University of Trento

Graduate School of social sciences

Doctoral Program in Economics and Management

Essays on the Ethiopian Agriculture

A dissertation Submitted to the Graduate School of Social Sciences in partial fulfilment of the requirements for the Doctoral degree (Ph.D.) in Economics and Management

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Summary

Improving agricultural productivity, agricultural commercialization and improving the livelihoods of the population are the main challenges in the Sub-Saharan Africa region where the majority of the population are poor and live in rural areas. Several factors including lack of improved farming practices, poor infrastructure, low level of market integration to the world market and within countries, climate change, and inadequate policy support restrained the performance of the agricultural sector in the region.

This thesis consists of four chapters, three empirical and one theoretical chapter. Each of the empirical chapters deals with selected topics pertinent to the agriculture sector in Ethiopia. The theoretical chapter reviews the agricultural policies adopted by the existing government and implemented over the past two decades. After the introductory chapter, the second chapter analyzes the impacts of climate change on crop yields and yield variability in Ethiopia.

The impacts of climate change appear to be different across crops and regions. However, the future crop yield levels largely depend on future technological development in farming practices. The third chapter aims to understand the extent of price transmissions from the world markets to domestic grain markets, and the extent of market integration in domestic grain markets.

The fourth chapter investigates and compares the volatilities of oilseeds prices in the world and domestic markets. The data used in the second, third and fourth chapters are obtained from various secondary sources.

The fifth chapter reviews major agricultural policies implemented over the last two decades and identifies policies that either enhanced the growth of the agricultural sector or holding back its performance. The sixth chapter underlines the main conclusions and indicates future research areas.

Keywords: Climate Change, Price Transmission, Price Volatility, Agricultural Policy

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Chapter 1: Introduction

Sub-Saharan Africa region in general is known for its abject poverty, low level of agricultural productivity, low level of social and economic development, and lack of adequate infrastructure that promote overall change in development. The majority of the region`s population, 62.6%, live in rural areas (Staatz and Dembele, 2007; FAOSTAT, 2012). Of these, more than 70% of the poor depend on agriculture as their sole means of livelihood (IFAD, 2012).

Agriculture accounts for 11.2% of Sub-Saharan Africa`s gross domestic product (GDP), excluding South Africa and Nigeria for the remaining 44 countries the share would increase to 21.1% (World Bank, 2013)[1].

Though strengthening smallholder agriculture that dominates the agricultural sector of the region is a pathway to escape poverty, the sector is largely constrained by lack of the key driving factors that increase agricultural productivity, profitability, and sustainability. Among these key driving factors, improved modern farming practices including use of modern inputs that result in high productivity and dearth of socio-economic infrastructures are decisive. As a result, since 1960 agricultural production in SSA failed to match population growth (Benin, 2006). Increasing agricultural productivity, therefore, is a major challenge in the region. Added to non-climatic factors that determine the transformation of the agricultural sector in the region, SSA is highly vulnerable to and disproportionately hit by adverse effects of climate change. This is mainly due to the fact that rain-

[1] Agriculture employees about 65% of the African population and contributes 32% of the continent`s GDP (Alliance for a Green Revolution in Africa, 2013).

fed farming dominates agricultural production, covering around 97% of total cropland. Irrigation systems have been promoted in the region, the impact on agricultural productivity is not as expected due to several reasons that include poor market access, low incentives for agricultural intensification, unfavorable topography, and inadequate policy (Calzadilla et al., 2009). Consequently, agriculture in SSA is characterized by low yield. The failure of agriculture, therefore, is mainly attributed to lack of supporting institutions, markets, lack of infrastructure, heavy dependence on rain-fed farming, low use of modern agricultural technologies such as chemical fertilizers, improved seeds, and pesticides (Johnson, Hazel, and Gulati, 2003; World Bank, 2007).

Likewise, Ethiopia, as one of the countries found in the region, shares the broad characteristics of agriculture in SSA region. Agriculture is the most important sector in Ethiopia as it contributes 43% to overall GDP, 90% of export earnings, and it employees 85% of the population and supplies 70% of the country`s raw materials to the secondary activities (MOFED, 2009/10). Smallholders dominate the sector, produce more than 90% of the total agricultural output, and cultivate close to 95% of the total cropped land, and the rest comes from the livestock subsector (CSA, 2009). Crop production, particularly cereal production, dominates the Ethiopian agriculture since crop production accounts for over 60 percent of agricultural GDP and 30% of the overall GDP. Out of the total grain crop area, cereals cover 80 % of the cropped land and contribute 86 % of crop production. Maize, wheat, and teff together constitute 52 % of the grain cropland and 56 % of the total grain production (CSA, 2010).

Owing to its sheer size, the influence of agriculture on the performance of the economy has been extensive. Nonetheless, agricultural production is heavily subsistence, low input-low output, and rain-fed. Low productivity is attributed to limited access to modern inputs such as chemical fertilizer, improved seeds, and limited access for finance, poor access to irrigation systems and agricultural markets, poor land management practices that resulted in severe land degradation[2]. Despite such drawbacks, the agricultural sector performed remarkably since 1996/97 and registered a growth rate of about 10% per annum until 2003/04 (MOARD, 2010). However, between 2003/04 and 2011/12 the growth rate slowed to 9.3%, as the growth rate for the year 2011/12 dropped to 4.9% (MOFED, 2013)[3].

Poverty head count index dropped from 45.5% in 1995/96 to 29.6% in 2010/11. In rural areas, the drop in poverty head count index appear substantial, from 47.5 in 1995/96 to 30.4% in 2010/11, while in urban areas poverty declined from 33.2% to 25.7% over the same period. Food poverty, on the other hand, declined from 49.5% in 1995/96 to 33.6% in 2010/11. The decline in food poverty head count index appear higher for rural areas as it declined from 51.6% to 34.7% between 1995/96 and 2010/11, and in urban areas dropped from 36.5% to 27.9%. Urban poverty rose up in 1999/00 to 46.7% and then after the pace of food poverty decline in urban areas is by far greater than the rate of the decline in food poverty in rural areas (MOFED, 2013)[4].

[2] Ethiopia has one of the highest soil nutrient depletion in Sub-Saharan Africa region. Overgrazing, deforestation, population pressure, and inadequate land use planning are among the factors that aggravate land degradation (MOARD, 2010).

[3] Over the same period between 2003/04 and 2012/13, the industrial sector and service sector registered a growth rate of 12.2% and 12.4%, respectively.

[4] Poverty line for the years in consideration set to be 1075.03 ETB (Ethiopian Birr) for total poverty and 647.81 ETB per adult per year.

The Ethiopian government recognizes the importance of smallholder agriculture as the most important subsector and considers increasing smallholder farmers` productivity as a key to poverty reduction, agricultural transformation and hence overall structural transformation of the Ethiopian economy. With this understanding, the share of agriculture in the government`s public expenditure reached around 16% (Ethiopian Agricultural Transformation Agency, 2010)[5]. The increase in investment in the sector, in turn, helped in overcoming short-term needs, but it failed to ensure food security (MOARD, 2010).

This thesis, composed of four chapters, examines the constraints that hindered the progress of the Ethiopian agriculture from various perspectives. This is important for two reasons. First, agriculture dominates the Ethiopian economy and the overall economic growth and hence development, at least in the short run, largely needs to be driven by the agricultural sector. Second, despite the huge potential and resources the country is endowed with, especially conducive for agricultural practices, the sector has been unable to perform as it should have been due to many factors that range from erratic rainfall to low level of technology applied in farming, poor infrastructure, and poor institutional framework to support the sector`s growth.

Based on these broad problems of interest, we have studied the influence of weather variability and climate change on crop yields and yield variability; the extent of the integration of the Ethiopian grain market to the world grain markets. For this reason, we select-

[5] The Ethiopian Government also signed the Comprehensive Africa Agriculture Development Program (CAADP) launched in 2003 by the African Union. CAADP is a continent wide framework that to foster agricultural growth and progress towards poverty reduction, food and nutrition security in Arica. It sets a target of 6% annual agricultural growth rate at the country level, and the allocation of at least 10% of national budgets to the sector.

ed major exchange markets where grain crops are traded such as the Paris Exchange Market, Chicago Board of Trade (CBOT), and the South African Exchange Market (SAFEX) and measured the degree of integration of the Ethiopian grain market with this markets and the price pass through between the domestic and the international markets. Further, we studied the integration of the domestic grain market taking 10 wheat and 11 maize markets. We also investigated the relationship of the oilseeds price volatility to that of the world oilseeds price volatility. Finally, we evaluated the policies and strategies particularly designed to boost agricultural growth.

The second chapter of this thesis studies the influence of weather variability and climate change on crop yield and yield variability for three crops, maize, *teff*, and wheat. We use historical rainfall and yield data from 14 zones located in three different regions in Ethiopia namely, Amhara, Oromia, and SNNP regions over the period of 28 years from 1979/80 to 2008/09, and investigate responses of crop yields to rainfall. The crop yield and yield variability response to the weather variability has been analyzed using the Just-Pope production function (1978). The method enables us quantify the impacts of *kiremt* and *belg* rainfalls on the mean and variance of *teff*, wheat, maize yields. The results obtained from the investigation of the preceding impacts of weather variability on average crop yield and yield variability are combined with the precipitation levels projected by global atmospheric circulation climate change models such as CGCM2, PCM, and HadCM3; and average crop yield and yield variability levels for the year 2050 are projected.

The results from the analysis reveal that the impacts of weather considerably differ across regions and crop types. Compared to the average crop yields and yield variability levels between 1993 and 2008, the projections for the year 2050 also imply varying impacts on the mean crop yields, yield variability, and suggest a likely shift in cropping pattern. In general, the projection shows that teff and wheat yield levels will drop in 2050 from their average between 1993 and 2008, while maize yield will increase.

The implication of this on household food security is that as the country is not food self sufficient a percentage fall in food crop yields are likely to result in more than proportionate decline in food consumption. Reduced food availability due to reduced yield levels stemming from adverse effects of climate change would push price levels up. Most importantly, since the real per capita food consumption expenditure constitutes about 46.5 percent of total real per capita consumption expenditure (MOFED, 2012), adverse climate change impacts on prices will have a disproportionately adverse impacts on all low income households, not just merely on agricultural households.

However, the limitation of the analysis is that it does not show how farmers will possibly react to the changes in climate. The descriptive analysis of the historical data reveals that mean crop yields have increased over the period of 28 years, but not remarkably; and average *kiremt* and *belg* rainfalls over the same period have not shown a statistically significant change. As a result, we note that weather variables per se cannot fully capture the changes in the productivity to either direction, except in drought seasons. This implies examining and comparing the relative importance of non-climatic factors is crucial.

Following the commodity market crisis between 2006 and 2008 and later in 2011, the global concern has shifted towards understanding the food price dynamics and its impacts so that such an understanding helps in designing policy responses. Particularly, the increased food prices caused significant challenges for developing countries, where households spend a larger share of their income on food, and studying how the domestic markets are linked to the world market and the extent of the pass through of the increases in food prices from the international market to domestic markets has become an essential part of food policy making.

As a result, in Chapter 3, we examine whether the Ethiopian grain market is integrated to the world grain markets. The chapter aims at addressing three issues. First, it investigates transmission of changes in the world food prices to domestic food prices and identifies the world prices that influence the evolution of domestic prices. Second, it examines the effects of exchange rates on the price transmissions. Third, it analyzes within country integration of grain markets located in different regions across the country.

To address the first issue, we analyzed the integration of domestic wheat and maize markets with the international markets for the two crops. Thus, we selected two markets for each crops, Paris Exchange Market, Chicago Board of Trade (CBOT) for wheat; South African Exchange Market (SAFEX) and the US Gulf port price, for maize. The exchange markets have been selected based on the objective of identifying the relevant international grain markets that influence the domestic food price formation. We used US maize and SAFEX maize prices as maize exchange market prices and examined the relationship with the Ethiopian maize market. For wheat, we used Paris milling wheat and Chicago Board of Trade (CBOT) soft wheat prices as exchange market prices and investigated the relationship of them with the Ethiopian wheat market.

We found that the Ethiopian wheat market is integrated into the world market as evidenced by its cointegration with the Paris wheat market. However, the cointegration happened to be uni-directional as only Paris wheat market reacts to the price developments in Ethiopia. No cointegration is observed between Ethiopian wheat market and Chicago exchange wheat market. This implies that the Ethiopian wheat market is integrated to the international wheat market, which is geographically closer. This may relate to the fact that Ethiopia imports most of its wheat from the Black sea and Mediterranean ports, for it requires lower transportation cost and the wheat imported through these ports is purchased with lower price at the exchange markets located in Europe.

Further, we found that the Ethiopian maize market is integrated into the world market. As in the case of wheat, geographically the nearest exchange market (SAFEX) appeared cointegrated with the Ethiopian maize market. While the US maize market does show no cointegration. However, the results must be taken with caution, as the no-cointegration relation does not necessarily guarantee that there is no price pass-through between any two markets investigated.

In order to identify the effects of exchange rates on price transmission and the cointegration relationships observed, we further investigated the cointegration relationship including exchange rate. We converted the domestic prices into local currency units because in the previous analysis when we convert the domestic prices into their US dollar values we implicitly assumed instatenous exchange rate pass-through. To relax this assumption, we used domestic prices in local currency units, international prices in US dollars and the exchange rate; and investigated the cointegration among these variables. The result implies that there will not be cointegration between domestic and international prices when the instatenous exchange rate pass-through assumption is relaxed. The bivariate cointegration tests of the domestic prices and the exchange rate implies that there is no link between the domestic prices and the exchange rate. Therefore, the cointegration relationships identified with an implicit assumption of instantaneous pass-through may be related to such assumption and hence this should be taken in to account in the interpretation of the results.

In the third chapter, we also examined domestic market price integration. The Ethiopian grain market has been under the influence of policy changes that resulted from the changes in governments and hence their ideologies towards the functioning of the market. In the post 1991 period, though not full-fledged, the grain market in Ethiopia has shown improvement in integration. This is mainly attributable to the developments in infrastructure such as road networking and telephone service expansion. Nonetheless, despite such developments, we observe that in the domestic wheat market price variability appears higher in the markets located in a distance outside the 300Km radius of the central market. In the maize market, we found that Gonder and Mekelle located at a distance of above 600 Kms and 700Kms, respectively, have shown average maize prices equivalent to the average price of other markets. This implies that the distance barrier of market integration has been declining following the national infrastructure development.

Thus, further intensification of the investment in market infrastructure and development of market institutions is essential in order to reduce the differences in prices and the price volatility across domestic markets.

The fourth Chapter compares the world and domestic price volatilities of oilseeds. We also provide global and domestic production, consumption and trade patterns of oilseeds. The oilseeds have been one of the important items in the Ethiopian primary commodity export profile for a long time. When compared with cereals, which have insignificant contribution in the foreign exchange earnings, the oilseeds are important contributors to the country's foreign exchange earnings and have immense potential for diversifying the primary commodity export profile. The global oilseeds production has increased between 1995 and 2012 mainly due to improvement in productivity. Over the same period, consumption of oilseeds at the global level has increased. However, the rate at which the consumption increases has slowed down since 2008 registering a growth rate below its 1999 level. Oilseeds export pattern has shown a growing trend since 1961, though we observe fluctuations overtime.

In Ethiopia, oilseeds constitute 7% of the total area under grain crops (cereals, oilseeds, and pulses) and 3% of the total grain production. The sector supports around 4 million small farmers that produce oilseeds for domestic consumption and the market. The analysis of oilseeds production over the period 1974 to 2012 shows that between 1974 and 1993 production of oilseeds has shown a remarkable growth, that mainly came from gains in productivity. In contrary to the shift in policy direction, considered favourable for agriculture and the broad economy, the change in production between 1994 and 2012 has not been as remarkable as it had been prior to 1993 and the registered growth has resulted from area expansion. The results of the economic reform and restructuring, which followed change in government in 1991, in the input and output markets and infrastructure over the last two decades did not significantly contribute in improving the oilseed sector that is known for its good commercial orientation. The trade performance of oilseeds implies that oilseeds export has dropped and imports increased. The export to production ratio also dropped over the years we studied.

In this chapter, we also compared the price volatilities of Linseed and Rapeseed in the world and domestic markets. The difference in the unconditional price volatilities (standard deviation) of the two commodities between the two markets reveals that the domestic Linseed nominal price volatility has exceeded its world counterpart by 17 % over the entire period of the analysis, by 40 % between 1999 and 2004, and by about 39% between 2009 and 2012. However, between 2005 and 2008 the world nominal Linseed oil price volatility exceeded its domestic counterpart by as much as 47% reflecting the commodity crisis that occurred during 2007/08. The real Linseed prices also followed the same trend except the difference in magnitude of volatility. The difference in Rapeseed price volatility, on the other hand, demonstrated a similar trend except that during the period between 2005 and 2008 the difference has been the smallest observed volatility difference as the World rapeseed price volatility has approached the higher domestic volatility.

The unconditional price volatility comparison, over different periods between 1999 and 2012, shows that over the entire period the unconditional price volatilities of oilseed items are higher in the domestic market than the world market. However, the unconditional price volatilities follow the world market situation when examined periodically. During the commodity market crisis, the world oilseeds price volatility exceeded its domestic counterpart in the case of Linseed oil, whereas it approached, and narrowed the difference with the domestic price volatility in the case of Rapeseed. This reveals two points in relation to the domestic oilseeds market. The first is that the domestic oilseeds market appears weakly integrated into the world market, as it has been insulated from the world oilseeds price volatilities, especially during the 2007/08 financial crisis. The second point relates to the decline in the ratio of export to domestic production. Between 2006 and 2008, oilseeds export and import declined following the financial crisis implying that increased domestic production, increased domestic supply and helped in filling the gap created as imports decline by as much as 24 thousand metric tonnes in 2006. Therefore, we may conclude that the increased domestic consumption insulated the domestic market from the volatility that would have been transmitted to the domestic market and aggravate the increase in the domestic oilseeds price volatility.

With regard to the conditional variance estimates provided by the GARCH(1,1) for both domestic and world market volatilities of Linseed and Rapeseed, we observe that in the domestic market there is no problem of volatility persistence where as volatility persistence appears the characteristic of the world market. What the markets for the two oilseed items have in common is the problem of volatility clustering.

Nonetheless, the magnitude of the influence of the news about past volatility on current volatility differs across crops and markets. The magnitude of the influence of the news about past volatility (innovations) is more than 8 times larger in domestic markets than the World market for Rapeseed, while in the world market three times as large as the domestic market for Linseed. The GARCH terms are significant in both domestic and world market except for Rapeseed in the domestic market implying that the impact of past variance on current variance is not statistically significant for domestic Rapeseed prices.

Chapter five reviews the policies and strategies particularly designed to boost agricultural growth. The agricultural policies reviewed relate to the input and output market policies, access to finance, agricultural extension services, and land tenure. The review exercise indicated that the input markets: fertilizer and improved seed markets, which are state led, appear inefficient in terms of improving access for agricultural technologies and increasing agricultural yield. The inefficiency is, particularly, manifested by lack of competition in the fertilizer sector, delays in distribution of fertilizer at the optimal planting time, quality deterioration due to lack of appropriate storage facilities at the last mile distribution points, and low incentive for the last mile distributors, primary cooperatives.

The improved seed sector, on the other hand, is also led by public institutions including Ethiopian Institute of Agricultural Research (EIAR), which consist of federal research centres, regional research centres, and agricultural universities and faculties, the Ethiopian Seed Enterprise, and the Ministry of Agriculture, which undertakes the regulatory work. The Ethiopian Seed Enterprise is responsible for the production of pre basic and basic seed, seed multiplication (subcontracted for private seed growers and farmers), and distribution through the regional agricultural extension service bureaus. The seed sector shares all the inefficiencies in the fertilizer sector and includes the following problems that appear holding back the seed sector and peculiar to the sector itself. First, the low profit margin, 5%, required by the Ethiopian Seed Enterprise for the supply of improved seed may work as an implicit entry barrier for private firms to join the business. Second, the research institutes lack qualified experts that innovate and develop improved high yielding seeds, and supply pre-basic and basic seed for multiplication. Third, low technical expertise of farmers in the seed multiplication, and the high cost that firms would pay to release new cultivars and comply with the regulatory requirements juxtaposed to the subsidized seed supply by the public enterprise make competition in the sector far away from the scene.

With regard to the output market, the Ethiopian Grain Trade Enterprise (EGTE) is tasked with price stabilization, export promotion, facilitating emergency food security reserve, and helping the disaster prevention and preparedness programs. However, the enterprise has been a victim of changing roles and responsibilities that hampered the roles of the enterprise. As a result, the Enterprise intermittently undertakes price stabilization though price stabilization is one its regular tasks the enterprise established for.

With regard to financial services, Ethiopia has one of the lowest financial inclusions in East Africa region. Only 1% of the rural households hold bank accounts. The rural financial inclusion, which is 3% in selected rural areas, reveal that very few people have access to formal and semi-formal financial services. At the national level, the financial inclusion is indicated at 14%, which is by far lower than the neighboring Kenya, which has a financial inclusion of 41%. The loan approved and dispersed to the agricultural sector, mainly to the large commercial farms, stood at only 14.6%. Thus, further innovative financial services to cater the needs of the small holders who are known for financial liquidity constraints in their efforts to increase productivity and transform their farms into commercial farms is crucial. In this regard, the contribution of micro finance institutions

(MFIs) and saving and credit cooperatives (SACCOs), though not tailored to the needs of farmers, may have helped in improving the outreach of the financial services to the small holder farmers.

The Agricultural extension service is provided with the objectives of increasing production and productivity of small-scale farmers through research generated information and technologies. It also aims at empowering farmers to participate actively in the development process; increasing the level of food self-sufficiency; increasing the supply of industrial and export crops and ensuring the rehabilitation and conservation of the natural resource base of the country. The service has been provided in the form of packages that include fertilizer, improved seed, pesticides and better cultural practices, improved post-harvest technologies, agro-forestry, soil and water conservation and beekeeping developed for different agro-ecological zones. Many studies show that the extension service has resulted in increased income and household food security, contributed to poverty reduction, and increased household consumption. However, the impressive results are not without controversy. In contrast to the positive evaluations of the agricultural extension service in Ethiopia, other studies show that farmers dis-adopted extension packages after a trial of a certain period. The reasons for dis-adoption include high cost of inputs, extension workers misguidedly took input distribution as their primary role and ignored provision of advice to improve technical efficiency of farmers, and numeric targets and coverage provided more emphasis than the technical issues that need to be resolved.

The other contentious policy in the Ethiopian agricultural sector is land policy. Enshrined in the country`s constitution, land is the property of the people administered by the state on their behalf, and cannot be sold, exchanged or mortgaged. Land is, thus, state property and farmers have only use rights over plots they have in their possession. The government asserts that land registration and certification provides tenure security to peasant farmers and justify its rural development policies. Results from studies evaluating the impact of land policy on farm productivity appear mixed. On top of this, the results tend to affirm that the evaluation task is marred with the fact that the people`s perception towards the impacts of land policy inclined towards the political sentiments of the farmers in different regions and localities.

The remaining parts of this thesis are structured as follows. Each chapter has its own introduction, data description, and empirical method used for the analysis. These are followed by empirical results discussion and conclusion. Each chapter contains its own list of references and appendices.

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Chapter 2: An Analysis of the Impacts of Climate Change on Crop Yields and Yield Variability in Ethiopia

2.1. Introduction

Recently, studies have shown that greenhouse gases such as carbon dioxide (CO_2) lead to changes in climate conditions such as temperature, precipitation, soil moisture, and sea levels. These climatic changes may be having adverse effects on ecological systems, agriculture, human health, and the economy. The Intergovernmental Panel on Climate Change (IPCC) forecasts that during this century, there will be an increase in the average global surface temperatures by 2.8ºC, with best-guess estimates of the increase ranging from 1.8 to 4.0ºC (IPCC, 2007a). It is thought that these increases will be brought about by the increase in the atmospheric concentration of greenhouse gases, assuming no additional emission control policies are instituted. As a result, the natural system would be altered in many ways: the frequency of extreme weather events would increase, sea levels would rise, ocean currents would reverse, and precipitation patterns would change.

These changes could bring about serious long-term social and economic consequences. Specifically, the potential of agricultural production will be substantially affected by the predicted changes in temperature and rainfall patterns. The agricultural impact of climate change, however, will most likely be unevenly distributed across regions: low-latitude and developing countries are expected to be more adversely affected (Stern, 2007). Recent estimates show that if measures to abate global warming are not carried out, global agricultural productivity will be reduced by 15.9 % by the 2080s, with developing countries experiencing a disproportionately large decline of 19.7 % (Cline, 2007).

Africa is considered the most vulnerable and disproportionately affected region in the world in terms of climate change. Farming is undertaken mainly under rain-fed conditions, increasing land degradation, and low levels of irrigation—6 % compared to 38 % in Asia (FAO, 2011). The contribution of agriculture to the gross domestic product (GDP) in Africa is far higher than in developed regions. This is perhaps nowhere more obvious than in sub-Saharan Africa, where economies are extremely sensitive to environmental and/or economic shocks in the agricultural sector.

Likewise, Ethiopia relies on rain-fed agriculture that contributes around 43% to the overall GDP, 90% of export earnings, and supplies 70% of the country`s raw materials to the secondary activities (MOFED, 2009/10). Due to its sheer size, the influence of agriculture on the economy has been extensive. This is indicated by the correlation of rainfall variations, Agricultural GDP growth, and GDP growth rates given in Figure 2.1. World Bank (2006) using Economy-wide model that incorporates hydrological variability shows that hydrological variability costs about 38% of the country`s potential growth rate and causes poverty to increase by 25%, implying the huge impact of drought and hydrological variability on the economy. Further, the study shows that with a very conservative assumption of a single drought event in a 12 year period (the historical average is every 3 to 5 years) average growth rates drop by 10% over the entire 12 year period[6].

[6] These estimates are based on the Hydro-Economic model constructed to quantify the economy-wide impacts of Ethiopia`s water resource endowment, variability, and management. The model is dynamic, economywide multi-market model that captures the impacts of both deficits and excess rainfall on agricultural and non-agricultural sectors.

Thus, the dependence on rainfall for agricultural production and the overall economic growth underlines the importance of the timing and amount of rainfall that occurs in the country.

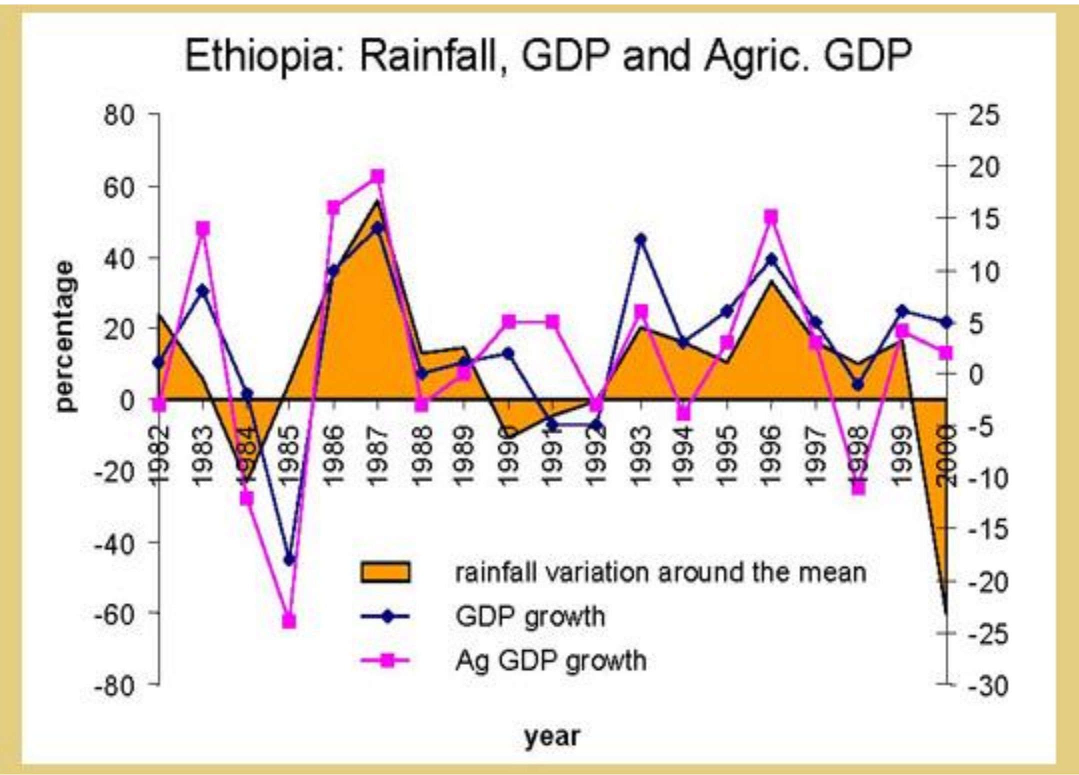

Figure 2.1 Rainfall, GDP growth and Agricultural GDP growth in Ethiopia.
Source: Water for Growth and Development (2006)

Heavy dependence on rainfall indicates that climate extremes such as drought or flood can cause significant health and economic threats to the entire population (Cheung et al, 2008). For instance, as of 2009/10, about 66% of the cereals produced were used for household consumption, 16% for sale, and 14% for seed (CSA, 2010). This implies that small proportion of total production is actually marketed, and hence a year-to-year fluctuations in production due to erratic rainfall could be easily transmitted to the thin grain markets. Moreover, since market infrastructure, that would insulate the adverse effects of production variability by facilitating trade between deficit and surplus regions of the country, is not well developed the impacts could be amplified and transmitted through input, price and income effects onto the broader economy (Water for Growth and Development, 2006).

In Ethiopia, the distribution of rainfall varies over the diverse agro-ecological zones that exist in the country. As a result, some pocket areas in the southwest receive mean annual rainfall of about 2000 millimetres whereas the Afar lowlands in the northeast and the Ogaden in the southeast obtain less than 250 millimetres. Similarly, mean annual temperature varies from about 10^{o}C over the highlands of the northwest, central, and southeast to about 35^{o}C on the north-eastern edges. In addition to variations across the country, the climate is characterised by a history of climate extremes such as drought and flood, and increasing trends in temperature and a decreasing trend in precipitation (Ministry of Agriculture, 2000).

The risk of these climate extremes increases because very few farmers irrigate, and hence when rainfall fails, agricultural production drops. These events imperil livelihood of the farming population (the Economist Group, 2002 as cited in Cheung et al, 2008). Droughts in Ethiopia can reduce household farm production by up to 90% of a normal year output (World Bank, 2003). In response to environmental calamities, farmers in Ethiopia have developed traditional coping mechanisms to deal with idiosyncratic shocks, but these mechanisms tend to fail in times of covariate shocks such as drought. Risk management choices such as opting for cultivation of lower-value, lower-risk, and lower return crops using little or no fertilizer keep away farmers from taking advantage of profitable opportunities; these choices are a fundamental cause of continued poverty (Dercon, 2005). Consequently, adaptation mechanisms based on limited information result in reduced agricultural supply and hence a rise in food prices. Given that agriculture invariably influences the poverty reduction efforts of agrarian economies, studying how climate change affects agriculture and how agriculture responds to a changing climate is important.

Deressa and Rashid (2009) using the household socioeconomic data collected from 1000 households selected from different agro-ecological settings in the Nile basin, and temperature and precipitation data collected from United States Department of Defence and the African Rainfall and Temperature Evaluation System (ARTES), respectively, regressed the *Ricardian model*[7]. The results show that marginally increasing temperature during summer and winter would significantly reduce net crop revenue per hectare whereas a small increase in precipitation during spring would significantly increase net crop revenue per hectare. Yesuf et al (2008), using the same household data set, but meteorological station data collected and interpolated specific temperature and rainfall values for each household using the thin plate spline method of spatial interpolation, analyzed the impact of climate change on food production in low-income countries. Their results indicate that adaptations to climate change have significant impacts on farm productivity. Their results also show that extension services, both formal and informal, as well as access to credit and information on future changes in climate variables significantly and positively affect adaptation to climate change. However, none of these studies tries to look at how weather variability over the past three or four decades shaped the

[7] see section 2.4

farming sector, and how farmers reacted to the variations. Analyzing the impacts of weather variability is important for two reasons. First, the variability in weather conditions has an impact on the farmer`s decision to use productivity-enhancing external inputs. This is because the financial liquidity of farmers engaged in rain-fed agriculture, especially the smallholders, largely depends on the availability and variability of rainfall. For instance, Yonas et al. (2009) shows that rainfall variability increases the risk and uncertainty associated with fertilizer use. Therefore, such an uncertainty together with rising fertilizer prices relative to output prices and with a resulting decline in the profitability of fertilizer use (Mulat et al, 1998) may impede the efforts to improve agricultural productivity. Second, linked to the first reason rainfall variability through its influence on production or yield variability will increase price volatility in the cereal markets. Gebre-Medhin and Mezgebou (2006) analyzed price volatility in markets for teff, wheat, and maize, and show that, despite infrastructural improvements and liberalization, price volatility remains high. The study further indicates that the high price volatility, measured in the coefficient of variation (CV) of monthly nominal prices, is largely attributable to weather induced variation in the production of these commodities (Gebre-Medhin and Mezgebou, 2006). Since weather variability differs across diverse agro-ecological zones in the country, the welfare effects of weather variability induced price volatility would also be different across regions and households within the same region.

Thus, in this chapter, we investigate the relationship between climate variations and crop yield variability; and project how crop yield variability responds to climate variations and change, and investigate whether such responses differ across regions and zones in different parts of Ethiopia.

We note that factors other than climate influence the variability of agricultural production. Using high-yielding varieties, planting practices, field operations, and use of fertilizers and pesticides would influence the variability of agricultural production. Although in the long run the extent of the degree of sensitivity depends on technological progress, crop climate adaptation, and CO_2 fertilization, examining the historical data and relating the yield variability to climate can help in identifying the sensitivity of agricultural yield variability to future climatic change.

With this understanding, we use a historical data of rainfall collected from different weather stations and crop yield data from the zones matching the weather stations over the period of 1979/80—2008/09 and investigate the statistical relationship of weather, mainly rainfall, and crop yields of three main crops namely: *teff*, wheat, and maize. The analysis is conducted in such a way that the effects of climate variable, rainfall, on mean and variance of crop yields can be distinguished. The results from the estimation of the statistical relationship are combined with three Atmosphere Ocean General Circulation Models (AOGCMs) including Coupled Global Climate Model (CGCM2), the Hadley Center Coupled Model (HadCM3), and the Parallel Climate Model (PCM) for the year 2050 based on A2 and B2 emission scenarios. The findings suggest that the impacts of climate change will be different across crops and regions.

The remaining sections of the chapter are organized as follows section 2 provides an overview of the Ethiopian climate, section 3 discusses data used in the study, section 4 provides the empirical model, section 5 discusses the empirical results, section 6 discusses simulation results, and section 7 concludes.

2.2. Climate of Ethiopia: An Overview

Located in the horn of Africa, Ethiopia shares borders with Eritrea in the north, Kenya in the south, Sudan in the west and Djibouti in the east. It is characterized by diverse topography. The country's main topographical features include the great East African Rift Valley (which stretches from southwest to northeast), the mountains and highlands to the right and left of this Rift Valley, and the lowlands surrounding these mountains and highlands in every direction. The diverse topography and various atmospheric systems affecting the Ethiopian climate, in turn, resulted in varying climatic conditions across the country. Due to differences in methods of classifying a climate system, the climate system of Ethiopia has been classified in many different ways. The most widely used classification systems are the traditional and agro-ecological zones (AEZ). The traditional classification relies on altitude and temperature and classifies the country into five climatic zones (see Table 2.1).

Table 2.1 Traditional climatic zones and their physical characteristics

Zone	Altitude (meters)	Rainfall (mm/year)	Average annual temperature(^{0}C)
Wurch(Upper highlands)	>3200	900-2200	>11.5
Dega(highlands)	2,300-3200	900-1,200	17.5/16-11.5
Weynedega(midlands)	1500-2300	800-1200	20.0-17.5/16
Koa(lowlands)	500-1500	200-800	27.5-20.0
Berha (desert)	<500	<200	>27.5

Source: Deressa et al. (2010)

National Meteorological Services Agency (NMSA) (1996) documented that the climate of the country is divided in to 11 zones, broadly categorized as dry climate, tropical rainy climate, and temperate rainy climate. Using agroclimatic zoning method that relies on the water balance concept and the length of growing season (including onset dates at certain probability levels), NMSA classified the country into three distinct zones namely the area without a significant growing period, areas with a single growing period, and areas with a double growing period.

The Ministry of Agriculture (MoA), again using the AEZ classification method, classifies the country into 18 AEZs, which are further subdivided into 49 AEZs (see Appendix 2A) (MoA, 2000)[8]. The 18 AEZs are broadly categorized into six major categories (Table 2.2).

Table 2.2 Climatic zones based on Agro-ecological zone method of classification

Zone	**Area coverage (in million ha)**	**% out of total area**	**Characteristic of the zone**
Arid zone	53.5	31.5	Less productive and pastoral
Semi-arid	4	3.5	Less harsh compared to the arid zone
Sub-moist	22.2	19.7	vulnerable to and highly threatened by erosion
Moist	28	25	Most suitable and for cereals cultivation
Sub-humid and humid	21.9	19.5	Suitable and ideal for annual and perennial crops; with significant forest coverage and wildlife; high biodiversity
Per-humid	1	1	Suitable for perennial crops and forests

Source: Table organized based on information in Deressa et al. (2010)

[8] The Ministry of Agriculture`s classifications are largely similar to that of NMSA (1996). Probably, as the National Meteorological Services Agency is the only responsible agency to investigate and study weather and climatic conditions of the country, the same agency may have produced the MoA (2000) classifications.

Past trends of climatic conditions indicate that rainfall and temperature are changing over time. NMSA (2007) indicates that annual minimum temperature has been increasing by about 0.37 ^{0}C every 10 year over the period of 55 years. The average annual rainfall, on the other hand, has shown a very high level of variability, characterized by wet and dry conditions, where the later marking drought and famine periods (Figure 2.2).

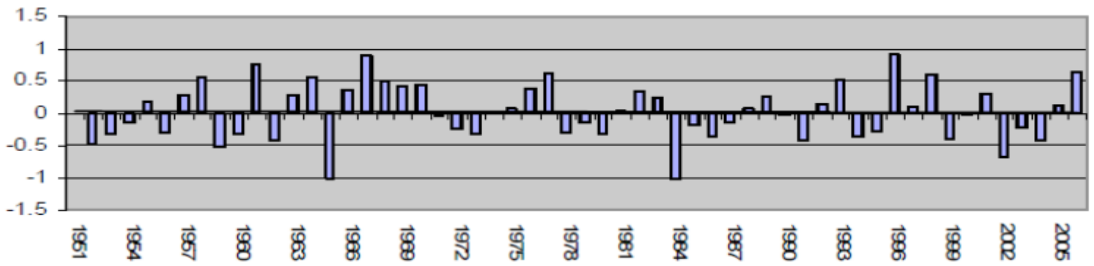

Figure 2.2 Year-to-Year Variability of Annual Rainfall and Trend across Ethiopia in Normalized Deviation (compared to 1971-2001 normal).
Source: National Meteorological Service (2007)

Most importantly, the varying topography and the different atmospheric circulation patterns observed in the country determine the rainfall patterns across the country. Despite the presence of ample ground water and surface water resources, agriculture in Ethiopia is largely rain-fed. As a result, rainfall is considered as the most important climatic element determining the performance of the Ethiopian agriculture and hence the broad economy. The failure of seasonal rains poses a risk of drought which presumably reduces a household`s farm production by up to 90 % (World Bank, 2003). Conversely, since the severity, occurrence, and frequency of drought vary across the country, understanding the rainy seasons of different parts of the country helps in identifying the growing seasons of the areas we investigate. That would help to associate the weather data to the yield data for the appropriate growing seasons.

Seasonality of rainfall across the country indicates that most parts of the country obtain both *kiremt* (long rainy season running from June to September) and *belg* (short rainy season running from February to May) rainfalls, with the exception of some areas in the northwest (see Figure 2.3). Some areas in the southwest obtain rainfall for about the period of 7 months running from April/May to October/November. The western part of Ethiopia has one rainfall peak during the year. The length of the rainy period decreases, and the length of the dry period increases as one goes toward the north within this region, because of the meridional migration of the Inter-Tropical Convergence Zone (ITCZ). The southern and the southeastern parts of the country, on the other hand, have two distinct dry periods (December to February and September to November).

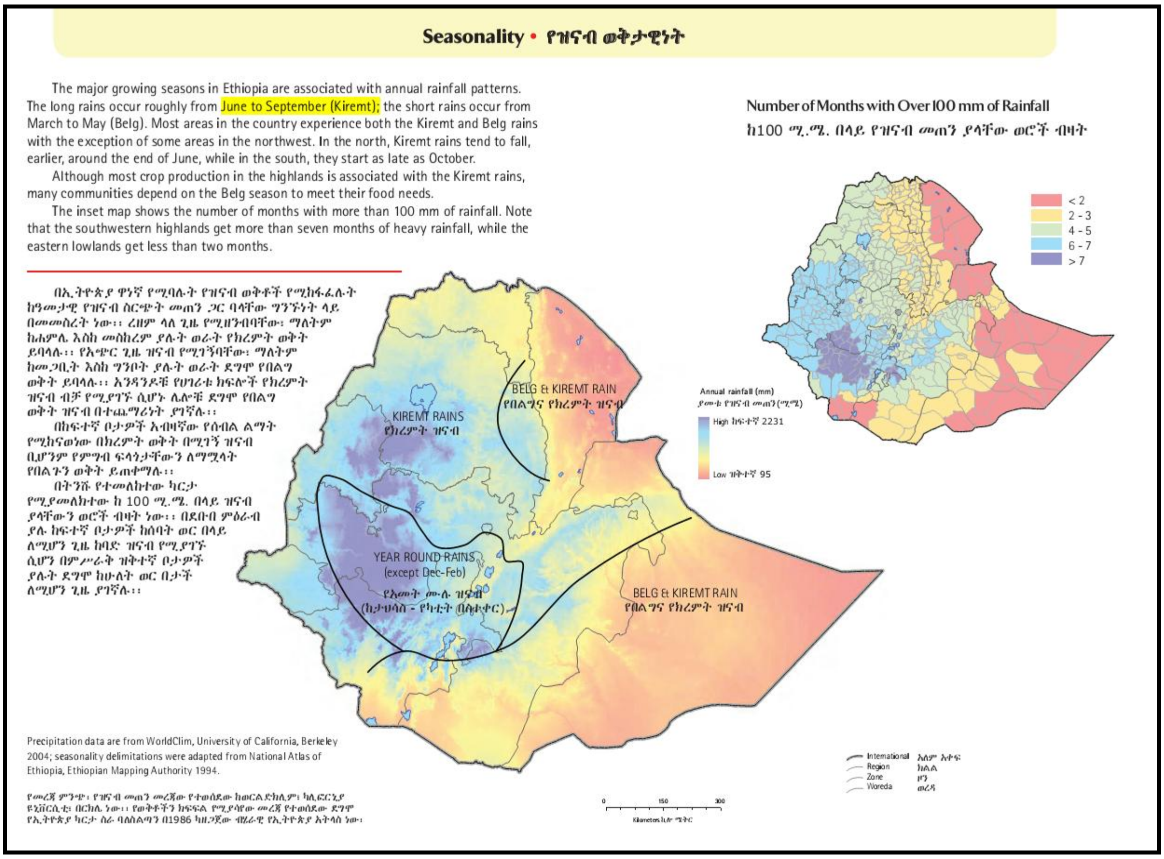

Figure 2.3 Seasonality of rainfall across Ethiopia.

Source: IFPRI, CSA (2006)

2.3. Data

2.3.1. Crop Yield Data

The study uses the yield data for three cereal crops: *teff*, maize, and wheat. We compiled the yield data from the agricultural sample surveys of the Central Statistical Agency (CSA) of Ethiopia conducted since 1979/80. However, the country has been under different political regimes during the period of our interest (1979/80-2008/09) and the geographical zoning of the country has been changing based on the ideology of the respective regimes, the latest being zoning by ethnic and linguistic background. As a result, the reporting units of the yield data varied following changes in government. From 1979/80 to 1987/88, the statistical data for crop yields reported at the regional level, *kiflehager*, in which the country classified into 16 regions including Eritrea. However, after 1988/89 the CSA crop yield data were reported at the sub-regional level and since 1993/94 at the zone level. In this analysis, we use the most recent reporting units, zones. In order to maintain the zonal level reporting units for the years prior to 1993/94, the average yield of the larger sub-regions in which the post 1993/94 reporting units traced back is used as an approximate average yield for the pre-1993/94 period (see appendix 2A for changes in zonal demarcations).

After this exercise, we organized data for 14 zones matching nearest weather stations capturing the weather information of the zones in three administrative regions as of the current administrative classification of the country. However, the pre 1993/94 values for all zones are approximated by the average yield values of the larger sub-regions in which the post 1993/94 zones had been located prior to the re-demarcation of administrative boundaries based on the ethnic map that delineated the borders of the new administrative units.

The relative risk in yields measured by the coefficient of variation of yields between *period 1 (1979-1993)* and *period 2 (1994-2008)* show large variability among crops and zones. In general, the relative risk in yields increased for *teff* and wheat, and decreased for maize. The coefficient of variation of yields for *teff* decreased in South Wollo, East Wollega, Sidamo, East Shoa, North Gonder, Bale and Arsi, but increased in the rest of the zones. Similarly, the coefficient of variation of yields for wheat decreased in S. Wollo, Sidamo, and Illubabor whereas the remaining states have shown increased variation. The coefficient of variation of yield for maize also has shown increases in E. Wollega, North Shoa (Oromia), and Gamo Gofa. Of the individual zones, relative risk in yields for *teff* was high in Gamo Gofa and Bale zones, for wheat in Sidamo, North Shoa (Amhara), North Gonder, and West Gojjam, for maize in South Wollo, East Wollega, North Shoa (Oromia), North Gonder, and Gamo Gofa. All have coefficient of variation in yield greater than 30 percent in the second period (see appendix 2E).

Over the past 28 years, crop yields at national level have shown improvement despite periodic setbacks due to confounding factors such as erratic rainfall, famine which wreaks havoc on subsistence farmers, and poor agricultural policies the country has experienced.

Table 2.3 Crop Yields (quintal/hectare) for Selected Years

Crops	**1979/80**	**2008/09**	**%change**
Teff	9.50	12.20	28.42
Wheat	17.34	22.24	28.30
Maize	11.09	17.46	57.44

Source: Agricultural Sample Surveys of respective years

While there are regional variations in yields for the three crops, regional and zonal changes in crop yields over the 28 years period largely followed the national trends. We observe from Table (2.3) that maize yield has increased over 60 % over 28 years while *teff* and wheat have shown an annual increase of 1%.

