change in the annual growth of factor supply and productivity (Thurlow *et al.*, 2011). In our case, the base-run simulation covers the period between 2006 and 2015.

Simulation 1

Since currently Ethiopia is in the process of accession to World Trade Organization (WTO) and most of the country's trading partners are the members of WTO, it is reasonable to take the WTO's tariff cut requirement to create scenario. Thus, we simulate a 24% tariff cut, assuming that Ethiopia will join in the category of developing countries within the simulation period. The maximum tariff cut for the agricultural items that developing countries are required is 24%. However, the tariff reduction for the non-agricultural items is not uniform. Thus, we apply a 24% tariff cut for all sectors. The result of this tariff cut on the economy may be affirmative or negative on the economy in general and on poverty in particular.

Simulation 2

In this scenario we simulate agricultural TFP using our estimation result given in Table 1. Accordingly, an increase in trade openness by 1% results in an increase in agricultural TFP by 0.144%, on average. This simulation is important to see how trade influences poverty in this economy through the agricultural TFP.

Simulation 3

This simulation is a combination of Sim-1 and Sim-2. It helps to understand how trade policy (tariff cut by 24%) associated with enhancing agricultural TFP due to trade openness influences the economy and the poor in this economy.

Simulation 4

One of the factors that can influence the agricultural TFP is the level of the usage of fertilizer. Here again we use the above estimation result. Suppose that the price of fertilizers decreases, then there will be a tendency to increase the application of fertilizer. If this is the case, an increase in the use of fertilizer by 1%, on average, has an incremental impact on the agricultural TFP by 1.06%. The importance of the introduction of this simulation in our model is to compare which of the simulations, i.e., Sim-2 or Sim-4, is more important in explaining the process of poverty reduction.

5.3 Simulation Results

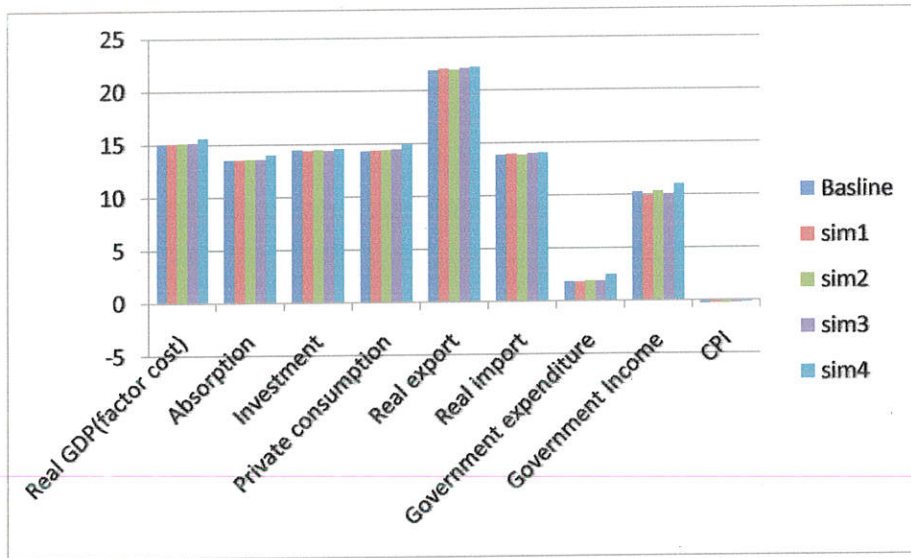
For the sake our study, we only present the simulation results pertaining to the macroeconomic and sectoral effects of the above scenarios.

5.3.1 The Macroeconomic Effects Simulation

The result of sim-1 in Figure 1 and Table 3(see also appendix C.1) shows that when a country uses a 24% trim downs of tariff, it results in an increase in RGDP at factor cost by 15.08% percent from its initial value but this is a 0.006% increment when we compare with business as usual (BAU) situation. This increase in RGDP at factor cost would be explained by the fact that though there is a reduction of investment and government expenditure, by 0.08 and 0.03 percentage point changes, respectively, it is clearly offset by an increase in 0.04 percentage point change in private consumption and a 0.16 percentage point change in real export. The increase in private consumption leads to an increase in absorption by 0.01 percentage point change from BAU (or 13.54% from the initial value), although investment and government expenditure decreases. An increase in a 0.11 percentage point change in real import is also recorded in this simulation. The decrease in government income by 0.33 percentage point change shows that the government revenue may not be maintained when it reduces tariff.