2.3.2. Rainfall Data

We use a time series average monthly rainfall data of 14 weather stations across three regions of Ethiopia, namely Amhara, Oromia, and SNNPR for the period from 1979 to 2008. We obtained the data from the National Meteorological Services Agency of Ethiopia (NMSA) and organized the average monthly rainfall into seasonal rainfalls matching the growing seasons, *kiremt* (*meher*) and *belg* seasons. The *belg* rainfall is used because *belg* rainfall provides a fair indication of *Meher* season crop yields both in long and short cycle crops. This correlation is implied in two ways. First, the long cycle crops such as maize and sorghum (not included in this study) largely depend on *belg* rains. Second, *belg* rainfall anomalies tend to persist into main growing season rainfall indicating that rainfall deficits that occur in *belg* season can negatively affect *meher* season crop yields. Since Ethiopia has a very diverse agro-climatic classification that resulted in different growing seasons for different locations across the country, weather stations have been matched with the administrative area they are located in and the crop yield reporting zones using the geographic information (latitudes and longitudes) of the weather stations and zones. Missing values for the rainfall series at the station level have been interpolated using the three years moving average method, as the three years moving average better approximates the series than regressing the rainfall series of the nearby station on the station for which missing data are reported. Figures 2.4 and 2.5 below show how the three year moving average approximates the actual *kiremt* (main season) rainfall for Hawassa and Fiche weather stations.

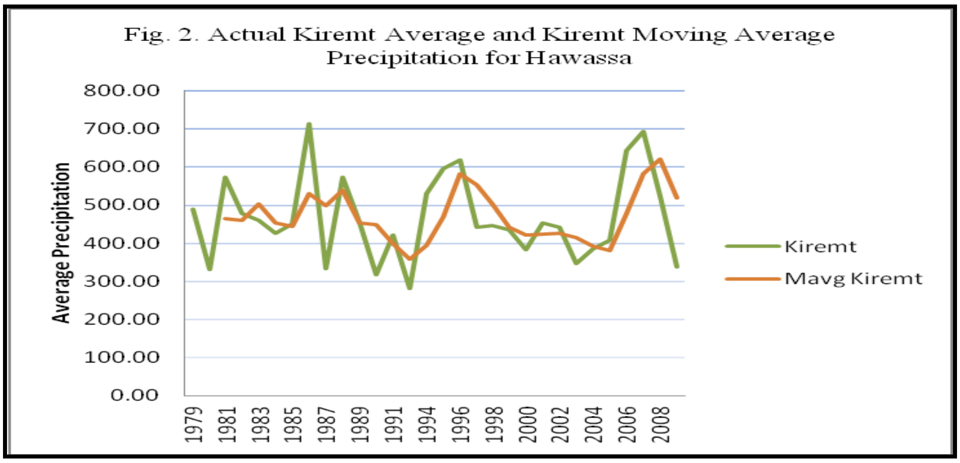

Figure 2.4 Observed Kiremt Average and Kiremt Moving Average Precipitation for Hawassa

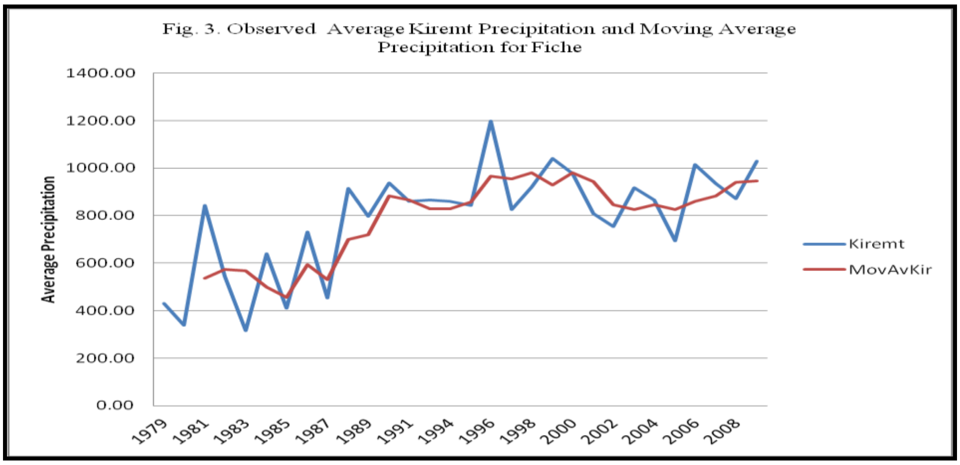

Figure 2.5 Observed Average Kiremt and Moving Average Precipitation for Fiche

2.4. Econometric Model

The impacts of climate change on agriculture have been studied employing different approaches. These include Agro-Ecological Zone (AEZ) Models, Agro-Economic Models, and the Ricardian Approach. In the following, we briefly describe each of these methods.

AEZ Model: The AEZ model uses simulated crop yields, rather than observed crop yields, and examines the potential production capacities across various ecological zones, not at what was actually occurring. In part, the reason for this focus on predicted values relates to lack of reliable and accurate yield data on a widespread basis. Thus, the model employs a yield biomass simulation model and estimates the maximum potential yields for a given production area. The disadvantage of this modelling process is that one cannot predict outcomes without explicitly modelling all relevant components. Even with relatively simple agronomic systems, it is difficult to build a general model that will predict actual yields across most locations. Just the omission of one major influence can damage the model's predictions (FAO, 2000). Although the AEZ model was designed not to perform economic analysis, economic variables may be incorporated in the model through a linear optimization component. The need to extend the model by including new technologies developed over time and the requirement to integrate farmers' economic behaviour into the model resulted in the Agro-economic model, which is a modified version of AEZ model.

The Agro-economic Model: It begins with a crop model that would be calibrated from carefully controlled agronomic experiments (Kaiser et al, 1993; Kumar & Parikh, 2001; Rosenzweig & Parry, 1994). Crops are grown in the field or laboratory settings under different possible future climates and carbon dioxide levels. No changes are permitted to farming methods across experimental conditions so that all differences in outcomes can be assigned to the variables of interest (temperature, precipitation or carbon dioxide). The failure of the above models to include adaptation raises a question about whether the experiments are representative of the entire farm sector. If applied in wider areas, this may not be a serious problem. However, in developing countries, there are only a few experimental sites and the results may not be conclusive.

The Ricardian Model: the Ricardian model is the most common cross-sectional method that attempts to capture the influence of economic and environmental factors on farm incomes or land values (Mendelsohn et al., 1994). This model analyzes a cross-section of farms under different climatic conditions and examines the relationship between the value of land or net crop revenue and agro-climatic factors (Mendelsohn et al., 1994; Sanghi et al., 1998; Kumar & Parikh, 1998).

The Ricardian model, named after David Ricardo, has been employed to value the contribution of environmental factors to farm income by regressing farm performance (land values or net income) on a set of environmental factors, traditional inputs (land and labour), and support systems (infrastructure). The model measures the contributions of each factor and detects the effects of long-term climate change on farm values (Mendelsohn et al., 1994; Mendelsohn and Dinar, 1999). In most studies conducted in developing countries such as South Africa (Benhin, 2006), Ethiopia (Deressa and Rashid, 2009), Brazil (Sanghi, 1998), and India (Sanghi et al., 1998, Kumar & Parikh, 1998), the Ricardian approach is applied to examine the sensitivity of agriculture to changes in climate.

In all cases, it has been shown that the Ricardian approach is suitable to incorporate farmers' efficient adaptations by including relevant variables that reflect adaptations made by farmers to alter their operations in accordance with a changing climate. The major weakness of the Ricardian approach, however, is that it assumes constant prices (Cline, 1996)[9] and hence measures the loss in producer surplus from climate changes.

Hassan (2010) states that most of the climate change studies focused on simulating the likely impact of future climate change conducted based on highly uncertain Global Climate Circulation Models (GCCM) in which the forecasting is not appropriately downscaled, and very little has been done with regard to the preceding impacts of climate change.

As we mentioned in the previous sections, we investigate the preceding impacts of climate, mainly rainfall, on crop yields of *teff*, wheat, and maize. To this end, using historical data on crop yields and rainfall, we estimate the Just-Pope production function that allows quantifying the potential impacts of climatic variables on the mean and variance of crop yields. The estimated production function reveals whether the climatic variables increase or decrease the mean and variance of crop yields. This approach, which follows Just and Pope (1978), and applied in Isik and Devadoss, 2006; McCarl et al, 2008, is important in two ways. First, it helps us show the preceding impacts of weather variability (climate change) on the average crop yields and variance of crop yields over time. Thus, this provides an insight into how the crop yield-climate relationship is evolving overtime

[9] The inclusion of price effects in to it is problematic. Existing cross-sectional studies depend on a cross section within a country where there is little price variation across farms, with the result that the studies have not been able to estimate the effects of prices. Hence, the assumption of constant prices in Ricardian studies leads welfare calculations to be biased (Cline, 1996). It takes no notice of price change that would occur if supply changed. As a result, it omits consumer surplus from the analysis. The result, according to Mendelsohn (2000), is that damages are underestimated (omit lost of consumer surplus) and benefits are overestimated (overstate value of increased supply).

so that we will have a benchmark to evaluate the reliability of projected likely impacts that depend on forecasts of future climate change. Second, it contributes to the literature documenting the historical relationships between crop yields and climate variables using a method that decomposes the impacts on average crop yields and variability of crop yields.

The Just and Pope (1978) stochastic production function of the crop yield for region (i), year (t), Y_{it}, is specified as follows:

$$Y_{it} = f\left(X_{it};\beta\right) + \varepsilon_{it} h\left(Z_{it};\delta\right)^{1/2} \quad \text{.. (1)}$$

Where ε_{it} is the stochastic term with $E\left(\varepsilon_{it}\right) = 0$, and $V = \sigma_{\varepsilon}^{2}$, β and δ are the production term variables to be estimated, and Z_{it} may contain the same elements as X_{it}.

The estimation of the first part of the above equation $f\left(X_{it};\beta\right)$ provides the effects of the independent variables on the mean crop yields, $E\left(Y_{it}\right)$. While estimating the second part provides the effects of independent variables on the variance of the crop yields, $V\left(Y_{it}\right)$, which is given by $\sigma_{\varepsilon}^{2} h\left(Z_{it};\delta\right)$ (Just and Pope, 1978). The explanatory variables, X_{it}, used in the model include a constant, rainfall (*kiremt* or main season, and *belg* or short rainy season), and trend. Thus, whether Z_{it} increases or decreases crop yield variability is determined based on the sign of h_{z} in the regression, because the Just-Pope production function does not impose *ex ante* restrictions on the risk effects of inputs considered in the model.

Thus X_{it} is said to be risk increasing if it increases the variance of crop yields, $h_{x} > 0$, under uncertainty, and risk decreasing otherwise. Saha et al (1997) has shown that estimating the Just and Pope Production function can be considered as an estimation method with multiplicative heteroscedastic errors given as follows:

$$Y_{it} = f\left(X_{it};\beta\right) + u_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{(2)}$$

Where $u_{it} = \varepsilon_{it} h\left(Z_{it};\delta\right)^{1/2}$

The Just-Pope production function has been estimated using either feasible generalized least squares (FGLS) or maximum likelihood (ML) method. However, Saha et al. (1997) shows that the maximum likelihood method is preferred to FGLS method in studying risk effects of inputs. Because in other types of heteroscedasticity models where FGLS is applied, the consistency of $\hat{\delta}$ guarantees efficient estimate of β and hence little concern is given for efficiency of $\hat{\delta}$. However, in studying risk effects of inputs the efficiency of $\hat{\delta}$ is important, for it captures the risk effects of inputs. For this reason, we used the maximum likelihood method to estimate our model (see comparison of FGLS and MLE results in appendix 2D).

We assume that the variance of the crop yields has the following exponential form: $V\left(Y_{it}\right) = V(u_{it}) = \exp\left(\delta Z_{it}\right)$ with $\sigma_{\varepsilon}^{2} = 1$ (i.e., $\varepsilon_{it} \sim N\left(0,1\right)$). This variance developed by Harvey (1976) bounds the crop yield variance to be non-negative.

The study investigates the effects of climate variables on crop yields in different regions/zones of the country and hence the region/zone specific effects in the estimation of the production function in (2) have been accounted for by developing a panel data estimation method.

The panel data estimation process relates crop yields to exogenous variables and results in estimates of the impacts of the exogenous variables on the average and variances of the crop yields. The model assumes that all the included variables are stationery, and hence deterministic and stochastic trends in variables can introduce spurious correlations between variables, as the errors in the data generating processes for different series might not be independent (Chen et al., 2004).

A positive trend existent in agricultural yields, thus, can be accounted for by introducing deterministic time trend. However, even after introducing the time trend the correlation between variables remains spurious. Thus, testing for stationarity of the variables may help satisfy ideal conditions for the regression; and inferences on the deterministic time trend can be appropriate once all the variables included in the regression become stationary. For this reason, a time series property of the panel data has been examined using the Fisher Type panel unit roots test (Maddala and Wu, 1999; Choi, 2001). Like the other panel unit roots tests such as the Im-Pesaran-Shin (IPS) test (2003), it allows for residual serial correlation and heterogeneity of the dynamics and error variance across groups. Nevertheless, unlike the other tests the Fisher test allows for gaps in the series.

2.4.1. Panel Unit Root Test

Suppose that the variable of interest, y_{it} , has a representation as a stochastic first order auto regressive process for zone *I* and time period *t*,

$$\Delta y_{it} = \alpha_i + \mu_i y_{it-1} + \varepsilon_{it}, i = 1,.....,N, t = 1,.....,T \quad (3)$$

Where $\Delta y_{it} = y_{it} - y_{it-1}$, and $\mu_i = \phi_i - 1$.

The null hypothesis of a unit root in (3) is then a test of

$H_0 : \mu_i = 0$, for all *i,* against the alternative,

$H_1 : \mu_i < 0$, for at least one *i*

The Fisher type panel unit roots test proposed by Madalla and Wu (1999) combines the *p-Values* of unit root tests for each cross section unit *i* in (3) to test for unit root in panel data. Suppose that D_{iTi} is a unit root statistic obtained by applying either Dicky-Fuller or Philip-Perron unit root test for the i^{th} group in (3) and assume that as, $T_i \to \infty, D_{iTi} \to D_i$. Let p_i be the *p-value* of a unit root test for the cross section *i,* i.e., $p_i = F(D_{iTi})$, where $F(.)$ is the distribution function of the random variable D_i . The proposed Fisher type test combining *p-values* is given as follows:

$$P = -2\sum_{i=1}^{N} \ln p_i \quad (4)$$

P is distributed as χ^2 with 2*N* degrees of freedom as $T_i \to \infty$ for all *N.*

Maddalla and Wu (1999) and Choi (2001) indicate that the Fisher type test is a better test than IPS in that: (1) it does not require balanced panel; (2) each group in the panel can have different types of stochastic and non stochastic components; (3) the time series dimension, T, can be different for each *I;* (4) the alternative hypothesis would allow some groups to have unit roots while others may not; and (5) it allows for gaps to exist in the individual group time series.

Thus, we conducted a panel unit roots test using Fisher type test, in which the Dicky-Fuller unit roots test statistic of AR (1) is used for the i^{th} group in model (3). The decision rule for the Fisher type test is that the null hypothesis $H_0 : \mu_i = 0$, for all i is rejected in favour of the alternative $H_1 : \mu_i < 0$, for at least one i at the significant level α when $P > c_{p\alpha}$, where $c_{p\alpha}$ is the upper tail of the chi-square distribution with $2N$ degrees of freedom (Choi, 2001).

As Table (2.4) shows below that for all the variables considered in the analysis, the null hypothesis that states all the panels contain unit roots is rejected at 1% significance level. Further, to check the robustness of the Fisher type panel unit roots test results; we conducted an Augmented Dickey-Fuller (ADF) test for all the variables in each panel unit. In appendix 2B, Tables 2A, 2B, and 2C provide the ADF test results of individual series of variables in the panel units (zones) and weather stations.

Table 2.4 Fisher Type Unit Root Test Results

	P (drift, lag (1), demeaned, N=14)
Crops	
Teff	145.32*
Wheat	138.72*
Maize	149.90*
Rainfall	
Kiremt	258.66*
Belg	180.36*
Annual	193.71*

*Significant at 1% with χ^2 (28) =48.28

Thus, the panel time series characteristics of the data used show that all the variables are stationary, $I(0)$. The stationarity of the variables included in the regression of the production function avoids spurious correlations between the variables and a deterministic time trend that will be included in the estimation of the production function in order to capture technological improvements over time and does not suffer from an inflated *t-statistic*, ensuring a valid inference.

Despite the rejection of the null hypothesis of unit roots, the ADF test of individual panel units shows that the variable teff is stationary in 71 percent of the units, wheat in 50 percent of the units, and maize in 57 per cent of the units. With regard to the rainfall data, the *kiremt* rainfall is stationary in 71 percent of the units, and *belg* rainfall in 86 percent of the units (see Table 2A-2C in appendix 2B).

Once we establish the time series properties of the variables, we determine the appropriate form of the panel model to be estimated. Following Isik and Devados (2006) and Saha et al (1997), the quadratic form assumed for the mean function is given as follows:

$$f\left(X_{it};\beta\right)=\beta_0+\beta_1 P+\beta_2 T+\beta_3 T^2+\sum_{i=1}^{2}\alpha_i D_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

where D_i is a region dummy variable taking values 1 or 0, P is precipitation, and T is a time trend. The variance function $\sigma_{\varepsilon}^2 h\left(Z_{it};\delta\right)$ with $\sigma_{\varepsilon}^2=1$ was assumed to have exponential form

$$h\left(X_{it};\delta,\eta\right)=\exp\left(\delta X_{it}+\eta D\right)=\exp\left(\delta_0+\delta_1 P+\delta_2 T+\delta_3 T^2+\sum_{i}^{2}\eta_i D_i\right)\ldots\ldots\ldots \text{(6)}$$

This form of variance function is due to Harvey (1976) and it has been employed by several studies such as Saha et al (1997), and Isik and Devados (2006), Attavanchi and McCarl (2011), and Cabas et al (2010). As mentioned above the Harvey type variance specification ensures positive output variance; and the risk effect of an input variable can be derived from the sign of the coefficient of that variable in the function. For instance, from (6) it can be obtained that $\partial h / \partial p = \delta_1 h$. As the variance of *h* is always positive, precipitation (P) will be risk increasing if $\delta_1 > 0$ and it will be risk decreasing if $\delta_1 < 0$. Thus, the mean function provided in (5) can also be used to study the maximum possible yield, minimum possible yield variance and impact of climate change on crop yield.

Previous studies included average rainfall for alternative units of time ranging from a month to a year. In this study, average seasonal, *kiremt* and *belg,* rainfalls are used. Average growing season rainfalls (*kiremt* and *belg*) measured in mm are expected to have positive effect on crop yields.

2.4.2. Estimation of Parameters

Since $Y_i \sim N\left(f\left(X_{it};\beta\right), h\left(X_{it};\delta\right)^2\right)$, under the assumption that $\varepsilon_{it} \sim N\left(0,1\right)$ the likelihood function is

$$L = \left[\tfrac{1}{2\pi}\right]^{N/2} \prod_{t=1}^{T}\prod_{i=1}^{n}\left[\frac{1}{h\left(X_{it};\delta\right)}\right]^{1/2} \exp\left[-\left\{Y_{it} - f\left(X_{it};\beta\right)\right\} \Big/ 2h\left(X_{it};\delta\right)\right] \quad \text{.......................... (8)}$$

Where *n* is the number of zones and *T* is the number of time periods and N=*nT*.

Hence the log-likelihood function is given by

$$\ln L = -\frac{1}{2}\left[N*\ln(2\pi) + \sum_{t=1}^{T}\sum_{i=1}^{n}\ln\left(h\left(X_{it};\delta\right)\right) + \sum_{t=1}^{T}\sum_{i=1}^{n}\frac{\left\{Y_{it} - f\left(X_{it};\beta\right)\right\}}{h\left(X_{it};\delta\right)} \right] \text{.......................} (9)$$

Thus, maximizing (9) provides a maximum likelihood estimates of the parameter vectors β and δ.

Since the independent variables used in the estimation of (9) vary across regions/zones and time, the region/zone and/or time specific omitted variables that affect changes in crop yields may hide the true relationship between the dependent and independent variables. For this reason, we need to choose between models that appropriately account for the characteristics of such omitted or unobservable variables.

The panel nature of the data allows estimating (9) using one of the two alternative forms of panel data models, fixed or random effects model. Therefore, we may employ the fixed effects model, which controls for omitted variables that differ between regions/zones but are constant over time, or, alternatively, the random effects model, which considers that some omitted variables, may be constant overtime but vary between panel units (regions/zones).

In choosing between the two alternative panel data models, we conducted the Haussmann specification test. Based on the test, the null hypothesis of no correlation between the unit specific errors (u_i) and the regressors is rejected implying that random effects model is appropriate in our case. The test statistics and *p*-values for the specification tests are reported in Tables (2.5 and 2.6).

2.5. Results and Discussion

The variables included in the model are in their logarithmic form in order to provide convenient economic interpretations (elastcities) and to reduce heterogeneity of the variance. In the estimation of equation (9), we employ main growing season (*kiremt*) rainfall, short growing season *(belg)* rainfall that comes before the main growing season, time trend and its square.

The time trend (year) has been used as a proxy for technical change in crop production technology such as development of new varieties and farm management practices which generally increase crop yields overtime.

We also add interaction terms between seasonal precipitation and regions. It is worth noting that the coefficient of the seasonal rainfall variable when a region interaction term is introduced in the equation represents the effect of the seasonal variable on crops for the base region, SNNP for teff and wheat yield functions and Oromia for maize yield function. The coefficients of the interaction terms reflect the difference between the effect of the seasonal rainfall over a given region and the base region. The estimated coefficients of the mean and variance functions are presented in Tables 2.5 and 2.6 below.

We find that main growing season (*kiremt*) rainfall has positive effects on teff and wheat yields across the regions. However, the relative comparison reveals that the importance of *kiremt* rainfall is higher in the SNNP region than the Oromia and Amhara regions. This is given by the coefficients of the interaction terms in the regression. The coefficients reveal that the elasticity of teff yields to changes in kiremt rainfall is lower in the

Amhara and Oromia regions by about 0.15% and 0.145%, respectively, when compared with the elasticity of the reference region SNNP. Likewise, the difference in the responsiveness of wheat yield to a 1% change in *kiremt* rainfall shows a difference of about 0.17% and 0.22%, respectively. The differences in all cases are statistically significant at 10%, except the difference between average yield elasticity in Amhara and the reference region. For maize, *kiremt rainfall* appears not so much important across regions.

The *belg* precipitation shows negative effects on teff and wheat yields; however, the result is statistically insignificant. It has positive and significant effects on maize yield for the Oromia region. The difference in maize yield response to *belg* rains appear lower in the SNNP and Amhara regions compared to that of the Oromia region. However, the difference is not statistically significant. The proxy for technical change in crop production, the trend coefficient, shows that for all crops technical change in crop production increases mean crop yields at an increasing rate.

The estimated coefficients of the variance function provided in (6) are presented in Table 2.6. The interpretation of the coefficients, as mentioned above, is that positive coefficients of the variance function imply that an increase in the covariates whose effects on the variance investigated leads to a higher yield variance and vice versa.

The study of factors affecting the variability of crop yields using the variance function shows that higher *kiremt* rainfall decreases variability of *teff* and wheat yields in the SNNP region, whereas the falls in the variability of yields of both crops in response to increased kiremt rains appear higher in the Amhara and Oromia regions. Further, we found that higher *kiremt* rainfall increases the variability of maize yields in the Oromia region; however, such an increase in variability is higher in the SNNP region and lower in the Amhara region when compared to the Oromia region.

Similarly, we find that increased *belg* season rainfall appear to have a decreasing effect on the variability of teff yield in the SNNP region and maize yield in Oromia region; however, the decrease in the variability of maize yield for the Oromia region is not statistically significant. The relative difference in the effect on the yield variability of teff due to an increase in *belg* rainfall shows that in the Oromia region *belg* rains have a higher reducing effect on teff yield variability than the reference region, whereas the difference between the Amhara and the reference region is not statistically significant.

The estimated coefficients of trend (technical change in crop production) reveal that technical change in production has a negative effect on crop yield variability; however, the effect is statistically significant only for the variability of maize yield.

Table 2.5 Estimate Coefficients from Mean Crop Yield Regressions

	Teff	**se**	**Wheat**	**Se**	**Maize**	**Se**
Kiremt	0.1436***	(0.0751)	0.1480***	(0.0810)	-0.0159	(0.0517)
Belg	-0.0327	(0.0292)	-0.0227	(0.0293)	0.1050***	(0.0618)
D1_kiremt	-0.1495***	(0.0875)	-0.1743***	(0.0941)	-0.0476	(0.0818)
D2_kiremt	-0.1452***	(0.0809)	-0.2239**	(0.0888)		
Trend	-0.0143***	(0.0074)	-0.0148**	(0.0073)	0.0017	(0.0094)
Trend^2	0.0007*	(0.0002)	0.0011*	(0.0002)	0.0005***	(0.0003)
D3_kiremt					0.0198	(0.1255)
D1_belg					-0.0413	(0.0859)
D3_belg					-0.1329	(0.1128)
D1	1.0562**	(0.5326)	1.0474***	(0.5750)	0.3940	(0.8080)
D2	1.0616**	(0.4831)	1.4419*	(0.5334)		
D3					0.5191	(0.9681)
Intercept	1.3620	(0.4623)	1.5484*	(0.5044)	2.1258*	(0.5106)
N	359		352		359	
Ha	7.85	(0.3460)	3.13	(0.6797)	8.37	(0.3983)

Note: 1. Standard errors in parentheses * ***p<0.10 ** p<0.05 * p<0.01*

2. Regional interacted dummies: D1: Amhara Region (East Gojjam, North Gonder, North Shoa (A), South Wollo, and West Gojjam); D2: Oromia Region (Arsi, Bale, East Shoa, North Shoa (O), E. Wollega, and Illubabor); D3: SNNP Region(Gamo Gofa, Hadiya, and Sidama)

3. Ha is a Haussmann test statistics, where the null hypothesis is: no correlation between the unit specific errors (u_i) and the regressors.

Table 2.6 Estimated Coefficients from the Variance Function Regression

	Teff	SE	Wheat	SE	Maize	SE
Kiremt	-0.936**	(0.434)	-0.578***	(0.307)	0.226	(0.155)
Belg	-0.939***	(0.553)	0.226	(0.234)	-0.328	(0.303)
D1_kiremt	0.716	(0.546)	1.101*	(0.425)	-0.689*	(0.167)
D2_kiremt	0.781***	(0.457)	0.868**	(0.373)		
D1_belg	0.952	(0.632)			0.276	(0.408)
D2_belg	1.213***	(0.627)				
D3_kiremt					0.410**	(0.170)
D3_belg					-0.0905	(0.664)
Trend	-0.00667	(0.0135)	-0.0166	(0.0191)	-0.0901*	(0.0121)
D1	-10.18**	(4.618)	-7.535*	(2.591)	2.813	(2.800)
D2	-11.34*	(3.801)	-5.736**	(2.284)		
D3					-2.228	(4.044)
Intercept	7.041**	(3.180)	-1.330	(2.340)	-2.055	(2.250)
N	359		352		359	
Ha	10.12	(0.1820)	4.12	(0.6605)	2.90	(0.8943)

Standard errors in parentheses, ***<0.10 **p<0.05 *p<0.01. Ha is the Haussmann test statistic.

2.5.1. Simulation of Impacts of Climate Change on Future Crop Yields

In order to investigate the implications of future climate change on crop yield and its variability, we use the coefficients estimated based on the historical data and combine them with the climate change projections for the year 2050.

We simulate the projected percentage change of average crop yield and yield variability using climate projections from three Atmosphere Ocean General Circulation Models (AOGCMs) including CGCM2, HadCM3, and PCM for the year 2050 based on A2 and B2 emission scenarios.

The IPCC developed long-term emission scenarios, which have been extensively used in the analysis of possible climate change, its impacts, and strategies to mitigate climate change. The scenarios built up four different baselines (A1, A2, B1, and B2), which assume distinctly different direction for future developments, that continue to diverge irreversibly. It is supposed that together the four scenarios describe divergent features that take in a significant portion of the underlying uncertainties in the main driving forces. The scenarios consider a wide range of key future characteristics such as demographic change, economic development, and technological change.

A brief description of the four scenarios based on IPCC (2000) is provided as follows:

- A1 scenario family describes a future world with very rapid economic growth and a world population that will grow until the middle of 21^{st} century and subsequently decreases, accompanied by the advent of new and more efficient technologies

- A2 scenario family describes a very heterogeneous world. The birth rates in different regions are only slowly converging, leading to a continuous rise of the world`s population. Economic growth is mainly regional and per capita GDP growth, as well as technological change, will be slower and more fragmented than in other scenarios.

- B1 scenario family assumes a world with the same global population in scenario family A1 but with rapid changes in the economy, moving towards a service and information oriented society with far less use of natural resources and the introduction of clean and resource efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

- B2 scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in B1 and A1 scenarios. While the scenario is also oriented towards environmental protection and social equity, it focuses on regional and local levels.

This study uses the simulated precipitation data under A2 and B2 scenarios from three climate models (see Table 2.7).

Table 2.7 Rainfall predictions for the year 2050

	Current*	**Precipitation in 2050**	**Precipitation change in % 2050**
CGCM2	76.77	66.79	-13.0
PCM	76.77	80.61	5.0
HadCM3	76.77	83.68	9.0

*Current indicates the 1961-2000 average. The 2050 precipitation is projected under A2 and B2 scenarios. Source: Strezepk and McClusky (2006)

Using the regression coefficients provided in (Table 2.5) with the projected rainfall for the year 2050, we simulated average crop yields for the year 2050 and analyzed the results to show the likely change between the recent past 15 years (between 1993 and 2008) average crop yield levels and the simulated crop yield levels. The percentage changes between the projected crop yields and the recent 15-year average is presented in Table 2.8.

We find that teff yield will drop in 12 of the 14 zones considered in this study. That is, except Gamo Gofa and Sidama zones, teff yield will drop by up to 2 % in the Hadiya Zone. The results also show that the main teff growing zones such as East Gojjam, West Gojjam, North Shoa (A), and North Shoa (O) will face less than 1% decrease in teff yield. Both the substantial increases and decreases occur in the SNNP region where teff cultivation is less popular when compared to maize and wheat cultivation.

With regard to wheat yield, the highest drop will occur in Hadiya Zone of the SNNP region, followed by Bale Zone of Oromia region. However, only Gamo Gofa and Sidama zones will have a positive change in yield levels for the mid 21st century. The yield levels of maize will show a positive shift in most of the zones, except reductions in Bale, Hadiya, Gamo Gofa, and Sidama Zones.

Nonetheless, when looked at the regional level, all the regions will experience a drop in crop yields in 2050, when compared with the recent average crop yield (see Table 2.9). However, maize yield will increase by around 48 % in Oromia region and teff yield shows an increase of around 2 % in the SNNP region. The results extrapolated to the national level show that average teff and wheat yields will decrease, whereas maize yield will increase in 2050.

Table 2.8 Percent Change in Mean and Variance of Crop Yields in 2050*

	Average yield			Standard deviation of yield		
Zone	**Teff**	**Wheat**	**Maize**	**Teff**	**Wheat**	**Maize**
Arsi	-0.57	-0.05	0.06	0.27	1.06	44.01
Bale	-0.78	-6.86	-1.79	-15.60	-0.65	25.01
E. Wellega	-0.62	-0.09	0.05	0.12	1.87	43.98
E.Gojjam	-0.43	-0.04	8.94	0.00	3.40	52.45
E.Shoa	-0.49	-0.07	0.05	0.09	1.53	41.84
Gamo Gofa	1.79	0.09	-0.02	12.04	0.07	38.94
Hadiya	-1.98	-17.24	-3.06	22.48	25.70	50.04
Illubabor	-0.60	-0.10	0.06	0.12	1.81	42.19
N. Gonder	-0.51	-0.04	10.07	-0.04	2.79	50.43
N.Shoa(A)	-0.44	-0.04	10.20	-0.01	3.22	53.16
N.Shoa(O)	-0.52	-0.09	0.06	0.07	1.61	41.52
S.Wollo	-0.44	-0.04	10.08	-0.03	2.89	51.99
Sidamo	2.07	0.11	-0.02	14.16	0.21	40.47
W.Gojjam	-0.12	-0.04	8.57	0.00	3.17	52.30

*Average of the three GCMs. Source: Author`s calculation based on simulation results.

The simulation results for the variability of crop yields in response to change in the climate variable (rainfall) are also presented in Table (2.8) above. We find that the standard deviation of average teff yield for the year 2050 declines in Bale, N.Gonder, N.Shoa (A), and S. Wollo, while the rest of the zones will have higher standard deviations. Average wheat yields will be more variable in 2050 except in Bale zone. With regard to maize, the standard deviation of yields will be higher in all zones. Of the three crops, maize yield will be the most variable.

Table 2.9 Percent change in mean and variance of crop yields at regional and national levels in 2050

	Average Yield			Standard deviation of Yield		
Region	Teff	Wheat	Maize	Teff	Wheat	Maize
Oromia	-3.58	-7.26	-1.51	-2.49	1.20	39.76
Amhara	-1.93	-0.19	47.86	-0.01	3.09	52.06
SNNPR	1.89	-17.04	-3.09	16.23	8.66	43.15
National	-2.43	-6.21	10.84	0.03	2.40	43.39

Source: Authors` interpolation based on results in Table 2.8.

The regional level results presented in Table (2.9) indicate that variance of teff yield declines in the Oromia and Amhara regions, but it increases in the SNNP region. The yields of wheat and maize will be more variable in 2050. Further, the projected results show that the yield variability for wheat will be higher in the SNNP region than the other regions, whereas the Oromia region will have higher maize yield variability than the SNNP and the Amhara regions. The national figures imply that all the three crops will face an increase in yield variability; maize yield appears the most variable crop.

2.6. Conclusion

The rise in CO_2 concentrations and hence change in climatic conditions is becoming less debateable. However, identifying whether the climate is changing differs from acknowledging the devastating impacts it brings on the ecosystem and global food productions and acting to counter its negative consequences. Climate change can be either beneficial to agricultural production or it may have adverse impacts on productivity. We have seen from the Just-Pope production function estimates that over the period of nearly 30 years from 1979 to 2008 the influences of growing season rainfalls on the average crop yields and yield variances are different across regions and crops. Combining the estimates from the Just-Pope production function with predictions of future climate change, rainfall levels in our case, we found that the impacts of future climate change on the average crop yield and the variability of crop yields would also be different across regions and crops.

The notable findings from the Just-Pope production function estimates are:

- An increase in *kiremt* rain increases mean teff and wheat yields in the SNNP region, whereas the increase in yields are lower in the Amhara and Oromia regions. This shows that in relative terms *kiremt* rainfall has been more important in the SNNP region.

- An increase in *belg* rain increases average maize yield in the Oromia region, but the increase in the other regions is lower when compared to that of the Oromia region. An increase in *belg* rains appear negatively related to average *teff* and wheat yields, but the results are not statistically significant. This implies that maize cultivation largely depends on *belg* rainfall and the importance of *belg* rainfall is higher in the Oromia region than the rest of the regions studied.

- Technical change or improvement in crop production technology increases mean crop yields across regions at an increasing rate

- An increase in *kiremt* rainfall decreases variability of teff and wheat yields in the SNNP region; however, the risk reducing effect of kiremt rainfall is higher in the Oromia and Amhara regions. With regard to maize kiremt rainfall increases maize yield variability in the Oromia region and Amhara regions, the variability appears lower in the Amhara region and higher in the SNNP region when compared to the Oromia region, and the differences are statistically significant.

- An increase in *belg* rainfall decreases variability of average teff yield in SNNP region and the decrease is higher in the Amhara and Oromia regions. With regard to maize, *belg* rains show a risk reducing effect on yield levels in all regions; however, there are differences in the magnitude of the effects.

- Technical change decreases variability of yields in all crops, but the effect is significant only in the case of maize.

Identifying the impacts of climate change on agricultural production will help in order to adapt to possible changes in climate conditions. The findings from the simulation exercise show that global climate change could entail significant negative effects on the Ethiopian agriculture. Further, the results indicate that the climate change projection for the year 2050 has varying impacts on the mean crop yields and yield variability. The general implication is that in the long run unless appropriate measures are taken the impacts could be worse as average crop yields drop and become more variable in 2050 than what we observed over the 15 year period between 1993 and 2008.

Nonetheless, from the results we obtained we cannot definitively conclude how farmers will possibly react to the changes in climate. From the descriptive statistic of the historical yield data, we see that mean crop yields have increased over 28 years, but not remarkably. The average growing season rainfalls and average crop yields in most of the sample zones have not shown a statistically significant difference. However, variance in growing season rainfalls and crop yield levels increased over the 28 years period we investigated (see annex 2E & 2F). This may tell us that, as it is obvious, crop yields do not depend on rainfall *per se*. Despite the rain fed nature of subsistence agriculture, technical improvements in farm management, use of pesticides, improved seeds, and fertilizers may have played a significant role in increasing observed yield levels over time. So investigating the relative importance of non-climatic factors on crop yields may give further insight on the appropriate interventions that facilitate the adaptation to climate change and counter its negative effects on future crop yields.

As can be seen from the prediction, *teff* and wheat yield levels will drop in 2050 from their 1993-2008 average levels, while maize yield increases. However, these national figures are tending to hide the difference across zones and regions. The results in Table 2.8 show that the change in rainfall patterns that occur following climate change create losers and winners in different parts of the country and with a varying effect on different crops across these areas. This implies that the national climate change adaptation programs and strategies must take into account such differences of climate change impacts on regions and crop items.

Further, the implication of the projected declines in crop yields on household food security is that as the country is not food self sufficient a percentage fall in food crop yields are likely to result in more than proportionate decline in food consumption. Reduced food availability due to reduced yield levels stemming from adverse effects of climate change would push price levels up. Most importantly, since the real per capita food consumption expenditure constitutes about 46.5% of the total real per capita consumption expenditure (MOFED, 2012), adverse climate change impacts when reflected on food prices will have a disproportionately adverse impacts on all low income households, not just merely on agricultural households.

The overall implication of the results is that policies, programs, or strategies that aim at reducing the adverse effects of climate change ought to focus on the smallest possible disaggregation of the targeted area of intervention. Because differences observed at the microclimate level are more informative of the likely impacts of climate change and help in designing efficient adaptation policies tailored according to the specific needs of the targeted locations. This is important in two ways. First, it helps in identifying the specific needs of different groups affected differently, and provides better information on how those who would benefit and loose from climate change need to be supported. Second, it helps to utilize resources allotted to enhance climate change adaptation and mitigation programs efficiently. Most importantly, the results implied that technological change in agricultural production appear to have a positive effect on average crop yields and a negative(risk reducing) effect on crop yield variability. Agricultural policies geared towards improving the livelihoods of the smallholders need to focus on improving agricultural technology adoption and intensity. To this end, introducing climate smart agricultural technologies and weather stress resilient crop varieties would be crucial in countering the adverse effects of climate change.

2.7. Reference

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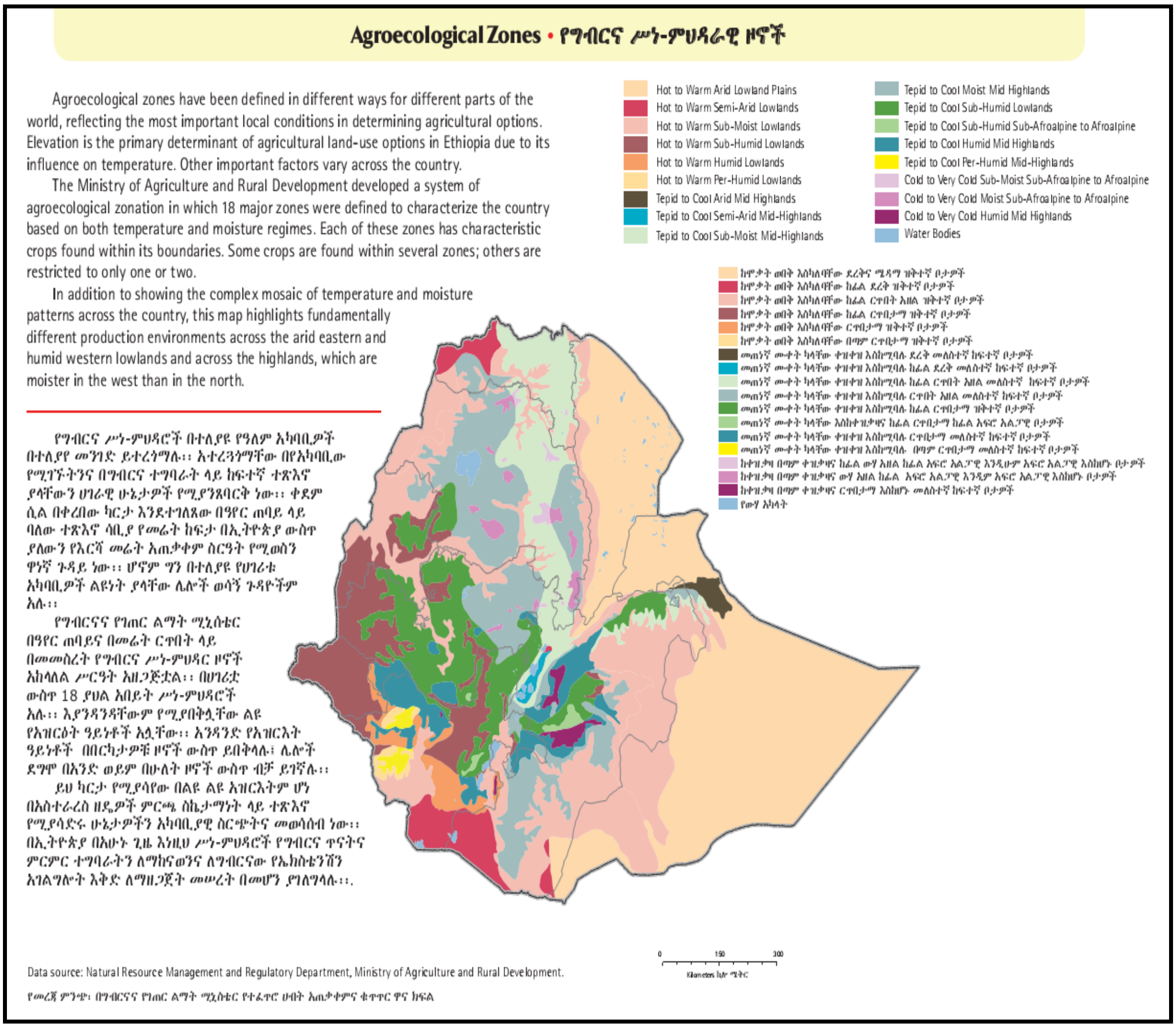
2.8. Appendix

Appendix 2A

Agroecological Zones of Ethiopia



Source: IFPRI, CSA (2006)

Appendix 2B

Change in the size of zones considered in the analysis. The Proportions Reported are calculated from population census results of 1984, 1997, and 2007

Regions	Change from the 1987/88 size to the 1988/89-1990/91 level	After 1993/94
Arsi		After the re-demarcation retained only 55 percent of its pre 1990/91 area.
Bale		Bale Zone represents only 37 percent of the pre 1990/91 sub region
Gamo Gofa	Classified as South Omo (14%) and North Omo (86%)	After the 1993/94 and later years the zone has been sub-divided into smaller administrative zones and special woredas. Most importantly, into Gamo Gofa, Wolaita, and South Omo. Of these, Gamo Gofa zone retained 44 percent of the pre 1990/91 larger region
Gonder	North and South Gonder	North Gonder constituted 59 percent of the pre 1990/91 Gonder
Gojjam	Sub-divided into East and West Gojjam	The zones East Gojjam and West Gojjam as of 2007 constituted 40 percent and 43 percent of the pre 190/91 Gojjam
Illubabor		Illubabor (*Ilu Aba Bora*) zone as of 2007 constituted 74 percent of the pre 1990/91 Illubabor
Shoa	Sub-divided into East, North and South Shoa	Further sub-divided into North Shoa of Amhara(17 percent), North Shoa of Oromo (13 percent), East Shoa (12 percent), and ethnic groups in South Shoa sub divided into different zones. Hadiya Zone, as part of the former South Shoa, constitutes 11 percent of the former Shoa Region.
Sidamo		Sidamo Zone as of 2007 represents only 38 percent of the former Sidamo Region
Wollega	East Wollega and West Wollega	The present day East Wollega represents only 34 percent of the pre 1990/91 Wollega
Wollo	North Wollo and South Wollo	South Wollo represents 50 percent of the pre 1991 Wollo

Source: Authors` calculation based on population censuses of various years and regional classifications after the Socialist regime.