When we look at CPI, it has increased by 0.05 percentage point change. This may be due to the fact that while real import has increased, the domestic producers are more interested to export instead of selling domestically. Since the increase in real export outweighs the increase in the real import (see appendix C.2), it implies that the domestic demand remains uncovered leading to an increase in CPI. In Sim-2, it can be understood that an increase in agricultural TFP due trade openness changes all the selected macroeconomic indicators positively within the simulation period in Ethiopia. Table 2 has shown that the increase in private consumption, investment, recurrent government expenditure and real export by 0.09% change, 0.01% point change, 0.08% point change, respectively, outweigh the increase in real import by 0.03% point.

Figure.1: Simulation results of Macroeconomic Indicators (% change from initial)



Source: Simulation result from the DCGE model.

Sim-3 contributes an increase RGDP at factor cost by 0.08% from BAU situation. Absorption has increased by 0.07% change as a result of an increase in private consumption, investment and the government expenditure. As agricultural TFP increase by 0.144%, the government income increase by 0.11% change. However, CPI has increased by 0.02% change.

Table 3. Simulation results of Macroeconomic Indicators(percentage point changes)

	sim1	sim2	sim3	sim4
Real GDP(factor cost)	0.00596	0.07509	0.08136	0.56043
Absorption	0.01412	0.06567	0.08012	0.48856
Investment	-0.08186	0.01329	-0.06822	0.09325
Private consumption	0.04319	0.0865	0.12987	0.64225
Real export	0.16215	0.03959	0.20234	0.30281
Real import	0.10617	0.02592	0.13257	0.19879
Government expenditure	-0.02647	0.08627	0.0615147	0.642856
Government Income	-0.33439	0.1052594	-0.229315	0.773974
CPI	0.04485	0.0172	0.06165	0.12712

Source: Simulation result from the DCGE model.

Comparing sim-3 with BAU situation, Table.5and Figure.1 provide the combination of sim-1 and sim-2 results an increase in RGDP at factor cost by 0.081%, absorption by 0.08%, private consumption by 0.13%, real export by 0.20%, real import by 0.13%, recurrent government expenditure by 0.06% and CPI by 0.06%. However, investment and recurrent government income have decreased by 0.068% and 0.23%, respectively. The increase in RGDP is aroused due to the increased in private consumption, recurrent government expenditure and real export greater than the decrease in investment and real import. The increase in private consumption also contributes absorption to change positively. In this scenario, the domestic demand still unable to be satisfied while real import has increased and this results CPI to increases.

Finally, the result of simulation 4 indicates that RGDP at factor cost has grown by 0.56% change because private consumption, investment, recurrent government expenditure and real export have increased as shown in Table 3 and Figure.1. The increase in absorption by 0.49% change would be explained by the increment of private consumption,

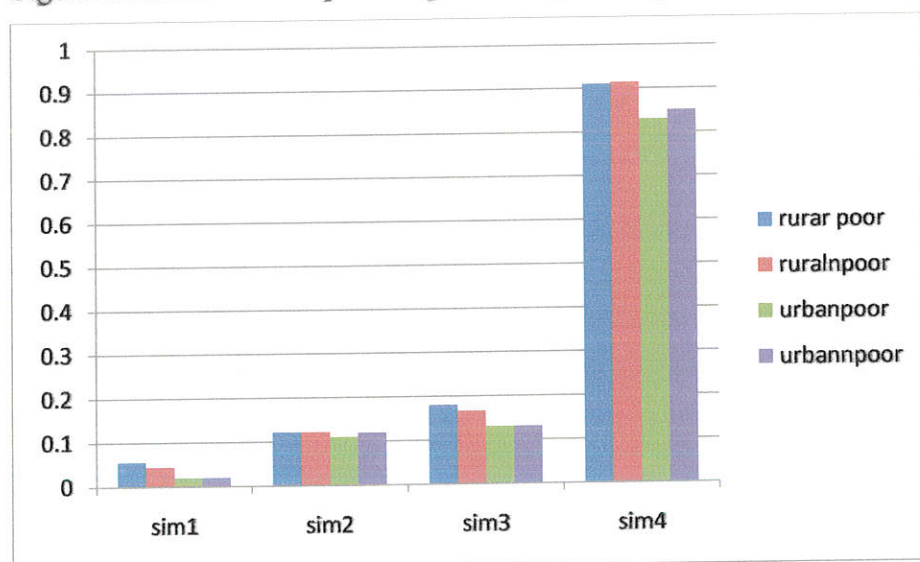
investment and government expenditure by 0.65%, 0.09% and 0.78% changes, respectively.

5.3.2 Consumption Expenditure Growth Effect of Simulation (% change from baseline)

In the simulation period, the consumption expenditure of all households group have registered very small growth as we relate with the baseline run simulation interlude. As Figure.2 portrays (see also appendix C.2), in sim1, expenditure of rural poor household and rural non poor household have raised by 0.056% and 0.044%. These changes are greater than that of urban households. This is also true in sim2 and sim3.