Appendix 2 C

Table 2A Unit Root Test Results for Variables in Labels, Oromia Region

Zone	Level Variable	Lags	Test Statistics	ADF 1%	5%	10%
Arsi	Lnteff	4	-1.814	-3.747	-2.132	-1.533
	Lnwheat	0	-3.034	-2.528	-1.725	-1.325
	Lnmaize	0	-4.666	-2.528	-1.725	-1.325
	Lnkiremt	1	-3.934	-2.492	-1.711	-1.318
	Lnbelg	0	-2.247	-2.479	-1.706	-1.315
Bale	Lnteff	0	-3.636	-2.528	-1.725	-1.325
	Lnwheat	1	-1.788	-2.583	-1.746	-1.337
	Lnmaize	1	-2.017	-2.583	-1.746	-1.337
	Lnkiremt	0	-4.338	-2.479	-1.706	-1.315
	Lnbelg	1	-2.59	-2.492	-1.711	-1.318
E.Shoa	Lnteff	1	-2.28	-2.583	-1.746	-1.337
	Lnwheat	2	-0.875	-2.681	-1.782	-1.356
	Lnmaize	1	-2.099	-2.583	-1.746	-1.337
	Lnkiremt	0	-4.455	-2.479	-1.706	-1.315
	Lnbelg	1	-3.728	-2.492	-1.711	-1.318
E.Wollega	Lnteff	1	-1.398	-2.583	-1.746	-1.337
	Lnwheat	2	-1.535	-2.718	-1.796	-1.363
	Lnmaize	1	-1.672	-2.602	-1.753	-1.341
	Lnkiremt	1	-1.475	-2.492	-1.711	-1.318
	Lnbelg	0	-5.994	-2.479	-1.706	-1.315
Illubabor	Lnteff	0	-2.242	-2.583	-1.746	-1.337
	lnwheat	3	-1.116	-3.365	-2.015	-1.476
	lnmaize	1	-0.954	-2.583	-1.746	-1.337
	lnkiremt	0	-4.262	-2.479	-1.706	-1.315
	Lnbelg	1	-2.854	-2.492	-1.711	-1.318
N.Shoa	Lnteff	0	-3.486	-2.528	-1.725	-1.325
	lnwheat	0	-3.048	-2.528	-1.725	-1.325
	lnmaize	0	-3.689	-2.528	-1.725	-1.325
	lnkiremt	3	-1.08	-2.528	-1.725	-1.325
	Lnbelg	0	-4.574	-2.492	-1.711	-1.318

Table 2B Unit Root Test Results for Variables in Labels, Amhara Region

Zone	Level Variable	Lags	Test Statistics	ADF 1%	5%	10%
E.Gojjam	Lnteff	1	-1.915	-2.583	-1.746	-1.337
	lnwheat	4	1.87	-3.747	-2.132	-1.533
	lnmaize	0	-3.33	-2.528	-1.725	-1.325
	lnkiremt	0	-5.638	-2.479	-1.706	-1.315
	lnbelg	1	-1.618	-2.492	-1.711	-1.318
N.Gonder	Lnteff	1	-2.013	-2.583	-1.746	-1.337
	lnwheat	1	-1.05	-2.583	-1.746	-1.337
	lnmaize	3	-1.025	-2.896	-1.86	-1.397
	lnkiremt	1	-1.169	-2.492	-1.711	-1.318
	lnbelg	1	-0.692	-2.492	-1.711	-1.318
N.Shoa (A)	Lnteff	3	-1.177	-2.896	-1.86	-1.397
	Lnwheat	0	-2.517	-2.539	-1.729	-1.328
	Lnmaize	0	-3.121	-2.552	-1.734	-1.33
	lnkiremt	1	-2.651	-2.492	-1.711	-1.318
	Lnbelg	0	-5.866	-2.479	-1.706	-1.315
S.Wollo	Lnteff	0	-2.688	-2.528	-1.725	-1.325
	Lnwheat	1	-2.761	-2.528	-1.725	-1.325
	Lnmaize	1	-1.687	-2.65	-1.771	-1.35
	lnkiremt	1	-1.14	-2.492	-1.711	-1.318
	Lnbelg	1	-1.933	-2.492	-1.711	-1.318
W.Gojjam	Lnteff	1	-1.56	-2.583	-1.746	-1.337
	Lnwheat	4	0.335	-3.475	-2.132	-1.533
	lnmaize	1	-1.25	-2.583	-1.746	-1.337
	lnkiremt	0	-5.473	-2.479	-1.706	-1.315
	lnbelg	0	-6.224	-2.479	-1.706	-1.315

Table 2C Unit Root Test Results for Variables in Labels, SNNPR

Zone	Level Variable	Lags	Test Statistics	ADF 1%	ADF 5%	ADF 10%
G.Goffa	Lnteff	1	-3.09	-2.583	-1.746	-1.337
	lnwheat	1	-1.379	-2.624	-1.761	-1.345
	lnmaize	0	-2.688	-2.528	-1.725	-1.325
	lnkiremt	0	-4.962	-2.479	-1.706	-1.315
	lnbelg	1	-2.638	-2.492	-1.711	-1.318
Hadiya	Lnteff	2	-3.436	-2.681	-1.782	-1.356
	lnwheat	2	-3.785	-2.681	-1.782	-1.356
	lnmaize	0	-4.072	-2.528	-1.725	-1.325
	lnkiremt	0	-5.402	-2.479	-1.706	-1.315
	Lnbelg	0	-4.98	-2.479	-1.706	-1.315
Sidama	Lnteff	2	-1.771	-2.896	-1.86	-1.397
	lnwheat	0	-2.235	-2.583	-1.746	-1.337
	lnmaize	0	-2.643	-2.567	-1.746	-1.337
	lnkiremt	0	-4.899	-2.479	-1.706	-1.315
	lnbelg	1	-4.087	-2.492	-1.711	-1.318

*Lag has been determined using Akaike Information Criteria (AIC)

Appendix 2D

A. Comparison of Mean Function Estimates Using MLE and FGLS Method

Dep. Var, Yield	Wheat				Maize				Teff			
	FGLS		MLE		FGLS		MLE		FGLS		MLE	
Kiremt	0.0937**	(-0.0310)	0.1480***	(-0.081)	1.205***	(-0.29)	-0.0159	(-0.0517)	0.248***	(-0.0325)	0.1436***	(-0.0751)
Belg	0.301***	(-0.0188)	-0.0227	(-0.0293)	0.132	(-0.342)	0.1050***	(-0.0618)	0.0557*	(-0.0232)	-0.0327	(-0.0292)
D1_kiremt	0.0399	(-0.0717)	-0.1743***	(-0.0941)	-0.0481	(-0.0441)	-0.0476	(-0.0818)	-0.123***	(-0.0352)	-0.1495***	(-0.0875)
D2_kiremt	0.131	(-0.0823)	-0.2239**	(-0.0888)					-0.125**	(-0.0415)	-0.1452***	(-0.0809)
D3_kiremt					-0.359***	(-0.0603)	0.0198	(-0.1255)				
D1_belg					0.0727	(-0.0563)	-0.0413	(-0.0859)				
D2_belg												
D3_belg					0.329***	(-0.0551)	-0.1329	(-0.1128)				
d1	-1.975	(-4.2)	1.0474***	(-0.575)	-2.090	(-1.223)	0.394	(-0.808)	9.307***	(-1.997)	1.0562**	(-0.5326)
d2	-5.310	(-4.062)	1.4419*	(-0.5334)					7.333***	(-1.960)	1.0616**	(-0.4831)
d3					4.055**	(-1.45)	0.5191	(-0.9681)				
Trend	0.0197*	(-0.0094)	-0.0148**	(-0.0073)	0.0952***	(-0.0088)	0.0017	(-0.0094)	-0.0121	(-0.0068)	-0.0143***	(-0.0074)
Trend2	-0.0001	(-0.0003)	0.0011*	(-0.0002)	-0.0007*	(-0.0003)	0.0005***	(-0.0003)	0.0007**	(-0.0002)	0.0007*	(-0.0002)
_cons	-0.937	(-1.382)	1.5484*	(-0.5044)	0.888	(-2.495)	2.1258*	(-0.5106)	1.323	(-1.170)	1.362	(-0.4623)
N	352		352		359		359		359		359	

Standard errors in parentheses ***<0.10 **p<0.05 *p<0.01 +p<0.001

B. Comparison of Variance Function Estimates Using MLE and FGLS Method

Dep. Var, Variance of yield	Wheat				Maize				Teff			
	FGLS		MLE		FGLS		MLE		FGLS		MLE	
Kiremt	-0.773	*(-0.454)*	-0.578***	*(-0.307)*	-0.500*	*(-0.22)*	0.226	*(-0.155)*	-0.798	*(-0.482)*	-0.936**	*(-0.434)*
Belg	0.136	*(-0.208)*	0.226	*(-0.234)*	-0.0784	*(-0.337)*	-0.328	*(-0.303)*	-0.745	*(-0.616)*	-0.939***	*(-0.553)*
D1_kiremt	1.307*	*(-0.569)*	1.101*	*(-0.425)*	0.100	*(-0.416)*	-0.689*	*(-0.167)*	0.543	*(-0.607)*	0.716	*(-0.546)*
D2_kiremt	1.147*	*(-0.486)*	0.868**	*(-0.373)*					0.743	*(-0.508)*	0.781***	*(-0.457)*
D3_kiremt					1.331*	*(-0.596)*	0.410**	*(-0.17)*				
D1_belg					-0.006	*(-0.477)*	0.276	*(-0.408)*	0.512	*(-0.702)*	0.952	*(-0.632)*
D2_belg									0.977	*(-0.698)*	1.213***	*(-0.627)*
D3_belg					-0.167	*(-0.642)*	-0.0905	*(-0.664)*				
d1	-8.502*	*(-3.473)*	-7.535*	*(-2.591)*	-0.385	*(-4.344)*	2.813	*(-2.8)*	-6.920	*(-5.135)*	-10.18**	*(-4.618)*
d2	-7.127*	*(-2.9)*	-5.736**	*(-2.284)*					-10.25*	*(-4.227)*	-11.34*	*(-3.801)*
d3					-7.632	*(-4.754)*	-2.228	*(-4.044)*				
Trend	-0.0168	*(-0.0135)*	-0.0166	*(-0.0191)*	-0.0781***	*(-0.0133)*	-0.0901*	*(-0.0121)*	-0.0018	*(-0.015)*	-0.0067	*(-0.0135)*
_cons	0.0978	*(-2.793)*	-1.33	*(-2.34)*	1.093	*(-2.541)*	-2.055	*(-2.25)*	5.214	*(-3.537)*	7.041**	*(-3.18)*
N	*352*		*352*		*359*		*359*		*359*		359	

Standard errors in parentheses ***<0.10 **p<0.05 *p<0.01 +p<0.001

Appendix 2E

Crop Yield Mean Difference Test between 1979-1993 and 1994-2008

Zone		1979-1993 Mean	1979-1993 SD	1994-2008 Mean	1994-2008 SD	t	F
Arsi	Teff	11.3	4.0	9.1	1.3	-1.9	9.7
	Wheat	14.6	2.5	17.0	2.9	2.3	1.3
	Maize	15.1	4.8	20.9	2.2	4.0	4.7
Bale	Teff	8.3	4.3	8.6	2.1	-0.2	4.2
	Wheat	10.8	3.2	16.8	3.3	-4.7	1.1
	Maize	15.6	7.3	19.2	3.8	-1.6	3.6
E. Shoa	Teff	10.9	3.4	10.8	2.4	0.1	2.1
	Wheat	11.6	1.6	17.0	2.8	-6.0	3.1
	Maize	15.4	3.9	22.3	4.2	-4.3	1.2
E.Wollega	Teff	8.5	2.0	8.8	2.2	-0.3	1.2
	Wheat	10.1	2.9	13.4	3.6	-2.8	3.5
	Maize	14.9	5.5	23.2	2.8	-4.9	3.9
Illubabor	Teff	10.0	2.7	9.5	2.2	0.4	1.5
	Wheat	8.8	3.6	10.6	3.4	-1.1	1.1
	Maize	14.7	5.7	19.1	2.1	-2.7	7.3
N.Shoa(O)	Teff	9.0	1.3	9.2	1.2	-0.5	1.1
	Wheat	11.4	2.2	12.4	1.8	-1.3	1.7
	Maize	15.0	4.1	13.1	4.3	1.1	1.1
E.Gojjam	Teff	9.4	1.8	10.9	1.4	-2.3	1.8
	Wheat	10.2	1.5	14.0	3.1	-3.8	4.5
	Maize	16.1	4.2	20.3	3.8	-2.6	1.3
N.Gonder	Teff	8.0	2.4	8.1	2.1	-0.1	1.3
	Wheat	9.1	3.0	11.0	3.0	-1.6	1.0
	Maize	10.6	3.2	15.4	4.9	-3.0	2.4
N.Shoa(A)	Teff	9.1	1.1	10.1	2.9	-1.1	6.7
	Wheat	11.5	2.0	14.4	5.2	-1.8	7.0
	Maize	14.8	4.4	14.9	3.3	-0.1	1.8
S.Wollo	Teff	8.5	3.1	9.9	1.3	-1.6	5.4
	Wheat	9.7	3.8	12.6	1.9	-2.5	4.0
	Maize	8.4	6.4	13.5	4.9	-2.2	1.7
W.Gojjam	Teff	9.1	1.8	9.2	2.9	0.0	2.7
	Wheat	9.8	1.9	14.1	4.8	-3.0	6.5
	Maize	15.4	4.9	23.2	3.0	-4.8	2.7
G.Goffa	Teff	6.9	3.4	5.8	3.4	0.8	1.0
	Wheat	10.5	2.8	7.8	6.0	1.6	4.5
	Maize	9.7	4.3	11.4	6.1	-0.9	2.0
Hadiya	Teff	8.8	1.1	9.2	1.6	-0.8	2.2
	Wheat	12.1	2.3	17.8	2.8	-5.7	1.5
	Maize	16.2	3.7	18.0	3.0	-1.4	1.5
Sidama	Teff	7.6	2.5	6.9	1.8	0.7	1.9
	Wheat	8.1	5.9	11.0	6.1	-1.2	1.1
	Maize	16.5	3.2	18.4	3.0	-1.5	1.1

Note: The t and F test statistics are used in the mean and variance difference tests, respectively.

Appendix 2F

Rainfall Mean Difference Test between 1979-1993 and 1994-2008

Weather Station		*1979-1993* Mean	*1979-1993* SD	*1994-2008* Mean	*1994-2008* SD	t	F
Negelle	Annual	723.6	15.6	638.9	144.4	1.1	2.8
	Kiremt	55.7	5.5	79.0	109.7	-0.8	13.4
	Belg	485.5	13.2	342.1	148.3	2.4	1.4
Ginir	Annual	1209.1	654.1	777.4	252.6	2.3	6.7
	Kiremt	209.9	74.3	159.0	46.3	2.2	2.6
	Belg	723.0	517.8	355.6	144.5	2.6	12.8
Arjo	Annual	1647.7	316.4	1823.4	458.4	-1.2	0.5
	Kiremt	1135.5	159.6	1247.9	322.1	-1.2	4.1
	Belg	361.7	119.4	390.4	177.1	-0.5	2.2
Nazereth	Annual	814.8	233.3	900.6	149.4	-1.2	2.4
	Kiremt	554.9	185.6	623.7	123.9	-1.2	2.3
	Belg	198.6	90.7	171.4	79.8	0.9	1.3
Gore	Annual	1817.9	297.8	1769.7	346.1	0.4	0.7
	Kiremt	1178.4	96.5	1061.7	177.7	2.2	3.4
	Belg	395.8	81.8	394.1	120.2	0.0	2.2
Fitche	Annual	909.1	285.9	1146.2	141.1	-2.8	4.1
	Kiremt	648.4	227.6	902.1	123.9	-3.7	3.4
	Belg	200.6	105.0	167.4	56.9	1.0	3.4
D.Markos	Annual	1285.5	179.0	1319.5	122.7	-0.6	2.1
	Kiremt	965.5	115.5	943.9	71.3	0.6	2.6
	Belg	206.1	82.3	284.2	215.1	-1.3	6.8
Gonder	Annual	1002.4	151.2	1307.0	348.1	-3.1	5.3
	Kiremt	782.2	106.4	591.3	526.9	1.4	24.5
	Belg	132.0	65.3	435.7	275.7	-4.1	17.8
Majete	Annual	1024.3	50.1	1209.1	198.9	-2.8	1.8
	Kiremt	566.7	139.8	798.1	167.2	-4.0	1.4
	Belg	280.0	100.0	220.2	85.7	1.7	1.4
Kombolcha	Annual	995.1	170.6	1036.9	138.8	-0.7	1.5
	Kiremt	599.5	161.6	576.9	297.3	0.3	3.4
	Belg	260.2	82.3	288.2	201.7	-0.5	6.0
Bahirdar	Annual	1315.6	187.6	1233.6	327.1	0.8	3.0
	Kiremt	1129.2	185.9	1037.7	279.8	1.0	2.3
	Belg	95.9	59.9	115.8	65.6	-0.9	1.2
M.Abaya	Annual	547.9	109.0	787.9	165.3	-4.6	2.3
	Kiremt	178.5	89.8	234.9	61.6	-2.0	2.1
	Belg	216.6	91.0	312.8	107.1	-2.6	1.4
Hossaena	Annual	1255.4	240.6	1189.0	162.9	0.9	2.2
	Kiremt	638.1	169.4	604.1	75.7	0.7	5.0

	Belg	394.3	141.2	396.7	68.7	-0.1	4.2
Hawassa	Annual	948.5	136.5	992.2	132.8	-0.9	1.1
	Kiremt	494.4	116.8	489.5	105.6	-1.0	1.2
	Belg	321.3	93.9	298.0	75.9	0.7	1.5

Appendix 2G

Coefficient of Variation of Yield in Period 1(1979-1993) and Period 2 (1994-2008) and Change between the two periods

State/Period		Teff	Wheat	Maize
Arsi	Period 1	0.35	0.16	0.48
	Period 2	0.24	0.18	0.11
	Change	-0.31	0.09	-0.77
Bale	Period 1	0.48	0.25	0.44
	Period 2	0.34	0.28	0.28
	Change	-0.30	0.12	-0.37
G.Gofa	Period 1	0.49	0.26	0.49
	Period 2	0.58	0.72	0.50
	Change	0.18	1.82	0.02
W.Gojjam	Period 1	0.20	0.19	0.31
	Period 2	0.29	0.37	0.23
	Change	0.46	0.93	-0.26
E.Gojjam	Period 1	0.21	0.15	0.24
	Period 2	0.14	0.22	0.23
	Change	-0.31	0.44	-0.01
N.Gonder	Period 1	0.30	0.30	0.31
	Period 2	0.25	0.32	0.35
	Change	-0.16	0.04	0.16
Illubabor	Period 1	0.22	0.40	0.32
	Period 2	0.26	0.36	0.27
	Change	0.19	-0.10	-0.18
N.Shoa(A)	Period 1	0.13	0.14	0.27
	Period 2	0.27	0.37	0.26
	Change	1.11	1.62	-0.03
N.Shoa(O)	Period 1	0.13	0.14	0.27
	Period 2	0.14	0.20	0.31
	Change	0.11	0.41	0.15
E.Shoa	Period 1	0.33	0.14	0.26
	Period 2	0.21	0.20	0.24
	Change	-0.37	0.36	-0.09
Hadiya	Period 1	0.14	0.15	0.25
	Period 2	0.17	0.17	0.16
	Change	0.24	0.17	-0.35

Sidamo	Period 1	0.33	0.72	0.20
	Period 2	0.24	0.61	0.16
	Change	-0.27	-0.16	-0.23
E.Wollega	Period 1	0.24	0.18	0.23
	Period 2	0.23	0.29	0.32
	Change	-0.03	0.66	0.37
S.Wollo	Period 1	0.36	0.42	0.85
	Period 2	0.20	0.20	0.35
	Change	-0.44	-0.53	-0.59

Chapter 3: Transmission of World Food Prices to Domestic Market: The Ethiopian Case

3.1. Background

Commodity price increases that occurred between 2006 and 2008, and later in 2011 have revealed the complexity of the world food system and the breadth of its connections to other non- food commodities. The incident drew widespread attention and renewed the interest in understanding the behaviour of the commodity prices themselves, the causes of the price spikes in the commodity markets, and the consequences of such shocks on poverty, food insecurity, and macroeconomic situation in the developing countries (Abbott and Battisti, 2011; Baffes and Tassos, 2010). Studies investigating the causes emphasize that a co-influence of supply and demand factors further driven by long term global development as well as short term domestic policy responses have been important in the evolution of the commodity prices. The widespread view is that the rising global demand following rapid and sustained economic growth in developing countries, which averaged 6.9% between 2003 and 2007, and population growth have put pressure on food and feed supply, and depleted stock. It has also been indicated that low price and low investment in agriculture contributed to a decline in agricultural production growth and this further tightened the supply. Baffes and Tassos (2010) stress that the combination of adverse weather conditions and diversion of some food commodities to the production of biofuels affected agricultural prices as the global stock-to-use ratios of several commodities dropped to levels lower than their levels in early 1970s. The resulting low stockpile, therefore, has made markets more inelastic, aggravated quantity shocks, and accelerated the price increases. The price increases led to increased income for farmers in developed countries and put pressure on the survival margins of the poor farmers in developing countries. The pressure in developing countries was manifested in terms of increased food and overall inflation, deteriorating terms of trade, increased farm input costs, burdening fiscal and financial positions, and aggravating hunger and poverty (Abbott and Battisti, 2011).

With regard to the extent of volatility of agricultural prices, there is no consensus on whether the recent global food price volatilities are new phenomenon. Gilbert and Morgan (2010) argue that the interaction of production and consumption shocks with supply and demand elastcities determine the level of volatility; but the increased volatility level of recent years is lower than it was three decades ago.

Nevertheless, the increasing risk and uncertainty that volatility poses in production and investment decisions would have substantial implications for the food insecure and/or the poor in developing countries. Further, changes in the prices of food commodities in developing countries affect, depending on their trade positions, the trade balance, reserves, and the exchange rate (Gilbert, 2011). Therefore, the increased food prices of recent years and the consequent significant policy challenges for developing countries, where households spend a larger share of their income on food, call attention to the relevance of understanding the extent to which high and volatile food prices on the word market are transmitted to the domestic markets in developing countries.

The degree of the pass-through can be limited due to government policies such as stabilization policies aimed at insulating domestic consumers from changes in the world prices; and high transport costs[10]. Further, transmission of food price shocks to domestic markets depends on the importance of the commodity in the country`s food staple, food status of the country, and other domestic factors. These factors confounding in many different ways limit the pass through of global food price inflation to domestic markets.

The empirical evidence on the degree of world price transmission to domestic markets is mixed. Hazel et al (1990), using data from 22 developing countries over the period 1961 to 1987, found that the variability in world prices has almost entirely transmitted to developing countries in the dollar value of their export unit values. However, the transmission is not complete on the average producer prices, thus concluding that in addition to trade restrictions, exchange rate misalignments or domestic distortions have been responsible for the discrepancy between domestic and world prices. Dawe (2008) has also shown that exchange rate appreciation has insulated complete price pass through in Asian countries. He used data spanning from 2003 to 2007 and examined the extent to which increases in international cereal prices have been transmitted to domestic prices in Asian countries. His findings concluded that the international food price transmission was generally incomplete in the Asian countries owing to the real appreciation of their currencies against the US dollar during the sample period, which neutralized a considerable portion of the global price increases when these cereals were imported into domestic markets.

[10] Higher transport costs define a band between the export parity price, at which it is profitable for the country to export, and import parity price, at which imports become profitable. The band moves up and down with world prices (Gilbert, 2011).

Mudlak and Larson (1992) in a study covering 58 countries over the period 1968 to 1978 conclude that most of the variations in world prices are transmitted and that they constitute the dominant component in the variation of domestic prices. Quiroz and Soto (1993), on the other hand, using a sample for 60 countries during 1966—1991, conclude that in an overwhelming majority of cases, transmission of international price signals in agriculture is either very low or nonexistent. Morriset (1998) examining the gap between domestic and world prices for major markets for industrial countries during 1975—1994, shows that while upward movement in world prices were clearly passed through to domestic prices, downward movements were not.

Other studies find that considerable differences exist between advanced and emerging countries. The findings indicate that the pass-through tends to be larger in emerging and developing countries (IMF, 2011). Conforti (2004) has shown that price pass through has been different in developing countries, for instance, incomplete in African countries, relatively more complete among Asian countries, and more mixed in Latin America.

The price pass through has also been indicated to be heterogeneous across commodity types. Dawe (2008) shows rice has a weaker pass through in developing Asia compared to wheat. Local policies on specific agricultural commodities, particularly rice from these Asian countries, seemed to have further stabilized and shielded domestic prices from the change in world prices. Having investigated the transmission of global price shocks to domestic prices in 11 Sub-Saharan Africa countries for eight food items during 2007—2008, Minot (2011) finds that there is a transmission of global food prices to domestic prices for rice and (to a lesser extent) maize. By studying the price transmission of global agricultural commodities to domestic food prices in India and the People`s Republic of China (PRC), Imai et al (2008) also finds that domestic prices for wheat, maize and rice tend to adjust faster to the international prices than those of fruits and vegetables.

In general, various studies point out the importance of domestic factors and policies in limiting the pass-through of food prices. The possible limiting factors and policy regimes highlighted include exchange rate movements, transaction costs, and subsidies for agricultural commodities among others (Quroz and Soto, 1995; Rapsomanikis et al., 2004; Timmer, 2008; Baffes and Gardner, 2003; Imai et al., 2008; Keats et al., 2010; Ianchovichina, et al., 2012; IMF, 2011).

In addition to the above studies, some studies with a focus on African countries examined price pass through from world to domestic markets and within price pass through among local markets in a country. For instance, Abdulai (2000) for Ghana, Rashid (2004) for Uganda, Lutz Kuiper and Van Tilburg (2006) for Benin, Negassa and Myers (2007) for Ethiopia, Van Campenhout (2007) for Tanzania, Myers (2008) for Malawi, Moser, Barret, and Minten (2009) for Madagascar, and Rashid (2011) for Ethiopia.

This chapter particularly seeks to address the following issues. Firstly, it investigates transmission of changes in the world food prices to domestic food prices and identifies the world prices that influence the evolution of domestic prices. Secondly, it examines the effects of exchange rates on the price transmissions. Thirdly, it analyzes within country integration of grain markets located in different regions across the country.

To answer the first question, unlike previous studies that use US prices as the world price for both wheat and maize, we use two exchange market prices for each commodity against which we analyze the integration of Ethiopian grain market to the world market and measure the price pass-through. That is, we use US maize and SAFEX maize prices as two world maize prices and investigate the link between these prices and the Ethiopian maize market price. For wheat, we use Paris Matif wheat price and Chicago Board of Trade (CBOT) soft wheat price to investigate the relationship of the Ethiopian wheat market to these exchange market prices that we consider as world wheat prices. The national prices for wheat and maize are computed as an average of prices in 11 and 10 local markets, respectively.

With regard to domestic market integration, following Gilbert (2011), we employed the principal component analysis (PCA) method and stationarity tests for price spreads over-time. We use PCA to investigate the pattern of market integration comparing the movement of the average prices that the different local markets have and the magnitude of price variability exhibited across markets. To demonstrate the long run characteristic of the markets, we employ PCA on the price series that are found to be I (1). To examine the short run level of market integration, we apply PCA on the monthly price changes which are found to be I (0), stationary.

The remaining sections of the chapter are organized as follows: Section 2 presents data source and methodology used for the analysis of world to domestic market price pass through; section 3 provides results and discussion of price transmissions from world to domestic market; section 4 analyzes intra-regional market integration; and section 5 concludes.

3.2. Data Source and Methodology

3.2.1. Data

The data used for the analysis is obtained from various sources. The time series monthly price data of maize and wheat for 10 to 11 local markets are obtained from the Ethiopian Grain Trade Enterprise (EGTE) for the period from July 2001 to December 2011. The national prices of the two food crops considered in this study are computed from the price data of local markets. The descriptive statistics of the domestic prices is given in section (3.4.1).

The corresponding international market prices for maize and wheat are taken from the historical data of Johannesburg Stock Exchange (JSEX), Chicago Board of Trade (CBOT), Paris *Matif* and the International Financial Statistics (IFS) database. The exchange markets are selected based on two objectives. First, to identify whether geographical proximity of exchange markets affect price transmission. That is, we compare the extent of price transmission from US maize and South African (SAFEX) maize markets, and CBOT wheat and Paris *Matif* wheat markets to the domestic maize and wheat markets, respectively. Further, the Paris *Matif* wheat market is selected based on the information that wheat traded in Paris is milling wheat and preferred by the Ethiopian government as learnt from its wheat procurement bids announcement. In addition, the wheat purchases made by the Ethiopian government for its food price stabilization entirely come from European markets. Thus, selecting Paris market for the analysis of wheat market price transmission is plausible. The CBOT wheat market included since the larger share of food aid shipments originate from the United States of America (USA) and we presume this also may result in a link with domestic markets. The descriptive statistics of national and international market prices are discussed below.

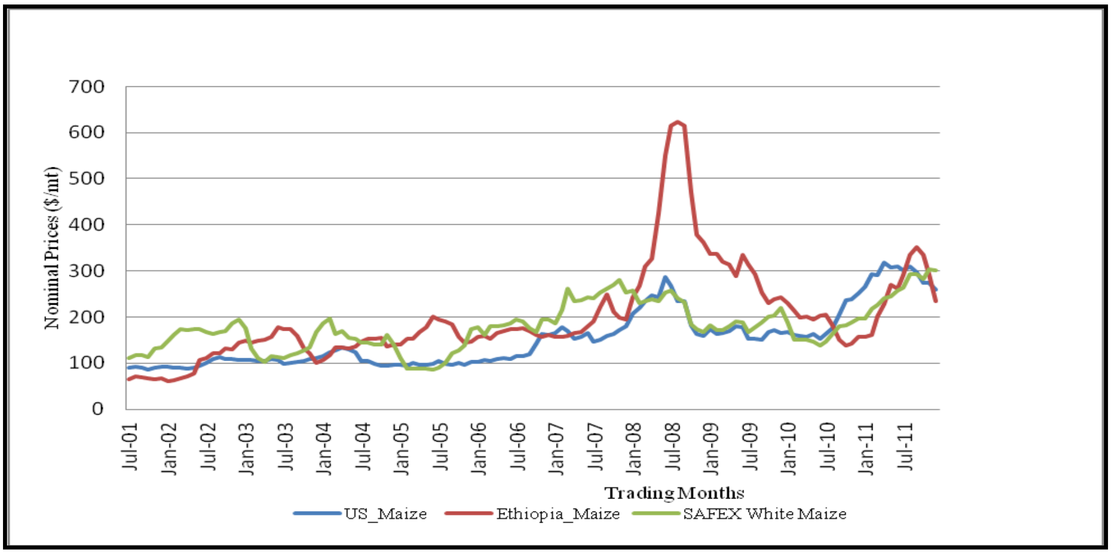


Figure 3.1 Nominal maize prices July 2001 to December 2011, US Gulf ports, SAFEX White, and Ethiopia

As Figure 3.1 indicates, the Ethiopian maize prices were in tandem with the international price movements up until the beginning of 2008. However, the nominal maize prices rose sharply and exceeded all the international market prices between January 2008 and August 2010. Since August 2010 national prices, though rose up gradually, remained well below the US and the SAFEX maize prices.

When we examine the quarterly changes of maize prices (not reported here), we observe that national prices in the second quarter of 2002 have sharply increased up until the last quarter of 2003. The price increases had been occurring despite the decreasing trends in the international maize market. Mainly because, in 2002 *meher* rain did not come on time and hence grain prices went up following the drought that occurred in 2002/2003. Again since the first quarter of 2008 national maize price increased consistently and registered the highest increase in the second quarter of 2008, showing an increase of about 60 percent of the already high prices experienced at the end of 2007. The price levels in the last quarter of 2011 have remained well above the last quarter of 2007 by as much as 43%, 57%, and 10%, for national, US Gulf port, and SAFEX maize, respectively.

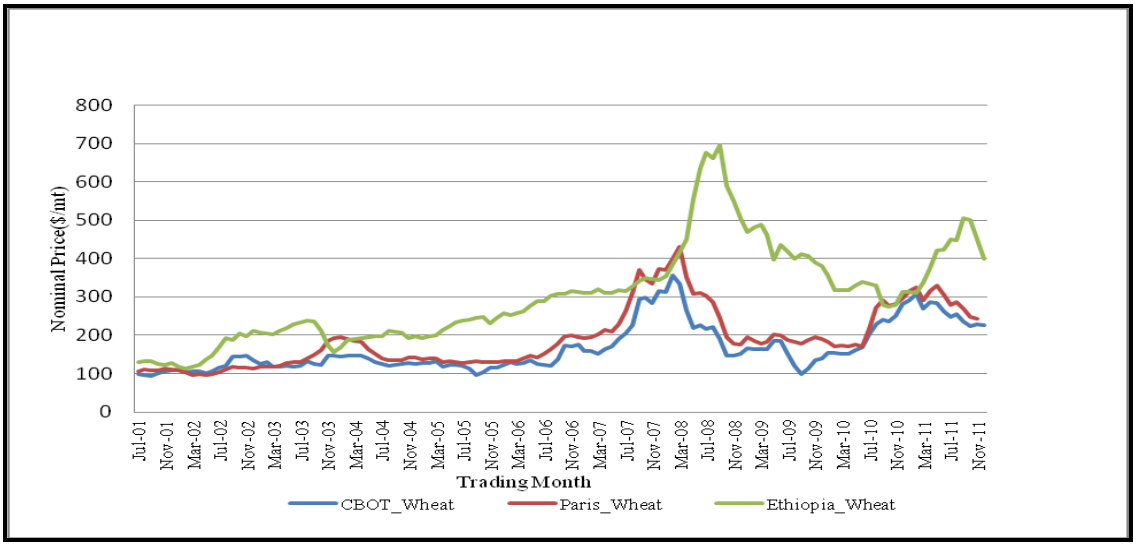


Figure 3.2 Nominal wheat prices from July 2001 to December 2011, for Paris, CBOT, and Ethiopia

With regard to the wheat price, we observe that the national wheat price has been consistently above the international market prices. The sharp increase in national prices has followed the 2007 and 2008 food price hikes, and spiked to an unprecedented level as high as USD 646 per metric ton. Since then the national price has exceeded the international market prices by far up until it converges for a brief period in 2010 and start diverging once again.

The national price hikes, though they coincide with the international boom and bust of grain prices in the world market that occurred in 2007-2008 and later in 2011, could also be attributed to the overall macroeconomic performance of the country. Because the country has registered a consecutive double digit growth since 2006 and inflation has also risen to the level as high as 64%, in July 2008, and in particular, the food price inflation peaked at 92%. For this reason, we remove such a bias from the national prices deflating the nominal prices by the CPI over the entire period considered in the study. The international prices are deflated using the unit value of exports for advanced countries. The unit value of exports is used as a deflator since it measures inflation in the international market. We have not opted for deflating all prices converted to their dollar equivalent using the CPI of USA (as in Minot, 2011), for the consumption basket considered in calculating the CPI for US consumers is considerably different from the consumption basket considered in calculating the Ethiopian consumers.

Table 3.1 Maize and Wheat Price Changes 2001 to 2011

	Percentage change Jul- 2001 to Dec-2011		**Percentage Range over the same Period**		**Standard Deviation of Monthly changes**	
	Nominal	**Real**	**Nominal**	**Real**	**Nominal**	**Real**
Maize						
US Gulf Ports	184.8%	83.2%	269.4%	165.2%	6.42%	6.04%
SAFEX White	174.5%	76.6%	250.3%	185.0%	8.86%	8.48%
Ethiopia	258.8%	-23.2%	924.7%	378.6%	9.96%	8.72%
Wheat						
CBOT	132.1%	49.32%	278.5%	242.7%	8.86%	8.90%
Paris	121.8%	42.71%	345.4%	186.9%	7.20%	6.83%
Ethiopia	207.6%	-34.19%	519.7%	170.0%	6.51%	5.54%

Source: Author`s computation data from EGTE for domestic prices, and from IMF/IFS for CBOT wheat and US maize, and Paris and SAFEX prices are obtained from the respective exchange markets.

Table 3.1 provides price changes, range, and standard deviation over the entire period considered in this study. Maize prices have substantially increased over the entire period both in the national and international markets. However, the increase in the national nominal price exceeds the increase in international markets nearly by 40%. Despite the huge increase in the nominal price, the Ethiopian real maize price dropped by around 23%, while the SAFEX and US real maize prices showed an increase of 77% and 83%, respectively. The range measures the extent of the price spike while the change in range measures the long run impact. The nominal price range of Ethiopian maize appears to be more than three times as large as the world market price range. This is because Ethiopia has experienced huge price hikes due to local factors such as high inflation rate, which has already been in a double digit mark before the onset of the crisis and later reached the unprecedentedly high level, which confounded with the global food crisis that occurred between 2005 and 2008, and later in 2011.

Maize price variability in Ethiopia has not been much different from the world market price variability. Both nominal and real prices considered price variability in Ethiopia is closer to the SAFEX price variability than the US gulf port maize price.

Nominal wheat prices have also increased over time in all markets. The increase in domestic nominal price appeared to be twice as large as the increase in the nominal world market prices. As has been the case for Maize, real wheat prices increased in the international market by 49% for CBOT and 43% for Paris milling wheat, while the Ethiopian real wheat price dropped by 34%.

The nominal price hikes appear to be higher both at the international and national markets; however, the nominal price of the Ethiopian wheat has shown a change in the price range that is 87% and 50 % higher than CBOT and Paris, respectively. This implies that in nominal terms the domestic price spikes in wheat market are higher when compared to the price hikes in the international market. Nonetheless, the price spikes in the domestic wheat market appear to be lower than that of the maize market. This is because the price stabilization interventions of the government largely focus on wheat than maize. The government has imported wheat and supplied at a subsidized price, which is below the market price by about 50 %. The price variability provided by the monthly changes shows that both nominal real wheat prices are less variable in domestic market than the international markets indicating that the price stabilization interventions have effectively insulated the wheat market from the international market fluctuations.

3.2.2. Methodology

The study of price transmission for homogeneous commodities in space, or for a product as it is transformed along the stages of the marketing chain has attracted the interests of agricultural economists for many decades.

Fackler and Goodwin (2001) provides a review of methods and empirical studies of price transmission and indicate that at the beginning empirical studies of price transmission used simple regression and correlation analyses (Isard, 1977; Monke and Petzel, 1984; Mudlak and Larson, 1992; Gardner and Brooks, 1994) that did not account for the dynamics and lead/lag relationships in price data. Throughout the 1980s, dynamic regression models that incorporated lagged prices (Ravallion, 1986; Timmer, 1987) and studies based on the concept of Granger Causality (Mendoza and Rosegrant, 1995) replaced simple regression and correlation based methods.

Simple correlation and regression analyses have been found implausible as they result in spurious results. This is because with the non-stationary nature of price data using simple regression and correlation violates the basic assumptions that an unbiased regression analysis must conform to. The fundamental theses in the co-integration approach, thus, cautions that before undertaking a regression analysis one must test whether the non-stationary price data are not only correlated with one another but are *co-integrated*. If two non-stationary price series are co-integrated, it means there is a linear combination of the non-stationary series that is stationary, and that the series share a common form of non-stationarity, and hence cannot drift apart indefinitely.

After Ardeni`s (1989) paper on price transmission on agricultural markets, the entire literature, except the few that use parity bounds model, literature on price transmission uses cointegration methods. In this section of the chapter, we use the Johansen (1988) Cointegration method as it provides an efficient estimate of the cointegrating vectors (β) and adjustment parameters (α). The Johansen procedure is advantageous over the traditional techniques such as like Engle and Granger (1987), Engle and Yoo (1991), in the following points (Gilbert, 2011):

i) It enables one to determine the number of existing cointegrating relationships among the variables based on the data;

ii) It distinguishes short run adjustment parameters from long-run (equilibrium) outcomes;

iii) It doesn`t restrict the equilibrium outcome to be unity

iv) It provides a possibility of symmetrical adjustment of national to world prices using reverse pass-through from former to the later.

Thus due to these merits, we use the Johansen procedure to identify whether the Ethiopian maize and wheat markets are integrated into the world market. Before proceeding with the test for cointegration, we investigate the time series properties of the price series to verify that the price variables are non-stationary with the same order, I (1). The non-stationarity of the price series is detected using Augmented Dicky-Fuller (ADF) method (Dickey and Fuller, 1981)[11]. The ADF is conducted with and without trend. Table 2 reports the test results.

[11] The ADF is based on the following regression: $(x_t - x_{t-1}) = \mu + \beta x_{t-1} + lags(x_t - x_{t-1}) + \varepsilon_t$, where x_t denotes the price series under consideration. A negative and significantly different from zero value of β indicates x_t is *I(0)*.

Table 3.2 Time series properties of nominal and real prices of maize and wheat

		ADF Statistics without Trend		ADF Statistics with Trend	
Markets	**Lag**	**Nominal**	**Real**	**Nominal**	**Real**
Maize US	3	-1.798	-1.664	-3.407	-2.845
	2	-1.440	-1.365	-2.856	-2.478
	1	-1.060	-1.138	-2.320	-2.202
	0	**-0.694**	**-0.9161**	**-1.864**	**-1.946**
SAFEX	3	-1.667	-2.623	-2.380	-2.673
	2	-1.605	-2.486	-2.285	-2.538
	1	-1.651	-2.494	-2.316	-2.546
	0	**-1.104**	**-1.768**	**-1.715**	**-1.833**
MAIZE ETH	3	-2.455	-2.129	-2.689	-2.544
	2	-2.871	-2.466	-3.179	-2.877
	1	-3.059	-2.319	-3.365	-2.738
	0	-1.732	-1.451	-1.687	-1.958
WHEAT ETH	3	-2.149	-1.216	-2.711	-1.931
	2	-2.224	-1.194	-2.776	-1.933
	1	-1.975	-1.09	-2.405	-1.862
	0	**-1.441**	**-0.7884**	**-1.548**	**-1.651**
PARIS	3	-1.959	-2.178	-2.375	-2.369
	2	-1.572	-1.731	-1.782	-1.839
	1	-1.802	-2.034	-2.112	-2.189
	0	-1.281	-1.341	-1.315	-1.365
CBOT	3	-1.977	-2.563	-2.652	-2.888
	2	-2.004	-2.604	-2.653	-2.912
	1	-2.106	-2.704	-2.757	-3.003
	0	**-1.593**	**-2.096**	**-2.021**	**-2.29**

* The Critical value of the ADF test without trend and with trend at 5% is -2.89 and -3.45, respectively.

The results in Table 2 show that all prices are non-stationary both in their nominal and real forms.

After identifying that the price series are non-stationary, I (1), we run a cointegration test to learn that whether a linear combination of any two or three non-stationary price series for each commodities exist. If it exists, the prices are cointegrated and likely that the two price series share common forms of non-stationarity implying that the pair cannot drift apart indefinitely. We used the Johansen procedure due to the merits mentioned above and the results are reported in Table 3.3.

Table 3.3 Statistical Properties of Wheat and Maize Price Series, July 2001 to December 2011

	Trace Statistics of Cointegrated rank			**Implied # of Cointegrating Vectors**
	r=0	***r≤1***	***r≤2***	
Wheat				
CBOT &Paris	12.77 (0.124)	4.56 (0.033)		1
CBOT&Ethiopia	7.18 (0.563)	1.07 (0.302)		No
Paris &Ethiopia	12.48 (0.136)	4.02 (0.045)		1
CBOT, Paris, &Ethiopia	24.0 (0.026)	12.47 (0.137)	3.21 (0.073)	2*
Maize				
US &SAFEX	10.98 (0.217)	1.13 (0.288)		No
US&Ethiopia	13.26 (0.105)	0.379 (0.538)		No
SAFEX & Ethiopia	14.22 (0.076)	4.62 (0.032)		1
US, SAFEX, & Ethiopia	25.64 (0.144)	10.66 (0.237)	0.691 (0.406)	No

*Cointegration is tested using Johansen procedure. The reported statistics are test of $\Gamma(\alpha\beta^{`}) \leq r$, $(r = 0,1,2)$. Tail probabilities are provided in "(..)" parentheses.

A bivariate cointegration test is conducted for the two exchange prices, US and SAFEX, for maize; and Chicago and Paris for wheat. We also conducted a bivariate cointegration test of the exchange prices with the domestic prices (US Maize price with Ethiopian Maize, SAFEX maize with Ethiopian Maize; and similar combinations of Wheat Exchange prices with Domestic price). The result provided in Table 3.3 shows that the two wheat world prices (exchange prices) are cointegrated with one cointegrating vector; Chicago and Ethiopian wheat prices are not cointegrated; and Paris and Ethiopian wheat prices are cointegrated with one cointegrating vector. The trivariate cointegration test for wheat prices implied cointegration among the world and domestic prices with two cointegrating vectors at a significance level of 10%.

Unlike the wheat market, the exchange prices of maize, US and SAFEX, have shown no sign of cointegration. This result is contrary to Gilbert (2011). The difference between our result and Gilbert (2011) might be due to the difference in the sample period considered, as he tested cointegration for a period from January 2005 to December 2009 while in this study we considered an extended period that ranges from July 2001 to December 2011.

The cointegration test between US and Ethiopian maize prices has also shown no cointegration; but SAFEX and Ethiopian maize prices appear to be cointegrated. We failed to identify any form of cointegration among the three maize prices in trivariate VAR (3) setting.

3.3. World Market Price Transmission to Domestic Market

Once we identify that the world and domestic prices are cointegrated, we can estimate the coefficients of the cointegrating vector (β) and the adjustment parameters (α).

The results of the cointegration test of the Paris and Chicago wheat prices in a bivariate VAR (2) setting signify that the two markets are cointegrated. That is, we reject the no cointegration hypothesis, but failed to reject the hypothesis $\Gamma(\alpha\beta^{`}) \leq 1$(see Table 3.3), implying that there is one cointegrating vector. The estimated coefficients of the cointegrating vector are: $\begin{pmatrix} \hat{\alpha}_{paris} \\ \hat{\alpha}_{chicago} \end{pmatrix} = \begin{pmatrix} 0.0036 \\ -0.0113 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.0038 \\ 0.0041 \end{pmatrix}$.

The coefficient for Paris is not significantly different from zero; however, the coefficient for Chicago is three times higher than that of the Paris reaction coefficient and statistically significant implying that Chicago reacts to the price developments in Paris market. This may indicate that Chicago plays a leadership role in the wheat market. Normalizing the cointegrating vector, we fail to reject the hypothesis that this is a unit cointegrating vector ($\chi^2 = 2.62$ with *p-value*=11%) implying that in the long term the two exchange prices move together. The α-matrix of the unit-cointegrating vector is given as follows: $\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Chicago} \end{pmatrix} = \begin{pmatrix} -0.0344 \\ 0.0184 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.0157 \\ 0.0173 \end{pmatrix}$.

In the case where a unit pass through is assumed Paris appears to react more to the changes in Chicago prices than that Chicago does to changes in a Paris price, and the reaction of Paris is nearly twice as large as that of Chicago and it is statistically significant.

In a bivariate setting, we test the Chicago and Ethiopian wheat market cointegration and we have found that Chicago and Ethiopian Wheat markets are not cointegrated.

The cointegration test in a bivariate VAR (2) setting for Paris and Ethiopian wheat markets shows that the two markets are cointegrated. That is, we fail to reject the hypothesis that $\Gamma(\alpha\beta^{`}) \leq 1$ indicating that there is one cointegrating vector (See Table 3.3).

The estimated coefficients of the cointegrating vector with no restrictions imposed are provided as follows:

$$\beta = \begin{pmatrix} 1 \\ -0.027 \end{pmatrix}, \ \begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.049 \\ -0.035 \end{pmatrix} \text{ with standard errors} \begin{pmatrix} 0.021 \\ 0.081 \end{pmatrix}.$$

The estimated coefficients indicate that the reaction of Paris to changes in the Ethiopian wheat market is greater than the reaction of the Ethiopian market to developments in Paris, and it is statistically significant.