In sim4 we found that greater percentage increment than the others simulations, that is, expenditure of rural poor, rural non poor, urban poor and urban non poor have increased on average by 0.91%, 0.914%, 0.83% and 0.85%, respectively, between 2006 and 2015. However, the registered augmentations on consumption expenditure are too small and less than 1%. Therefore, one should not expect these changes to reduce poverty. The household consumption expenditure per adult (Exp/adult), which is not reported here but we employed in the micro-simulation model, confirms the above facts that in each simulation it has increased with insignificant amount.

Figure 2: Private Consumption Expenditure (% change from baseline)



Source: Simulation result from the DCGE model.

5.3.3 Sectoral Effects of Simulations

Under this topic we present the effects of the simulations on the agricultural, the industry and the service sectors growth. We divide the agricultural sector into cereals, cash crops and other agricultural outputs. We also carve up the industrial sectors into manufacturing and other industries growth.

Figure 3 and Appendix C.3 depict that in the business as usual scenario case the growth of cereals production, cash-crops, other types of agricultural products, manufacturing, other types of industrial outputs and services increases by 15.74%, 16.68%, 13.49%, 19.18%, 18.27% and 15.14%, respectively. In sim-1, reduction of tariff will result in an increase in cereals production by 15.7%. Comparing this percentage change with the baseline scenario, it is less. This could be explained by when tariff decreases, imported cereals become cheaper than domestically produced, thus domestic producers may be enforced to reduce their production. Cash-crops and other agricultural products also increase by 16.67% and 13.48%. This situation is similar to the case of cereal production. In the industrial sector's production case both manufacturing and other industrial sector productions have grown by 19.4% and 18.37%, respectively. These growths are greater than that of the BAU situation. This is because a reduction of tariff enables the efficient domestic industries to import raw materials with cheap cost. Therefore, the industrial output has increased. However, in this simulation the service sector has grown by less than the growth in the base-run simulation.

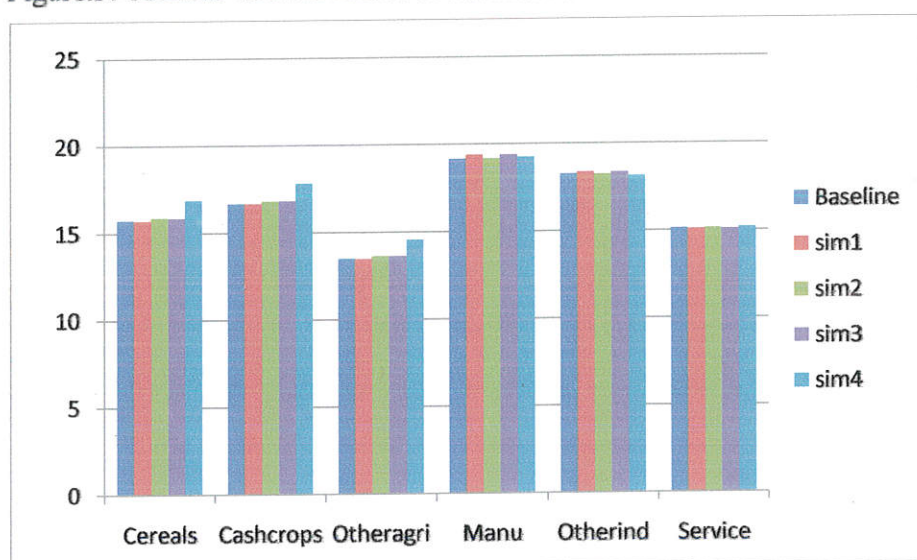
In simulation 2, all sectors' production has grown except the service sector in comparison with the baseline growth. This implies trade induced agricultural TFP enhance the production of the agricultural and the industrial sectors. This again helps to understand there is some kind of relatively strong link between these two sectors. But, there is less significant growth of the service sector due to this simulation.

The combination of tariff reduction and trade induced agricultural TFP in sim-3 also shows that similar result as sim-2 except they have different values. Nevertheless, the growth in service sector has declined. This may be tariff reduction and trade induced

agricultural TFP more favor to the agricultural and the industrial sectors than service sector. In the case of Ethiopia the link between the service sector with the agricultural sector is very much less and tariff reduction is mostly applied to non-service sectors. As a result any progress in the agricultural sector is not reflected in the service sectors.

In the last simulation, productions of all sectors have grown. For example, cereals production has swelled by 16.88%, manufacturing products has grown by 19.25% and the service sectors also have shown an increment by 15.17%. Comparing with the baseline scenario, the results of sim-4 are higher.