We then imposed a unit pass through restriction and tested for its validity. The likelihood ratio test failed to reject the restriction that the cointegrating vector is a unit cointegrating vector ($\chi^2_{(1)} = 1.4$, with *p-value=24%*). The corresponding β and α matrix is

$$\beta = \begin{pmatrix} 1 \\ -1 \end{pmatrix}, \begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.04 \\ -0.01 \end{pmatrix} \text{ with standard errors} \begin{pmatrix} 0.015 \\ 0.014 \end{pmatrix}.$$

The reaction from the Paris exchange market to disequilibrium is 4 times as large as the reaction from the Ethiopian market and implying that errors are corrected rapidly in Paris market than Ethiopia, and the coefficient is statistically significant. Subsequently, we tested whether the two markets individually react to the disequilibrium (weak exogeneity). Firstly, we assumed that the Ethiopian market does not react to changes in the Paris exchange prices, i.e., $\alpha_{Eth} = 0$. Secondly, we suppose the Paris exchange market does not react to the changes in the Ethiopian domestic wheat prices, $\alpha_{Paris} = 0$. We failed to reject the restriction that the Ethiopian wheat market does not react to the changes in Paris exchange prices ($\chi^2_{(1)} = 2$, with *p-value=16%*).

$$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.047 \\ 0.000 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.018 \\ 0.000 \end{pmatrix}$$

However, we reject the hypothesis that Paris exchange prices do not react to changes in Ethiopia wheat prices ($\chi^2_{(1)} = 3$, with *p-value=8%*).

$$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.000 \\ 0.031 \end{pmatrix} \text{ with standard errors} \begin{pmatrix} 0.000 \\ 0.013 \end{pmatrix}.$$

The weak exogeneity restrictions applied together with the unit pass through assumption also produce an identical relationship with the above results.

$$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.04 \\ 0.00 \end{pmatrix} \text{ with standard errors} \begin{pmatrix} 0.015 \\ 0.000 \end{pmatrix}, \text{ LR test: } \chi^2_{(2)} = 2, \textit{ p-value=36\%}$$

$$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.000 \\ -0.006 \end{pmatrix} \text{ with standard errors} \begin{pmatrix} 0.000 \\ 0.013 \end{pmatrix}, \text{ LR test: } \chi^2_{(2)} = 8.3, \textit{ p-value=1.5\%}$$

The implications of the weak exogeneity test are that the Ethiopian wheat market does not react to changes in the prices of Paris milling wheat whereas the Paris milling wheat prices react to changes in the Ethiopian wheat market. This is against the conventional "small country" assumption that would characterize the Ethiopian wheat market in an international context. However, we could argue that the contrary results can be attributed to two possible reasons. Firstly, when we look at the trend of wheat import to Ethiopia, we see that the wheat import has shown a significant growth in the period between 2001 and 2011 than between 1991 and 2000, 10% and 17%, respectively. The average annual import has been 688 thousand and 662 thousand metric tonnes per annum during the two periods, respectively, showing a 4% difference between the periods on per annum average import and a 14% increase in the total amount of wheat imported[12].

The involvement of private traders on wheat import business is virtually nil, despite the liberalization measures adopted by the incumbent government after its coming into power in 1991. As a result, the import of wheat apart from wheat imported in the form of food aid has been entirely procured by the Ethiopian government. Government procurement deals over the years have shown that almost all the purchases have been made from suppliers in Europe and supplied at the Black sea port. Since the Ethiopian government announces wheat procurement bids based on local developments such as production and supply to the local market, it is reasonable to think that international suppliers who aim at taking part in the procurement bids may closely observe developments in the domestic market and foresee potential purchases that would be made by the Ethiopian government, whether it is panic or planned purchase. Hence, international wheat suppliers may reflect such signals from local developments in the exchange markets.

Further, we can argue that based on drought situations and local emergency food requirements donor agencies and/or countries appear in the exchange markets or make purchases from international suppliers who are believed to be market players in the exchange market. Both purchase needs to occur either together or separately may imply that developments in

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[12] The result calculated from FAOSTAT wheat import data provides slightly different results. It shows on average Ethiopia has imported 0.5 million meteric tonnes of wheat between the years 1993-2000 and more than double of this figure (1.03 million metric tonnes) between the years 2001-2010. The share of the total quantity imported is 4 percent out o the total imported to Africa, and 28 percent out of the total imported to East Africa between the years 2001-2010 (Here East Africa according FAO`s regional mapping constituted 19 countries). The result, however, does show no significant difference when the share is computed considering Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Uganda, and Tanzania as an East African group. The share only jumped to 29 percent.

local wheat market situations are likely to be read by international wheat suppliers and hence we hardly rule out the possibility that Ethiopian wheat market situations could indirectly influence exchange market prices.

On the contrary, the second reason dwells upon explaining the absence of reaction from the side of local markets to international wheat market developments. Lack of market information infrastructure and system is one of the culprits that immediately come to one`s mind in an effort to justify why Ethiopian markets are isolated from international markets. However, it is clear that Ethiopia is a net importer of wheat and other grains and the local marketable surplus out of total production is not more than 30%. Therefore, it is counter intuitive to anticipate a supply response from the Ethiopian wheat market to international market price developments, even with the assumption of complete access for international market information.

Besides this, even if they understand that the import parity prices is below domestic prices implying the profitability of importing wheat and selling at the domestic market, local traders cannot import and sale wheat on the domestic market due to several problems that include lack of access for foreign exchange. However, there is no legal restriction put in place preventing importing wheat. As a result, local traders merely closely watch the actions of the government, for it either uses its stock reserve or import and sale at a subsidized price with an objective of local price stabilization. This compels local traders to focus on domestic developments per se than keep abreast of international market developments. Further, we argue that the introduction of local food aid purchase program since 1996[13] may have

[13] In 1996, in response to Government appeals to donors, the European Commission initiated a local procurement program. In subsequent years a more widespread program has been introduced with the following objec-

changed the price formation in the Ethiopian grain market. Local food aid purchase between 1996 and 2004 has accounted for on average nearly 12% of the total marketed surplus of cereals, which ranges from 28 to 30% (Walker and Wandschneider, 2005). Therefore, it is reasonable to believe that such local food aid purchases by different aid and humanitarian agencies possibly influence local price levels[14]. This may draw the attention of local traders to follow their actions and procurement needs than adhering to the developments of the international market for which they are incapable to react[15].

Next, we add the Ethiopian prices to the world market prices and test for cointegration in trivariate setting VAR (3). The result shows that there are two cointegrating vectors, $\Gamma(\alpha\beta^{`}) = 2$, at the 10% level of significance. As explained above the integration of the Ethiopian market is established indirectly in contrast to its limited openness to the world market.

From the study of the Paris and Chicago wheat prices we have seen that they are cointegrated with a unit cointegrating vector, and hence we can proceed with the restriction that

tives: a) to procure food aid locally/ regionally as part of a more general policy support linking food aid with market development; b) to improve food aid targeting through diversifying grain types; c) to support domestic prices during years of good harvest in order to provide production incentives to farmers; d) to encourage entry and expansion of the domestic grain trade by familiarizing farmers with more formal contract arrangements and help food aid activities into the broader domestic grain marketing. However, Walker ad Wandschneider (2005) question the contribution of the procurement scheme with regard to its objective of helping the development of agricultural markets to be more formal.

[14] Organization that have been participating in local food aid purchases include the World Food Program (WFP), Euronaid, Deutsche Gesellschaft für Internationale Zusammenarbeit (GTZ/GIZ), and Save the Children, among others.

[15] Over the years between 1996 and 2004 locally procured food aid (proxied by local purchases of cereals for food aid purpose) accounted for 25 percent of total relief food aid imported.

$\beta_1 = \begin{pmatrix} 1 \\ -1 \\ 0 \end{pmatrix}$, and we further consider that the two markets will have an equal effect on the Ethiopian wheat market, we restrict $\beta_2 = \begin{pmatrix} \frac{1}{2} \\ \frac{1}{2} \\ -1 \end{pmatrix}$, here Chicago is allowed to have an equal impact as that of Paris prices on the Ethiopian market. However, as we have indicated above the bivariate cointegration test of Chicago and Ethiopian wheat market indicated the two markets are not cointegrated. For this reason, we relax the equal impact assumption in a subsequent discussion.

We further impose a "small country" assumptions on the α-matrix showing that Ethiopia may not affect the world market prices in both exchange markets. That is, we restrict $\alpha_{21} = 0$ and $\alpha_{22} = 0$ hypothesizing that the Ethiopian price does not impact the Paris and Chicago wheat exchange prices. The estimated α-matrix is:

$$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Chicago} \\ \hat{\alpha}_{Ethiopia} \end{pmatrix} = \begin{pmatrix} -0.037 & 0.000 \\ 0.016 & 0.000 \\ 0.000 & 0.005 \end{pmatrix} \text{ with standard errors} \begin{pmatrix} 0.016 & 0.000 \\ 0.018 & 0.000 \\ 0.000 & 0.017 \end{pmatrix}.$$

However, the log likelihood ratio test rejected the restrictions ($\chi^2_{(5)} = 14.87$ with *p-value=1%*). Though we observe that Paris reacts more than Chicago to deviations from the equilibrium, we reject the hypothesis that the two markets are independent of one another. The result in here confirms our result that we established in a bivariate cointegration test of the Ethiopian and Paris prices, where we rejected the hypothesis that exchange markets do not react to the developments in the Ethiopian wheat market.

For the maize market, we analyze US maize price, SAFEX white maize spot price and Ethiopian maize price. First, we check the cointegration of the two exchange markets: SAFEX and US. The bivariate cointegration VAR (2) shows that the two markets are not cointegrated, as we fail to reject $\Gamma(\alpha\beta^{`}) = 0$ (see Table 3.3).

We also conducted a bivariate cointegration test on each of the two exchange prices with the Ethiopian maize prices. The results show that the US maize price is not cointegrated with the Ethiopian price whereas the SAFEX price does. Thus, in the following we look in detail the cointegration relation between the SAFEX and the Ethiopian maize prices. As we can see from Table (3.3) that the two markets are cointegrated with one cointegrating vector, $\Gamma\left(\alpha\beta'\right) = 1$, providing a one dimensional space where the cointegrating vector is positioned. The coefficients estimated with no restriction are as follows:

$$\begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.065 \\ -0.023 \end{pmatrix} \text{ with standard errors} \begin{pmatrix} 0.023 \\ 0.021 \end{pmatrix}.$$

The SAFEX coefficient is significantly different from zero implying that only SAFEX reacts to changes in price disequilibrium, and the coefficient of the SAFEX is three times as large as the Ethiopian.

We have also tested whether the cointegrating vector is a unit cointegrating vector, but we reject the unit cointegrating vector hypothesis ($\chi^2_{(1)} = 4.8$, with *p-value=3%*) implying that elasticity of the long run price transmission is not unity.

Next, we investigated the weak exogeneity assumption imposed on the two markets. First, we employ the weak exogeneity test on both prices leaving the adjustment coefficients unrestricted. We first impose $\beta_1 = 0$, assuming that changes in SAFEX price does not depend on the price difference between SAFEX and the Ethiopian price. We failed to reject the hypothesis ($\chi^2_{(1)} = 2.15$ with *p-value=14%*) implying that SAFEX prices do not rely on the lagged difference between Ethiopian and SAFEX prices. In other words, much of the information that cause changes in the SAFEX prices emanate from its own previous year prices, and hence SAFEX tends to become an autoregressive series. We further added a restriction that SAFEX does not react to any price differences between its own and Ethiopian maize prices, i.e, $\alpha_{12} = 0$, and the hypothesis is weakly rejected ($\chi^2_{(2)} = 4.8$ with *p-value=9%*).

Nonetheless, we strongly reject the hypothesis ($\chi^2_{(2)} = 4.3$, with *p-value=4%*) when we leave out the restriction ($\beta_1 = 0$) and test the restriction on α separately. Thus, we could confirm that SAFEX prices react to Ethiopian market prices when cointegration is any other than unitary.

In the following, we investigated the reaction of the Ethiopian maize market to the price differences between itself and SAFEX prices. The unit cointegrating vector hypothesis is rejected above. So let us suppose that $\beta_2 = 0$, implying the Ethiopian maize price changes does not carry any information from the price differences between itself and SAFEX prices. The test on the restriction is rejected ($\chi^2_{(1)} = 3.34$ with *p-value=7%*) implying that in the long term there is a possibility that the two prices relate and changes in the Ethiopian maize market price consider the discrepancy between it and the SAFEX prices. Further, we impose the restriction that Ethiopian prices do not react to changes in SAFEX prices, $\alpha_{12} = 0$. The result is that, we failed to reject the hypothesis ($\chi^2_{(2)} = 4.3$ with *p-value=12%*) implying that the Ethiopian market does react to price differences between itself and the SAFEX maize prices.

This hypothesis ($\alpha_{12} = 0$), however, is not rejected when we leave out the restriction on the cointegrating vector ($\chi^2_{(1)} = 0.66$ with *p-value=42%*) implying that the Ethiopian market does not respond to the developments in SAFEX maize prices. The α coefficients and their standard errors for restrictions discussed above are given as follows:

1. For restrictions on the Ethiopian market

$$\beta_2 = 0, \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.08 \\ 0.03 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.035 \\ 0.032 \end{pmatrix}$$

$$\beta_2 = 0, \ \alpha_2 = 0, \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.08 \\ 0.00 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.035 \\ 0.000 \end{pmatrix}$$

$$\beta\text{-no restriction, } \alpha_2 = 0, \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.094 \\ 0.000 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.03 \\ 0.00 \end{pmatrix}$$

2. For restrictions on SAFEX

$$\beta_1 = 0, \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.065 \\ 0.075 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.041 \\ 0.036 \end{pmatrix}$$

$$\beta_1 = 0, \ \alpha_1 = 0, \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.000 \\ 0.078 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.000 \\ 0.035 \end{pmatrix}$$

$$\beta\text{-no restriction, } \alpha_1 = 0, \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.000 \\ 0.035 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.000 \\ 0.015 \end{pmatrix}$$

Adding the Ethiopian maize price to the cointegration test, we obtain no cointegration among the prices in trivariate VAR (3) setting (see Table 3.3).

Summary of the Results

In this part, we examined whether the Ethiopian wheat and maize markets are integrated into the world market. To this end, we investigated cointegration relations between the Ethiopian wheat market and two exchange wheat markets (Chicago and Paris); and the Ethiopian maize market and two exchange maize markets (SAFEX and US).

We summarize the main results that emerge from the analysis as follows:

- We found out that the Ethiopian wheat market is integrated into the world market as implied by its cointegration with the Paris wheat market. Nevertheless, this cointegration could not be directly evidenced by the reaction of the Ethiopian market to developments in Paris wheat market.

- Chicago exchange and Ethiopian wheat market have shown no cointegration. This may imply that the geographical proximity of Paris to Ethiopia than Chicago may have influenced the relation of the two markets. As provided in the discussion, Ethiopia imports most of its wheat from the Black sea and Mediterranean ports; thus, Ethiopia may prefer to look at Paris prices than Chicago.

- With regard to maize, the Ethiopian maize market is found to be integrated into the world market. As in the case of wheat, geographically the nearest exchange market (SAFEX) appeared cointegrated with the Ethiopian maize market. While the US maize market shows no cointegration.

- Exchange markets in the case of wheat, Paris and Chicago, appear cointegrated while maize exchange markets, SAFEX, and US found to be not cointegrated.

We can see from the results shown above that the Ethiopian wheat and maize markets are linked to the corresponding international markets. Nevertheless, the impacts of international commodity price rises may not be automatically and fully reflected in national prices. The extent of international price transmission also depends on the degree of domestic market integration and on policy and trade measures both at the border and within the country.

During the 2008 food crisis, the Ethiopian government introduced a range of domestic policy measures in an effort to insulate the effects of international price spikes on domestic prices. These measures include an export ban on cereals, the suspension or reduction of value added tax (VAT) or other taxes on food items, releasing stocks of food crops at a subsidized prices (mainly wheat), market intervention, and cash transfers. A full assessment of the contributions of policy measures to imperfect price transmission would require a large amount of data in order to yield reliable results. The irregularity of the policy measures as well as their duration would further complicate investigation of the above-mentioned measures (see appendix 3B for the chronology of changes in domestic grain markets).

Although it is difficult to analyze the impact of policy changes, the analysis of exchange rate impacts is more straightforward. In the following, we examine the effects of the exchange rate on the price transmission results we obtained above.

3.3.1 Effects of Exchange Rate on Price Transmission

A trivariate cointegration test is conducted on the domestic and international market price pairs for which cointegration is established, and the exchange rate (domestic currency to USD). The domestic prices in this case are in domestic currency units whereas in the earlier analysis they were converted into US dollars, implicitly assuming full and instantaneous exchange rate pass-through.

Exchange rates are believed to play a significant role in determining in country prices, depending on the exchange rate regime. Exchange rate appreciation would tend to insulate the country against world price increases, whereas depreciation would diminish the effects of declining world prices on border prices in local currencies. Since October 2001 the exchange rate has been determined by daily inter-bank foreign exchange market auction, the exchange rate regime continued to be managed floating exchange rate where the exchange rate is allowed to float in a certain range determined by policy makers and not by market forces.

During the period under investigation, the Ethiopian exchange rates showed little variability up until 2007 and a significant depreciation occurred only after 2008. The nominal exchange rate suffered only 5% depreciation between 2002 and 2007, but depreciated by 89% between 2007 and 2011. A significant depreciation occurred between 2008 and 20011 (76%). The movement of the domestic prices, on the other hand, reveals the existence of a disconnection between domestic prices and the exchange rate. That is, the spikes in domestic prices were not associated with the developments in the exchange rate as prices peaked at times in which there was a small change in exchange rate while the exchange rate continued to depreciate over the period 2009 and 2010 when grains prices were falling (see Figure 3.4).

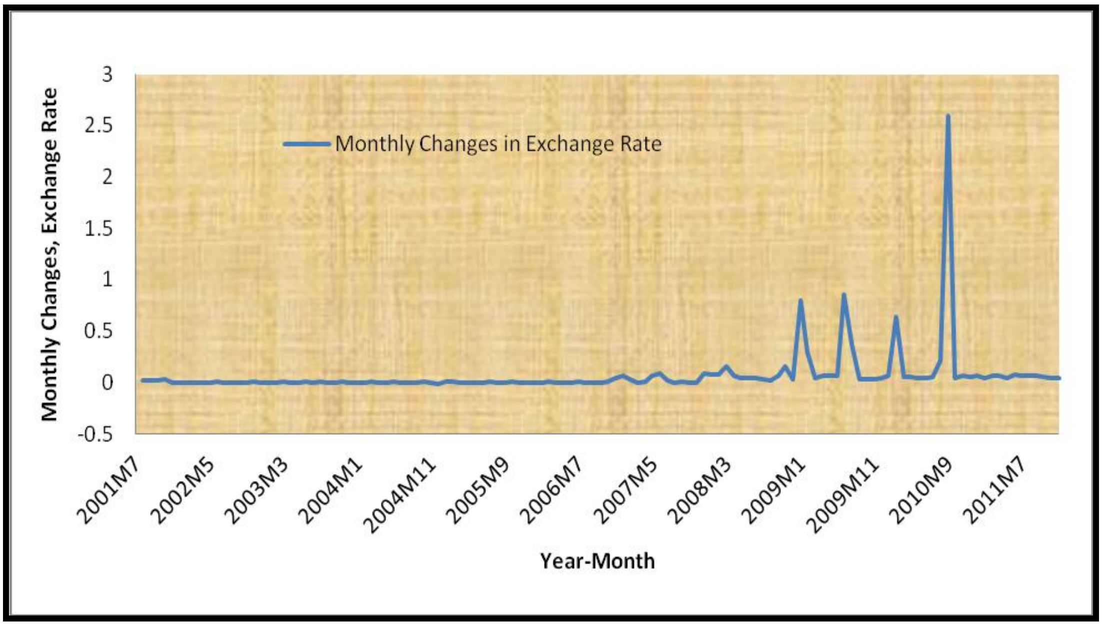

Figure 3.3 Exchange rate monthly changes, July 2001 to December 2011.
Source: IMF, IFS database.

As a result, the exchange rate has been relatively constant while domestic prices have been rising. Assefa (2013) argues that the rising inflation during the 2008 crisis was accompanied by government restrictions on imports and purchase of foreign exchange rather than depreciating the exchange rate. That is, even if domestic prices increased by double digits, exchange rate were kept relatively constant between June 2007 and June 2008. We further explain this uncoupling of domestic prices and exchange rate with the help of the trivariate cointegration analysis of domestic prices (wheat and maize), world prices (Paris wheat, SAFEX maize), and the exchange rate.

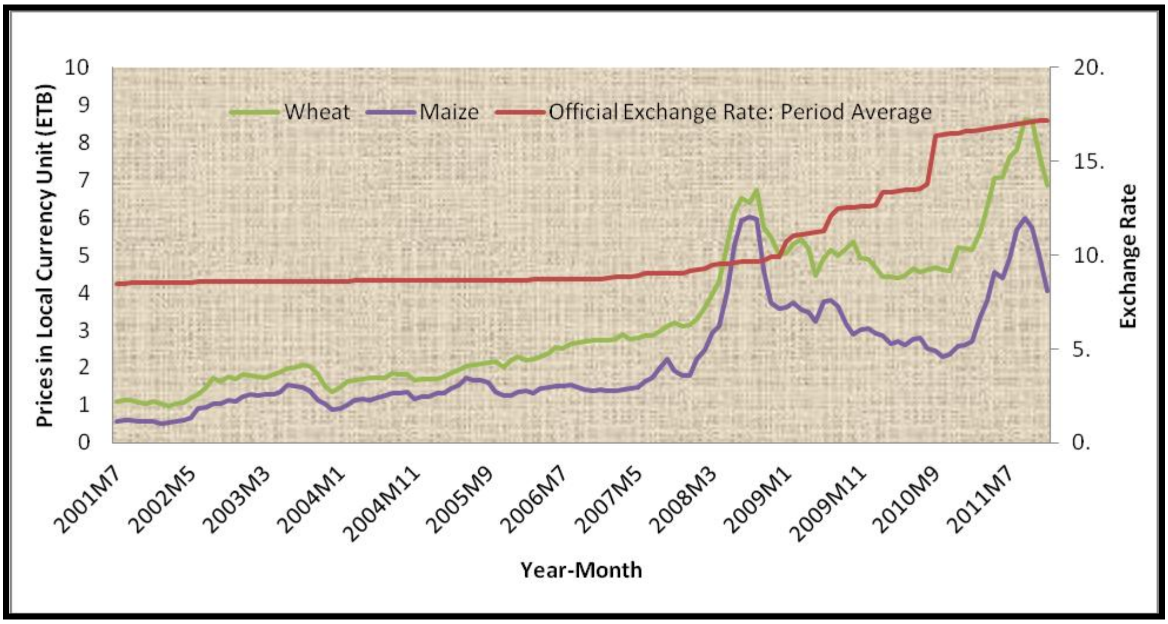

Figure 3.4 Exchange rate and domestic prices overtime from July 2001 to December 2011.
Source: EGTE for domestic prices, and IMF/IFS for exchange rates.

Table 3.4 Time series properties of domestic prices in local currency unit and exchange rate

	Lag	**ADF Without Trend**	**ADF With Trend**
Wheat	3	-1.272	-3.163
	2	-1.307	-3.135
	1	-1.253	-2.915
	0	-0.913	-2.037
Maize	3	-1.898	-3.002
	2	-2.158	-3.510
	1	-2.078	-3.245
	0	-1.534	-1.989
Exchange	3	1.939	-0.601
	2	1.892	-0.681
	1	1.846	-0.752
	0	2.205	-0.682

* The Critical value of the ADF test without trend and with trend at 5% is -2.89 and -3.45, respectively.

The non-stationarity tests presented in Table 3.4 show that the domestic prices series in local currency unit and the exchange rate are non-stationary. Since the time series properties of the world prices, SAFEX maize and Paris wheat, are examined in the previous section, we have directly used them in the cointegration test below.

The Johansen cointegration results indicate that there is no cointegration between the domestic prices in local currency units and the international prices. Further, the exchange rate does show no cointegration with both domestic prices in local currency units, and the international prices. The cointegration tests in a trivariate setting also reveal no cointegrating relationship (see Table 3.5).

Table 3.5 Statistical Properties of Wheat and Maize Price Series, July 2001 to December 2011

	Trace Statistics of Cointegrating rank			**Implied # of Cointegrating Vectors**
	r=0	***r≤1***	***r≤2***	
Wheat				
Ethiopia and Exchange Rate	8.80 (15.41)	0.67 (3.76)		-
Ethiopia and Paris	12.68 (15.41)	1.45 (3.76)		-
Ethiopia, Paris, Exchange Rate	23.61 (29.68)	7.49 (15.41)	0.80 (3.76)	-
Maize				
Ethiopia and Exchange Rate	10.42 (15.41)	1.58 (3.76)		-
Ethiopia and SAFFEX	11.60 (15.41)	2.15 (3.76)		-
Ethiopia, SAFEX, Exchange Rate	20.91 (29.68)	8.76 (15.41)	2.40 (3.76)	-

*5% critical values in parenthesis

Therefore, as the descriptive analysis hints that exchange rate in Ethiopia does not affect domestic prices and a pass-through of changes in exchange rate to domestic prices cannot be easily identified. This might be due to the reason that the government intervenes in the exchange market and such intervention, when applied to the exchange market per se, disentangles the likely exchange rate pass-through to the domestic market. Linked to this, the weak financial sector in the country and low level of financial inclusion possibly limit transmission of monetary policy changes such as changes in exchange rates to agricultural markets.

3.4. Intra-Regional Food Market Analysis

3.4.1. Evolution of Cereal Marketing Policy

Since the Imperial regime, cereal market policy has been put in place. The policies that have been adopted during the last three regimes, including the incumbent, fundamentally tailored to their ideological inclinations

During the Imperial regime, a high share of marketable surplus out of the total production, and very high transport costs due mainly to the minimal road networks and telecommunication services characterized cereal markets. The marketed surplus, which was around 25-30 percent of the total production, however, is hardly a result of increased productivity. Rather, it was sourced from the in-kind rent and revenue paid by the renters to the church and the state. Government intervention during this period was through the Ethiopian Grain Board (EGB) established in 1950, that later reformed and renamed the Ethiopian Grain Council (EGC) in 1960. Initially, the EGB was mandated to export licensing for oilseeds and pulses, quality control, supervision of marketing intelligence, and regulation of domestic sales (Rashid and Asfaw, 2012).

The Grain Board reformed and renamed to Ethiopian Grain Council in 1960 as the Grain Board failed to achieve its objectives. The Grain Council was provided new roles and mandated to hold stocks, stabilize grain prices in urban areas, and improve the production of cereals, oilseeds and pulses for export. Yet again, the Grain Council also failed to achieve its objectives. Further, the policy interventions through the Grain Council did not contribute to the improvement in market integration, because the Grain Council focused its interventions in a limited number of production regions and urban areas, while disregarding larger parts of the country (Holemberg, 1977 cited in Rashid and Asfaw, 2012).

The Socialist regime that came to power in 1974, established Agricultural Marketing Corporation (AMC) in 1976, with the support from the World Bank. Through the corporation, it directly involved in wholesale and retail trade. The corporation was tasked with a range of activities, which include handling almost all agricultural input and output markets. The corporation determines annual quotas that farmers and traders had to supply to the corporation at a fixed price, which is far below market prices in most areas. It had put restrictions on private grain trade and interregional grain trade. As a result, of these restrictions, rural incomes depressed; resources had transferred from rural households to a small group of urban households through artificially cheap prices; and consequently depressed cereal production in Ethiopia over the years the restrictions were in place (Lirenso, 1995; Dercon, 1994; Franzel et al., 1989).

Cognizant of the setbacks that stem from the misguided cereal policy adhered, the Socialist government undertook major grain market policy reforms over the years since 1987 due mainly to increasing pressure from donors, worsening economic conditions, and political and economic policy changes in the great socialist blocks such as the USSR, and Eastern Europe (Rashid and Asfaw, 2012). Hence as of March 1990, quota requirements abolished and movement restrictions lifted. Private traders were allowed to move grain across regions only when they agree to sell half of their supply to AMC at a specified price (Franzel et al., 1989). These measures, though eliminated the AMC`s monopoly power, the socialist regime collapsed a year after, and AMC went on another round of restructuring.

Following the downfall of the socialist regime, the Agricultural Marketing Corporation has been reorganized as a public enterprise known as the Ethiopian Grain Trade Enterprise (EGTE).The Transitional government instituted policies reorienting the country towards a market economy. For this reason, the EGTE allowed to operate in the market and compete with the private sector. In line with this, it has been given new roles: to stabilize prices both to encourage production and protect consumers from price shocks; to earn foreign exchange through grain exports to the world market; and to maintain strategic food reserves for disaster response and emergency food security operations.

The restructured enterprise has reduced grain-marketing networks, fewer purchase and sales centres than the AMC. These factors juxtaposed to shortage of working capital that the EGTE encountered and the under utilization of available resources made the enterprise fell short of expectations, especially in price stabilization (Lirenso, 1994).

In later years, an attempt has been made through a series of proclamations and regulations, which gradually withdraw the EGTE from the price stabilization role and redirect its efforts towards export promotion, facilitating emergency food security reserves, and helping national disaster prevention and preparedness programs.

In the face of a series of regulations, which require the EGTE to concentrate on issues other than price stabilization, the EGTE has been returned to its price stabilization roles in two occasions. Firstly, following the 2000/1 and 2001/2 bumper produce of grain; and secondly, to stabilize the food price spikes between 2005 and 2008. During these years, as we indicated in section 3.3, regardless of major reported supply shocks in the country, prices of major cereals have been rising sharply since late 2005. This was further fuelled by the general macro inflation that peaked to above 60% in the summer of 2008. These imply that EGTE was required to deal with two diametrically opposite challenges. In the first instance, it was supposed to deal with the decline of maize prices by an unprecedented amount as large as 80 % in early 2002 that occurred because of increased maize productivity. Maize farming, thus, has become highly unprofitable, for the ratio of input to the producers` price has climbed from 1.7 in 2000 to about 9.0 in 2002, leading to a fall in fertilizer application by about 22 % in the following crop year (Rashid and Asfaw, 2012). The implication of the incident was that the increase in productivity could not simply translate into improvements in farmers` well-being.

Returning to its stabilization role, on the other hand, EGTE procured 18000 metric tonnes of maize, of which it exported 11000 metric tonnes. Unfortunately, the bumper harvest could not be extended to the 2002 crop year due to both the delay in the 2002 *meher (main growing season)* rainfall, and decline in the application of modern inputs because of higher input-output price ratio, which made using modern inputs unprofitable. Unsurprisingly, in the next year the country has faced a food security crisis, which was averted through generous donor support and about 1 million metric tonnes of maize imported as food aid.

The incident of the 2000/1 and 2001/2 has been a showcase in that agricultural policy measures that aim to increase productivity and promote technology adoption can be sustained only when the marketing infrastructure is developed hand in hand with the improvement in productivity. As market infrastructure by itself cannot result in desired outcomes, systems that aim to bring efficient marketing outcomes need to be put in place. This, in turn, may increase the share of the producers` price both in the wholesale and retail prices, and hence improves the welfare of the smallholder farmers that contribute more than 90% of the food supply. In the following section, we explore the extent of physical infrastructure and market infrastructure development in terms of its impetus to food market integration in the country.

3.4.2. Infrastructure Development

The market mechanism works where the necessary and sufficient conditions for its operation are satisfied. That is, market functioning towards the desired objectives depends on the adequacy of physical, informational, and institutional infrastructure. In a place where at least the physical infrastructure is virtually non-existent, as it was in the 1980s and early 1990s Ethiopia, there are likely to have been different prices across the country characterized by inter-regional price differentials, differing variability, and inefficient price formation. Poor infrastructure may also have contributed to the famines that occurred in mid 1980s and before. Since in times of drought, it was not possible to transport the surplus produce available in an unaffected area to the drought stricken areas due mainly to lack of infrastructure connecting the two places. For example, in the 1980s, more than 90 percent of the country's population lived in a distance of more than 48 hours walk from a paved road (WFP, 1989); the government largely controlled transportation, telecommunication was thin, and mobile phone technology was non-existent. Up until 1991, the country had about 4109 kms of asphalt road, 9298 kms of gravel road, and about 5601kms of rural roads. The construction of all types of roads, especially rural roads, has been given due attention by the new government that came into power in 1991. As a result, total road networks increased by 29 % as of

2000. The rural road network grew by around 68 %, gravel roads by around 23%, while asphalt road network fell by about 10%. During the later years, the construction of new rural and gravel roads, upgrading existing gravel roads to asphalt roads, continued consistently. Between 2000 and 2011, total road network grew by about 39%. Of these asphalt roads increased by 6%, gravel roads by 14%, and rural roads by 21% showing that due attention has been given to connect rural areas to main all weather and asphalt roads thereby reducing the number of hours that someone has to walk to reach the main roads connecting towns or cities. The focus provided for the construction of rural roads is reasonable because of the fact that Ethiopia is largely a rural country, where more than 80% of the population resides.

Table 3.4 Road Network, Telephone Subscription, and Penetration Rate

	Road Network(km)				**Telephone Subscription and Penetration Rate**			
Year	**Gravel**	**Asphalt**	**Rural**	**Total**	**Fixed Line**	**Fixed Line***	**Mobile**	**Mobile***
Average 1993-1999	11.41	3.68	9.40	24.49	153.80	0.26	6.74	0.01
2000	12.25	3.82	15.48	31.55	231.95	0.35	17.76	0.03
2001	12.47	3.92	16.48	32.87	283.68	0.42	27.50	0.04
2002	12.56	4.05	16.68	33.29	353.82	0.51	50.37	0.07
2003	12.34	4.36	17.15	33.85	404.79	0.57	51.32	0.07
2004	13.91	4.64	17.96	36.51	484.37	0.67	155.53	0.21
2005	13.64	4.97	18.41	37.02	610.35	0.82	410.63	0.55
2006	14.31	5.00	20.16	39.47	725.05	0.95	866.70	1.14
2007	14.63	5.45	22.35	42.43	880.09	1.13	1208.50	1.55
2008	14.36	6.07	23.93	44.36	897.29	1.13	1954.53	2.46
2009	14.23	6.94	25.64	46.81	915.06	1.13	4051.70	4.99
2010	14.37	7.48	26.94	48.79	908.88	1.10	6854.00	8.26
2011	13.61	8.82	29.61	52.04	829.01	0.98	14126.66	16.67
Average 2000-2011	13.56	5.46	20.90	39.92	627.03	0.81	2481.27	3.01
Average 1993-2011	13.39	5.32	20.01	38.73	590.62	0.77	2290.92	2.77
Average Annual Growth (%)	1.59	7.66	11.00	6.69	16.05	12.38	97.10	92.50

Source: Data on Road Network (1993-2008) is taken from Rashid and Asfaw (2012) and for the years 2009 to 2011 compiled from CSA Statistical Abstracts various years. Data on telephone subscription and penetration rate are obtained from UN Data/World Telecommunications/ICT database.

* The penetration rate is calculated by dividing the number of telephone subscriptions by the population and multiplying by 100

Information flow plays a significant role in the performance of markets. For this reason, increasing means of information flow and hence enhancing access for it is fundamental to achieve market efficiency or integration of markets across regions. Telecommunication service is one of the means by which market information could be transmitted between buyers and sellers, and prices possibly negotiated between trading partners. In the Ethiopian context, the virtue of telecommunication service with regard to market information flow has not been exploited until recently. For example, in 1991 the penetration rate of fixed lines was 0.27 per 100 individuals, showing that telecommunication services were largely inaccessible during the Socialist regime. Mobile telephone service was not available until 1999. However, the penetration rate of fixed lines reached 0.98 in 2011 and mobile telephone service penetration rate reached 17. This development in telecom service may have a positive contribution towards improved market information flow across the country and possibly lead to a better integration of local grain markets.

3.4.3. Analytical Approach

The integration of the domestic food markets is analyzed using a principal component analysis (PCA). PCA is fundamentally a dimension reduction technique. It may be used to estimate factor structure on the assumption that factors are uncorrelated and "specific" variances (i.e., those of the unexplained components) are equal for all items considered. This is an exploratory statistical technique which specifies a linear factor structure between variables, and especially useful when the data under consideration are correlated. If the underlying data are uncorrelated, PCA will have little utility. In the sense of this paper, we use PCA to analyze the integration of regional market prices taking 10 to 11 cereal markets in Ethiopia. We consider two crops, maize and wheat.

The procedure for PCA begins with the raw price data of the above-mentioned cereals on *m* markets for *n* months. As we need all markets to have equal importance, we calculate the eigenvalues and eigenvectors using a correlation matrix. The size of the eigenvalues reflects the percentage of the variance explained by each component. To calculate the amount that each eigenvalue explains, we sum up the value of all of the eigenvalues, and then divide each eigenvalue by the sum. Since we do the principal component analysis based on the correlation matrix, essentially the eigenvalues on the diagonal will sum up to 1 and hence we would expect any major factor would at least be able to generate its share of variance. The eigenvectors, on the other hand, are weights (regression coefficients) attached to each variable in the computation of each principal component.

The first principal component is a linear combination of the original variables

$(m_1, m_2, ..., m_n)$:

$$PC_1 = \varphi_{11} m_1 + \varphi_{12} m_2 + ... + \varphi_{1n} m_n$$

that varies as much as possible for the individual markets, subject to the condition that the weights of the principal component (PC) coefficient, *eigenvectors*, add up to one, i.e.,

$$\varphi_{11} + \varphi_{12} + ... + \varphi_{1n} = 1$$

Thus the variance of $PC_1, Var(PC_1)$, is as large as possible, provided the constraint on the constants. Likewise, for m-markets we will have *m*-principal components, where each consecutive component accounts for as much variation in the underlying data as possible, that is, $Var(PC_1) \geq Var(PC_2) \geq ...... \geq Var(PC_m)$.

Each principal component is uncorrelated with every other component. Lack of the correlation means that the indices are measuring different dimensions of the data, and hence provide the above principal component variance ordering, i.e., the eigenvalues of the principal components in descending order. The idea in the principal component analysis is that the variance of every new variable will be so low that most of the variation in the data will be explained by the first few *PC* variables. The number of the principal components to be retained in the analysis can be determined in two ways. Firstly, based on some theoretical knowledge of the subject of the study and desired objectives to be met; only a few of principal components that explain the majority of the variation underlying the data can be retained. This is done by observing the cumulative percentage explained.

Secondly, using the time plot of eigenvalues ordered from the largest to the smallest, we examine the *scree plot* of eigenvalues. It helps in visually demonstrating the proportion of total variance each principal component accounts for, and that we can throw away the lower principal components without losing much explanatory power. That is, we look for a point on the *scree plot* where the values of the eigenvalue drop dramatically and from that point on the remaining values have nearly about the same size. That turning point will serve as a *cut-off* point to consider those principal components up until the kink.

Market integration analysis using PCA differs from the conventional cointegration analysis in that cointegration looks for long run relationships between different prices, while PCA, applied to price changes looks for short run co-movement between different prices. There can be considerable co-movement without cointegration but also cointegration with only limited short run co-movement. Applied to price levels PCA is closer to cointegration analysis but can give very different results if one price has much larger trend than another does; this can dominate the first PCA without explaining much of the other series. For that reason, we also conduct a PCA analysis on price changes so that we reduce the impact of the market price with larger trend, if any, and demonstrate the short run co-movement of market prices.

The results from the principal component analysis are corroborated by examining the stationarity of the price spreads between the central market, Addis Ababa, and other regional markets. This is because the stationarity of price spreads can be used to suggest that markets are efficient and integrated. The intuition behind the price spread stationarity is that price spread stationarity implies a market in which locations are, in the long run, both efficient and fully integrated. This means that the market equilibrates in the long run, as arbitrage opportunities exploited, and that shocks originating in one location are eventually transmitted fully to the other location. However, more contentious is the explanation that would emerge from non-stationarity of price spreads. It may imply that markets are in a long run disequilibrium situation. More likely, it may imply integration is less than complete, because either markets are isolated or marginal adjustments occur.

Thus, drawing conclusions about the extent of integration are difficult to justify using linear dynamic regression per se, because a switching regime regression (before and after a certain factors, which likely improve market integration, have been introduced) is more appropriate. Further, other tests such as like cointegration tests of spatial integration are heavily dependent upon assumptions, which may, in most cases, be quite strong. These assumptions may pertain to transaction costs, which are assumed to be stationary or represented in an ad hoc simplistic manner.

For this reason, the investigation of market integration should not simply dwell upon analysis of whether prices are integrated. Exploratory results from the analysis of market integration based on price data provide an insight of revealed patterns of integration. This opens up an agenda for inferential analysis so that we examine what factors possibly influenced the observed market integration. Though we are well aware of the importance of analyzing the factors that contributed to the revealed market integration, we have not been able to go beyond uncovering the patterns due mainly to lack of data on market infrastructure tailored to the market locations.

3.4. Results and Discussion

In the following, we discuss the results obtained from the principal component analysis.

3.4.1. Wheat Market

In the analysis of wheat market integration, we use a time series wholesale wheat price data obtained from the Ethiopian Grain Trade Enterprise (EGTE) for the period from July 2001 to December 2011 across 11 local markets namely: Addis Ababa (AA), Ambo, Assela, Dire Dawa (DD), Dessie, Gonder, Jimma, Mekelle, Nazereth, Robe, and Shashemene. Addis Ababa, the capital city of the country, is treated as a central market and all the other market prices compare against the central market.

Table 3.5 Summary Statistics of Nominal and Real Prices of Wheat in 11 Markets

Markets	**Percentage Change July 2001 to December 2011**		**Percentage Range Over the same period**		**Standard Deviations of Monthly Changes**		**Mean**		**Standard Deviation**	
	Nominal	**Real**	**Nominal**	**Real**	**Nominal**	**Real**	**Nominal**	**Real**	**Nominal**	**Real**
AA	313%	-37%	546%	184%	25%	21%	30.69	22.01	1297%	1660%
Ambo	395%	60%	684%	665%	27%	186%	27.03	16.83	1263%	1871%
Assela	416%	-24%	670%	187%	28%	29%	28.05	19.79	1280%	1598%
DD	202%	-44%	327%	372%	26%	73%	35.87	24.16	1349%	1961%
Dessie	173%	-39%	461%	335%	27%	45%	31.27	22.90	1287%	1753%
Gonder	320%	-39%	524%	476%	28%	136%	32.27	23.08	1386%	2077%
Jimma	165%	-35%	338%	168%	30%	20%	34.91	21.56	1332%	1639%
Mekelle	309%	-5%	530%	240%	23%	30%	30.16	17.11	1281%	1598%
Nazereth	440%	-27%	959%	226%	35%	75%	24.86	20.18	1257%	1691%
Robe	383%	-34%	607%	171%	26%	19%	28.73	21.50	1277%	1636%
Shash	309%	-34%	527%	171%	23%	19%	30.15	21.50	1279%	1636%
National	308%	-34%	520%	168%	23%	19%	30.12	21.47	1269%	1636%

Source: Authors` calculation

Table 3.5 provides price changes, percentage range, standard deviation of monthly changes, average prices, and standard deviation of the monthly price series over the entire period considered in this study.

The nominal wheat prices have increased substantially in all markets. The increase in most of the markets, except Dire Dawa, Dessie, and Jimma, was well above the increase in the national price. The real wheat prices have fallen in all the markets over the period July 2001 to December 2011; however, Ambo exceptionally has shown an increase of about 60 percent. The range measures the extent of price spikes, while the change in range measures the long run impact. The percentage range in Ambo, Dire Dawa, Dessie, and Gonder has been above 300 percent, the largest being in Ambo. These markets have experienced a price spike that is 2 to 3 times as large as the price spikes of the rest of the markets. The price variability provided by the standard deviation of the monthly changes espouses the difference in price fluctuations across markets. Price variability in Ambo, Dire Dawa, Gonder, and Nazereth is more than twice as large as the variability in other markets. However, the average price over the entire period across markets has not shown substantial difference. Markets in Ambo and Dire Dawa have shown the smallest and largest average price, respectively. This is commensurate with the fact that traditionally Ambo is a surplus market and hence it is more likely to have lower average prices than other places whereas Dire Dawa is a deficit market where prices, unless there are interventions from the government, would be higher than the surplus markets and the central market by a substantial amount.

We conducted the PCA of the 11 wheat markets, and based on the scree plot and cumulative variation method, we retained two principal components. Because, we found that the first two principal components explain more than 90 percent of the variation in the price data of the 11 markets.

Table 3.6 Wheat markets PCA, Standard deviation, and distance of market from the central market

Variable	**Comp1**	**Comp2**	**Nominal Wheat Price**	**Distance in Km from the central Market**
AA	0.3139	-0.0573	1297%	
Ambo	0.3084	-0.2496	1263%	125
Assela	0.3090	-0.2436	1280%	175
DD	0.2852	0.4302	1349%	515
Dessie	0.3023	0.2017	1287%	401
Gonder	0.3057	0.0397	1386%	725
Jimma	0.2492	0.6723	1332%	346
Mekelle	0.3165	-0.0386	1281%	783
Nazereth	0.2906	-0.4088	1257%	98
Robe	0.3126	-0.1605	1277%	430
Shash	0.3166	-0.0377	1279%	251
Eigenvalue	9.9264	0.7006		
Proportion Explained	0.9024	0.0637		
Cumulative Variation	0.9024	0.9661		

The first principal component assigns nearly equal (positive) weights to all the markets. It, therefore, shows that there is a common component to price changes in all markets. We demonstrate this by plotting the score values obtained using the weights of the principal components and the standardized market prices of the markets. Figure(4) below shows that except Dire Dawa and Gonder the average prices of markets are moving together throughout the period under consideration.

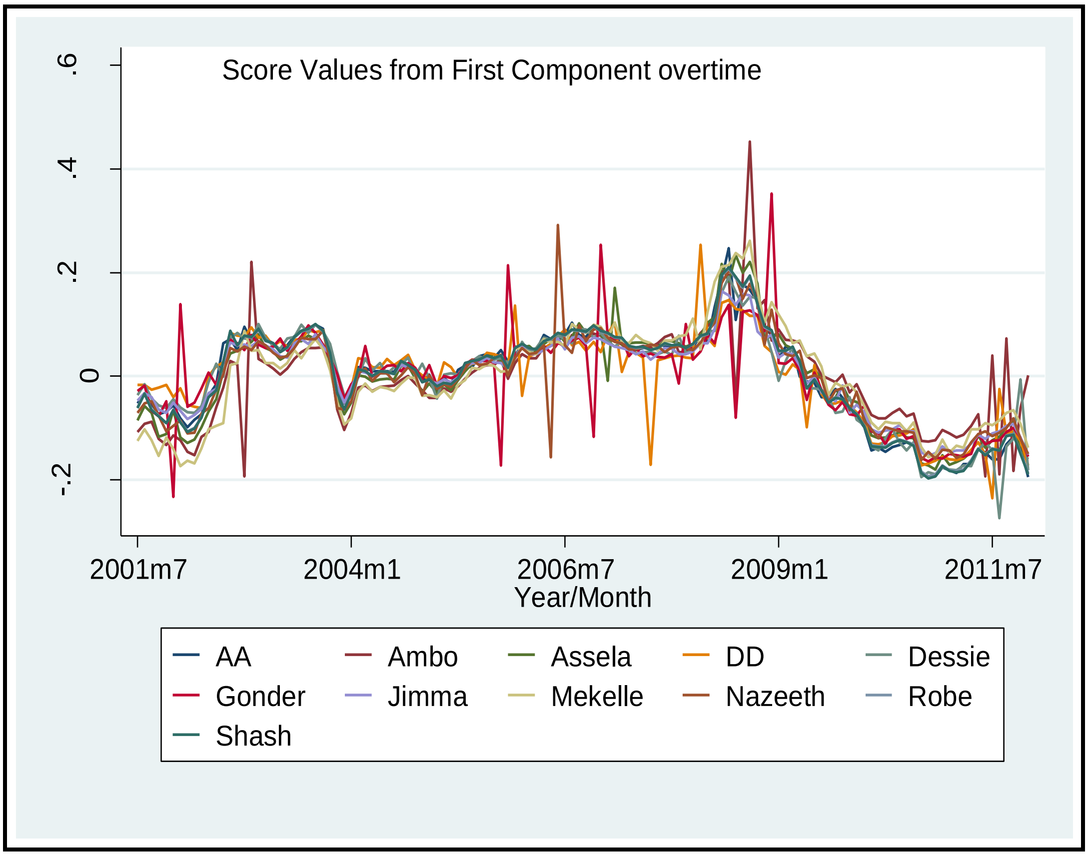

Figure 3.4 Score Values of Wheat Markets from First Component Overtime

The results from the second component provide more explanation on why the wheat prices of the two markets (Dire Dawa and Gonder) differ from the others. The second principal component helps us in categorizing markets in terms of the magnitude of price variability, as it provides patterns of price variability across markets. Though we find that the average price across markets is nearly the same, the second component elucidates that price variability across markets is different. We deduce from the results that there is a negative price variability correlation between markets located within the 300 km radius of the central market, Addis Ababa, and those located outside the 300 km radius, except Mekelle. That is, price variability within the 300 km radius is lower than price variability outside this radius implying that the further markets are located from the central market, the more variable wheat prices become. Figure (5) provides the patterns of price variability over time.