Figure.3: Sectoral Growth Effect of simulations



Source: Simulation result from the DCGE model.

5.3.4 Poverty Effects of Simulations

To get the impacts of our simulation on poverty we demarcate the poverty line is based on the EDRI's SAM which defines the bottom 40% as poor in terms of descending household consumption expenditure level. Therefore, the poverty line is birr 1782.98. The important thing that we note is that in the SAM rural, households are disaggregated into ten based on zonal level and urban households are divided into four on the basis of small and large settlement. We aggregated the rural households into two as rural poor and

rural non-poor. However, the IFPRI's DCGE is modeled as urban households into urban poor and urban non poor. Then we introduced the adjusted exp/adult and poverty line in DAD to calculate the poverty indices using FGT. Thus, the result is as follow.

Poverty Head Count Index (P_0)

From Table 4, we understand that poverty head count index has recorded small rise in national, rural and urban areas in all simulations except sim-4 comparing with the baseline scenario case. When we look at the poverty head count index of rural and urban, poor pre population in rural is higher than urban area. This result can be explained as in sim-1, the reduction of tariff has strong impact on the agricultural sector than the industrial sector in the case of Ethiopia. This policy enables the country to import more agricultural items with lower price from either the country with efficient agricultural sector or the country that subsidized the agricultural sector. As a result the domestic farm output price declines or remains unsold.

In urban area tariff reduction reduces prices which may drive some domestic firms to exit the market notwithstanding the depressed price that leads to an increase in the number of poor people. As the majority of the rural peoples' livelihood is based the agricultural sector the impact of such policy has a dramatic effect on this subdivision of the country's sector than the others. Therefore, higher level of poor per population is revealed in rural area. In sim-2, trade induced agricultural TFP also has a declining price effects because it has a direct effect on the agricultural items that is farmers could produce the greater amount of output than before. At the given level of the national and RoW demand, there may exist a surplus which its substantial amount leftovers unsold or sold by small prices that leads farmers to allocate resources sub-optimally. But, the outcome of this simulation on industry is indirect. Thus it is expected that there will be less increment in the number of poor in urban than rural. The result of sim-3 can be enlightened using the combined justification of sim-1 and sim-2.

Simulation 4, however, results a greater change in the national, rural and urban poor. The national, the rural and the urban poverty head count index have grown by 8.97%, 10.2% and 8%, respectively. This again could be elucidated as in the above three simulations.

Table. 4: Poverty Head Count Index (P_0)

simulation	baseline	sim1	sim2	sim3	sim4
National	0.1001	0.1291	0.1109	0.1398	0.1898
Rural	0.1107	0.1452	0.1239	0.1579	0.2127
Urban	0.0918	0.1164	0.1006	0.1256	0.1718

Source: *Micro-simulation result*

Poverty Gap Index (P_1)

The micro-simulation result shown in Table 5 indicates that the aggregate consumption shortfall relative to the poverty line has widened in all scenarios between 2006 and 2015.

In sim-1, the reduction of tariff leads to the poverty gap of the national poor, rural poor and urban poor have grown by 2.26%, 2.43% and 2.14%, respectively. The substitution and income effects of tariff cut for imported foreign goods are negative implying that domestically produced goods are substituted. Although tariff cut would provide variety of items with cheap price, the domestic producers selling prices are decreased strongly and end up with domestic production cut as well as unemployment. Therefore, the separation distance between the aggregate consumption shortfall and poverty line has further increased. In sim-2, sim-3 and sim-4, we also found similar consequence as sim-1 but the interpretation are different. In sim-2, the poverty gaps have increased by 1.88%, 1.99% and 1.79%, for the national poor, the rural poor and the urban poor, respectively. The fourth simulation also has similar direction. In general, the result of sim-2 and sim-4 show that as agricultural TFP increases, cheap agricultural output would prevail in the market. Although the registered rise of poverty gap index is relatively small, the potential impact should not be underestimated. Unless the industrial sector increases its productivity which enables to absorb the surplus of labor in the agricultural sector as a result of the increased agricultural TFP, the poor will further become poorer. The third simulation revealed that the combined effect of sim-2 and sim-3 guides an increase in poverty gap in the three categories of the poor. From these simulation results we understand that more resources are needed to eliminate the disparity between the aggregate consumption short-fall and the poverty line.

Table. 5: Poverty Gap Index (P_1)

simulation	baseline	sim1	sim2	sim3	sim4
National	0.0168	0.0226	0.0188	0.025	0.0354
Rural	0.0177	0.0243	0.0199	0.0269	0.0386
Urban	0.0161	0.0214	0.0179	0.0235	0.0329

Source: Micro-simulation result

Poverty Severity Index (P_2)

This measurement of income poverty is vital in a sense that it captures both the distance separating the poor from poverty line and gives more value for those poor who are way far from the poverty line. Thus, it helps to see the magnitude of the poverty level on the poor. Our simulations result is presented in Table 6.

When we relate sim-1 with BAU scenario, the severity of poverty in the national poor has increased by 0.17%. The respective increment in poverty severity in the rural and the urban poor are 0.18% and 0.16%. We found similar result in sim-2 and sim-3 as sim-1 designating little growth of the poverty severity. However, huge percentage increases in sim4 are disclosed that 55.78%, 62.19% and 50.76% growth in the national, rural and urban, respectively, poverty severity. Overall, the rural poor are greatly affected by these policy simulations and what we have gained is these policies should be incorporated with other pro-poor policies.

Table.6: Poverty Severity Index P_2

simulation	baseline	sim1	sim2	sim3	sim4
National	0.0046	0.0063	0.0052	0.0071	0.5624
Rural	0.0047	0.0065	0.0053	0.0073	0.6266
Urban	0.0045	0.0061	0.0051	0.0068	0.5121

Source: Micro-simulation result

6. CONCLUSION AND POLICY IMPLICATIONS

Understanding of the impact of trade on poverty is a crucial issue for underdeveloped countries. However, whether trade has impeding effects on poverty remains debatable. Trade is believed to reduce poverty by introducing new technology which enables efficient resource allocation, enhancing productivity and making available diversity of products with fewer prices. Whereas others argue that trade associated with tariff reform and openness may have exacerbating effect on poverty because it displaces domestically produced goods and wind up with higher idle domestic resource. In this viewpoint, we set forth our attempt to analyze the impact of trade on poverty through agricultural TFP in the case of Ethiopia.

Since such issue covers both the macro and micro aspect of the economy, we employed the dynamic computable general equilibrium model linked with the micro-simulation model. Their link is based on the “top-down” approach. To create simulation scenarios we used the WTO’s maximum tariff requirement for agricultural items of developing nations and we estimated the agricultural TFP with respect to trade openness. For DCGE-micro-simulation purpose we utilized the 2005/06 EDRI’s SAM and the HICE survey data of 2004/5. Whereas for the econometric estimation we utilized the agricultural sample surveys data of CSA and import and export of ITC UN between 2006 and 2010.

The simulation exercises result in little increase in most macroeconomic variables. As expected, all simulations stimulate growth in GDP, absorption, export, import and private consumption. However, the increase in household consumption expenditure is insignificant that in all scenarios it exhibited below one percent. On the other hand, tariff cut leads to a reduction of investment, government expenditure and government income in the simulation period. This shows tariff reduction may discourage domestic producers to invest in the domestic economy and government may not be able to compensate the reduction of its revenue using imposition of domestic tax.

When we look at the impact of trade on poverty, we consider both tariff policy, trade openness and the application of fertilizer (just only for the purpose of comparison). The micro-simulation result suggests that the proposed level of tariff cut and trade induced

agricultural TFP will slightly worsen the level of poverty in both rural and urban areas in the simulation period.

Finally, we need to note that achieving a positive impact of trade on poverty through agricultural TFP needs pro-poor complementary policies that boost the industrial sector productivity and human capital development, and policies that create efficient market.

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APPENDICES

Appendix A: Basic Econometrics Tests

Appendix A.1: Summery Statistics

```
. sum ln_tfp ln_allfertilizer ln_seed ln_pesticide ln_irrigation ln_extensionpackege
ln_trade dummy2
```

Variable	Obs.	Mean	Std. Dev.	Min	Max
ln_tfp	25	.5647392	.9818062	-.7765288	1.945196
ln_allfirt~r	25	10.91885	.8414551	8.719808	12.19876
ln_seed~d	25	11.6127	1.03498	9.624633	12.91507
ln_pesticide	25	8.628933	1.143395	7.283448	10.97399
ln_irrigat~n	25	8.359715	.8602573	6.953684	10.20267
ln_extensi~e	25	11.55046	.6524056	10.4726	12.68888
ln_trade	25	1.677235	1.292881	-.8218042	3.965765
dummy2	25	0	0	0	0