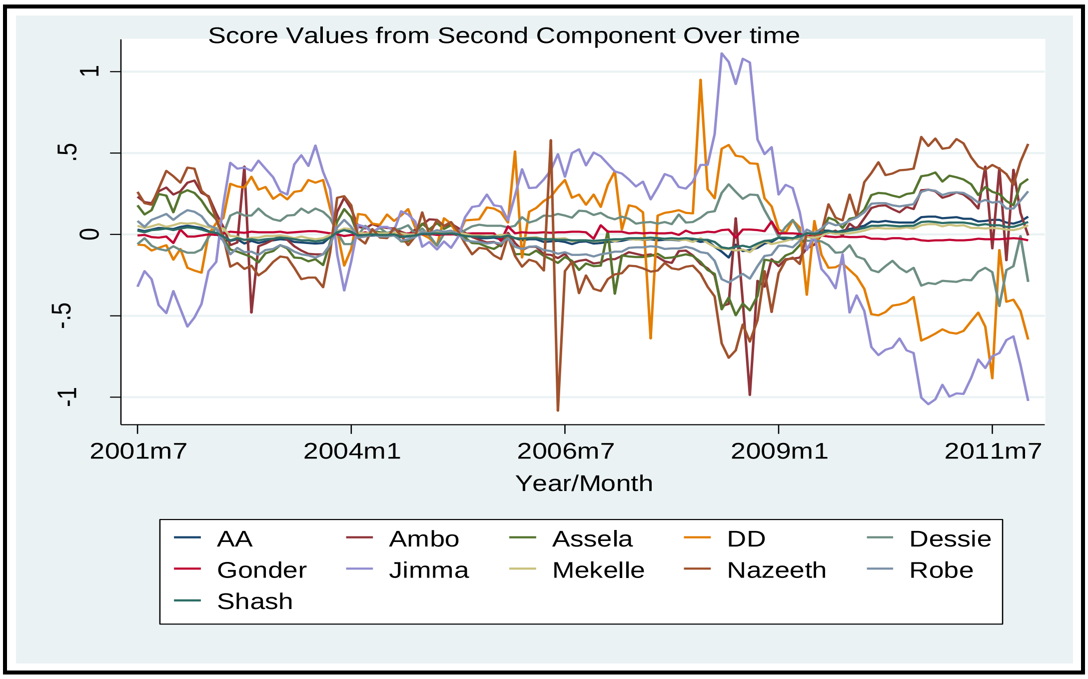

Figure 3.5 Score Values of Wheat Market from Second Component Overtime

3.4.1.1. PCA on Monthly Wheat Price Changes

To demonstrate the short run dynamics of the price movements across the markets, the PCA has been conducted on the monthly changes of the wheat price.

The PCA conducted on the monthly changes of the prices of wheat at different markets reveals that in the short run the average monthly change in the prices of wheat categorizes the markets under investigation into two blocks: Group 1- Ambo, Dire Dawa, Dessie, Gonder, and Nazereth; Group 2-Addis Ababa, Assela, Jimma, Mekelle, Robe, and Shashemene. In Group 1 we observe that the average monthly changes are less than Group 2.

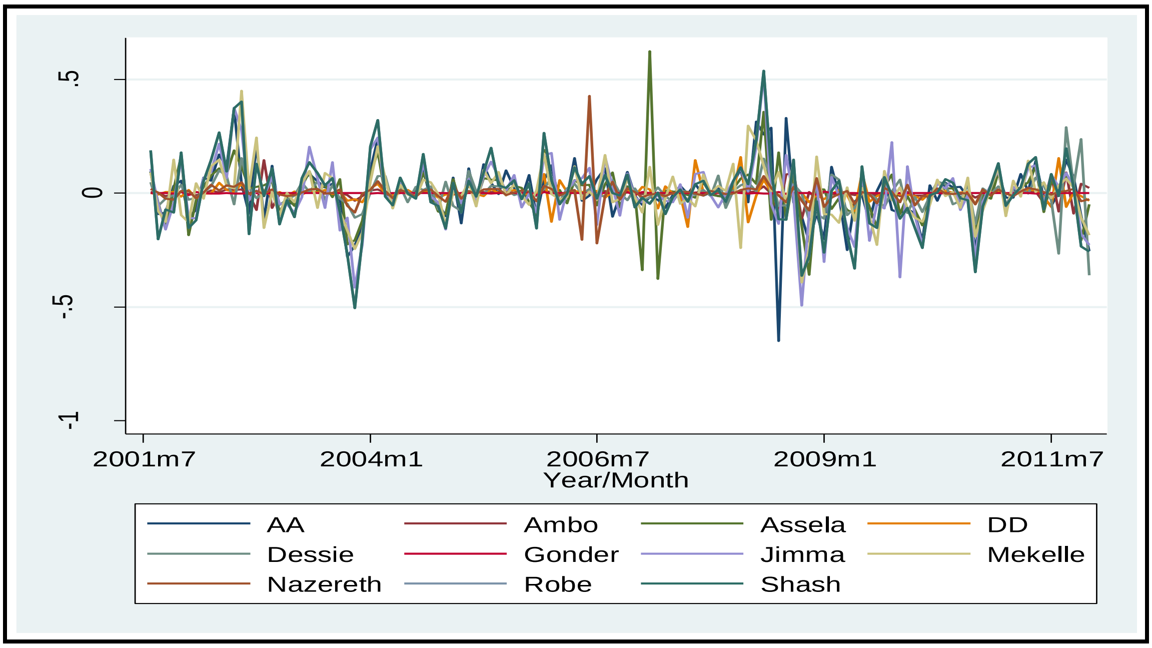

Figure 3.6 Score Values of Wheat Price Monthly Changes From First Component Overtime

From the second score value we observe that the price variability in the short run is the highest in Ambo, Dire Dawa, and Dessie.

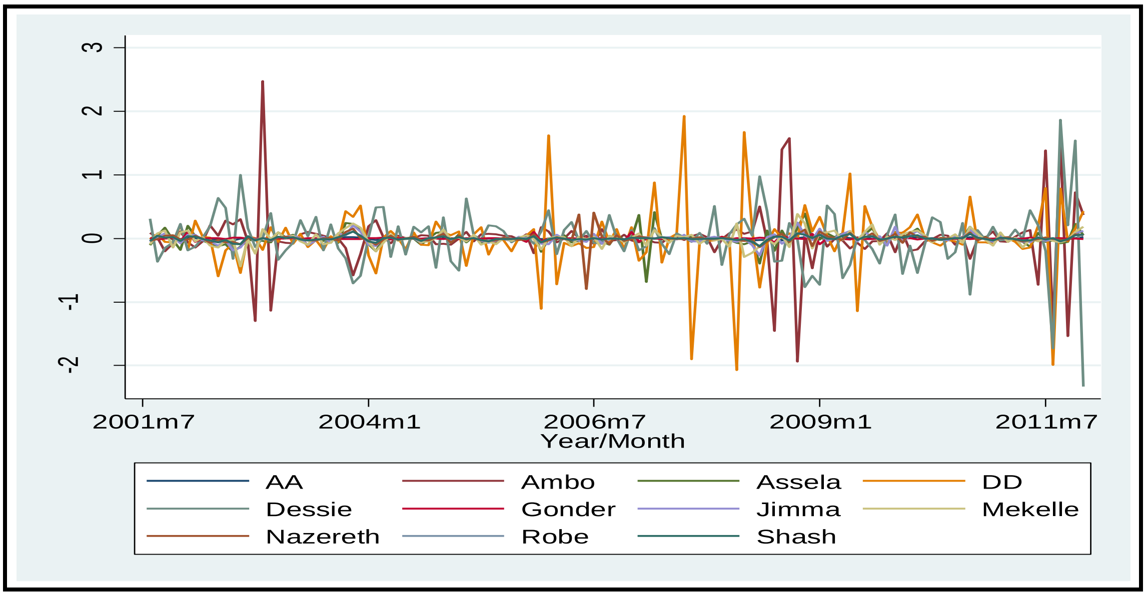

Figure 3.7 Score Values of Wheat Price Monthly Changes from Second Component Overtime

3.4.2 Maize Market

For the analysis of the maize market, we look into the maize prices of 10 local markets namely: Addis Ababa, Ambo, Dire Dawa, Dessie, Gonder, Jimma, Mekelle, Nazereth, Nekemete, and Shashemene. As for the case in the wheat market, Addis Ababa is considered the central maize market and all other local market prices compare against the Addis Ababa maize price.

The summary statistics provided in table (3.7) indicate that nominal prices have increased substantially between July 2001 and December 2011. The increase in Addis Ababa, Ambo, Jimma, Nekemte, and Shashemene happened to be above the increase in the national price level. In contrast, the Dire Dawa and Mekelle prices changed below the national average. As these two markets are deficit markets some kind of price stabilization intervention may have been introduced so that prices don`t change as large as the other markets. The real prices, on the other hand, have fallen in all markets except Nekemte. The percentage range of nominal prices also shows that price spikes are relatively low in the deficit markets compared with the central market and markets considered as surplus markets. However, when it comes to real prices the story is different, as we observe that even price stabilization interventions, if any, would not be able to effectively stabilize the market. Markets that appear to be benefiting from some form of price stabilization have not consistently reflected it in the real price series. For instance, the percentage range of real price in the Dire Dawa market exceeds the national percentage range by 50% showing that unlike its nominal counterpart real price in Dire Dawa has shown larger price spikes, yet below some of the markets located proximate to the central market.

Table 3.7 Summary Statistics of Nominal and Real Prices of Maize in 10 Markets

Markets	**Percentage change July 2001 to December 2011**		**Percentage Range over the same period**		**Standard deviations of monthly changes**		**Mean**		**Standard Deviation**	
	Nominal	**Real**	**Nominal**	**Real**	**Nominal**	**Real**	**Nominal**	**Real**	**Nominal**	**Real**
AA	309%	-13%	954%	383%	10%	30%	20.28	14.43	3764%	461%
Ambo	328%	-9%	1151%	438%	10%	32%	19.16	13.49	3763%	457%
DD	22%	-74%	541%	429%	11%	35%	25.27	19.19	3874%	757%
Dessie	212%	-33%	824%	375%	10%	29%	21.13	15.16	3776%	465%
Gonder	235%	-28%	801%	329%	9%	29%	21.26	15.32	3607%	467%
Jimma	387%	4%	1358%	460%	12%	36%	18.22	12.73	3782%	462%
Mekelle	177%	-41%	690%	344%	9%	28%	23.38	17.08	3749%	495%
Nazereth	209%	-34%	940%	366%	14%	45%	19.81	14.11	3600%	433%
Nekemete	443%	16%	1563%	495%	13%	39%	17.47	12.09	3775%	459%
Shash	313%	-12%	1076%	403%	11%	35%	19.45	13.73	3745%	454%
National	259%	-23%	925%	379%	10%	30%	20.08	14.26	3730%	451%

Source: Authors` calculation using data from EGTE

With regard to price variability, the standard deviation of monthly changes shows that the nominal price variability has not shown a difference of more than one percentage point across markets including the national price, with the exception of Jimma, Nekemete, and Nazereth, which have, 12%, 13%, and 14% nominal price variability, respectively. The variability in the real prices appeared to be higher than the variability in the national price level in 6 of the 11 markets, the highest being in Nazereth. The two deficit markets, Dire Dawa and Mekelle, have higher average prices than the other markets. The overall price variability provided by the standard deviation of the price series over the entire period indicates that maize prices are more variable in Dire Dawa than any other market. In most markets, the nominal maize price variability is above the variability in the national nominal price, the exceptions are Nazereth and Gonder. Nazereth also has demonstrated the lowest variability in real prices, which is below the national real price variability.

As indicated in Table (3.8) we retained only two principal components, since the first two principal components explain 98% of the variation in the price data of the 10 local maize markets. The first principal component sheds light on the pattern of average maize price across the 10 local markets. It shows that average maize prices move together across 9 of the 10 markets studied, except Dire Dawa. Because, Dire Dawa market is a deficit market and located far from the central market at a distance of over 600 kms, and hence it is expected that average prices would be higher. Unlike Dire Dawa, markets such as Gonder and Mekelle both located at a distance of 600 and 783 kms, respectively, have average maize prices equivalent to the average price of other markets. This implies that the distance barrier as an obstacle to market integration has been overcome following the infrastructure developments observed in the areas where these markets are located.

The second component, on the other hand, hints the extent of price variability in the deficit and surplus markets. It projects into Dire Dawa and Mekelle and compares their price variability to the other markets. As it can be seen from the score values of the second component depicted in Figure (9), prices are more variable in Dire Dawa than any other market, followed by Mekelle. Thus from the results we observe that improving market infrastructure would help in making prices less unpredictable across regions in the country. This is because of the fact that in integrated markets shocks in one market will instantly transmit to the other market and affect the other market either proportionately or less proportionately depending on the extent of integration. For this reason, within a certain time period markets adjust to nearly the same level of average prices, resulting in one national price.

Table 3.8 PCA results, Standard Deviation, and Distance from central market, Maize Market

Variables	**Comp1**	**Comp2**	**Nominal Maize Price**	**Distance in Km from the central market**
AA	0.3352	-0.0375	3764%	
Ambo	0.3332	-0.1037	3763%	125
DD	0.1344	0.9577	3874%	515
Dessie	0.3344	0.0373	3776%	401
Gonder	0.3246	-0.0528	3607%	725
Jimma	0.3302	-0.1366	3782%	346
Mekelle	0.3253	0.1222	3749%	783
Nazereth	0.3297	0.0137	3600%	98
Nekemete	0.3266	-0.1699	3775%	430
Shash	0.3333	-0.0618	3745%	251
Eigenvalue	8.8652	0.9098		
Proportion Explained	0.8865	0.0910		
Cumulative Variation	0.8865	0.9775		

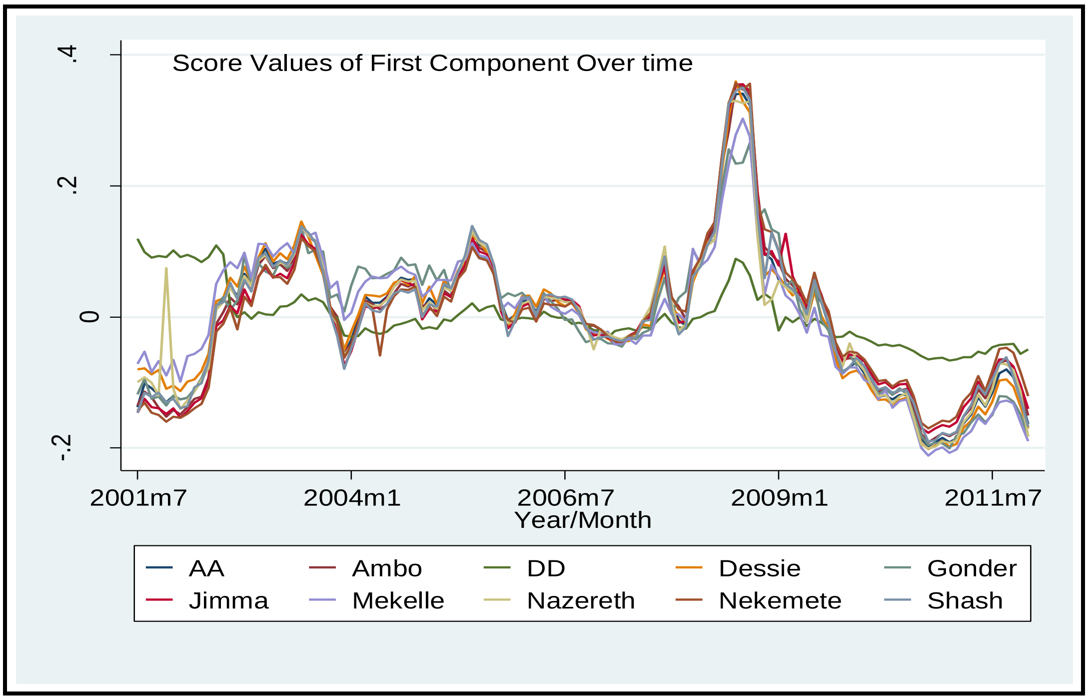

Figure 3.8 Score Values of Maize Markets from First Component Overtime

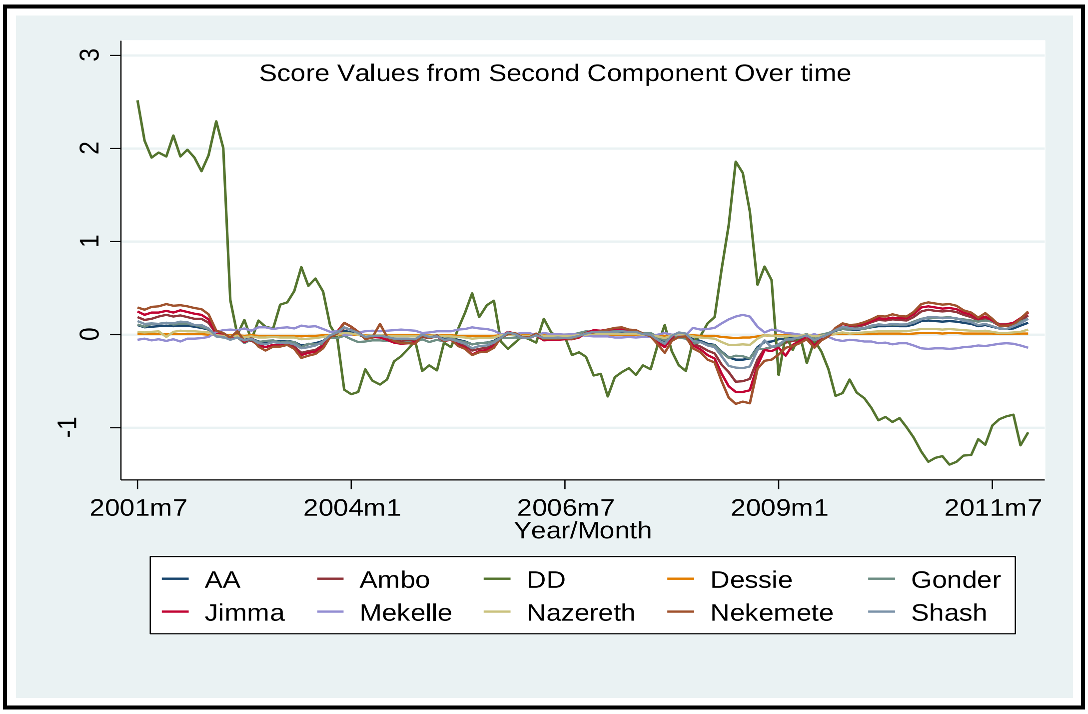

Figure 3.9 Score Values of Maize Markets from Second Component Overtime

3.4.2.1. PCA on Monthly Maize Price Changes

The PCA employed on monthly price changes, as discussed in section 4.3, implies the co-movement of prices in different markets in the short run. As can be seen from Figure 10 below, the prices in all markets follow a similar trend in the short run, except Dire Dawa. Thus, those markets known as deficit markets in maize production such as Mekelle, Gonder, and Dessie have shown improvement overtime following the development of market infrastructure. However, Dire Dawa, despite such developments remained an isolated deficit market characterized by price trends moving contrary to the markets under consideration.

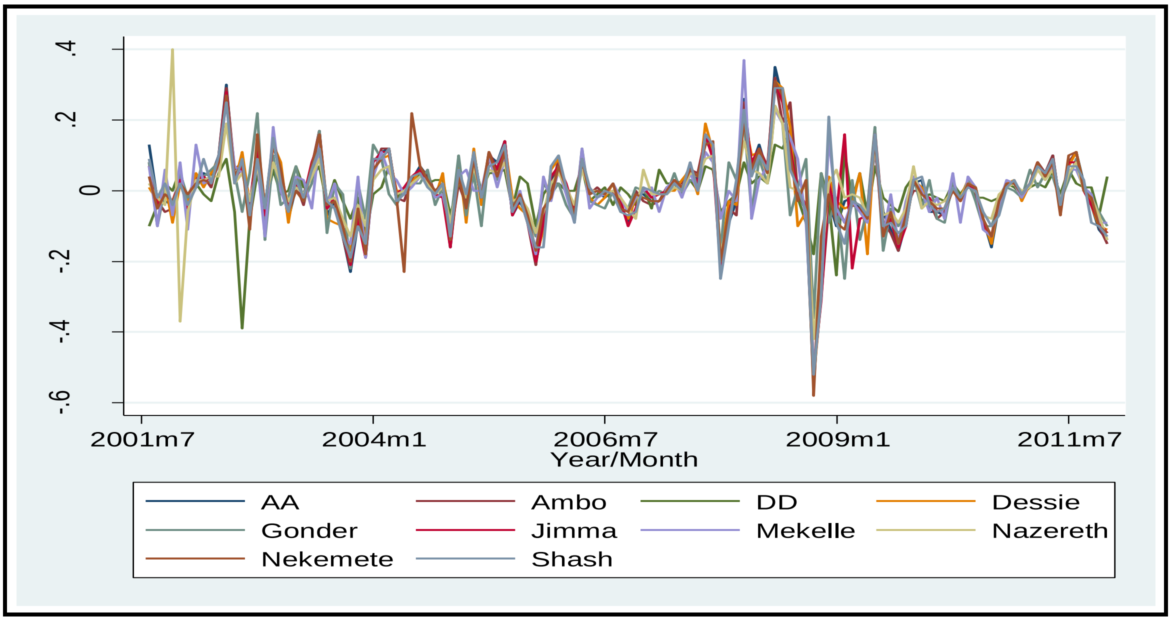

Figure 3.10 Score Value of Maize Price Monthly Changes from First Component Overtime

With regard to the variability of the monthly price changes across markets, the second component of the PCA on monthly price changes reveals that the prices are more variable in the short run in Dire Dawa followed by Nazereth and Shashemene.

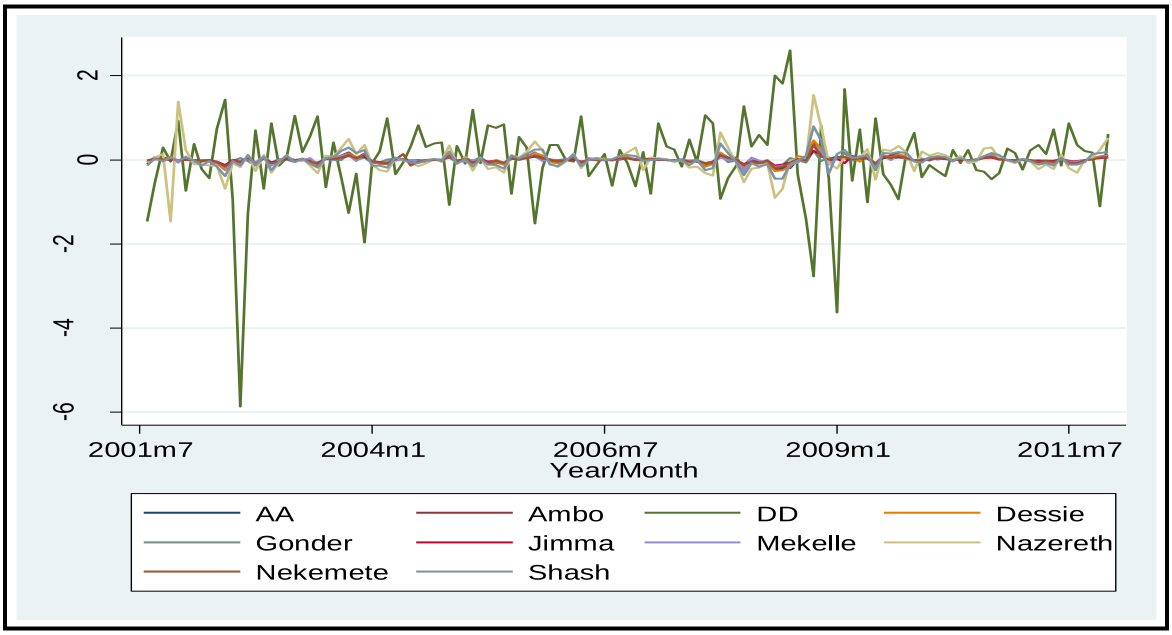

Figure 3.11 Score Value of Maize Monthly Price Changes from Second Component Overtime

3.5. Price Spreads

As an exposition to the long run tendency of the integration of local markets, in this part we discuss the pattern of price spreads between the central market, Addis Ababa, and other local markets of wheat and maize.

Negative values of average price spreads show that prices in Addis Ababa are lower than the corresponding local markets and vice versa. In the wheat market the highest average price spreads occurred in Ambo and Mekelle, where real wheat prices were below the Addis Ababa price by $5.16 and $4.88 per ton, respectively (see Table 3.9 below). In markets such as Dire Dawa, Gonder and Dessie wheat prices have been on average above the Addis Ababa price by the amount $2.14, $1.06, and $0.88 per ton, respectively. Two points emerge from these results. First, even if Ambo is the market closest to Addis Ababa, the real wheat price difference between the two markets happens to be larger on average. However, the price spreads have declined over time (see appendix 3C). The reason for such price difference may relate to the intervention of intermediate market brokers who might have distorted market information despite the closeness of the market to the centre. This, in turn, implies that the structure of market organization by itself plays a significant role in price determination and transmission of price signals across markets. Second, in contrast to its wheat production status and distance from the central market, the Mekelle market has exhibited higher positive price spread on average implying that real wheat prices in Mekelle have been lower than the central market over the period under consideration. This might be due to the food aid releases to the area and the subsequent effect of such intervention on market prices.

The stationarity test of price spreads (last column of Table 3.9) from the central market for all markets shows that in the long run the price differences across markets tend to die out indicating that the integration of local markets has been improving over time.

Table 3.9 Price Spreads from the central market of Wheat, July 2001 to December 2011

Markets	Average Price Spread	Standard Deviation of Price Spreads	Distance (in Km)	Is Spread Stationary?
Ambo	5.16	1249%	125	Yes
Assela	2.21	483%	175	Yes
DD	-2.14	866%	515	Yes
Dessie	-0.88	452%	401	Yes
Gonder	-1.06	1240%	725	Yes
Jimma	0.45	247%	346	Yes
Mekelle	4.88	798%	783	Yes
Nazereth	1.82	686%	98	Yes
Robe	0.51	218%	430	Yes
Shash	0.51	218%	251	Yes

With regard to maize market**,** the price spreads, as reported in Table (3.10), indicate that markets further from the central market have the highest average price spreads. In other words, the real maize price that prevails in the central market has been lower than other local markets located in a distance of more than 400 kms, with the exception of Nekemte. The maize market of Nekemte appears to be relatively less integrated to the central market. However, the graphical illustration of the price spreads indicates that price spreads between Nekemte and the central market have been declining owing to the development of infrastructure connecting the two market sites (see appendix 3C). Likewise, the Mekelle maize market also appears to be weakly integrated into the central market; but it has shown improvement over time.

Table 3.10 Price Spreads from the central of market maize, July 2001 to December 2011

Markets	**Average Price Spread**	**Standard Deviation of Spreads**	**Distance**	**Is Price Spread Stationary?**
Ambo	0.94	1.64	125	Yes
DD	-4.76	25.22	515	Yes
Dessie	-0.73	1.77	401	Yes
Gonder	-0.89	4.45	725	Yes
Jimma	1.70	2.65	346	Yes
Mekelle	-2.65	4.74	783	Yes?
Nazereth	0.32	3.38	98	Yes
Nekemete	2.33	3.52	430	No?
Shash	0.69	1.71	251	Yes

Summary of the Results of Intra-Regional Market Integration

Wheat Market

- Nominal wheat prices increased substantially in all markets. The increase in most of the markets, except Dire Dawa, Dessie, and Jimma, was well above the increase in the national prices.

- The real prices of wheat have fallen in all markets over the period from July 2001 to December 2011; however, Ambo exceptionally has shown an increase of about 60 per cent.

- Price variability in Ambo, Dire Dawa, Gonder and Nazereth appeared to be more than twice as large as the variability in other wheat markets. However, the average price over the entire period across markets has not shown substantial difference.

- Results from PCA of the wheat market show that except Dire Dawa and Gonder, average wheat prices across markets are moving together over the entire period under consideration.

- Further, we observe that there is a negative price variability correlation between markets located within the 300 Km radius of the central market, Addis Ababa, and those located outside the 300 Km radius, with the exception of Mekelle. This implies that the further markets are located from the capital, or the central market, the more variable wheat prices become.

- With regard to the short run characterization of the wheat market, wheat prices in Ambo, Dire Dawa, Dessie, and Nazereth tend to move together whereas prices in

Addis Ababa, Assela, Jimma, Mekelle, Robe, and Shashemene move together. However, higher short run price variability is observed in Ambo, Dire Dawa, and Dessie.

Maize Market

- Nominal prices of maize have increased substantially across markets between July 2001 and December 2011. The increase observed in Addis Ababa, Ambo, Jimma, Nekemte, and Shashemene happened to be above the increase in the national price level. In contrast, the Dire Dawa and Mekelle prices changed below the national average.

- The real prices of maize, on the other hand, have fallen in all markets except Nekemte. Price spikes in maize market appear to be low in the deficit markets compared to the central market and the markets considered as surplus markets.

- The nominal price variability has not shown a difference of more than one percentage point across markets including the national price, with the exception of Jimma, Nekemte and Nazereth, which have 12%, 13%, and 14% nominal price variability, respectively.

- The overall price variability provided by the standard deviation of the price series over the entire period indicates that maize prices are more variable in Dire Dawa than any other markets.

- The PCA results also show that the average maize prices move together in all markets studied, except Dire Dawa.

- Unlike Dire Dawa, markets such as Gonder and Mekelle located at a distance of 600 Kms and 700Kms, respectively, have shown average maize prices equivalent to the average price of other markets. This implies that the distance barrier as an obstacle to market integration has been overcome following the national infrastructure developments. Nevertheless, maize prices appear to be more variable in Dire Dawa and Mekelle.

- With regard to the short run price dynamics, maize price in all markets demonstrated a similar trend, except in Dire Dawa. The short run price variability happened to be more in Dire Dawa followed by Nazereth and Shashemene.

Price Spreads

- In the wheat market, the highest average price spreads occurred in Ambo and Mekelle, where real prices of wheat were below the Addis Ababa price by $5.16, and $4.88 per ton, respectively.

- Looking the price spreads between the central market and other markets we observe that even if Ambo is the market closest to the central market, the difference in the real prices of wheat between the two markets happens to be larger on average, but the spreads have been declining over time. On the other hand, Mekelle has exhibited higher positive price spread on average implying that real prices of wheat in Mekelle have been lower than the central market in the period under consideration.

- The stationarity test of the price spreads for all markets shows that in the long run the price differences across markets tend to die out indicating that the integration of local markets has been improving.

- The price spreads of the maize market reveal that the real price of maize that prevail in the central market has been lower than other local markets located at a distance of more than 400 Kms, with the exception of Nekemte. However, the price spreads are converging overtime implying that maize markets across the country has become more integrated overtime.

3.6. Conclusion

Following the commodity market crisis between 2006 and 2008 and later in 2011, the global concern has shifted towards understanding the food price dynamics and its impacts so that such an understanding helps in designing policy responses. Particularly, since the increased food prices caused significant challenges for developing countries, where households spend a larger share of their income on food, studying how the domestic markets are linked to the world market and the extent of the pass through of the increases in food prices in the international market to domestic markets has become an essential part of food policy making.

Various studies have shown that transmission of food price shocks to domestic markets depends on the importance of the commodity in the country`s food staple, food status of the country, domestic factors, and policies. These factors come together in many different ways to limit the pass through of global food price inflation to domestic markets.

In this study, we addressed two issues. Firstly, we have shown that the domestic grain market prices, though thought to be structurally isolated, appeared to be integrated to the international grain market. This has been demonstrated using two exchange market prices for each commodity against which we analyze the integration of Ethiopian grain market to the world market. That is, we used US maize and SAFEX maize prices as maize exchange market prices and examined the relationship with the Ethiopian maize market. For wheat, we used Paris milling wheat and Chicago Board of Trade (CBOT) soft wheat prices as exchange market prices and investigated the relationship of them with the Ethiopian wheat market.

We found that the Ethiopian wheat market is integrated into the world market as evidenced by its cointegration with the Paris wheat market. However, the cointegration happened to be uni-directional as only Paris wheat market reacts to the price developments in Ethiopia. No cointegration is observed between Ethiopian wheat market and Chicago exchange wheat market. This implies that the Ethiopian wheat market is integrated to the international wheat market, which is geographically closer to it. This is evidenced by the fact that Ethiopia imports most of its wheat from the Black sea and Mediterranean ports, for it requires lower transportation cost and the wheat imported through these ports is purchased with lower price at the exchange markets located in Europe.

Further, the Ethiopian maize market also appears integrated into the world market. However, we have seen that geographically the nearest exchange market (SAFEX) is relevant in the evolution of domestic maize prices as SAFEX maize prices are linked to the Ethiopian maize market. While the US maize market does show no cointegration. However, the results must be taken with caution, as the no-cointegration relation does not necessarily guarantee that there is no prices pass through between any two markets investigated. Therefore, it might be helpful to further investigate a regime switching cointegration model to see whether the co-integrations observed are due to some form of policy interventions.

The cointegration relationship with the inclusion of exchange rate implies that the identified cointegration exists only when an instatenous exchange rate pass-through is assumed. The bivariate cointegration tests of the domestic prices and the exchange rate implies that there is no link between the domestic prices and the exchange rate. Therefore, the cointegration relationship identified with an implicit assumption of instantaneous pass-through may be related to such assumption and hence the interpretation of the results must consider this. The important implication of the results is that exchange rate regimes that link with the domestic price would facilitate the price pass through from international to domestic markets. Thus, for the exchange rate to be a viable instrument in insulating domestic markets from external price shocks, developing and strengthening the mechanism through which monetary policy transmits to the domestic agricultural prices is crucial.

In the study further, we examined domestic market price integration. The Ethiopian grain market have been under the influence of policy changes that resulted from the changes in governments and hence their ideologies towards the functioning of the market. In the post 1991 period, though not full-fledged, the grain market in Ethiopia has shown improvement. This is mainly attributable to the developments in infrastructure such as road networking and telephone service expansion.

Nonetheless, despite such developments, we observe that in the domestic wheat market price variability appears to be higher in the markets located in a distance outside the 300Km radius of the central market. The exception in this regard is Mekelle, which has been categorized as deficit market. With regard to the short run characterization of the wheat market, wheat prices in Ambo, Dire Dawa, Dessie, and Nazereth tend to move together whereas prices in Addis Ababa, Assela, Jimma, Mekelle, Robe, and Shashemene move together. The short run price variability tends to be the highest in Ambo, Dire Dawa, and Dessie.

In the maize market analysis, we found that Gonder and Mekelle located at a distance of 600 Kms and 700Kms, respectively, have shown average maize prices equivalent to the average price of other markets. This implies that overtime the problem of distance barrier as an obstacle to market integration has been improving following the national infrastructure developments.

The price spreads between the central market and other markets have shown that over time the price differences are declining. But we observe that even if Ambo is the market closest to the central market, the difference in the real prices of wheat between the two markets happen to be larger on average, but the spreads have been declining over time. On the other hand, Mekelle has exhibited higher positive price spread on average implying that real prices of wheat in Mekelle have been lower than the central market in the period under consideration.

These mixed results imply that domestic market integration is not complete. Thus further intensification of the investment in market infrastructure and development of market institutions is essential so that the differences in prices and hence the price volatility across domestic markets could be reduced.

The analysis on price transmission indicated that the Ethiopian grain market is affected by changes in food prices in the international market. The link may further develop owing to changes in food security status of the country, improvements in agricultural productivity, and hence trading positions of the country. An increase in agricultural productivity that results in an increased marketable surplus may change the country's trading position from net importer to net exporter. This, in turn, enhances integration into the international market and may broaden the mechanism through which changes in international food prices pass through to the domestic market. Thus, more dependence on cereal consumption, especially wheat and maize, may expose domestic consumers to a possible welfare losses or gains that emanate from food price volatilities in the international market. Producers, on the other hand, may benefit from higher prices provided that input prices change less proportionately than changes in food prices. However, they lose if food prices crush down. Therefore, more openness of the economy and increased participation in the international grain trade may have trade-offs. This requires improving institutional capacity to monitor price changes and to evaluate the resulting welfare impacts on both producers and consumers.

Further strengthening the link between domestic markets and international markets would foster agricultural commercialization. To this end, creating access for information with regard to international grain prices and providing technical assistance so that the producers produce in line with the quality and standard requirements of grains, especially wheat and maize, traded in the international markets will serve as an incentive for producers. However, for this to happen introducing improved agricultural technologies, facilitating access for finance, and organizing the small holders into cooperatives and building the capacity of the cooperatives should be given due attention.

Strong integration and efficiency of local markets provides a conducive platform for participation in the international markets. Ensuring efficient flow of market information across regions improves market efficiency and may guarantee producers to claim a fair share of the final price of their output. This will have a positive impact on productivity and welfare of the producers. Above all, it facilitates agricultural commercialization as market orientation among farmers develops.

Thus, the government and other development partners that actively engage in development programs, which aim at transforming the agricultural sector in particular, the structure of the economy in general, have to focus on improving market linkages among producers, traders, and other actors along the food value chain. More specifically, expanding physical infrastructure and creating a mechanism to supply reliable market information to the producers, largely small holders, is crucial.

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3.8. Appendix

Appendix 3A

Missing Value Imputation Technique

The missing values of the price series of the local markets have been interpolated using the following technique after (Gilbert, 2011).

Let the price of a commodity in market m and month t be p_{mt}, $(m = 1,....,n; t = 1,....,T)$.

The set of months for which p_{mt} is observed for a market m is denoted by S_m. To estimate the missing prices suppose

$$\ln p_{mt} = \ln \pi_t + \delta_{mt} + \varepsilon_{mt}$$

Where π_t is the (unobserved) representative national price in month t, δ_m is the average market m differential relative to the national average and ε_{mt} is a random error. Given estimates $\hat{\pi}_t$ and $\hat{\delta}_{mt}$, a missing price, $\tilde{p}_{mt}$, can be estimated as

$$\ln \hat{p}_{mt} = \ln \hat{\pi}_t + \hat{\delta}_{mt} \qquad \left(t \in S_m\right)$$

The procedure implemented in this paper is as follows:

I. For the price series where we have at least one price observation for a month t, we estimate π_t as a median of the observed prices. Here we use median instead of the average since the median will be less affected by the pattern of missing observations and the presence of high and low price markets.

II. If no prices are reported for a particular month t, which rarely happens, we interpolate the national price of that particular month as $\ln \hat{\pi}_t = \frac{1}{2}[\ln \hat{\pi}_{t-1} + \ln \hat{\pi}_{t+1}]$. We have not faced this problem in this study, however.

III. Then we estimate the differentials $\tilde{\delta}_{mt} = \ln p_{mt} - \ln \hat{\pi}_t \quad (t \in S_m)$. Suppose the differentials are AR (1), $\delta_{mt} = \kappa_m + \rho_m \delta_{m,t-1} + \upsilon_{mt}$. We estimate the parameters of this AR(1) by OLS over S_m, this allows interpolation of δ_{mt} as

$\hat{\delta}_{mt} = \hat{\kappa}_m + \hat{\rho}_m \hat{\delta}_{m,t-1}$, in the case that $t-1 \in S_m$ and $\hat{\delta}_{mt} = \hat{\kappa}_m + \hat{\rho}_m \hat{\delta}_{m,t+1}$, otherwise.

The national prices of all food crops considered in this paper are medians of the local market prices for the missing values of any particular month has been interpolated using the above technique.