Appendix A.2 Breusch and Pagan Lagrangian multiplier test for random effects

$$\ln_tfp[id,t] = Xb + u[id] + e[id,t]$$

Estimated results: Var sd = sqrt(Var)

ln_tfp	.9639434	.9818062
e	.0211368	.145385
u	0	0

Test: Var(u) = 0

chi2(1) = 2.22

Prob > chi2 = 0.1362

Appendix A.3: Endogeneity Tests

```
ivregress 2sls ln_tfp ln_allfertilizer ln_seed ln_irrigation ln_extensionpackege ln_trade (
ln_pesticide=dln_pesticide)
```

```
Instrumental variables (2SLS) regression      Number of obs =   24
      Wald chi2(6) = 241.49
      Prob > chi2  = 0.0000
      R-squared    = 0.9096
      Root MSE    = .29398
```

```
-----+-----
      ln_tfp |   Coef.  Std. Err.   z  P>|z|  [95% Conf. Interval]
-----+-----
ln_pesticide | -.0011791 .1292141  -0.01  0.993  - .2544341  .252076
ln_allfirtr | .9070034 .2614945   3.47  0.001   .3944836  1.419523
ln_seeds | -1.215103 .1556962  -7.80  0.000  -1.520262  -.9099443
ln_irrigatn | -.5120469 .1246115  -4.11  0.000  -.7562809  -.2678129
ln_extensi~e | -.5631993 .1704226  -3.30  0.001  -.8972214  -.2291771
      ln_trade | .0986141 .0558696   1.77  0.078  -.0108884  .2081165
      _cons | 15.41512 1.974617   7.81  0.000  11.54494  19.2853
```

Instrumented: ln_pesticide

Instruments: ln_allfertilizer ln_seed ln_irrigation

ln_extensionpackege ln_trade dln_pesticide

. estat endogenous

Tests of endogeneity - Ho: variables are exogenous

Durbin (score) chi2(1) = .144128 (p = 0.7042)

Wu-Hausman F(1,16) = .096666 (p = 0.7599)

Appendix B: The standard CGE model of IFPRI

Appendix B.1: Definition of Sets, Parameters and Variables

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 nongovernmental 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 ca intermediate input per unit of activity a

icd – quantity of commodity ca trade input per unit of c' produced and sold domestically

$ice_{cc'}$ – quantity of commodity ca trade input per exported unit of c'

$icm_{cc'}$ – quantity of commodity ca trade input per imported unit of c'

int_{aa} – quantity of aggregate intermediate input per activity unit

$iva\ a$ – quantity of value-added per activity unit

\overline{mps}_i – base savings rate for domestic institution i

$mps01i$ – 0-1 parameter with 1 for institutions with potentially flexed direct tax rates

$pwe\ c$ – export price (foreign currency)

$pwm\ c$ – import price (foreign currency)

$qdst\ c$ – 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

$tins01i$ – 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

Parameters (Grecce)

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

α_a^{ac} – shift parameter for domestic commodity aggregation function

α_c^q – Armington function shift parameter

α_c' – CET function shift parameter

β_{ach}^h – marginal share of consumption spending on home commodity c from activity a for household h

β_{ch}^m – marginal share of consumption spending on marketed commodity c for household h

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

δ_c^q – 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}^m – 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_c^{ac} – domestic commodity aggregation function exponent

ρ_c^q – 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 saving(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 savings rates (=0 for base; exogenous variable)

EG – government expenditure

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
MPS_i – marginal propensity to save for domestic non-government institution
PA_a – activity price (unit gross revenue)
PDD_c – demand price for commodity produced and sold domestically
PDS_c – supply price for commodity produced and sold domestically
PE_c – export price (domestic currency)
PINTA_a – aggregate intermediate input price for activity *a*
PM_c – import price (domestic currency)
PQ_c – composite commodity price
PVA_a – value-added price (factor income per unit of activity)
PX_c – aggregate producer price for commodity
XAC_{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 *c*
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 *c*
QM – quantity of imports of commodity *c*
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 *c*
QXAC_{ac} – quantity of marketed output of commodity *c* from activity *a*

TABS – total nominal absorption

TINS_i – direct tax rate for institution *i* ($i \in \text{INSDNG}$)

TRII_{ii'} – transfers from institution *i'* to *i* (both in the set INSDNG)

WF_f – average price of factor *f*

YF_f – income of factor *f*

YG – government revenue

YI_i – income of domestic nongovernment institution

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

Appendix B.2: Equations of the Model

STATIC PART

Price Block

- 1) $PM_c = pwm_c(1+tm_c)EXR + \sum_{c' \in CT} PQ_{c'} . icm_{c'c}$ $c \in CM$
- 2) $PE_c = pwe_c . EXR - \sum_{c' \in CT} PQ_{c'} . ice_{c'c}$ $c \in CM$
- 3) $PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} . icd_{c'c}$ $c \in CD$
- 4) $PQ_c . (1-tq_c) . QQ_c = PDD_c . QD_c + PE_c . QE_c$ $c \in (CD \cup CM)$
- 5) $PX_c . QX_c = PDS_c . QD_c + PE_c . QE_c$ $c \in CX$
- 6) $PA_a = \sum_{c \in C} PXAC_{ac} . \theta_{ac}$ $a \in A$
- 7) $PINTA_a = \sum_{c \in C} PQ_c . ica_{ca}$ $a \in A$
- 8) $PA_a . QA_a = PVA_a . QVA_a + PINTA_a . QINTA_a$ $a \in A$
- 9) $CPI = \sum_{c \in C} PQ_c . cwts_c$
- 10) $\overline{DPI} = \sum_{c \in C} PDS_c . dwts_c$

Production and Trade Block

$$11) QVA_a = iva_a \cdot QA_a$$

$a \in ALEO$

$$12) QINTA_a = int a_a \cdot QA_a$$

$a \in ALEO$

$$13) QA_a = \alpha_a^a \cdot (\delta_a^a \cdot QVA_a^{-\rho_a^a} + (1 - \delta_a^a) \cdot QINTA_a^{-\rho_a^a})^{\frac{1}{\rho_a^a}}$$

$a \in ACES$

$$14) QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot QF_{fa}^{-\rho_a^{va}} \right)^{\frac{1}{\rho_a^{va}}}$$

$a \in A$

$$15) \frac{QVA_a}{QINTA_a} = \left(\frac{PINTA_a}{PVA_a} \cdot \frac{\delta_a^a}{1 - \delta_a^a} \right)^{\frac{1}{1 + \rho_a^a}}$$

$a \in ACES$

$$16) WF_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot QF_{fa}^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot QF_{fa}^{-\rho_a^{va} - 1} \quad a \in A,$$

$f \in F$

$$17) QINT_{ca} = ica_{ca} \cdot QINTA_a$$

$a \in A, c \in C$

$$18) QXAC_{ac} + \sum_{h \in H} QHA_{ach} = \theta_{ac} \cdot QA_a$$

$a \in A, c \in CX$

$$19) QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{\frac{1}{\rho_c^{ac} - 1}}$$

$c \in CX$

$$20) PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac} - 1}$$

$a \in A, c \in CX$

$$21) QX_c = \alpha_c^t \cdot \left(\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}}$$

$c \in (CE \cap CD)$

$$22) \frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}}$$

$c \in (CE \cap CD)$

$$23) QX_c = QD_c + QE_c$$

$c \in ((CD \cap CEN) \cup (CE \cup CDN))$

$$24) QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + (1 - \delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{\frac{1}{\rho_c^q}}$$

$c \in (CM \cap CD)$

$$25) \frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1-\delta_c^q} \right)^{\frac{1}{1+\delta_c^q}} \quad c \in (CM \cap CD)$$

$$26) QQ_c = QD_c + QM_c \quad c \in ((CD \cap CEN) \cup (CE \cup CDN))$$

$$27) QT_c = \sum_{c' \in C'} (icm_{cc'} \cdot QM_{c'} + QE_{c'} + icd_{cc'} \cdot QD_{c'}) \quad c \in CT$$

Institution Block

$$28) YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \quad f \in F$$

$$29) YIF_{if} = shif_{if} \left[(1-if) \cdot YF_f - trnsfr_{rowf} \cdot EXR \right] \quad i \in INSD, f \in F$$

$$30) YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{igov} \cdot \overline{DPI} + trnsfr_{irow} \cdot EXR \quad i \in INSDNG$$

$$31) TRII_{ii'} = shii_{ii'} \cdot (1-MPS_{i'}) \cdot (1-TINS_{i'}) \cdot YI_{i'} \quad i \in INSDNG$$

$$32) EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1-MPS_h) \cdot (1-TINS_h) \cdot YI_h \quad h \in H$$

$$33) PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma_{ac'h}^h \right) \quad c \in C, h \in H$$

$$34) PXAC_{ac} \cdot QHA_{ach} = PXAC_{ac} \cdot \gamma_{ach}^h + \beta_{ach}^h \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma_{ac'h}^h \right)$$

$$a \in A, c \in C, h \in H$$

$$35) QINV_c = \overline{IADJ} \cdot \overline{qinv}_c \quad c \in CINV$$

$$36) QG_c = \overline{GADJ} \cdot \overline{qg}_c \quad c \in C$$

37)

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

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

$$+ \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YIF_{govf} + trnsfr_{govf} \cdot EXR$$

$$38) EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{igov} \cdot \overline{DPI}$$