Appendix 3B

Chronology of Government Grain market interventions in Ethiopia, 1992-2011

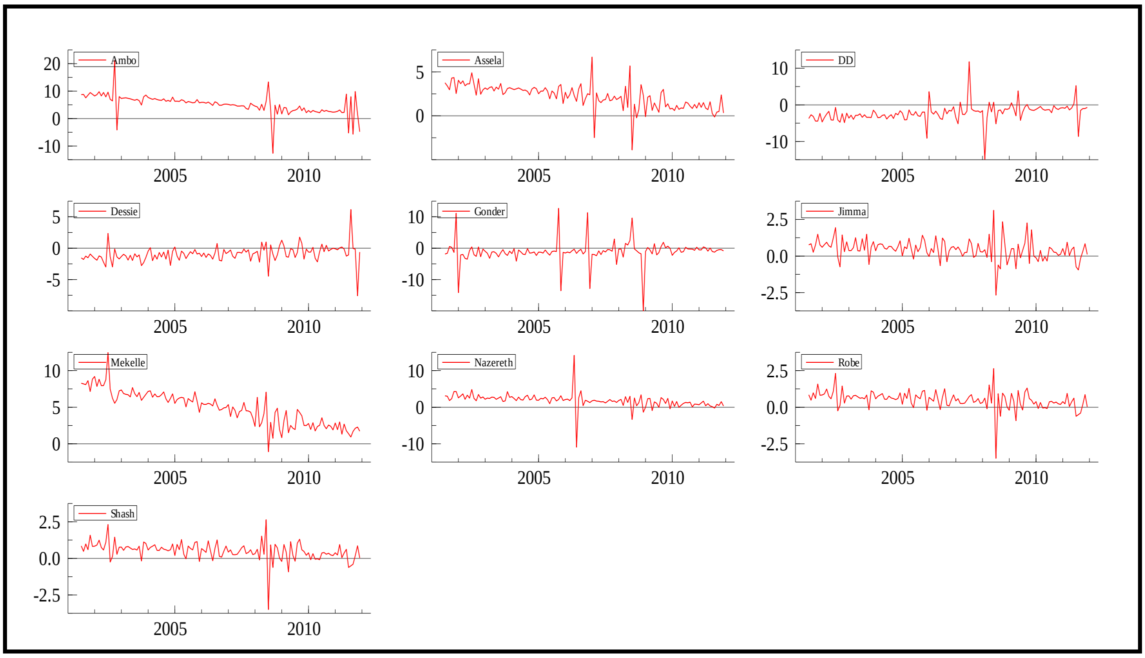
Proclamation/Notice/ Regulation No. and Year	Relevant Institution Affected	Stated Objectives of Policy Intervention
Council of Ministers Regulation No. 25/1992	Ethiopian Grain Trade Enterprise (EGTE)	✓ To stabilize markets and prices in order to encourage producers to increase their output and protect consumers from unfair grain prices ✓ To export grains o earn foreign exchange ✓ To maintain grain buffer stock for market stabilization, and to engage in any other activity for the attainment of its objectives
Council of Ministers Regulation No. 58/1999	Ethiopian Grain Trade Enterprise (EGTE)	✓ To purchase grain from farmers and sell in local and mainly in export markets ✓ To contribute toward stabilization of markets for farmers` produce to encourage them to increase their outputs ✓ To engage in other related activities conducive to the attainment of its purpose
Proclamation No. 67/2000	Ethiopian Food Security Reserve Administration	✓ To provide adequate capacity to prevent disaster through loan provision, to the Disaster Preparedness and Prevention Commission (DPPC) and organizations involved in humanitarian relief activities
Proclamation No. 212/2000	National Disaster Prevention and Preparedness Fund Establishment	✓ To maintain a readily available cash reserve to combat disasters which are likely to threaten the lives of the people and livestock until other resources can be mobilized locally or from abroad ✓ To assist the implementation of Employment Generation Schemes (EGS) that would support the achievement of the National Food Security
Proclamation No. 380/2004	Ethiopian Grain Trade Enterprise (EGTE)	✓ The accountability of EGTE change from the public enterprise authority to Ministry of Agriculture and Rural Development
Ethiopian Commodity Exchange Proclamation No. 550/2007	Ethiopian Commodity Exchange (ECX)	✓ To create an efficient, transparent, and orderly marketing system that serves the needs of the buyers, sellers, and intermediaries and that promotes increased market participation of Ethiopian small holder producers ✓ To provide automated back office operation to record, monitor, and publicly disseminate information on Exchange transactions
Ethiopian Commodity Exchange Proclamation No. 551/2007	Ethiopian Commodity Exchange (ECX)	✓ To ensure the development of an efficient modern trading system, and to regulate and control the secure, transparent, and stable functioning of a commodity exchange and to protect the rights and benefits of sellers, buyers, intermediaries and the general public
01 May 2008		✓ VAT removed on food commodities ✓ The Government imported 150,000 tonnes of wheat for the state subsidized distribution scheme implemented since March 2008 ✓ Export Ban on cereals

13 July 2010		✓ Export ban on cereals lifted following good harvests and lower prices on domestic markets
07 January 2011		✓ Maximum consumer prices set up for 17 basic food commodity items. Price caps introduced on 17 consumer items

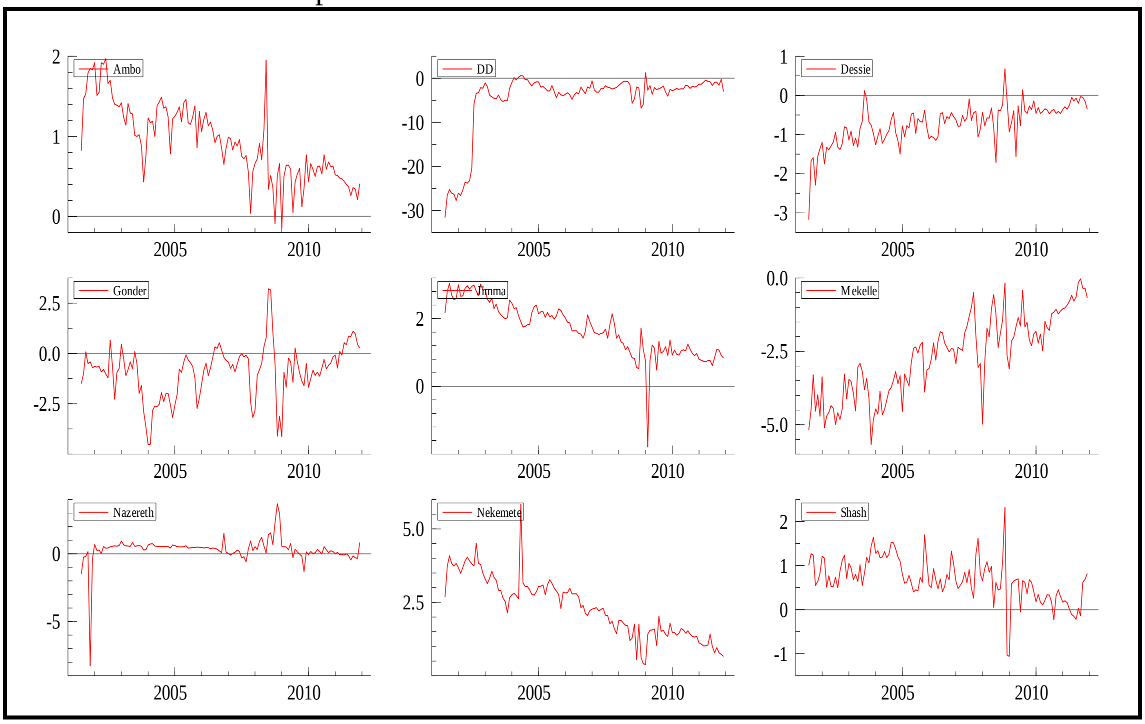
Source: Rashid and Asfaw (2012) and FAO/GIEWS

Appendix 3C

1. Wheat Market Price Spreads Overtime



2. Maize Market Price Spreads overtime



Appendix 3D

Table 3.11 Results of Wheat Market Principal Components Analysis (Principal Components)

Principal Components	Number of observations	126
(Components/Correlation)	Number of components	4
	Trace	11
Rotation: Unrotated Principal	Rho	0.9871

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	9.9264	9.2258	0.9024	0.9024
Comp2	0.7006	0.5569	0.0637	0.9661
Comp3	0.1437	0.0568	0.0131	0.9792
Comp4	0.0869	0.0270	0.0079	0.9871
Comp5	0.0598	0.0180	0.0054	0.9925
Comp6	0.0419	0.0273	0.0038	0.9963
Comp7	0.0146	0.0033	0.0013	0.9976
Comp8	0.0113	0.0015	0.0010	0.9987
Comp9	0.0098	0.0050	0.0009	0.9995
Comp10	0.0047	0.0044	0.0004	1.0000
Comp11	0.0003		0.0000	1.0000

Table 3.12 Eigenvectors of the first four Wheat Market Principal Components

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
AA	0.3139	-0.0573	-0.0584	0.0404	0.0186
Ambo	0.3084	-0.2496	0.2712	0.5746	0.0031
Assela	0.3090	-0.2436	-0.1466	-0.1674	0.0213
DD	0.2852	0.4302	-0.1824	0.4130	0.0678
Dessie	0.3023	0.2017	-0.0870	0.1209	0.0541
Gonder	0.3057	0.0397	0.9011	-0.1457	0.0010
Jimma	0.2492	0.6723	-0.0683	-0.0180	0.0091
Mekelle	0.3165	-0.0386	-0.0550	-0.4358	0.0352
Nazereth	0.2906	-0.4088	-0.0750	-0.4527	0.0664
Robe	0.3126	-0.1605	-0.0972	-0.0246	0.0049
Shash	0.3166	-0.0377	-0.0972	-0.0246	0.0049

Table 3.13 Results of Maize Market Principal Components Analysis (Principal Components)

Principal components	Number of observations		126
(Components/Correlation)	Number of Components		4
		Trace	10
Rotation: Unrotated: Principal		Rho	0.9954

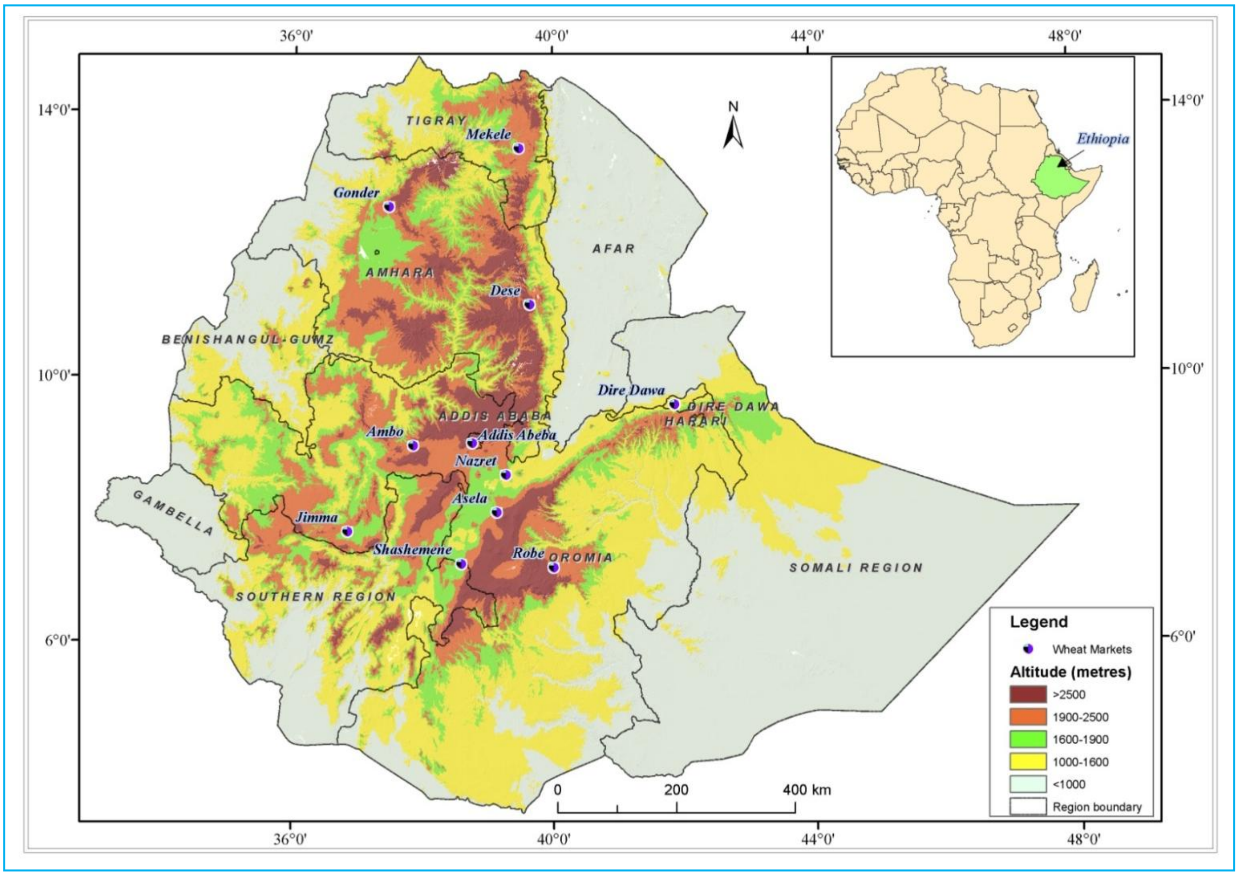
Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Comp1	8.8652	7.9554	0.8865	0.8865
Comp2	0.9098	0.7799	0.0910	0.9775
Comp3	0.1299	0.0810	0.0130	0.9905
Comp4	0.0489	0.0262	0.0049	0.9954
Comp5	0.0227	0.0149	0.0023	0.9977
Comp6	0.0079	0.0019	0.0008	0.9984
Comp7	0.0060	0.0005	0.0006	0.9990
Comp8	0.0055	0.0026	0.0005	0.9996
Comp9	0.0028	0.0016	0.0003	0.9999
Comp10	0.0012	.	0.0001	1.0000

Table 3.14 Eigenvectors of the first four Maize Market Principal Components

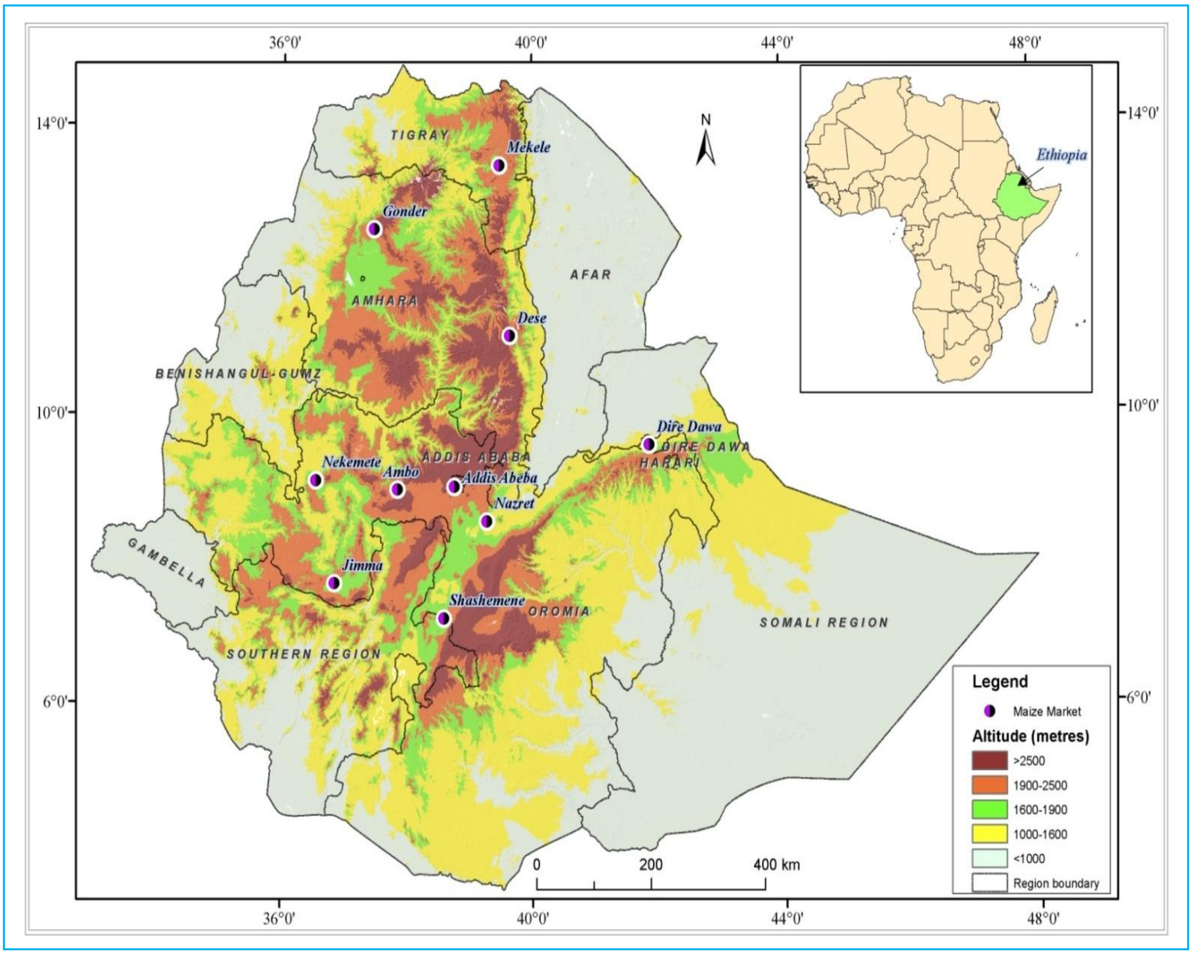
Variables	Comp1	Comp2	Comp3	Comp4	Unexplained
AA	0.3352	-0.0375	0.0278	-0.0253	0.0025
Ambo	0.3332	-0.1037	0.1397	0.1338	0.0026
DD	0.1344	0.9577	0.1727	0.1670	0.0001
Dessie	0.3344	0.0373	-0.0703	-0.1410	0.0056
Gonder	0.3246	-0.0528	-0.6063	0.4172	0.0069
Jimma	0.3302	-0.1366	0.2889	0.1616	0.0042
Mekelle	0.3253	0.1222	-0.5532	-0.2073	0.0065
Nazereth	0.3297	0.0137	0.1339	-0.7355	0.0074
Nekemete	0.3266	-0.1699	0.3695	0.3839	0.0034
Shash	0.3333	-0.0618	0.1829	-0.0469	0.0070

Appendix 3F

1. Map of Wheat Markets



2. Map of Maize Markets



Chapter 4: A Comparison of World and Domestic Price Volatility of Oilseeds

4.1 Introduction

Prices of agricultural commodities undergoing rapid adjustments were in the spotlight following the food crises in late 2007 and 2008, and again more recently in the summer and fall of 2010, raising concerns about increased price volatility, whether temporal or structural. The problems face all countries, which produce agricultural commodities, but are more serious for agricultural commodity dependent countries, which are dependent on agricultural commodity export. However, it is important to distinguish between the *ex ante* effects of volatility and *ex post* effects of extreme outcomes. The *ex ante* effects of volatility is that it induces farmers decisions towards or away from risky activities, whereas the *ex post* effects result from farmers adjustment of their expectations of future incomes in response to current earnings, or their current expenditure plans to the income short falls that they find difficult to cope with (Dehn et al, 2005). The same study shows that although poorer farmers consider weather-related risks, yield risks, illnesses of household members and weak demand for their off-farm labor as the main sources of their risks, price risks appear more important for commercially oriented farmers with surplus production and cash crop incomes. Evidences from coffee exporting developing countries, Nicaragua and Dominican Republic, show that price risks are the main sources of income risk (Ibd.).

Thus, in primary agricultural product exporting countries, uncertainty may have an impact on crop choice. To deal with the uncertainty and the resulting risk, farmers may engage in diversifying their farming across crops or family labor inputs across agricultural and non-agricultural activities. This may prevent farmers from exploiting comparative advantages, yet it can be effective in reducing risk. It may also influence the likelihood of adopting better agricultural technologies and improving farming efficiency. As a result, it retards economic growth and puts substantial strain on efforts to reduce poverty.

The impact of price volatility is high on governments that heavily depend on revenues from commodity exports. The linkage between commodity prices and government revenues can be either direct, through export taxation, or indirect, if fluctuations in commodity export revenues are transmitted to the broader economy and hence to government receipts (Dehn et al., 2005). However, the impact of variability of commodity export revenues on government revenues will be broadly proportional to the share of the commodity exports in the overall exports.

Since African countries have been less successful in diversifying their primary commodities export profile, the impacts of export revenue variability on government revenues are higher in Africa coffee producing countries than Latin American countries (Gilbert 2003 cited in Dehn et al. 2005). Further the study indicates that in some African countries like Kenya, Tanzania, and Cameroon diversification of sources of revenues have reduced the impacts of export revenue variability on government revenue. However, in most cases governments remained reliant on taxes of the traditional commodity exports. The implication of this is that commodity exporting African countries mainly need to have policies that encourage diversifying their sources of revenue so that the pressure from the export volatility of commodities on the macroeconomic stability could be reduced.

From the above discussion, we learn that commodity price volatility has formidable implications at the household level through its effects on production and consumption decisions, and on the macro level through its impacts on government revenue.

With this understanding, in this study we investigate price volatilities of domestic oilseeds prices and world oilseeds prices, and compare the degree of volatility in both markets. Investigating the price volatility of domestic oilseeds is important for two reasons. First, as oilseeds are the second largest export items in the Ethiopian primary commodity export profile, the implications of price volatilities in the prices of these commodities would be formidable both on the welfare of producer households that cultivate oilseeds for commercial purpose. Second, we characterize the oilseeds price volatility patterns both in the domestic market and in the world market and compare the magnitude of the volatility between the two markets. Third, and most importantly, understanding the domestic price volatility may help to identify cause of the shock and design appropriate policies that help in overcoming the adverse effects of extreme volatility on household`s production decisions, and hence on government revenue. This is because higher price volatilities may imply price risk and influence production decisions of oilseeds producing households. This, in turn, may affect level of oilseeds production and hence exports levels, with an implication on government revenues.

Oilseed are the second largest export items in Ethiopia and support nearly 4 million small holder farmers, account for 7% of total area under grain crops, and 3% of the total grain production. Unlike any other grain crops in the country, around 50% of the oilseeds produced are marketed while 35% used or household consumption and 13% kept as a seed for the next season (CSA, 2012). Thus, the oilseeds sub-sector due to commercial orientation could be a vital starting point in the commercialization of the agricultural sector, and hence transformation of the agricultural sector to high value crops.

The oilseeds have been in the export items list of Ethiopia for a long time. When compared with cereals, which have no significant contribution in foreign exchange earnings, the oilseeds are important contributors to the country's foreign exchange earnings and help in diversifying the primary commodity export profile and relieve the heavy dependence on coffee as the crucial source of foreign exchange earnings.

Recently, for instance, the exports of sesame have overtaken the long held position of coffee as the major foreign exchange earning export item. This shows that there is a potential in the oilseeds subsector that enable the country diversify its primary commodity export profile towards high value crops such as oilseeds, pulses, vegetables, and fruits. The recent addition of flower export and its growing importance as a source of foreign exchange is also an indication that rather than relying on a few primary commodities diversifying on the export profile helps in dealing with shocks in primary commodity prices.

Despite the importance of the sub-sector, the attention given to the oilseeds sector has been minimal. Studies conducted to characterize the local oilseeds market are very few.

For instance, in an effort to show the importance of other primary commodities that have the potential to contribute to the diversification, Rashid et al. (2010) studied the potential of pulses in the Ethiopian agriculture, challenges in the pulses value chain, and implies the way forward. The study shows that pulses account for 10% of the agricultural value addition, and are the third largest export crops following coffee and sesame. Most importantly, pulses, as a high value export crop, contribute greatly towards the small holder farmers` income, serve as a relatively cheaper sources of protein that account approximately 15% of protein intake by farm households. However, the potential of the pulses sector is constrained by low productivity, currently blow 50% of the potential; undeveloped export markets due mainly to inconsistent policy interventions, lack of scale efficiencies as small holders dominate in the production, and poor market acumen (Rashid et al., 2010).

Table 4.1 Shares of Coffee, Oilseeds, and Pulses out of the total export value (%)

	Year					
Export crop item	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**2010/11**	**2011/12**
Coffee	35.80	35.80	26.00	26.40	30.60	26.40
Oilseeds	15.80	14.90	24.60	17.90	11.90	15.00
Pulses	5.90	9.80	6.30	6.50	5.00	5.10

Source: NBE Annual Reports various Years

As Table 4.1 shows the share of the oilseeds out of the total value of exports declined between 2006/07 and 2011/12. The share of oilseeds out of the total export value reached the maximum in 2007/08 over the six years period between 2006/07 and 2011/12, and then dropped subsequently. The fluctuations in export earnings from these commodities are commensurate with the fact that primary commodities are vulnerable to shocks in the world market. Such vulnerability to external shocks, which is beyond the control of the exporting countries, substantially hampers the livelihoods of poor smallholder farmers and results in uncertainties in production decisions and affects government revenue.

Studies that put the tradable sector into international perspectives and analyze its linkage to the world market are essential to forecast the movements of the world market trend and its linkage to domestic market and hence the implications on farm households.
We also explore the production, consumption, and trade performance of oilseeds both in the world market and in the domestic market.

Using a historical data from February 1999 to December 2012, we have analyzed the un-conditional and conditional price volatilities of oilseeds. The unconditional volatility is studied using standard deviation of monthly price changes (log of price returns), and the conditional volatility analyzed using GARCH (1, 1).

The results reveal that the unconditional price volatility comparison over different periods between 1999 and 2012 shows that over the entire period the unconditional price volatilities of oilseed items is higher in the domestic market than the World market. However, when observed periodically, the unconditional price volatility tends to follow the World market situation. The conditional variance estimates (GARCH (1, 1)) imply that in the domestic market there is no problem of volatility persistence where as volatility persistence appears as the characteristic of the World market. Volatility clustering happens to be the common feature of both the domestic and the world market. .

Nonetheless, the magnitude of the influence of the news about past volatility on current volatility differs across crops and markets. The magnitude of the influence of the news about past volatility (innovations) is higher in domestic markets than the World market for Rapeseed, whereas in the case of Linseed the effects of the news are higher on the world market than the domestic market.

The remaining parts of the chapter are organized as follows section 2 describes production, consumption, and trade of oilseeds in the world and in Ethiopia, section 3 discusses data source and methodology; section 4 provides results and discussion; and section 5 concludes.

4.2. Oilseeds: production, consumption, and trade

4.2.1 Production

At the global level, production of oilseeds has shown an overall growth rate of 83 % between the years 1995 and 2012. However, the annual growth rate of production has been highly volatile with a coefficient of variation of 131% due to various reasons, which may include weather variability, change in cropping pattern, and price volatility, among others.

As can be seen from Figure 4.1, the growth rate in area cultivated for oilseeds production has shown an overall growth rate of 38 % between the years 1995 and 2012. The yield per hectare has shown an increase of 33 percent (increased from 1.53 in 1995 to 2.04 tonnes per hectare in 2012) implying that at the global level a great deal of improvement in productivity in the oilseeds production has come from the use of improved technology applied in the farming of oilseeds. Consolidating this argument, the correlation between the growth rates of area cultivated and yield levels appears to be -0.35 implying that an increase in area cultivated does not necessarily result in an increase in output of oilseeds (see Figure 4.2).

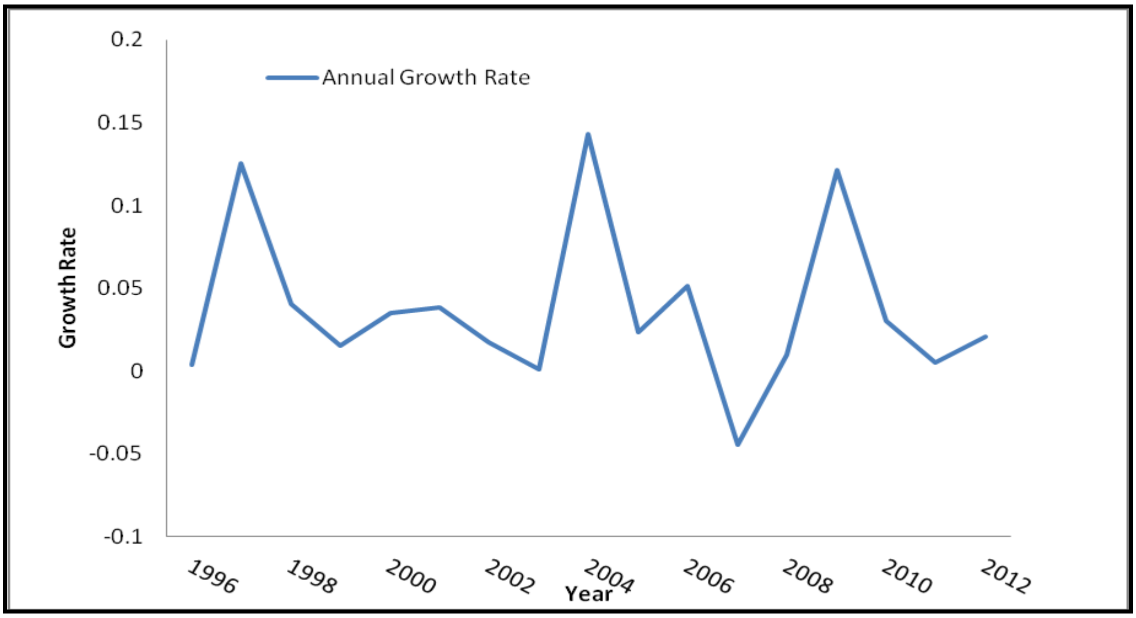


Figure 4.1 Global Oilseeds Production Annual Growth Rate (1996-2012).

Source: FAOSTAT, 2012

Although area harvested and yield have shown a similar average growth rate over the entire period between 1995 and 2012, they have shown a substantial difference in the fluctuation of the annual growth rates provided by their coefficient of variation of the growth rates of the 2 variables, 160 % for area cultivated and 269% for yield. In line with the above argument, the higher level of variability in yield can be associated with the increased application of improved technology in the production process of oilseeds. Figure 4.2 below shows that the movement in the growth rates of area cultivated and yield indicates the inverse relationships that discussed in the above discussion. We observe that an increase in the growth of area cultivated is not accompanied by a corresponding increase in yield level and an increase in yield level is not entirely a result of an increase in area cultivated. Despite all these facts, production of oilseeds at the global level has shown a remarkable growth over the period under consideration.

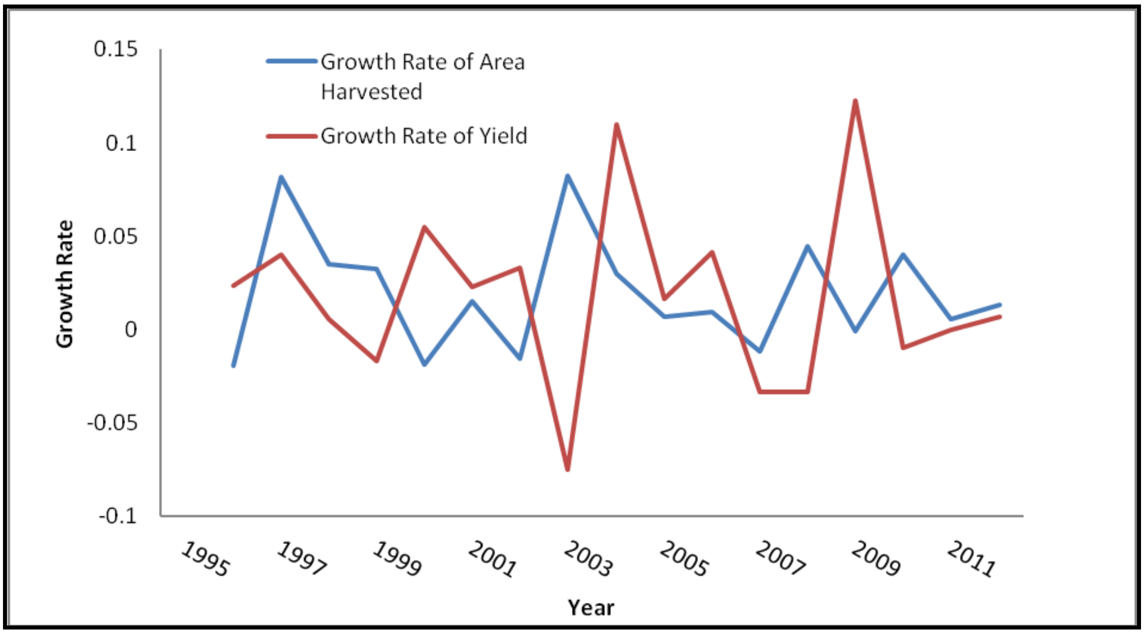


Figure 4.2 Growth rates of area harvested and yield, Global.

Source: FAOSTAT, 2012

In Ethiopia oilseeds constitute 7% of the total area (818.5 thousand ha) under grain crops (cereals, oilseeds, and pulses) and 3% of the total grain production. The sector supports around 4 million small farmers that produce oilseeds for domestic consumption and the market. The major oilseeds cultivated are Niger seed (*nueg*), Linseed, groundnuts, sunflower, sesame, and rapeseed. Of these, Niger seed accounts for 37% of total area under oilseeds and 29% of total oilseeds production. Sesame is the second largest oilseed following Niger seed; it accounts for 29% of total area under oilseed crops and 25% of total oilseeds production. Linseed, Groundnuts, and Rapeseed are also the other important oilseeds produced. Linseed, Groundnuts, and

Rapeseed cover 16%, 11%, and 6% of the total area under oilseed crops and 17%, 17% and 10% of the total oilseed production, respectively.

Oilseeds production over the period 1974 to 2012 shows that between 1974 and 1993 production of oilseeds has shown a remarkable growth that mainly came from the gains in productivity (see appendix 4A). However, the change in production between 1994 and 2012 has not been as remarkable as it had been prior to 1993 and the registered growth resulted from area expansion. This is striking for two reasons. First, prior to 1993 the policy environment towards agriculture and the broad economy was not considered favourable to bring growth to the agricultural sector and the overall economy. It has also been implied by various studies that the incentives to stimulate productivity in the agricultural sector have been non-existent. Rather, the output market had been centralized and price controls were put in place depressing the price levels far below the market prices (Rashid et al, 2009). Befekadu and Tesfaye (1990) on the other hand, show that the increased productivity of oilseeds ring the Socialist regime may relate to shift in the mix of production as farmers switch from production of cereals to oilseeds in order to evade the grain delivery quota set by the AMC.

Second, after 1993 the new economic policy reforms introduced appeared to be favourable in terms of getting-rid-off the distortions that dragged the economy backwards and tied up the economic agents from fully exploiting the opportunities, that possibly come along their way. To this end, to stimulate the agricultural sector the post 1991 government (the incumbent) has adopted a strategy known as Agriculture-Led Industrialization (ADLI) in 1995.

Since then ADLI lived up as a flagship strategy of the agricultural sector. Despite such a strategy and other subsequent policy documents adopted to reform and restructure the input and output markets, and improving infrastructure over the last two decades, what the second largest export commodity, oilseeds, sector has been implying is dismal. This is evidenced by the fall in the growth rate of yield/ha from 14% between 1974 and 1993 to 5.4% between 1994 and 2012. However, the average yield/ha in absolute terms increased from 4.7 (1974-1993) to 5.8 metric tonnes (1994 and 2012).

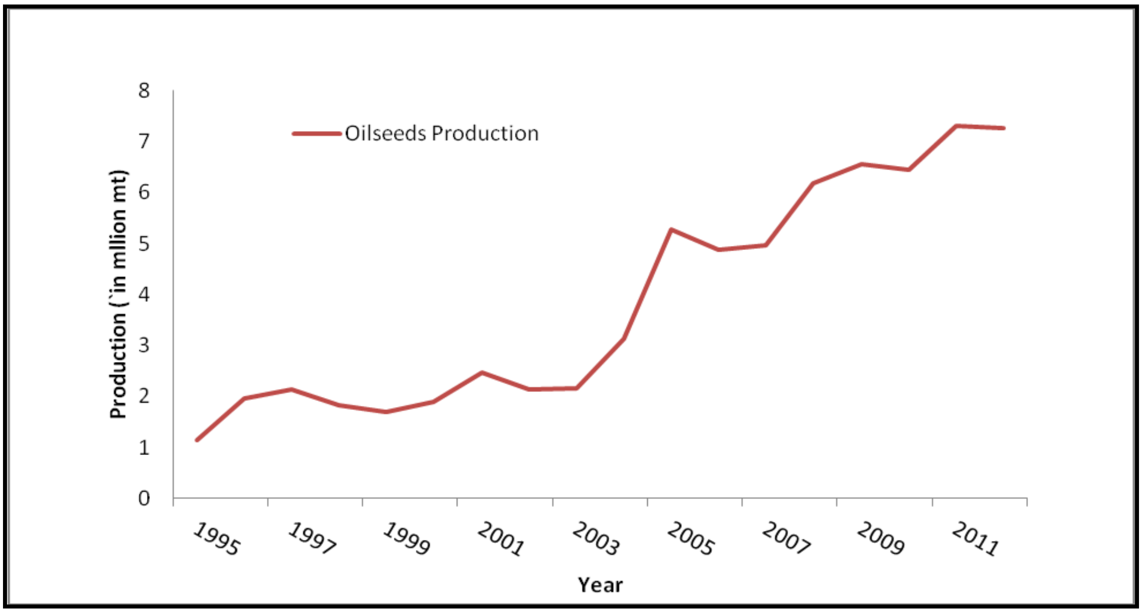


Figure 4.8 Production of Oilseeds (1995-2012).
Source: CSA Agricultural Sample Survey Reports various years

4.2.2 Consumption

Consumption of oilseeds at the global level has increased over the period from 1995 to 2012. However, the rate at which the consumption increases has slowed down since 2008 registering a growth rate below its 1999 level. Over the entire period, consumption of oilseeds has grown on average by about 3.4%, where as the growth in other uses of oilseeds on averaged 1.8% over the entire period. However, the growth in other uses is much more volatile than the growth in consumption with 10.2% and 2.6% standard deviation, respectively (OECDSTAT, 2013).

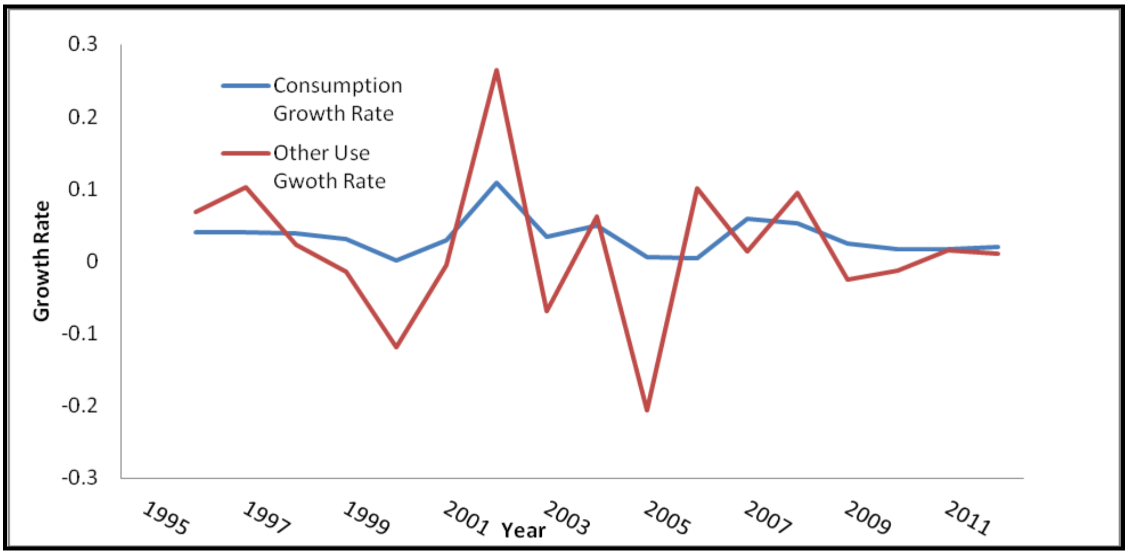


Figure 4.3 Growth Rate of Consumption and Other Uses of Oilseeds.

Source: OECDSTAT, 2013

The data buttress that unlike cereals and pulses, oilseeds production in Ethiopia is mainly for sale. CSA (2012) shows that 35%, 13% and nearly 50% of the oilseeds produced were used for household consumption, seed, and sale, respectively[1].

4.2.3 Trade

The global export trends of oilseeds since 1961 to 2010 are demonstrated in Figure 4.4. The Oilseeds export pattern shows a growing trend since 1961. However, it had peaked between the years 1970 and 1973 and dropped back to its pre 1970 level. After the year 1974, the oilseeds export quantity increased steadfastly. The dramatic rise in exports took place since the year 1994 onwards.

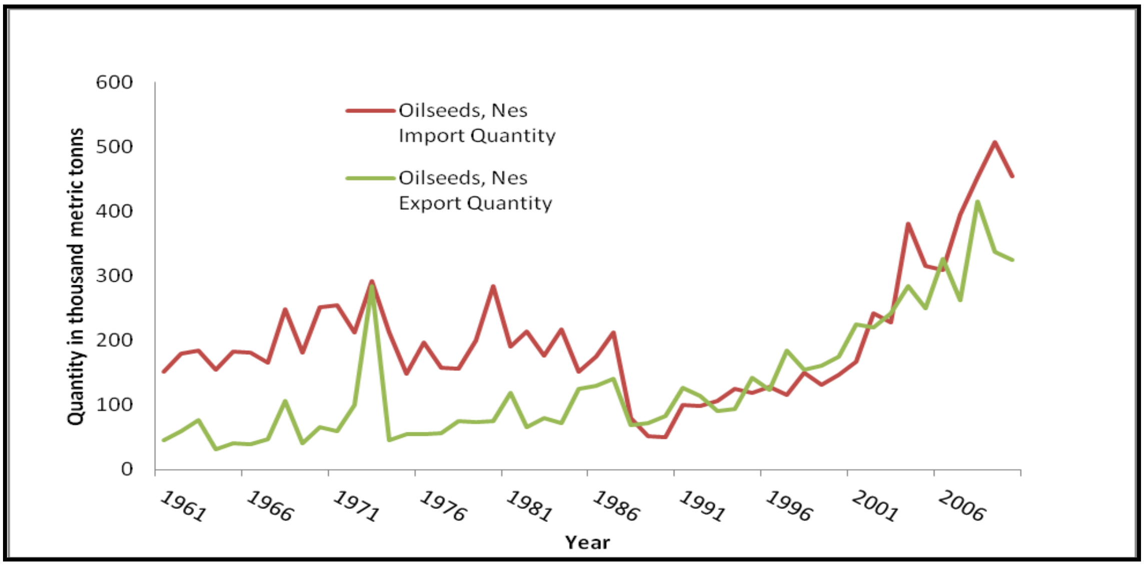


Figure 4.4 Export and Import Quantities of World Oilseeds from 1961 to 2010.

Source: FAOSTAT, 2012

[1] Followers of the Ethiopia Orthodox Church, which constitute more than 40% of the country`s population don`t consume meat, dairy and dairy products during the fasting days which happen to be above 250 days when strictly executed. As a result, vegetable oils are widely used and hence oilseeds cultivation is an important agricultural activity with a huge potential domestic market.

The trade performance of oilseeds implies that oilseeds export has dropped since the early 70s and remained below 50 thousand metric tonnes up until the early 2000s and rose up until 2005 and dropped between 2006 and 2008 might be due to the fall in demand following the financial crisis occurred during the same period. Similarly, the amount of oilseeds imported remained below 5 thousand metric tonnes until 2005 and peaked to 24 thousand metric tonnes in 2006, and dropped the following year following the fall in exports. This may imply that the fall in exports may have been compensated by the fall in imports and hence rising domestic demand.

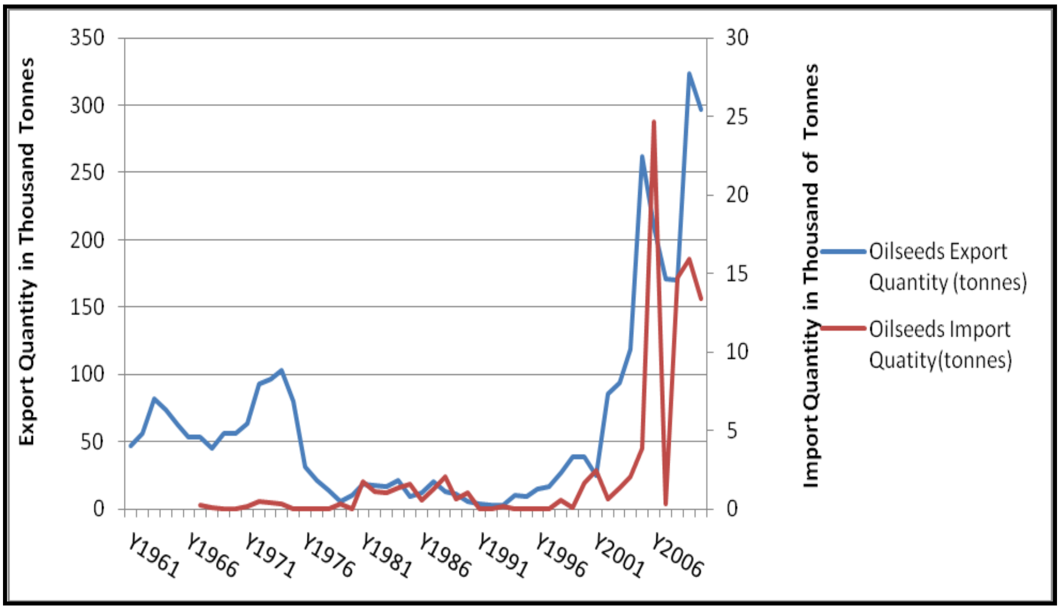


Figure 4.10 Oilseeds export and import, domestic market.

Source: FAOSTAT, 2012

4.3. Data Source and the Empirical Model

4.3.1. Data

For the study of price volatilities of oilseeds, we use a time series data on prices of Oilseeds for both domestic and international markets over the period between February 1999 and December 2012. The data for the domestic market is obtained from the Ethiopian Grain Trade Enterprise (EGTE). The international prices of the oilseeds corresponding to the items in the domestic market are obtained from International Financial Statistics (IFS) database of the International Monetary Fund (IMF). The descriptive statistics of the domestic oilseeds prices are provided in Table 4.2. As we observe from Table 4.2, between February 1999 and December 2012 Nigger seed (*nueg*) appeared to have the highest average price, USD 51 per quintal. The variance over the entire period also witnesses that Nigger seed has the highest variability, followed by Linseed.

Table 4.2 Descriptive Statistics of Domestic Nominal Oilseeds, February 1999 to December 2012

Statistics	Linseed	Nigger Seed	Rape Seed
Mean	45.99	50.94	36.26
Standard Err.	1.40	1.60	1.26
Standard Dev.	18.10	20.62	16.23
Minimum	17.43	20.18	13.35
Maximum	101.03	109.49	88.15
N	167	167	167

Source: Author`s Computation using data obtained from EGTE

The descriptive statistics of the international prices of oilseeds is provided in Table 4.3. Between January 1999 and December 2012, Linseed oil registered a higher average price USD 894/mt followed by palm oil and soybean oil. In terms of variability, Linseed happens to be the most variable followed by Soybean. The price spikes provided by the range of the data series indicates that Soybean oil prices witnessed the largest price spike followed by Linseed Oil prices.

Table 4.3 Descriptive Statistics of International Nominal Oilseeds Prices, January 1999-December 2012

Statistics	**Linseed oil**	**Palm oil**	**Soybean oil**	**Rape Seed**
Mean	894.01	568.97	689.43	366.54
Standard Error	30.92	22.11	24.37	12.40
Standard Dev.	400.82	286.59	315.81	160.77
Minimum	350.00	185.07	321.40	173.73
Maximum	1948.00	1248.55	1414.40	735.39
N	168	168	168	168

Source: Author`s Computation using data from IFS February 2013

4.3.2. The Empirical Model

Following Balcombe (2010), we measure the level of price volatility over different periods classified based on reasons interesting for volatility comparison. That is, we compare volatility between periods 1999-2004, 2005-2008, and 2009-2012 and the entire period.

The temporal classification of the data into the above-mentioned periods is important in two ways. First, it allows as comparing price movements before the onset of the global commodity price crises, to the crisis period and to price developments following the crisis. As Figures 4.11 and 4.12 indicate that domestic oilseeds prices started to increase as of early 2005, peaked between 2007 and late 2008 and started to drop in early 2009 and again rose up in late 2010, and finally started to drop after late 2011. The international oilseeds prices, except Linseed oil, show a similar trend to that of the domestic price movements. Thus, we classified the period into three periods based on such development, and with the purpose of comparing price volatilities during the high commodity price period with price volatilities before the onset of the crisis and after the end of the major crisis. The classification into such temporal space helps in characterizing price volatilities during such different periods characterized by different market developments. Second, linked to the first reason, classifying the comparison of volatilities into such time spaces helps us to identify how the world and domestic oilseeds markets have been behaving before, during and after the commodity crisis.

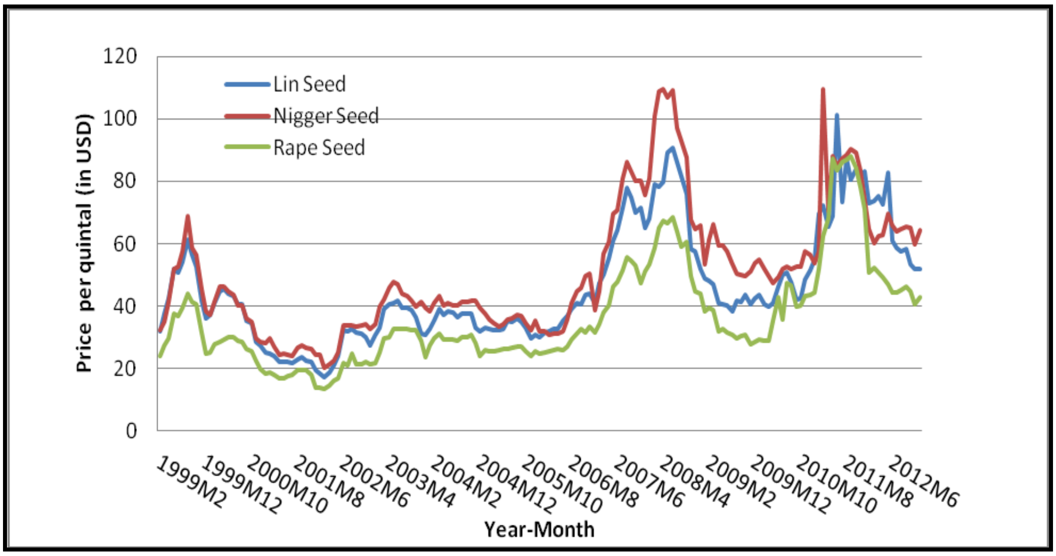


Figure 4.11 Domestic Oilseed Prices February 1999 to December 2012. Source: EGTE

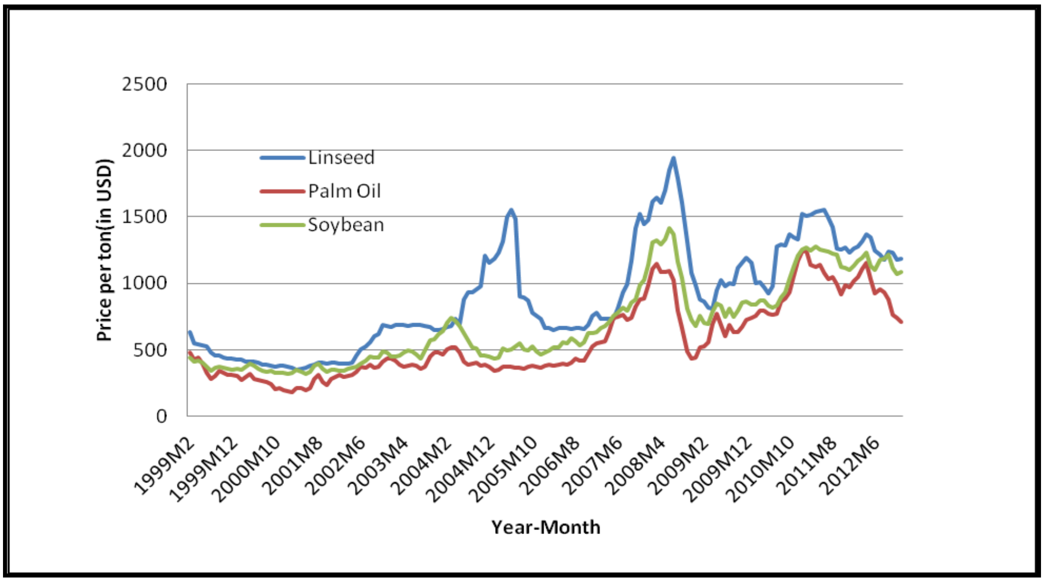


Figure 4.12 Domestic Oilseed Prices February 1999 to December 2012. Source: EGTE

The simple specification used is provided as follows:

$$V = \sqrt{\sum \tfrac{1}{N-1}\left(p_t - \overline{p}\right)^2}\,, \qquad (1)$$

Where V is volatility (standard deviation), p_t is the log of the price return, $\overline{p}$ the mean of the log price return, and N is the number of observations. This measure of volatility, which is a standard deviation of log price returns, provides the level of volatility over a specified period, but it doesn`t measure how it evolves within that period.