System Constraint Block

$$39) \sum_{a \in A} QF_{fa} = \overline{QFS}_f \quad f \in F$$

$$40) QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + QG_c + QINV_c + qdst_c + QT_c \quad c \in C$$

$$41) \sum_{c \in CM} pwm_c \cdot QM_c + \sum_{f \in F} trnsfr_{rowf} = \sum_{c \in CE} pwe_c \cdot QE_c + \sum_{i \in INSD} trnsfr_{irow} + \overline{FSAV}$$

$$42) YG = EG + GSAV$$

$$43) TINS_i = \overline{tins}_i \cdot (1 + \overline{TINSADJ} \cdot tins01_i) + \overline{DTINS} \cdot tins01_i \quad i \in INSDNG$$

$$44) MPS_i = \overline{mps}_i \cdot (1 + \overline{MPSADJ} \cdot mps01_i) + \overline{DMPS} \cdot mps01_i \quad i \in INSDNG$$

$$45) \sum_{i \in INSDNG} MPS_i \cdot (1 - TINS_i) \cdot YI_i + GSAV + \overline{EXR} \cdot \overline{FSAV} = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$$

$$46)$$

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

$$47) INVSHR.(TABS) = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$$

$$48) GOVSHR.(TABS) = \sum_{c \in C} PQ_c \cdot QG_c$$

DYNAMIC PART

$$49) AWF_{fa}^a = \sum_a \left[\left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot WF_{fa} \cdot WFDIST_{fat} \right] \dots\dots\dots \text{average price of factor } f$$

$$50) \eta^a_{fat} = \left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{fa} \cdot WFDIST_{fat}}{AWF_{fa}^a} - 1 \right) + 1 \right) \dots\dots\dots \text{Share of new capital}$$

$$51) \Delta K^a_{fat} = \eta^a_{fat} \cdot \left(\frac{\sum_{ct} PQ_{ct} \cdot QINV_{ct}}{PK_{fa}} \right) \dots\dots\dots \text{Quantity of new capital}$$

$$52) PK_{ft} = \sum_c PQ_{ct} \frac{QINV_{ct}}{\sum_{c'} QINV_{c't}} \dots\dots\dots \text{unit price of capital}$$

$$53) QF_{fat+1} = QF_{fat} \cdot \left(1 + \frac{\Delta K_{fat}^a}{QF_{fat}} - v_f \right) \dots\dots \text{average quantity demanded of factor } f \text{ from activity } a$$

$$54) QFS_{ft+1} = QFS_{ft} \cdot \left(1 + \frac{\sum_a \Delta K_{fat}}{QFS_{ft}} - v_f \right) \dots\dots \text{average capital rental rate}$$

Appendix C: DCGE and MS results

Appendix C.1 Macroeconomic effects of the simulations

Macro indicators	Initial	Baseline(2006-2015)	Sim1	Sim2	Sim3	Sim4
Real-GDP(factor cost)	122324.8	15.07	15.11	15.15	15.19	15.63
Absorption	162219.9	13.52	13.59	13.59	13.66	14.01
Investment	31885.83	14.47	14.05	14.48	14.06	14.56
Private consumption	110384.8	14.34	14.56	14.43	14.65	14.99
Real export	16530.9	21.91	22.67	21.95	22.71	22.21
Real import	-46708.7	13.86	14.36	13.89	14.39	14.06
Government expenditure	17443.24	1.86	1.76	1.94	1.85	2.5
Government Income	30858.3	10.26	8.61	10.37	8.71	11.04
CPI	19.949	-0.3	-0.16	-0.28	-0.16	-0.174

Source: Simulation result from the DCGE model.

Appendix C.2 Consumption Expenditure Effects of the Simulations

Column1	sim1	sim2	sim3	sim4
rurar poor	0.056	0.122	0.18	0.91
ruralnpoor	0.044	0.122	0.166	0.914
urbanpoor	0.02	0.11	0.13	0.83
urbannpoor	0.02	0.12	0.13	0.85

Source: Simulation result from the DCGE model.

Appendix C.3 Sectoral Growth Effect of the Simulations

Column1	Baseline	sim1	sim2	sim3	sim4
Cereals	15.74232	15.7012715	15.89874	15.8581	16.88029
Cashcrops	16.68228	16.6709884	16.8379	16.82652	17.83478
Otheragri	13.49987	13.486654	13.6423	13.62882	14.55693
Manu	19.18351	19.4012808	19.19894	19.41693	19.25559
Otherind	18.2759	18.3752484	18.26243	18.35995	18.1487
Service	15.14184	15.0796511	15.14634	15.08494	15.17891

Source: Simulation result from the DCGE model.

Declaration

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

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