Thus, to investigate the movement of volatility over time we need to use models that help in capturing the change in variance of a variable over time. This leads us to models that study the volatility of a time series such as the Autoregressive Conditional Heteroscedasticity (ARCH) type models as first introduced by Engle (1982) and later generalized by Bollerslev (1986) and known as Generalized Autoregressive Conditional Heteroscedasticity (GARCH).

The study of volatility or variability of a time series has been motivated by problems in finance. The rationale for the ARCH and the later generalization of ARCH, GARCH modelling is that the underlying forecast variance of a price return may change over time and it is predicted in a better way by past forecast errors. The later generalization by Bollerslev (1986) included past (lagged) variance in the explanation of future variance which help in reducing the number of lagged terms used in the ARCH model.

Of all the GARCH models, GARCH (1, 1) is the most popular and widely used GARCH specification. For this reason, we also found it plausible to estimate the GARCH (1, 1) model. The mean and variance equations of the model, respectively, are given as:

$$p_t = \omega_0 + \omega_i p_{t-i} + \varepsilon_t \qquad (2)$$

$$\delta_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \delta_{t-1}^2 \qquad (3)$$

with the constraints $\alpha_0 > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$.

δ_t^2, is conditional variance because it is one period ahead forecast variance based on the past information. α_1, which is the coefficient of the lag of the squared residual from the mean equation (ε_{t-1}^2), is the ARCH term. It gives us the news about the volatility from the last period. The volatility clustering is implied by the size and significance of α_1 while β_1 is the GARCH term.

The sum of the ARCH and GARCH terms ($\alpha_1 + \beta_1$) measure persistence of volatility. If $\alpha_1 + \beta_1 = 1$, any shock to volatility is said to be permanent. This also may imply that the unconditional variance is infinite or an Integrated GARCH (IGARCH) process as indicated by Engle and Bollerslev (1986). In IGARCH volatility persistence is permanent and past volatility appears to significantly predict future volatility. If $\alpha_1 + \beta_1 > 1$, volatility is said to be explosive. That is, a shock to volatility in one period will lead to even greater volatility in the next period.

4.3.3. Estimation method for GARCH

In order to estimate the GARCH model, we first need to examine the time series properties of the data. Accordingly, we conducted a unit root test on the price series of both domestic and world oilseeds items and found out that all the return price series are stationary (see appendix 4B). Then we test for the ARCH effects using the ARCH-LM test to check for whether ARCH effects exist in the price series. The test for ARCH effects in the price return series is conducted using the Lagrange Multiplier test proposed by Engel (1982) and the procedure is described in the following section.

4.3.3.1. Lagrange Multiplier (LM) Test for ARCH Effects

We use the Lagrange Multiplier (LM) test to identify whether each of the time series has ARCH effects. Engel (1982) proposed the LM test for ARCH effects in a time series.

Under the null hypothesis, it is assumed that the model is standard dynamic regression, which can be written as

$$y_t = x_t\beta + \varepsilon_t \quad .... (1)$$

Where x_t is a set of weakly exogenous and lagged dependent variables and ε_t is a Gaussian white noise process,

$$\varepsilon_t \mid I_{t-1} \sim N(0, \delta^2) \quad .... (2)$$

Where I_{t-1} denotes the available information set. The alternative hypothesis is that the errors are ARCH *(q)*,

$$\varepsilon_t^2 = w + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 \quad .... (3)$$

The straightforward derivation of the LM test provided by Engel (1984) leads to the N*R^2 test statistic, where N is the sample size and R^2 is computed from the regression of ε_t^2 on a constant and $\varepsilon_{t-1}^2, ..., \varepsilon_{t-q}^2$. Under the null hypothesis that there is no ARCH, the test statistic is asymptotically distributed as χ^2 distribution with *q*-degrees of freedom. The intuition behind this test is that if the data are homoscedastic, then the variance cannot be predicted and variations in ε_t^2 will be purely random. However, when ARCH effects exist, large values of ε_t^2 will be predicted by large values of the past squared residuals.

As an alternative form of the LM test, we may use the asymptotically equivalent Portmanteau tests, such as the Ljung and Box (1978) statistics, for ε_t^2. The results of the ARCH effect test for the variables used in this study are presented in Table 4.4.

The results show that all the domestic oilseeds price and world oilseeds price series have ARCH effects. However, among the world oilseed prices, for Soybean and Rapeseed the ARCH effect is observed at the second lag.

Table 4.4 Lagrange Multiplier Test for ARCH Effects on domestic and world oilseed price returns

	χ^2	***df***	***p***$>\chi^2$
Domestic Prices			
Linseed	10.93	1	0.00
Niger Seed	31.45	1	0.01
Rape Seed	3.45	1	0.00
World Prices			
Linseed Oil	66.31	1	0.00
Palm Oil	4.29	1	0.04
Soybean Oil	8.11	2	0.02
Rape Seed	4.72	2	0.09

H0: no ARCH effects H1: ARCH (p) disturbance

Thus, since we found ARCH effects in the price series, the estimation of ARCH/GARCH model can be made in order to find out the conditional price volatility overtime.

4.4. Results and Discussion

4.4.1. Price volatility of oilseeds in the domestic market

The price volatility computed using the log real monthly price changes is reported in Table 4.4 for oilseeds traded in domestic market.

We measure volatility using standard deviation of the log monthly price changes over different periods in order to show changes in volatility over time. We compare volatilities over the entire period, pre-crisis period (February, 1999- December, 2004), during the recent food crisis (January 2005 to December 2008), and the post crisis period (January 2009- December 2012). We see that volatility has decreased during the commodity price boom in the world market, except Nigger seed; however, in the post crisis period volatility increased in all commodities. We can also see that oilseeds prices have become more volatile in the post crisis period implying that the uncertainty of price movements may have implications on production decisions.

The comparison of volatility between periods prior to 2005 and after 2009 shows that volatility increased in the prices of oilseeds. The analysis of the nominal price volatility by commodity over the corresponding times appears nearly identical to the above discussion.

Table 4.5 Volatility Measure Using Standard Deviation of Log of Monthly Price Changes

	All Period	1999-2004	2005-2008	2009-2012
Lin Seed	9.3	9.1	7.4	11.4
Nigger Seed	10.5	9.0	9.5	13.5
Rape Seed	9.4	9.9	6.4	11.0
Lin Seed	8.8	8.3	7.0	11.1
Nigger Seed	10.1	8.2	9.5	12.9
Rape Seed	8.7	9.2	6.2	10.0

In what follows, we explain the change in volatility over the period under consideration. Firstly, we explore volatility clustering and persistence. For this we use estimates from GACH (1, 1) model and explain how past volatility affects future volatility and the volatility clustering. In the estimation of Nigger seed prices, $\alpha+\beta$ exceeded 1 indicating that GARCH (1, 1) does not fit the data and we do not provide discussion of Niger seed conditional price volatility.

The estimation results for the volatilities of domestic oilseeds prices imply that in general the oilseeds prices in Ethiopia are volatile. α that demonstrate the contributions of past innovations (news) regarding volatility appears to be statistically significant for both oilseeds at 5% . These results show that there are problems of volatility clustering in the domestic oilseeds prices. On the other hand, β that shows the one period ahead forecast of volatility based on previous period volatility is found statistically significant for Linseed. Further, we conducted Wald test to check for persistence of volatility. As indicated in Table 4.6, volatility persistence in the linseed and rapeseed prices is rejected as the Wald test rejects the null hypothesis at 1% and 5% significance level, respectively.

The test for the joint significance of α & β shows that in all both cases the parameters are significantly different from zero with 1 % significance level.

Table 4.6 GARCH (1, 1) Coefficient Estimates for Oilseeds in the Domestic Market

Coefficients	Lin Seed	Rape Seed
ω	0.0034	0.0036
	(0.0011)	(0.0015)
α	0.2582	0.2461
	(0.1137)	(0.1201)
β	0.3290	0.2944
	(0.1297)	(0.2325)
$\alpha+\beta$	0.5872	0.5405
Wald Test (χ^2)	9.21	5.56
	[0.0024]	[0.0184]
Lc	172.5405	175.4346
$H_{0:}\ \alpha=\beta=0$	18.71	12.29
	[0.0001]	[0.0021]

Parenthesis (.) and [.] show standard errors and *p*-values, respectively.
Wald test null hypothesis is $\alpha+\beta=1$.

4.4.2. Price volatility of oilseeds in the world market

The Oilseeds volatility, as provided in Table 4.7, show that the volatility of Palm oil prices appear more volatile prior to 2005. Linseed oil, Soybean oil, and Rapeseed prices exhibited the highest volatility between 2005 and 2008. Over the entire period between 1999 and 2012, we observe that the price of Palm oil shows the highest volatility (8.5%), followed by Linseed oil (7.7%). Between 1999 and 2004, Palm oil price appears more volatile than any other oilseeds.

Table 4.7 Oilseeds Volatility Using Standard Deviation of Log of Monthly Price Changes, World

	All period	1999-2004	2005-2008	2009-2012
Nominal				
Linseed Oil	7.7	5.5	10.8	6.9
Palm Oil	8.5	8.9	8.6	7.8
Soybean Oil	6.3	6.0	7.4	5.3
Rapeseed	5.9	5.9	6.3	5.6
Real				
Linseed Oil	7.3	5.3	10.1	6.3
Palm Oil	8.1	8.8	7.3	7.8
Soybean Oil	5.8	5.9	6.3	5.1
Rapeseed	5.5	5.8	5.2	5.3

However, between 2005 and 2008 Linseed appeared to be more volatile than other oil crops with 10.8% volatility, followed by Palm oil (8.6%). After 2008 it seems that the volatility of all oil crops has dropped; for instance, the volatility of Linseed dropped by about 36% (see Table 4.7).

Next, we discuss the GARCH (1, 1) estimates for the World oilseeds prices. The results presented in Table 4.8 show that Palm oil, Soybeans, and Linseed oil price volatilities are not persistent as the Wald test of the null hypothesis $\alpha+\beta=1$ is rejected at 10, 10, and 5 percent, respectively. However, Rapeseed price volatility appear persistent as the Wald test failed to reject the null hypothesis with $\chi^2=1.42$, *p*-value=23%. The volatility clustering as provided by the α coefficient show that all the oilseeds in the world market demonstrate problem of volatility clustering. That is, the news about volatility in the previous period *(t-1)* tend to influence current volatility (*t+1)*. The size of the influence of news regarding past volatility on current volatility is 27, 21, 3, and 61% for Palm oil, Soybeans, Rapeseed, and Linseed oil, respectively, and statistically significant at 5, 10, 5, and 1 %, respectively. The GARCH term indicated by β is also statistically significant at 5, 5, 1, and 5 percent level of significance for Palm oil, Soybean, Rapeseed, and Linseed oil, respectively; implying that variance of the previous period has a formidable impact on the current variance level.

Table 4.8 GARCH (1, 1) Coefficient Estimates for Oilseeds in the World Market

Coefficients	Palm Oil	Soybeans	Rapeseed	Linseed Oil
ω	0.0016	0.0010	0.0006	0.0030
	(0.0009)	(0.0006)	(0.0005)	(0.0005)
α	0.2676	0.2106	0.0311	0.6090
	(0.1160)	(0.1083)	(0.0152)	(0.1853)
β	0.5083	0.5312	0.7683	-0.0666
	(0.1799)	(0.2249)	(0.1450)	(0.0249)
$\alpha+\beta$	0.7758	0.7418	0.7994	0.5425
Wald Test (χ^2)	2.9647	3.26	1.42	4.0703
	[0.0851]	[0.0710]	[0.2328]	[0.0436]
Log Likelihood	185.5658	233.4877	241.8562	223.3676
H0: $\alpha=\beta=0$	0.77	1.09	991.63	13.42
	[0.3795]	[0.2973]	[0.0000]	[0.0002]

Parenthesis (.), and [.] show standard errors and *p*-values, respectively. Wald test null hypothesis is $\alpha+\beta=1$

4.4.3. Comparison of world and domestic price volatility of Oilseeds

As Ethiopia has a few number of commodities exported in the oilseeds category, it s not possible to make a comparison of price volatilities of all the items that appear in the section of world market price volatility analysis. For this reason, we limit our comparison of volatilities only to those commodities where relative comparison is possible.

Thus in this section, we provide the comparison of Linseed and Rapeseed price volatilities in the world and Ethiopian markets. To begin with, we compare the unconditional price volatility of the Linseed and Rapeseed as measured by the standard deviation of the log of monthly price changes.

As provided in Table 4.9, the domestic nominal and real prices of Linseed and Rapeseed are found to be more volatile when examined over the entire period under consideration.

Table 4.9 Comparison of domestic and world unconditional price volatilities, Linseed and Rapeseed

Domestic	All Period	1999-2004M12	2005-2008M12	2009-2012M12
Nominal				
Lin Seed	9.3	9.1	7.4	11.4
Rape Seed	9.4	9.9	6.4	11.0
Real				
Lin Seed	8.8	8.3	7.0	11.1
Rape Seed	8.7	9.	6.2	10.0
World	All period	1999-2004M12	2005-2008M12	2009-2012M12
Nominal				
Lin Seed Oil	7.7	5.5	10.8	6.9
Rapeseed	5.9	5.9	6.3	5.6
Real				
Lin Seed Oil	7.3	5.3	10.1	6.3
Rapeseed	5.5	5.8	5.2	5.3

The difference in the unconditional volatilities of the two commodities between the two markets reveals that the domestic Linseed nominal price volatility has exceeded its world counterpart by 17 percent over the entire period of the analysis, by 40 percent between 1999 and 2004, and by about 39 percent during the period 2009 and 2012. However, between 2005 and 2008 the world nominal Linseed oil price volatility exceeded its domestic counterpart by as much as 47 percent reflecting the commodity crisis that occurred during 2007/08. The real Linseed prices also followed the same trend except the difference in magnitude of volatility.

A similar trend is also observed in the Rapeseed price volatility differences, except the difference during the period between 2005 and 2008 has been the smallest observed volatility difference as the world Rapeseed price volatility has approached the higher domestic volatility. Both nominal and real Rapeseed price volatility had been higher in domestic markets than the World market. That is, the rapeseed volatility difference was as high as 49 and 47 per cent between 2009 and 2012, and the lowest difference observed between 2005 and 2008 with 1 percent and 16 percent, in the nominal and real rapeseed prices volatility, respectively.

The above unconditional price volatility comparison over different time periods between 1997 and 2012 shows that over the entire period the unconditional price volatilities of oilseed items is higher in the domestic market than the World market. However, when observed periodically, the unconditional price volatility tracks the World market situation. This is to say that during the commodity market crisis the World oilseeds price volatility exceeded the domestic one in the case of Linseed oil and approached and narrowed the difference with the domestic price volatility in the case of Rapeseed. This, in turn, reveals two characteristics of the domestic oilseeds market. The first is related to the weaker integration of the domestic oilseeds market to the world market, as it did not buy out the World oilseeds price volatilities, especially during the 2007/08 commodity market crisis. The second is ascribed to the decline in the ratio of export to domestic production. Between 2006 and 2008, oilseeds export and import declined following the financial crisis implying that the decline in imports, that was as high as 24 thousand metric tonnes in 2006, was covered by the increased domestic supply that would have been exported.

Therefore, we may conclude that the increased domestic consumption insulated the domestic market from the volatility that would have been permeated into the domestic market and rock the already higher domestic oilseeds price volatility.

With regard to the conditional variance estimate provided by the GARCH(1,1) for both domestic and World market volatilities of Linseed and Rapeseed, we observe that in the domestic market there is no problem of volatility persistence where as volatility persistence appear as the characteristic of the World market. What the markets for the two oilseed items have in common is the problem of volatility clustering. Nonetheless, the magnitude of the influence of the news about past volatility on current volatility differs across crops and markets. The magnitude of the influence of the news about past volatility (innovations) is more than 8 times larger in domestic markets than the World market for Rapeseed, and it is three times as large as the domestic market for Linseed. The GARCH terms are significant in both domestic and World markets except for Rapeseed in the domestic market implying that the impact of past variance on current variance is not statistically significant for domestic Rapeseed prices, though the magnitude of the change in current volatility in response to past volatility is about 29%.

4.5. Conclusion

Prices of agricultural commodities undergoing rapid adjustments were in the spotlight following the food crises in late 2007 and 2008, and again more recently in the summer and fall of 2010, raising concerns about increased price volatility. The increased price volatility will have implications on household decisions (production and consumption) and government revenues, especially in countries where export earnings are concentrated on a limited number of primary commodities and constitute the larger share of government revenue.

In this chapter, we have investigated price volatilities of oilseeds in the domestic market and in the world market, and compared the volatilities between the two markets.

As one of the most important export items, oilseeds have been vital in the Ethiopian economy. When compared with cereals, which have negligible contribution in foreign exchange earnings, the oilseeds are important contributors to the country's foreign exchange earnings and have a huge potential to diversify the primary commodity export profile of the country, and hence sources of government revenue.

The global oilseeds production has increased between 1995 and 2012 mainly due to improvement in productivity. Over the same period, consumption of oilseeds at the global level increased. However, the rate at which the consumption increases has slowed down since 2008 registering a growth rate below its 1999 level.

In Ethiopia, on the other hand, oilseeds production over the period 1974 to 2012 shows that between 1974 and 1993 production of oilseeds has shown a remarkable growth that mainly came from the gains in productivity. This in part might be attributable to the quota delivery imposed on cereals by the then governemnt parastatal. In an effort to evade the quota delivery, farmers switched their cultivation from cereals to oilseeds (Befekadu and Tesfaye, 1990).

However, in contrary to the shift in policy direction, considered favourable for agriculture and the broad economy, the change in production between 1994 and 2012 has not been as remarkable as it had been prior to 1993 and the registered growth in the later period largely has resulted from area expansion. The results of the reform and restructuring that followed government change in the input and output markets, and infrastructure development over the last two decades did not seem to significantly contribute in improving the oilseed sector with a reasonably good commercial orientation. This is evidenced by the slow and highly variable growth in production, the variability rising from 32% between 1974 and 1993, to 309% between 1994 and 2012, and much of the growth in production resulted from area expansion. The trade performance of oilseeds implies that oilseeds export has dropped and imports increased.

The unconditional measure of volatility provided by standard deviation of the log monthly price changes indicate that price volatility of most of the commodities plunged during the financial crisis (January 2005- December 2008) when compared to pre-crisis period (February 1999- December 2004), except for Niger seed prices.

However, in the post crisis period (January 2009- December 2012) volatility increased in all oilseed prices. We can also see that oilseeds prices have become more volatile in a post crisis period implying that the increased uncertainty of price movements may have implications on production decisions. The comparison of volatility between periods prior to 2005 and after 2009 shows that oilseeds price volatility in the domestic market increased after the commodity price crisis than it was before the crisis.

The change in volatility over time, conditional volatility, shows that there are problems of volatility clustering in the prices Lin seed and Rapeseed prices. However, volatility is not persistent in the domestic oilseeds market.

Contrary to the domestic market, the world oilseed prices registered the highest volatility during the financial crisis, and the volatility of all oil crops dropped after end of 2008; for instance, the volatility of Linseed dropped by about 36%.

The World market evolution of volatility indicates that all the oilseeds in the world market demonstrate problem of volatility clustering. With regard to persistence of volatility, we found that Palm oil, Soybeans, and Linseed oil price volatilities are not persistent whereas Rapeseed prices demonstrate persistent volatility.

The comparison of domestic and world oilseed prices volatility conducted on two oilseeds, Linseed and Rapeseed, shows considerable difference. Unconditional volatility of the domestic Linseed nominal price has exceeded its world counterpart by

17 % over the entire period of the analysis, by 40 % between 1999 and 2004, and by about 39 % during the period between 2009 and 2012. However, between 2005 and 2008 the world nominal Linseed oil price volatility exceeded its domestic counterpart by as much as 47 % reflecting the commodity crisis that occurred during 2007/08.

The difference in the Rapeseed price volatility, on the other hand, indicated a similar trend except that the volatility difference during the period between 2005 and 2008 has been the smallest observed volatility difference as the world Rapeseed price volatility approached the higher domestic volatility.

Thus, the unconditional price volatility comparison over different periods between 1999 and 2012 shows that price volatilities of oilseeds were higher in the domestic market than the world market over the entire period. However, when observed periodically, the unconditional price volatility tends to follow the world market situation. This is to say that during the commodity market crisis the world oilseeds price volatilities exceeded the domestic levels in the case of Linseed, whereas in the case of Rapeseed the world volatility levels approached and narrowed the difference with the domestic Rapeseed price volatility. This, in turn, reveals two characteristics of the domestic oilseeds market. Firstly, domestic oilseeds market appear weakly integrated to the world market, as it did not buy out the world oilseeds price volatilities, especially during the 2007/08 financial crisis. Secondly, the decline in the ratio of export to domestic production may have helped in insulating the price boom in the international market. Between 2006 and 2008, oilseeds export and import declined following the financial crisis implying that the decline in imports, that was as high as 24 thousand metric tonnes in 2006, was covered by the increased domestic supply that would have been exported. Therefore, we may conclude that the increased domestic consumption insulated the domestic market from the volatility that could have been permeating into the domestic market and further increase the already higher domestic oilseeds price volatility.

With regard to the conditional variance estimate provided by the GARCH (1, 1) for both domestic and World market volatilities of Linseed and Rapeseed, we observe that in the domestic market there is no problem of volatility persistence where as volatility persistence appear as the characteristic of the World market. However, volatility clustering appears common problem in the two markets.

The higher domestic oilseeds price volatility may imply that the price risks are high in the domestic oilseeds market. This might be a concern for the enhancement of the oilseeds sector`s production and export performance. As extreme price volatility influences farmers` production decision, they may opt to other less risky, low-value and less profitable crop varieties. The implications of such retreat is that it may keep the farmers in the traditional farming and impede their transformation to the high value crops, and results in lower income hindering the poverty reduction efforts of the governemnt. This is more important to consider today than was before, because measures undertaken to reduce poverty must bring sustainable change in the lives of the rural poor. For this, reason, agricultural policies that enable farmers cope with price risks and enhance their productivity are crucial.

We note that measuring the impacts of oilseeds price volatilities on producing households, and government revenue levels will depict a better picture of the envisaged implications on household welfare and government revenue.

4.6. References

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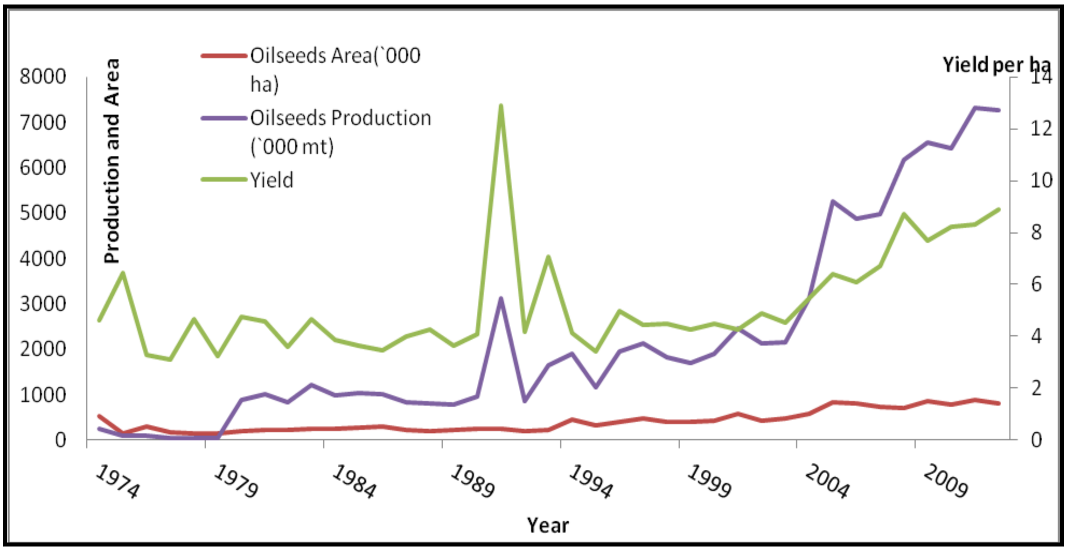
4.7 Appendix

Appendix 4A

Domestic Production, Area cultivated and yield, Oilseeds



Appendix 4B

Unit Roots Test

Table 4.10 Unit roots test for domestic oilseeds (log of price returns)

	ADF Test Statistics		
Lags	**Linseed**	**Niggerseed**	**Rapeseed**
0	-12.93**	-14.38**	-11.48**
1	-7.935**	-9.145**	-7.752**
2	-6.526**	-6.959**	-5.722**
3	-5.976**	-6.450**	-5.860**

** indicates 1% significance level, ADF tests (T=162, Constant; 5%=-2.88 1%=-3.47)

Table 4.11 Unit root test for World Oilseeds Prices (log of price returns

	ADF Test Statistis			
Lag	**Linseed Oil**	**Palm Oil**	**Soybean Oil**	**Rapeseed**
0	-9.180**	-8.726**	-9.115**	-9.836**
1	-7.018**	-9.207**	-7.733**	-7.793**
2	-5.575**	-6.351**	-6.173**	-5.812**
3	-5.184**	-4.798**	-4.751**	-5.003**

** indicates 1% significance, ADF tests (T=163, Constant; 5%=-2.88 1%=-3.47)

Appendix 4C

1. Graph of Oilseeds Price Returns

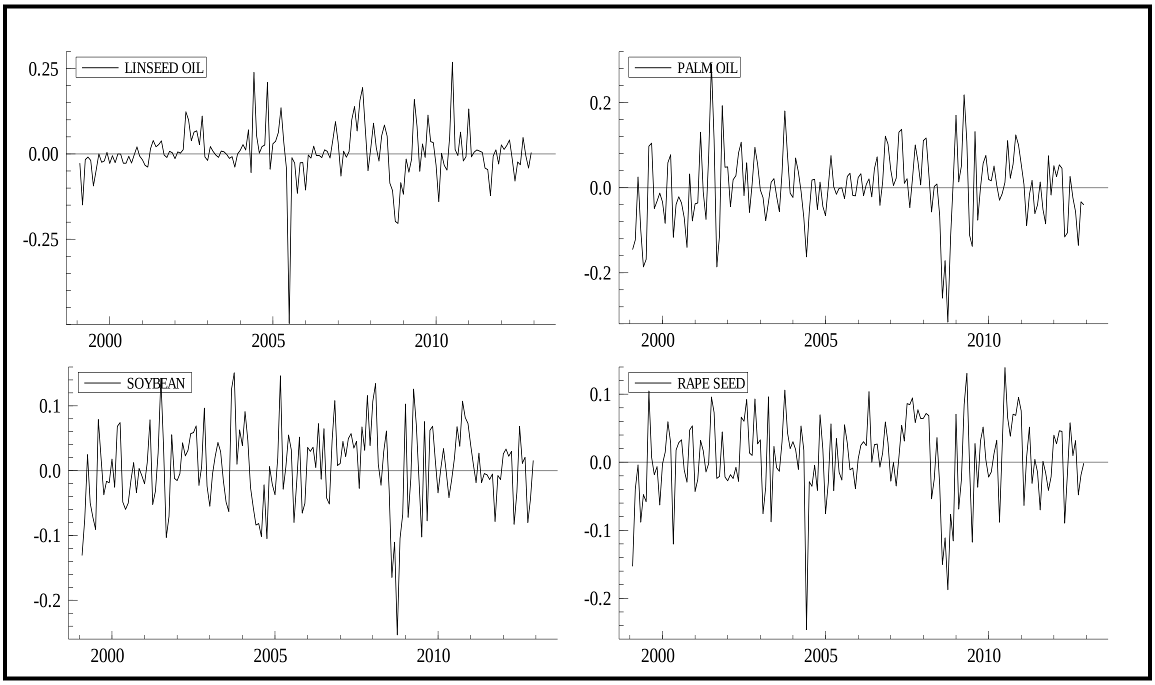


Figure 4.12 World market Oilseeds price returns

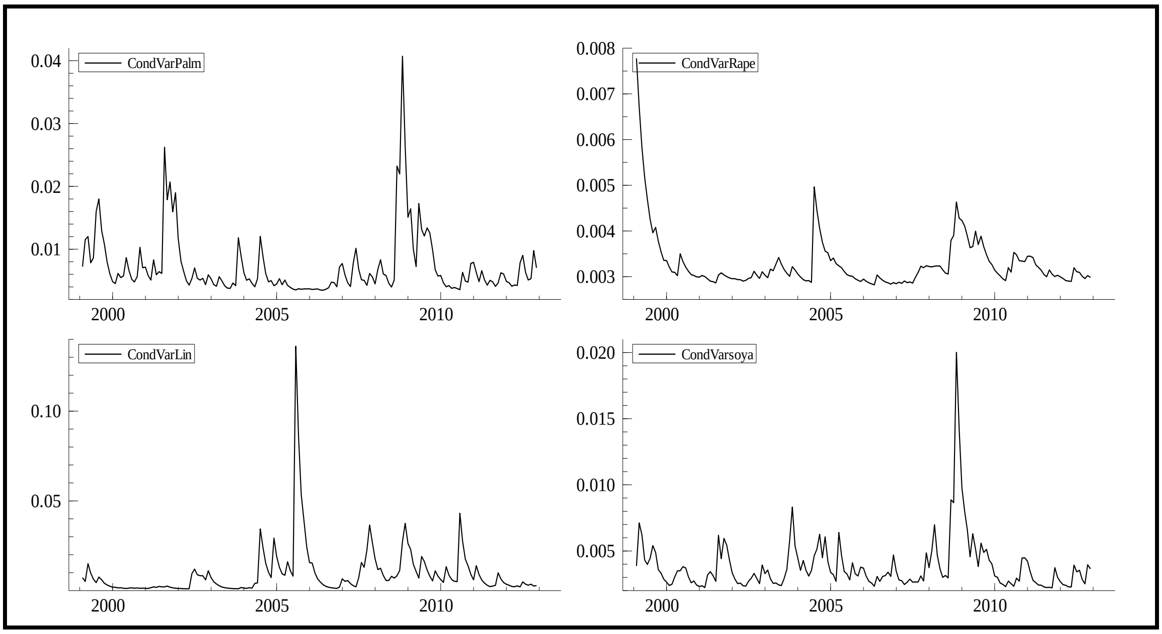


Figure 4.13 Conditional Variance of World Oilseeds Prices

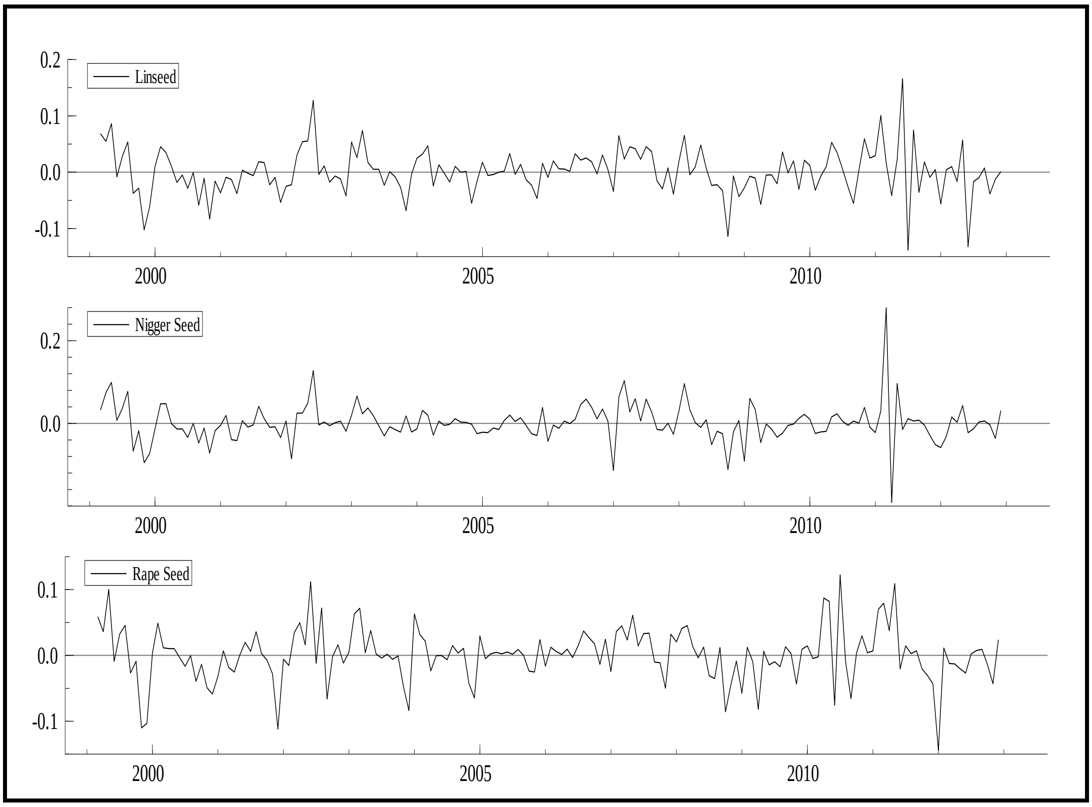


Figure 4.14 Domestic Market Oilseeds Price Returns

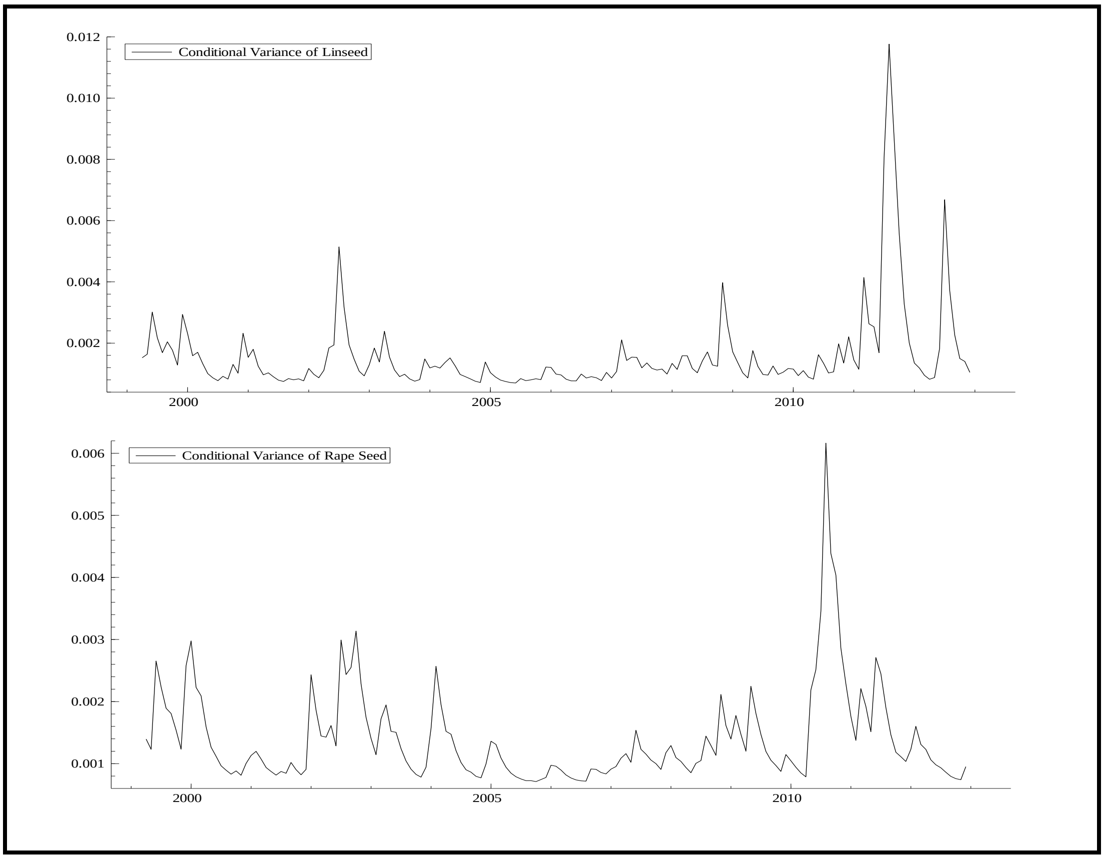


Figure 4.15 Conditional Variance of Domestic Oilseeds

Chapter 5: Review of the Ethiopian Agricultural Policy

5.1. Introduction

Ethiopia has endured three ideologically distinct governments over the last five decades. All the regimes, however, invariably put agriculture at the forefront of their policy initiatives; yet, the policymaking and the strategies designed are much more linked with the broad ideological inclinations of the regimes. What we are interested in here is not examining such policy making process, but how public policies, especially agricultural policies, adopted by these governments have impacted the pace of agricultural development and hence structural transformation of the economy. The review focuses on the agricultural policies of the incumbent government, however.

We provide a review of agricultural policies and other public policies that have been influencing agriculture either directly or indirectly. That is, we critically review the policies that worked against or for agricultural development in Ethiopia. To this end, we investigate policies that focus on input and output markets, technology adoption, provision of infrastructure, access to finance, access to advisory services, and land rights. Exploring these points in a macro setting, we provide a highlight on policies and institutional arrangements that played a role in the pace of the development of the agricultural sector.

Despite huge potential in the country, the agricultural sector enjoyed far less changes in productivity and consequently postponed the structural transformation of the economy. According to Badiane (2011) for the structural transformation to be realized, any agrarian countries must deal with two key challenges: (i) to raise labor productivity sustainably in the agricultural sector and the rural economy, while (ii) diversifying into higher valued goods outside agriculture in emerging higher productivity, urban-based manufacturing and service sectors. The factors determining the success or failure of countries to transform successfully are linked to the adequacy of human and physical assets, institutional and technological resources, as well as policy and coordination capacities. Lack of such critical factors is often cited as the main constraint holding back the agricultural sector.

With the aim of identifying the key challenges in the sector, we discuss the agricultural policy reforms introduced by the existing government (led by the Ethiopian Democratic Revolutionary Front (EPRDF)) to overcome the challenges encountered in the process of realizing structural transformation. The agricultural policy reforms mainly broadly aim at improving smallholder productivity, enhancing food security, and commercializing the smallholder agriculture. Thus, the review shows the contribution of the supporting policies towards those objectives and identifies the critical constraints that need further consideration.

The remainder of the chapter goes as follows, section 5.2 discusses the input market, section 5.3 briefly takes on the output market, section 5.4 describes infrastructure development, section 5.5 discuss access to finance, section 5.6 looks on agricultural extension services, section 5.7 investigates land tenure security, and section 5.8 concludes.

5.2. Input Market

In this section, we examine the role that the input market plays in the process of agricultural development in Ethiopia. As a result, we examine the general fertilizer policy, fertilizer prices and profitability, fertilizer market structure, seed policy, improved seed adoption, seed demand and supply, and seed market structure.

5.2.1. Fertilizer Policy

The reform of the fertilizer policy introduced in the early 1990s, following the down fall of the Socialist regime, resulted in liberalization of fertilizer importation and distribution. Consequently the government parastatal Agricultural Inputs Supply Corporation (AISCO) renamed to Agricultural Inputs Supply Enterprise (AISE) and stripped off its monopoly power. The reform opened up a space for the private sector and around 67 private wholesalers and 2,300 retailers emerged (Spielman et al., 2011). However, the gales of competitive market reversed at its embryonic stage as the private sector exited the market and replaced by holding companies affiliated to the ruling party, EPRDF, and established by regional governments. Following this move, only AISE and two regional holding companies accounted all fertilizer imports and distribution in 2001(Jayne et al., 2003). Since 2007, fertilizer imports have been controlled by AISE and the cooperatives. Nonetheless, in the later years, AISE has emerged as the sole importer and since then the cooperatives have been involved in distribution per se.

Furthermore, regional governments play a significant role in fertilizer supply. When fertilizer was delivered on credit at below market interest or even at zero interest, regional governments provided a 100 percent credit guarantee scheme on farmer`s fertilizer purchase (Spielman et al., 2011). Currently, AISE is the sole importer of fertilizer and the distribution is carried out by the cooperatives and regional agricultural bureaus. The primary cooperatives and woreda agricultural bureaus serve as the last mile distributors. In spite of the inefficiencies in distribution and hence large carry over stock, which was as large as 50 percent in 2010 and now stood at 10 percent (Nigussie et al., 2012), the total consumption of fertilizer has been increasing since 1991. The average total fertilizer consumption during the Socialist regime was 46, 322 tonnes and rose to 162,288 tonnes during the entire period of the EPRDF regime (see Figure 5.1). In the last decade, particularly, total fertilizer consumption increased by more than 28 percent (FAOSTAT, 2012). Therefore, the general implication of the above-mentioned data is that state-led-policies with regard to increasing fertilizer consumption over the last decade appear successful[2], but not without controversy. The state-led fertilizer distribution system has been blamed for untimely distribution, poor storage facilities and quality deterioration, and monopoly market power. Since there are no private firms in the fertilizer market, there is no way to compare whether private firms could handle the procurement and distribution any better than the government.

[2] Several factors may justify the importance of state intervention at the early stages of fertilizer market distribution. These may include liquidity constraint, small size purchases small holders, and settlement pattern a road network, on the demand side; and economies of size in international procurement and shipping, on the supply side are presented as a justification for the continued intervention of the government in agrarian economies like Ethiopia (Harrigan 2008).

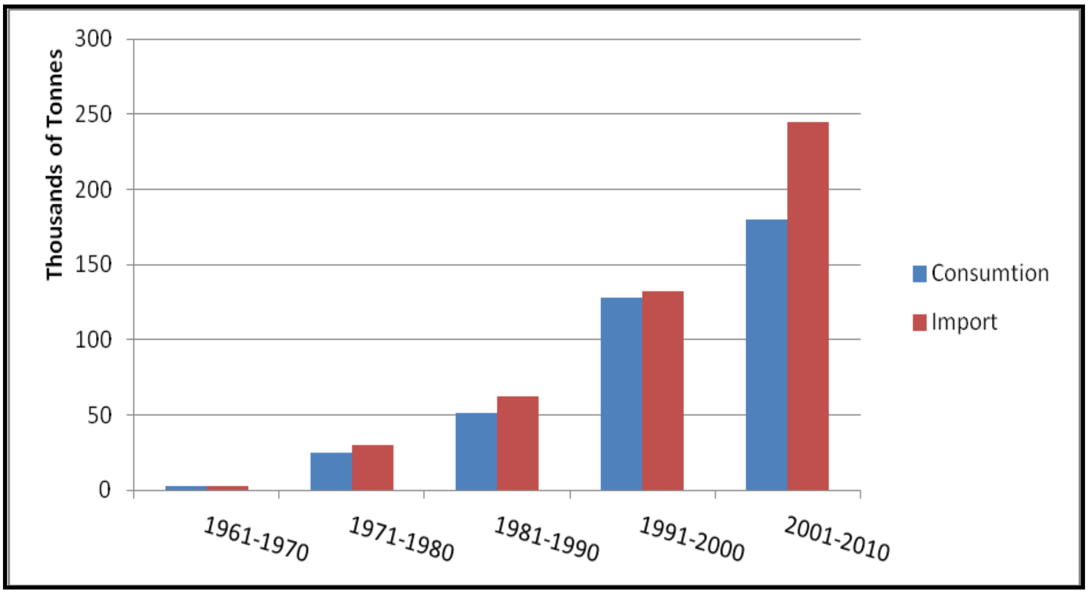


Figure 5.1 Fertilizer Consumption and Import in Ethiopia

Source: FAOSTAT, 2012

Above, we have discussed that fertilizer consumption has remarkably increased over the last decade. CSA (2013) indicates that currently about 39 % of the farmers use fertilizer in their cultivation of mainly *teff*, wheat, and maize.

A. Fertilizer prices and profitability

Since around 60% of the smallholder farmers have a landholding size of at least 1ha, they may not find technology adoption, which is often costly, a viable investment. To this end, evaluating the price and profitability of the available agricultural technologies is important. In doing so, appropriate and profitable technology can be supplied and the promotion would be easy as the profitability could convince the smallholders.

In addition, the profitability and the appropriateness can ensure the sustainability of the agricultural technology adoption by the smallholders. A widely used measure of profitability has been the value cost ratio (VCR) method. The VCR is defined as the sales value of the extra yield produced by applying a certain agricultural technology divided by the cost of the technology applied. Normally a VCR of at least 2 is required, although a VCR of this level is considered risky if there is drought and crop prices drop.

Spielman et al. (2010) computed VCR for four years between 1992 and 2008 and show that the return to fertilizer use has been generally positive in recent years with a VCR around the threshold of 2, assuming that fertilizer use is profitable where VCR is greater than two[3]. Nigussie et al., 2012, on the other hand, imply a VCR of above 2 for the major food crops. They justify that the high return might be due to high food prices observed during recent years.

Various studies (Spielman et al., 2011; Nigussie et al., 2012) indicate that fertilizer prices in Ethiopia are competitive and the margin between domestic and international prices is higher in Ethiopia than in Asian and Latin American countries, but it is comparable to the margin in other Sub-Saharan African countries, including South Africa. The price build-up from port to farm gate is estimated at 26 %, and comparisons with other African countries indicate that marketing margins in Ethiopia are somewhat lower. Though fertilizer prices reflect one dimension of the market performance, qualities of the product and distribution inefficiencies are issues of

[3] The VCR appears similar to the national result when disaggregated by regional markets, except Arsi/Bale for Teff and Welega/Keffa for maize.

concern. Late delivery of fertilizer[4], inflexible distribution providing only two types of fertilizer (DAP and urea), both in 50kg bag[5], and lack of competition in the fertilizer market are some of the main problems that hamper the efficiency of fertilizer market in Ethiopia.

As discussed above, input distribution in Ethiopia is undertaken mainly through government channels with an involvement of cooperatives. And further, the credit scheme of input distribution appears a limiting factor for the involvement of the private sector. As a result, those who can afford to purchase on a cash basis under favourable terms than on credit are not able to do so since there are no private traders serving them.

Rather, the guaranteed loan program with below-market interest rate creates an uneven playing field in the rural finance sector as it undermines efforts to set up alternative financial institutions such as microfinance institutions, independent financial cooperatives, and branches of commercial banks that enhance the financial services outreach to the rural poor.

[4] A study of Ethiopian smallholders by Bonger et al. (2004) found that half of farmers surveyed for the study reported that fertilizer arrived after planting, while 32 percent reported underweight bags, 25 percent complained of poor quality, and almost 40 percent reported that their planting was delayed by fertilizer problems. Studies by DSA (2006) and EEA/EEPRI (2006) found that while fertilizer quality problems had been reduced in recent years, delays in delivery were still common, with 25 percent or more of farmers complaining of late delivery.

[5] Also unlike neighboring countries, Ethiopia does not offer fertilizer in smaller packages that could be used by smallholders, or in different formulations needed for different types of agroclimates, soils, and crops.

The guaranteed credit scheme also resulted in high fiscal costs and fiscal risks. Because credit recoveries are largely related to production and market performance, whenever the production drops due to bad weather or the market, collapses due to surplus production farmers face difficulties in settling their debts. In case of default, regional governments are forced to settle the credit based on the credit guarantee. Therefore, the credit guarantee is working as an indirect subsidy not included in the government budget, despite the government withdrew the subsidy on fertilizers long ago.

Due to distribution inefficiency, the carry over stock over the past several years amounted 50% of the total fertilizer import resulting in huge storage cost and quality deterioration. The implication of this on the performance of the agricultural sector in general is dismal. Further, as the extension agents are involved in the credit recovery effort, often accompanied by coercive measures, the farmer-extension worker relationship unnecessarily hampered and influenced the extension agents` actual work of helping farmers improve their productivity through technology transfer.

The main problem of the fertilizer sector, therefore, revolves around three main points. First, it appears that due to appropriate fertilizer demand planning, the carry over sock has been excessive, but an improvement has been made in this regard, as it dropped from 50% of the import to 10%. Still the bottom-up build up o the demand planning procedure is problematic. Second, due to the transport service inefficiency and lack of sufficient warehouses across the country, and lower profit margins to the last mile distributors (primary cooperatives), fertilizer distribution is generally inefficient. Third, the exiting state-led importation and distribution, even if it resulted in increased fertilizer consumption, does not entertain the private actors and hence the sector lacks competitiveness that possibly offer farmers alternative terms of purchase and probably lower prices.

More strikingly, Spielman et al. (2010) show that the increased fertilizer use combined with use of improved seed has not necessarily resulted in high technical efficiency and profits in Ethiopia. The reason the study put forth is that the low technical efficiency is ascribed to the application of standard packages to vastly diverse environments, and hence leading to non-optimal use of these packages by many farmers. In addition, untimely distribution and poor quality of the inputs supplied are some of the drawbacks worth mentioning in relation to state-dominated inputs supply.

In short, the Ethiopian government has failed to establish an efficient fertilizer distribution system, in contrast to the Kenyan government (Yamano and Ayumo, 2010; Nigussie et al., 2012).

5.2.2. Seed Policy

The National Seed Policy has been introduced in 1992 following the change in government. Since then various policy initiatives put in place to foster the development of the seed sector and the supply of improved seed in the country. However, despite the policy initiatives the adoption of improved seed has remained very low. According to CSA estimates the national total quantity supply of improved seed increased since 1996/97 and farmer use of improved seed coverage increased on average from 4.7% in 2007/8 to 7% in 2012/13 (CSA, 2008; CSA, 20013). Though all the figures represent a very low adoption rate, different surveys and studies show different adoption rates. For instance, the Ethiopian smallholder survey (ERSS) conducted in 2005 show 3%; Nigussie et al., 2012 based on the Ethiopian Agricultural Marketing Household Survey (EAMHS) conducted in 2008 show that of the total households cultivating cereals only 7.4% adopted improved seed.

However, Spielman e al., (2010) argue that the reported low adoption rate understates the actual adoption rate, especially of open pollinated varieties (OPV) that farmers recycle year on year. This is commensurate with the fact that most farmers still rely on farmer-to-farmer exchange or saved seed. Belay (2004) and Lantican et al. (2005) find that only 43% of the area under improved wheat varieties was sown with varieties released since 1995 showing the extent of seed recycling. The reported low adoption rate does not go well with the findings of various studies conducted on improved seed adoption of specific cereals in Ethiopia[6].

The other issue in the seed industry in Ethiopia is related to the structure of the industry and the inefficiency that comes along with it. As we see below, it is the public sector almost entirely responsible for the production of pre-basic, basic and improved certified seed varieties and distribution to the farmers across the country. Therefore, the market demand for improved seed is estimated through official chan-

[6] For example, Lantican et al., (2005) reported that in 2001 71% of all wheat area in the country was sown with improved seed varieties.

nels that range from kebelle to regional and national levels. Then the state owned Ethiopian Seed Enterprise (ESE) responds to the demand estimates. Nonetheless, due to capacity limitations of the enterprise and other difficulties inherent to the sector such as insufficient provision of breeder and low research outcomes from the research institutes responsible for developing improved seed varieties[7], ESE has been struggling to meet the seed demand by the farmers. For instance, only 28% of the improved seed demanded was supplied in 2008. Moreover, poor cleaning, broken seed, low germination rates, and the supply of mixed seeds are the general deficiencies of the ESE supplied seed (DSA, 2006). Late delivery of seed, and seed varieties that does not match the farmers` expectation of seasonal weather changes at the local level are among the problems affecting the seed industry in particular and the input distribution in general (Sahlu and Kahsay 2002; EEA/EEPRI 2006).

A. Seed industry structure

The seed industry structure in Ethiopia involves a range of public and private actors. The Ethiopian Institute of Agricultural Research (EIAR) leads the national research system, which consist of federal research centres, regional research centres, and agricultural universities and faculties. The institute and its regional affiliates and the universities are tasked with developing improved varieties, breeder, and pre-basic seed needed by other players in the industry. The Ministry of Agriculture (MoA) performs the regulatory work with regard to varietal release reviews and seed certi-

[7] Ethiopia has the least qualified agricultural research staff in Africa in terms of post graduate qualification, and women participation in agricultural research is comparatively low (Flaherty et. al., 2010).

fications. The Ethiopian Seed Enterprise (ESE)[8], on the other hand, undertakes the production of basic and certified seed on its own farms alongside private companies, private subcontractors, state farms, and cooperatives.

The distribution of improved certified seed takes place through regional, state-run extension and input supply system that operates with the command from the MoA. The regional distribution channel, in turn, involves regional bureaus of agriculture, their woreda (district) offices, and extension agents known as development agents (DAs) that work at the kebelle level. The input and credit distribution is carried out with a close collaboration of the farmers` cooperatives and regional saving and credit institutions.

As it has been the case for the fertilizer sector, the seed industry also enjoyed a policy reform that came after the change in government in the early 1990s. As a result the private sector was allowed to take part in the industry and as of 2004 there were 8 firms active in seed production, mainly in hybrid maize seed, as ESE subcontractors (Langyintuo et al.2008; Alemu et al. 2007); and by 2008 the number climbed to 11, yet again most of them operating as ESE subcontractors.

In the production of hybrid maize, technically more secure and potentially profitable for the private sector to involve in, ESE and state owned development enterprises have the share of 60% with an additional 10% subcontracted; and the private firms

[8] State-owned regional seed enterprises emerged in Oromia and SNNPR (in 2008) and in Amhara (in 2009).

including Pioneer that operate independently from public sector`s seed production system contribute 30%. In addition to production, more domination of the public sector is observed in the distribution of improved seed. The public sector through its regional extension and input supply systems controls 80% of the total sales of improved seeds, mostly distributed on a credit scheme against public guarantees (World Bank 2006c cited in Spielman et al., 2011).

The seed business in Ethiopia appears less appealing for the private firms to involve in for the following main difficulties. First, the market failures that characterize seed markets (described earlier) constrain the potential for profitability. Second, the seed business depends on the availability of a good supply of high quality pre-basic and basic seed for the production of certified seed that can then be distributed to farmers. The institutions that supply pre-basic and certified seed, EIAR and its federal research centres, ESE, and the Universities are not doing enough in the supply of pre-basic and basic seed, and hence a significant underperformance in the supply of these key inputs is observed. Third, the seed business is risky because seed production is closely correlated to the same weather risks faced by farmers. Seed production in Ethiopia drops during drought periods just as crop production does[9]. Fourth, ESE supplies improved certified seed with a lower profit margin, 5%. But for the industry to be viable, seed prices have to be high enough for private seed firms to

[9] Seed production on irrigated land can mitigate this risk to some extent, and much of ESE's maize seed production operations and subcontracted production currently take place on irrigated land in the Awash River basin. However, the shortage of irrigated land in Ethiopia makes reliable seed production a real challenge for both the public and private sectors (MoA, 2008).

recoup their investments in seed production without making seed unaffordable for both farmers who regularly use improved seed and for new adopters.

Thus, the optimal seed price is based on the demand derived for the grain that is produced from that seed. A volatile seed-to- grain ratio that tracks the grain production and market performance indicate volatile returns to investing in the seed business in Ethiopia. Similarly, the retail profit margin determined by the regional bureaus of agriculture with some inter-regional variations in pricing policies appear less viable for the cooperative unions and primary cooperatives to execute the distribution efficiently[10].

Production and distribution monopoly enjoyed by the public enterprise serve as an entry barrier and makes it difficult for the private sector to step in with new products, new distribution channels, and sell at competitive price.[11] Other costs that come with releasing new cultivars and passing through the regulatory procedure would entail a significant cost that makes the entry more difficult.

Therefore, the policies pertaining to the seed industry such as: National Seed Industry Policy (1992); a legal framework for seed system operations (Proclamation 206/2000); the inclusion of commercial seed production as a sector under the Investment Code, and the enactment of legislation on breeders' rights and plant vari-

[10] The low profit margins means that the government supplies hybrid seed at a cheaper price, which is indicated to below 50 % of the price of the private suppliers

[11] At present, only Pioneer markets its own product lines through a network of 15 dealers and through direct sales to state farms, commercial farms, cooperative unions, nongovernmental organizations, and from warehouse purchases

ety protection in 2006 (Proclamation 481/2006), are proclamations that are enacted without the necessary institutional reform that would pave the way for private breeders to participate in production and distribution of improved hybrid seed and supply at competitive price. To this end, capacity building of the existing agricultural research institutes, and reforming the seed market are crucial.

5.3. Output Market Policy

The output market policy is discussed broadly in chapter 3, section 3.4. Thus, in this section we provide a brief discussion of output market policies introduced under the existing government.

The Ethiopian Grain Trade Enterprise, established after the downfall of the Socialist government has been responsible for controlling the output market. As a result, the enterprise involves in marketing activities that aim at price stabilization, protecting consumers from price fluctuations, grain exporting, and maintaining strategic food reserves for disaster response and emergency food security operations. However, following the restructuring of the enterprise reduced its operational capacity and reduced its marketing networks across the country, and encountered working capital shortage. These together with underutilization of the available resources prevented the enterprise from achieving its objectives, especially in price stabilization (Lirenso, 1994). In later years, an attempt has been made through a series of proclamations and regulations, which gradually withdrew the EGTE from the price stabilization role and redirected its efforts towards export promotion, facilitating emergency food security reserves, and helping national disaster prevention and preparedness programs.

In the face of a series of regulations, which require the EGTE to concentrate on issues other than price stabilization, the EGTE has been on and off its price stabilization roles. The enterprise has been back into the price stabilization role, following the 2000/1 and 2001/2 bumper produce of grain; and during the food price spikes between 2005 to 2008. Since, regardless of consecutive years of reported good harvest, prices of major cereals began rising sharply as of late 2005.

Following the two incidents mentioned above the enterprise dealt with two different types of problems. One required the enterprise to stabilize falling maize prices by intervening in the market and procure maize at a price above the prevailing market price. However, despite such efforts, the wrong signal in the supply response of maize farming was not avoided and hence the glut in supply could not be observed in the following year. The other, required EGTE to stabilize the soaring food prices between 2005 and 2008. As a result, EGTE procured wheat from the international market and distributed to urban consumers at a subsidized price.

Most importantly, the incident of 2001/2 witnessed that productivity enhancing agricultural policy measures, for instance, agricultural technology dissemination can only be taken up sustainably when the marketing infrastructure and market outlets are developed hand in hand with the improvement in productivity. We further note that market infrastructure by itself cannot lead to desired outcomes; it must be accompanied by systems that aim to bring efficient marketing outcomes. This, in turn, may result in market conditions in which the share of the producers` price increases, both in the wholesale and retail prices, and hence improve the welfare of the small-holder farmers that contribute more than 90 % of the food supply.

5.4. Infrastructure Development

Adequate infrastructure is believed to be the engine of economic growth. Transforming agricultural markets from the traditional to modern marketing system and commercializing smallholder agriculture requires developing infrastructure networks that connect rural areas to towns and local markets. When such infrastructure is lacking, commercializing the smallholder agriculture and transforming the rural sector would be a daunting task. For instance, during the Socialist government about 90% of the country`s population lived in a distance of 48 hrs from the main road, and telecommunication services were poor and non-existent in some parts of the country. As a result, we have every reason t believe that regional price differences most likely had been huge marked with high variability and inefficient rice formation. Poor infrastructure is also believed to contribute to the famines that occurred in the 1980s. When we look at the road network density prior to 1991, the country had about 4109 kms of asphalt road, 9298 kms of gravel road, and about 5601kms of rural roads.

However, the new government that came into power in 1991 recognized the importance of infrastructure, especially rural to urban road networks, and telecommunication infrastructure, in the efforts of poverty alleviation, combating hunger, and ensuring food security. Further, in its flagship economic policy, known as agriculture-led-industrialization (ADLI), the government emphasized the importance of improving agricultural productivity and creating rural urban linkages in order to facilitate the transformation to industrialization. It is axiomatic that in ADLI strategy increasing agricultural productivity lies at the heart of poverty reduction given the importance of agriculture in the economy, employment, and export. Moreover, it is well known that without raising agricultural productivity and creating a market system, which provides incentives to go beyond subsistence level to produce commercial surpluses, industrialization cannot take place or it would be inordinately delayed.

With this intention, the construction of all types of roads, especially rural roads, has been given due attention by the new government. As a result, total road networks increased by 29 % between 1993 and 2000. The rural road network grew by around 68%, gravel roads by around 23%, while asphalt road network dropped by about 10%. Further intensifying the road network growth, between the 2000 and 2011, total road network grew by about 39%, of these the highest growth observed in rural road network which increased by 21% while gravel roads and asphalt roads increased by 14 and 6%, respectively. These significantly reduced the number of hours someone has to walk to reach the main roads and increased the road density/1000 persons from 0.5 in 2000 to 0.75 in 2012; and the road density/1000km^2 similarly increased from 30 in 2000 to 57.3 in 2012. These improved road network coverage therefore may have a great deal of contribution in domestic market integration, rural urban linkages, and agricultural commercialization and the overall rural transformation.

For markets to function properly and yield desirable outcomes, efficient market information flow is crucial. For this reason, increasing the mechanisms of information flow and hence fostering access is one of the fundamental factors that ensure market efficiency or integration of markets across regions. In this regard, telecommunication service is one of the important mechanisms by which market information could be transmitted between buyers and sellers, and prices possibly negotiated between trading partners. In the Ethiopian context, the virtue of telecommunication service with regard to market information flow has not been exploited until recently. The expansion of telecom services in the country has been remarkable. For example, the penetration rate of fixed lines increased from 0.27 in 1991 to 0.98 in 2011. Mobile telephone service introduced in 1999 and as of 2011, the penetration rate reached 17% implying that the platform for market information flow has been remarkably improving.

5.5. Access to Finance

Agriculture is a major source of livelihood throughout the world, especially for the majority of poor people living in rural areas in developing countries. One of the key challenges for the majority of these farmers is - access to finance. Lack of access to finance is a key impediment to farmers because it seriously constrains their likelihood of adopting better technology and improving their production efficiency.

The history of agricultural finance in Ethiopia shows that despite its huge contribution to the GDP, employment, and national food production, the sector consistently has been underserved. Of the total DBE loans disbursed during 1951-to-1969, only 42 % went to agriculture, of which small farmers received only 7.5 %. Moreover, between 1982 and 1992 rural credit accounted for only 9% of the total loan disbursements (Assefa, 1987). These figures, provided the significant role agriculture plays in the economy in terms of contribution to the GDP, employment, raw material supply to the nascent industrial sector, foreign exchange earnings, and food supply to the urban dwellers, imply that the sector`s financing needs have been accorded insufficient attention. The financial liberalization that introduced in 1992 had been successful in shifting the direction of financial resources from public sector to the private sector; it did not make the agricultural sector much appealing. As a result, the share of agriculture in the total credit disbursed between 1991/92 and 1997/98 had only been 14.7 %; while the share of domestic trade and industry had been 32.2% and 13.2%, respectively.

Likewise, between 2005 and 2009 of the total commercial bank loans agriculture accounted for 9.6%, and the amount of loan approved and disbursed to the sector reached 14.6%. The non-performing loan (NPL) as of June 2011 reported to be 0.2% at the Commercial Bank of Ethiopia, 6% at the Oromia Cooperative Bank, and 12.8% at the Development Bank of Ethiopia (World Bank, 2012).

With regard to access to credit and financial services, in Ethiopia few people have access to formal or semiformal financial services. With 45,000 people per commercial bank or Micro finance institution (MFI) branch, the country is below comparable low-income countries where the respective ratio is one branch per 35,000 customers. However, this figure is more dismal when we look at the density of commercial banks or MFI branch in the rural areas per se, which is 125,158:1, implying more limited access for financial services. Moreover, bank branches are concentrated in urban areas whereas MFIs largely serve the rural poor. Nevertheless, the figures above indicate that millions of poor households, which constitute about 80% of the population and reside in the rural areas are excluded from the formal financial services. This is further evidenced by the recent World Bank report that shows only 1% of the rural households hold a bank account. Wolday and Peck (2010), taking a sample from selected rural regions in Ethiopia, show that notwithstanding the vigorous effort by MFIs and Saving and credit cooperatives (SACCOs) to foster financial inclusion in rural Ethiopia, rural financial inclusion found to be only 3% in selected rural regions. As Figure 5.2 shows, Ethiopia in general appears to have one of the lowest financial inclusion ratios in the East Africa region.

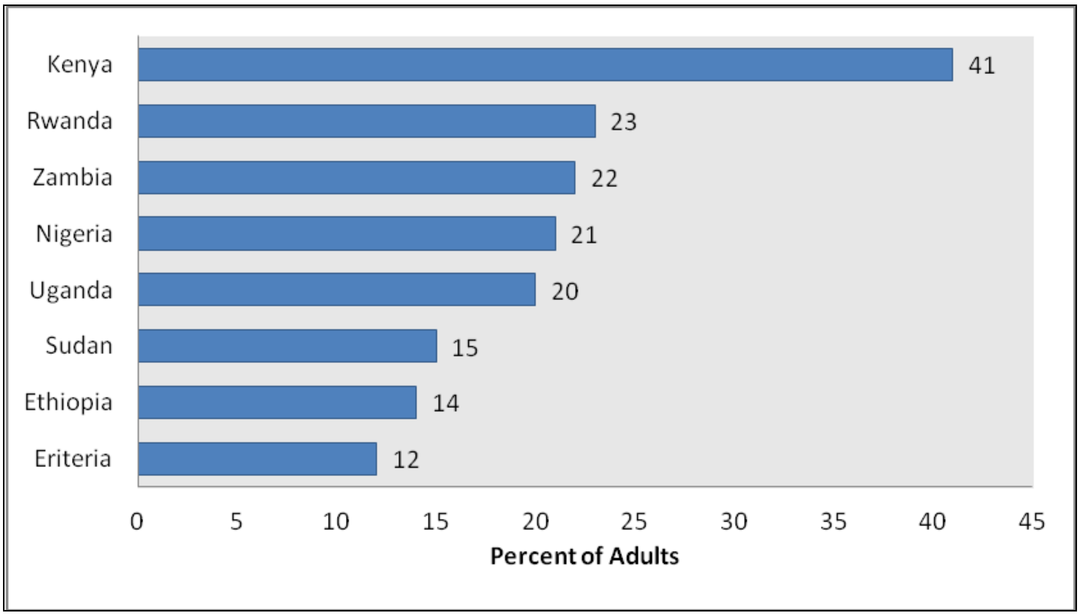


Figure 5.2 Financial inclusions in Ethiopia in relation to other SSA countries (% of adults). Source: Wolday and Peck (2010)

Many factors can be raised for the limited access to finance for the rural poor in Ethiopia. First, the formal financial institutions do not serve the rural poor because the rural poor largely cannot fulfil the criteria set by these institutions to make formal credit request. Because only standardized agricultural machinery and equipment are acceptable for collateralizing agricultural loans, and the land belongs to the state, farmers cannot generally own land titles, and hence farmers have no property rights. It is difficult for the smallholder farmers who do not have the agricultural machinery and equipment and cannot use land as collateral are ineligible to request bank loans. Second, the high covariant risk inherent to the agricultural sector, mainly stemming from the effects of weather and the ensuing high lending rates prevent financial institutions from expanding their service to the rural poor. Third, the policy directives have no special provisions to enhance the outreach of access to finance to the rural poor. Fourth, the high transaction costs that result from the small amount of loans required by the small holding farmers appear unprofitable for the banking sector.

As a result, only MFIs and SCCOs have been expanding their outreach and providing loans to the smallholder farmers. These financial institutions have dedicated two-third of their overall loan portfolio to the agricultural sector (Wolday and Peck, 2010). However, the loans are not tailored to the needs of the smallholder farmers, as provided for 6 to 12 months maturity period, repayable monthly on higher interest rates. Therefore, this makes the MFI and SACCOs lending unsuitable for the capital investment required to improve productivity; and the loan size offered is too small (on average USD 170) to have a significant impact on the agricultural sector.

5.6. Agricultural extension services

Agricultural extension is one of the key factors that help in bringing agricultural development and promoting improved management of the natural resource base. The policy framework shapes the objectives and functions of an agricultural extension system. This section gives the background to agricultural extension service and reviews the status of agricultural extension service in Ethiopia, and identifies the technical and policy related constraints to effective and efficient service delivery in the country.

Agricultural extension is one of the various forms of rural extension. Feder et al. (1999) describe agricultural extension system as a means to transfer information and technology for sustainable agricultural production, transformation and marketing; and help in building organizational, managerial, and technical capacity of farmers.

In general, agricultural extension focuses on technological innovations (to increase production and technical efficiency), and on strengthening institutional capacity (organizational and leadership development) to help rural people have better livelihoods. It assists them to identify and overcome production, management, processing, and marketing problems. It also help farmers to improve the use of their resources in the most economical and sustainable way. By so doing, it achieves its main objective of empowering farmers and building their confidence to break out of the poverty trap and to participate in the overall national development process.

In light of these functions of agricultural extension, we provide a review of agricultural extension service delivery in Ethiopia and its impact on agricultural productivity of the rural poor.

Ethiopia introduced an extension services in 1953 by the Imperial Ethiopian College of Agricultural and Mechanical Arts (also known as Alemaya University and recently renamed Haramaya University) following the style of a U.S. land grant university. And later extension services were provided to a larger number of farmers in the 1960s under the Comprehensive Integrated Package Projects (CIPP). In the 1980s, the extension system transformed itself into a Training and Visit (T&V) style that was favoured by the international donor community at the time (Abate, 2008).

Following the change in government in 1991, T&V system of the socialist regime continued as a national extension program with increased government financing until its replacement by the Participatory Demonstration and Training Extension System (PADETES) in 1995[12]. PADETES was adopted from the SASKAWA Global-2000(SG-2000) extension approach initiated in Ethiopia in 1993 by the Sasakawa Africa Association and Global 2000 of the Carter Centre. PADETES, therefore, was initiated after a critical evaluation of the past extension approaches and the experiences of SG-2000[13]. Major objectives f the PADETES program include increasing production and productivity of small scale farmers through research generated information and technologies; empowering farmers to participate actively in the development process; increasing the level of food self sufficiency; increasing the supply of industrial and export crops and ensuring the rehabilitation and conservation of the natural resource base of the country (Task force on Agricultural Extension, 1994b as cited in Belay, 2003).

[12] A task force set up to evaluate the T&V program concluded that the previous extension systems including the T&V were marred with organizational and attitudinal problems. That is, the organization of the agricultural extension services were provided by different Ministries and even by different departments in the MoA and teams organized by discipline but not AEZ or production functions. The weak organization of the service and poor linkage between research and extension services compounded with poor linkages between credit and marketing agencies resulted low participation of farmers in technology multiplication (Habtemariam, 2008). This national program also provided regional states the mandate to plan, implement, monitor and evaluate their own extension programs.

[13] As clearly indicated by Quinones and Takele (1996), the SG 2000 extension programme had the following objectives: a) to assist Ethiopia's efforts to increase agricultural production through an aggressive technology transfer programme that disseminates improved production technologies to small-scale farmers through the extension service of the Ministry of Agriculture; b) to strengthen the capacity of extension services for the expedient dissemination of proven, research-led technologies to small-scale producers, particularly in food crops; c) to invigorate the linkages between research and extension in order to streamline the process of technology generation and dissemination and to provide appropriate feedback to research for technological interventions when necessary and, d) to extend, through extension services, improved grain storage and preservation technologies as well as agro-processing techniques suitable for small-scale producers.

Due to the many components it encompasses, the program followed the package approach to bring agricultural development and foster the research-extension and input-credit distribution linkage (MoA, 1994b; Quinones et al., 1997; Belay, 2003). Initially PADETES concentrated on cereal production packages; however, over the years the packages have been diversified to high value crops (spices, oil crops, vegetables), livestock (diary, poultry, beekeeping, fattening), improved post-harvest technologies (handling, transport and storage), agro-forestry, soil and water conservation and beekeeping developed for different agro-ecological zones (Belay, 2003; Habtemariam, 2008).

The extension package was mainly composed of fertilizer, improved seed, pesticides and better cultural practices mainly for cereal crops (teff, wheat, maize, barely, sorghum, and millet). PADETES implementation followed extension management training plot (EMTP) approach, a centrepiece of SG-2000s technology transfer approach, which as a technology transfer model promotes linkages between research, extension, and input and credit distribution.

Under PADETES, the extension agents were tasked with organizing demonstration trials, assisting farmers in obtaining agricultural inputs and channelling farmers' problems to the relevant organizations, particularly to the district agricultural office. Farmers, on the other hand, were encouraged to participate in planning and implementing farm trials, establishing rural development committees at various levels from development centre to regional levels. In addition, women and youth participation in the program was encouraged; and developing packages suitable for the various agro-ecological zones (AEZs) was emphasized. Most importantly, PADETES came up with a proposal to support provision of inputs through credit under local governments` collateral agreement. However, as mentioned in section 5.2.1, the default by farmers forced regional governments to settle the credit as agreed to the commercial banks, and the result was a subsidy that remained unaccounted for in the government budget.

Due to the increase in financing PADETES, the government expenditure on provision of agricultural extension services reached about USD 50 million or almost 2% of agricultural GDP and ranked one of the highest in the developing countries and regions (Roseboom, 2004).

The agricultural extension program, particularly PADETES, resulted in a significant increase in agricultural production in the country (EEA/EEPRI, 2006); increased access to extension services to around 9 million farmers by 2007/08 (Adugna, 2008); increased the number of extension workers three fold to almost 47500 in 2008 and 70,000 in 2013; and around 15000 Farmer Training Centers established, each of which meant to host three development agents(extension agents) with a range of technical skills, and provide demand responsive extension service and training services.

Evaluating the impact of the integrated household extension program adopted by the Tigray Regional State based on the general framework of PADETES, Kidanemariam et al. (2013) show that households who participated in the program have shown an improvement in their welfare. Particularly, the program resulted in a 7.6

to 13.8% increase in household income, 2-fold increase in livestock investment, and 20 to 30% increase on overall asset investment. Similarly, Dercon et al., (2009) using Ethiopian Rural Household Survey (ERHS) show that agricultural extension services in Ethiopia resulted in 9.8% reduction in the poverty headcount and 7.1% increase in household consumption over the 10 years between 1994 and 2004.

Earlier studies such as Bonger et al.(2004), Bonger et al.(2006), and EEA/EEPI (2006), in contrast to the above mentioned studies, indicated that almost one-third of the farmers adopted the extension packages discontinued the program due to various reasons. Chief among which include poor extension service as extension service agents view fertilizer and credit distribution as their primary role, increased price of inputs, and numeric targets of physical input use were given much more emphasis than improving technical efficiency and profitability of input use (EEA/EPPI, 2006).

5.7. Land Tenure Security

As we have seen elsewhere in this chapter, a wide range of political and economic reforms introduced following the overthrow of the Socialist regime in 1991. These reforms include the ratification of a new constitution, establishment of an ethnic based federal system of political administration, reforming the property rights, economic policy, and investment policy. The reforms fundamentally differ from the Socialist system and conform to a more liberalized, market oriented economic system. However, the land policy remained similar, but not identical, to that of the

Derg largely, though backed up with main initiatives that focus on providing peasant farmers robust tenure security to some extent[14].

The Ethiopian constitution Article 40 states that land is the property of the people administered by the state on their behalf, and cannot be sold, exchanged or mortgaged (FEDRE, 1995). Land is, thus, state property and farmers have only use rights over plots they have in their possession. This article in the constitution governs all the regional laws and other laws pertaining to land. The regions are responsible for land administration within their jurisdiction, however. Further, the constitution promises access to land for all rural persons a right and entitles each adult in the rural areas land sufficient for his or her livelihood.

The periodic land redistribution of the socialist regime, which some localities had three times in the space of ten to twelve years, and the state ownership of land enshrined in the constitution have been causes of tenure insecurity. The present government has been a lot more restrained in this regard than the Derg. Nevertheless, the 1997 contentious land redistribution in Amhara region has left a legacy of insecurity and resentment among many peasants in the region, and doubts and uneasiness in other rural areas (Dessaleng, 2007). Redistribution has not entirely ruled out in the constitution and regional legislations, though it is tied up with a number of conditions, which make frequent redistribution less likely. The Federal law is less

[14] The current land policy differs from the Derg in that it provides a limited form of land transfers such as inheritance and renting. Landholders can transfer their possession to their heirs; however, some regions impose conditions on inheritance.

stringent in this regard than some of the regional laws. The farmer`s right to land is confined to land management which may include deciding on farming strategies, utilization of farm inputs and on land transactions as stated under the law.

The government justifies its land policy on grounds of social equity, with a provision set in the law that every rural individual has the right to a plot of land sufficient for his/her livelihood and should claim the right in his/her kebele. Going against private ownership, the government claims that private ownership results in high concentration of rural property in the hands of a few, as farmers would involve in distress sales. However, the real world evidence does not substantiate the argument. Dessalegn (2009) affirms that there is no evidence in Ethiopia or elsewhere to show that with the absence of such restrictions peasants will sell their land swiftly. Nonetheless, a study by the Ethiopian Economics Association has shown that farmers are not willing to sell their land if the law permits them to do so (EEA, 2002), implying that the governments justification is implausible.

The other equity principle in the government`s policy justification relates to overcoming landlessness. The government hopes that with the absence of periodic land redistribution and the provision in the law that entitles a plot of land to every rural adult individual, the problem of landlessness would be relieved. The reality, however, is that with no periodic land redistribution young people who were not young enough to benefit from the last land redistribution end up landless when they become adults. As a means to deal with these problems, measures have been taken to privatize hillsides and distribute them to members of the surrounding community.

Landlessness is a dynamic problem exacerbated by population growth and the end result of accommodating the increasing demand results in land fragmentation and subsequently leads to a decline in holding sizes (Dessalegn, 2007). This, in turn, hampers agricultural technology adoption and agricultural commercialization.

As a means of ensuring tenure security, the Ethiopian government has introduced land certification. Land certification, which was launched in a limited number of localities in 2003, has since then turned into a massive program undertaken at an accelerated rate throughout the country. By the end of 2006 more than half of the rural households in the country have had their land registered and received user certificates.

The farmers, mostly, have positively taken the certification program; though they consider the certificate as a means of claiming compensation in case of eviction and or land disputes, if any.

On the other hand, the government foresee land registration to: a) provide secure right of tenure to farmers and protect the rights of vulnerable groups such as women; b) reduce land disputes and litigation; c) facilitate land use planning and management of community and state lands; d) increase investment by small holders on their plots; e) provide better opportunities for access to credit service (Solomon et al., 2006; Deinnger et al., 2007).

The available evidence so far raises considerable doubt in respect of these objectives, and, rather confirms that as far as rural poor empowerment is concerned, there has been very little change observed. Land certification is a new experience in Ethiopia and the evidence with regard to its importance is mixed as well. Whether land certification resulted in tenure security is a debatable issue.

Dessalegn (2009) investigated the reception of land certification by the farmers in two localities in Ethiopia namely, Dessie Zuria and Wolaita. The study reveals that in Dessie Zuriya 44% of the farmers interviewed considered distribution is likely, while 29% were against such opinion. While in Wolaita, though they accept it as a positive measure, farmers are less enthusiastic about land certification. The reason is that other problems such as demographic pressure and declining soil fertility are the main concerns of the farmers residing in that area. Population growth and increasing scarcity of land are concerns that all the rural dwellers across the country have in common.

Recently, Hossaena and Holden (2013) studied the link between land tenure security and food security using five rounds of panel data collected between 1998 and 2010 from Tigray region in Northern Ethiopia. The study found that land certification contributed to enhanced calorie availability (intake) and improved child nutrition measured by body mass index (BMI), especially for female headed households either though enhanced participation in land rental market or increased investment and productivity on owner operated land. The study, therefore, call for reform of the restrictive regional land law that allows only short-term rental contracts and prohibits land holders from renting more than 50% of their holdings.

5.8. Conclusion

In this chapter we reviewed the policies and strategies particularly designed to raise agricultural productivity. The agricultural policies reviewed relate to the input and output market policies, access to finance, agricultural extension services, and land tenure. The review exercise indicated that the input market: fertilizer and improved seed market, which is state led, appear inefficient in terms of improving access for agricultural technologies and increasing agricultural yield. The inefficiency is, particularly, manifested by lack of competition in the fertilizer market, delays in distribution of fertilizer at the optimal planting time, quality deterioration due to lack of appropriate storage facilities at the last mile distribution points, and low incentive for the last mile distributors. The profit margin that primary cooperatives allowed to mark up, i.e., 2% of the price of the fertilizer, is insufficient to cover the annual administrative costs of the primary cooperatives and hence they are not capable to undertake the distribution and storage properly.

The seed sector also shares all the inefficiencies in the fertilizer sector and includes the following problems peculiar to the sector that appear holding back the seed sector. The state owned seed enterprise, ESE, supplies improved seed at a subsidized price, which acts as an implicit entry barrier for private firms and the research institutes lack qualified experts. As a result, innovation and market competition in the seeds market is limited.

With regard to the output market, the Ethiopian Grain Trade Enterprise controls the market and works towards achieving price stabilization, export promotion, facilitating emergency food security reserve, and helping the disaster prevention and preparedness programs. However, alternating roles of the enterprise may have influenced its performance and kept the enterprise away from achieving its targets effectively.

With regard to access for financial services, Ethiopia appears one of the countries in East Africa with low financial inclusion. Only 1% of the rural households hold bank accounts and very few people have access to formal and semi-formal financial services. At the national level, the financial inclusion stood at 14%, which is by far lower than the neighboring Kenya, which has a financial inclusion of 41%. The loan approved and dispersed to the agricultural sector, mainly to the large commercial farms, stood at only 14.6%. This implies that innovative financial services that enhance financial inclusion serve the needs of the financial constrained smallholder rural poor are indispensable. In this regard, the contribution of micro finance institutions (MFIs) and saving and credit cooperatives (SACCOs) have been commendable in improving the outreach of the financial services to the smallholder farmers.

The Agricultural extension service provided across the country employs more than 70,000 extension workers and provides trainings for farmers in more than 15,000 Farmers Training Centers (FTCs) located across the country. As several studies show that the extension service resulted in increased income, increased household food security, reduction in poverty rates, and increased household consumption. However, the impressive results are not without controversy. In contrast to the positive evaluations of the service, other studies indicated farmers' dis-adoption of extension packages after a trial of a certain period due to the high cost of inputs and the service provided by the extension workers was misguided. It was misguided because the extension agents considered input distribution as their primary role and ignored provision of advice to improve technical efficiency of farmers, and accorded numeric targets and coverage more emphasis than the technical issues that need to be resolved.

The other contentious policy in the Ethiopian agricultural sector is land policy. Enshrined in the country`s constitution land is the property of the people administered by the state on their behalf, and cannot be sold, exchanged or mortgaged. Land is, thus, state property and farmers have only use rights over plots they have in their possession. The government believes in that land registration and certification provides tenure security to peasant farmers and overcome the insecurity problem raised by concerned stakeholders. Some studies attempted to evaluate the impact of land policy on farm productivity and reported mixed results. On top of this, the results tend to affirm that the evaluation task is blemished, as people`s perception towards the impacts of land policy inclined towards the political sentiments of the farmers in different regions and localities. The recent study conducted using a panel data obtained from the Tigray region in northern Ethiopia shows that land certification resulted in increased household food security and improved child nutrition.

Although this is not an evaluation exercise, the review in general implies that various agricultural policies introduced during the last two decades have been beneficial, yet not sufficient. Most importantly, the inefficiency of the input and output markets may indicate that the overall incentive mechanism in the sector is ineffective in inducing productivity and facilitating commercialization of the agricultural sector. Therefore, further reforms of the input and output markets are crucial. Further, agricultural commercialization in the context of smallholder agriculture fundamentally rests on enhancing agricultural productivity. To this end, introducing policies and programs that facilitate agricultural technology adoption and improve productivity are essential. In this regard, enhancing access for finance to the smallholders overcomes their financial liquidity constraints and facilitates better technology adoption.

5.9. References

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Chapter 6: Conclusion and Future Research Directions

6.1. Conclusion

This thesis contains four chapters on selected topics on the Ethiopian agriculture. In this concluding chapter, we provide major findings of each of the four chapters, the policy implications drawn, and in the following section, we point out future research directions.

This thesis begins with introduction chapter. In the second chapter, we investigate responses of crop yields to varying precipitation levels due to climate change modelled by Global Circulation Models. The results from the empirical model show that the impacts vary across different crops and regions. This shows that climate change creates opportunities and challenges as it results in positive changes in agricultural production in some parts of the country and while affecting other areas negatively. Therefore, identifying the pattern of climate change impacts across the country helps in coming up with adaptation strategies that are commensurate with the likely impacts in different areas and the necessary change in cropping pattern. The results also show that improving farming technology appear to be a crucial factor to increase agricultural production and deal with production variability that emanates from climate change.

Unless appropriate measures are taken, climate change could entail significant negative effects on the Ethiopian agriculture. Nonetheless, from the results we obtain we cannot identify how farmers will possibly react to the change in climate. The historical data of crop yields reveal that mean crop yields have increased over 28 years, but not remarkably; and average *kiremt* and *belg* rainfall over the same period have not shown a statistically significant change. These shows that although weather has been the scapegoat for the poor performance of the Ethiopian agriculture, low technical improvements in farm management, low use of pesticides, improved seeds, and fertilizers may have contributed their own share. For this reason, investigating the relative importance of non-climatic factors on crop yields may shed light on where appropriate interventions to adapt to climate change and counter its negative effects on future crop yields could be made.

The projections based on the predict climate change imply that teff and wheat yield levels will drop in 2050 compared to their 1993-2008 average, while maize yield for the same period will increase. The implication of this on household food security is that as the country is not food self sufficient a percentage fall in food crop yields are likely to result in more than proportionate decline in food consumption. Reduced food availability due to reduced yield levels stemming from adverse effects of climate change will have adverse effects on household welfare. Since the real per capita food consumption expenditure constitute about 46.5 percent of total real per capita consumption expenditure, adverse climate change impacts on prices will have a disproportionately adverse impacts on all low-income households, not just merely on agricultural households.

The limitation of the study on climate change and crop yield variability is that due to lack of temperature variable in all the weather stations included in the study, the impacts of temperature are not accounted for. However, as rainfall is the most important climatic variable in the Ethiopian case where significant variability in temperature levels is not reported, though it is increasing overtime, the implications after including temperature could not be substantial. Further, including onset and ending dates of growing seasons may better inform the implications of climate change on crop yields variability.

The third chapter examines the relationship of domestic grain market with world grain markets and investigate price transmissions between the two markets. The recent global food crisis has revealed that change in food prices in the global market can easily permeate into domestic markets and pose significant challenges in countries where households spend a larger share of their income on food. However, the degree of the pass-through can be limited due to government policies such as stabilization policies aimed at insulating domestic consumers from changes in the world prices; and high transport costs. Further, transmission of food price shocks to domestic markets depends on the importance of the commodity in the country`s food staple, food status of the country, and other domestic factors. These factors confounding in many different ways limit the pass through of global food price inflation to domestic markets.

Thus, the chapter investigates the integration of the Ethiopian market to the world markets, identifies whether geographical proximity of the international markets is important in the integration and in influencing the evolution of domestic prices, and identifies whether there is price pass through to and from the World market.

The empirical results show that the domestic grain market prices, though thought to be structurally isolated, appear integrated to the international grain market. This has been demonstrated using two exchange market prices for each commodity against which we investigate the integration of the Ethiopian grain market to the world market.

That is, we use US and SAFEX maize prices as maize exchange market prices and examine the relationship with the Ethiopian maize market. For wheat, we use Paris milling wheat and Chicago Board of Trade (CBOT) soft wheat prices as exchange market prices and investigate the relationship of them with the Ethiopian wheat market.

We found that the Ethiopian wheat market is linked to the world market as evidenced by its cointegration with the Paris wheat market, and not to the Chicago wheat market. However, the identified cointegration with Paris wheat market happened to be uni-directional as only Paris wheat market reacts to the price developments in Ethiopia. This finding is contrary to the conventional "small country" assumption that would characterize the Ethiopian wheat market. However, we argue that this relationship could be the result of both local food aid purchase programs and/or other emergency food aid requirements of the region and resulting grain procurement in the international market. He integration with Paris what market also implies that the domestic wheat price developments are related to international market which geographically closer. The possible reason for the linkage with the nearest international market probably relate to the fact that Ethiopia imports most of its wheat from the Black sea and Mediterranean ports, for it requires lower transportation cost and the wheat imported through these ports is purchased with lower price at the exchange markets located in Europe.

With regard to maize, the Ethiopian maize market is also integrated into the world market. As it is the case for wheat, geographically the nearest exchange market (SAFEX) appears the relevant international maize market for Ethiopian. The US maize market does show no cointegration. However, the results must be taken with caution, as the no-cointegration relation does not necessarily guarantee that there is no price passes through between any two markets investigated. Therefore, it might be helpful to investigate a regime switching cointegration model to see whether the co-integrations observed are due to some form of policy interventions.

To this end, we have investigated the effects of exchange rate developments on the indentified cointegration relationships. In the previous analysis, we have converted all prices into US dollar; thereby we implicitly assumed an instantaneous exchange rate pass-through. However, we evaluated the cointegration relaxing the instantaneous exchange pass-through assumption and investigated cointegration between domestic prices in local currency units, the international prices in the US dollar, and the exchange rate. The results reveal that when the instantaneous exchange rate pass-through assumption is relaxed, the above cointegration cannot be observed. This is mainly because there is no cointegration between domestic prices in local currency units and the exchange rate implying that the domestic prices don not react to exchange rate developments in the country.

In addition, the third chapter examines domestic market price integration. The Ethiopian grain market have been under the influence of policy changes that resulted from the changes in governments and hence their ideologies towards the functioning of the market. In the post 1991 period, though not full-fledged, the grain market in Ethiopia has shown improvement. This is mainly attributable to the developments in infrastructure such as road networking and telephone service expansion.

Nonetheless, despite such developments, we observe that in the domestic wheat markets price variability appears higher in the markets located in a distance outside the 300Km radius of the central market. The exception in this regard is Mekelle, which has been categorized as deficit market. In the maize market, we found that Gonder and Mekelle located at a distance of 600 Kms and 700Kms, respectively, have shown average maize prices equivalent to the average price of other markets. This implies that improvements in infrastructure are helpful in reducing the impacts of distance on market integration.

The price spreads between the central market and other markets have shown that over time the price difference is declining. But we observe that even if Ambo is the market closest to the central market, the difference in the real prices of wheat between the two markets happen to be larger on average, but the spreads have been declining over time. On the other hand, Mekelle has exhibited higher positive price spread on average implying that real prices of wheat in Mekelle have been lower than the central market in the period under consideration.

These mixed results imply that domestic market integration is incomplete. Thus further intensification of the investment in market infrastructure and development of market institutions is essential so that the differences in prices and hence the price volatility across domestic markets could be reduced. Further, studying the co-movements of cereal prices with high value crop prices and change in land use patterns due to the price incentives help in characterising the grain market.

The fourth chapter aims to examine and compare the price volatility of oilseeds between the Ethiopian market and the World market. Because oilseeds are important export crops in Ethiopia, studying the price volatility of these crops helps in identifying the uncertainty that price volatility entail in production decisions of the producers. As a potential means of diversifying sources of foreign exchange earnings, oilseeds sector require due attention.

The investigation of domestic oilseeds price volatilities using the unconditional measure of volatility, standard deviation of the log of monthly price returns, indicate that price volatility of most of the commodities plunged during the financial crisis (January 2005- December 2008) when compared to pre-crisis period (February 1999- December 2004), except for Niger seed. However, in the post crisis period (January 2009- December 2012) volatility increased in all prices of oilseeds. The important implication of this is that oilseeds prices have become more volatile in after the high commodity price period, implying that the increased uncertainty of price movements may have influenced production decisions.

The comparison of volatility between periods prior to 2005 and after 2009 shows that volatility increased in the prices of all types of oilseeds.

The change in volatility over time, conditional volatility, shows that there are problems of volatility clustering in Lin seed and Rapeseed prices, whereas there is no problem of volatility persistence. Contrary to the domestic market, the world oilseed prices registered the highest volatility during the financial crisis, and the volatility of all oil crops dropped after end of 2008; for instance, the volatility of Sunflower oil dropped by more than 50%, and that of Linseed dropped by about 36%.

The world market evolution of volatility indicates that all the oilseeds in the world market demonstrate problem of volatility clustering. With regard to persistence of volatility we found out that Palm oil, Soybeans, and Linseed oil price volatilities are not persistent whereas Rapeseed prices demonstrate persistent volatility.

The direct comparison of price volatility between world and domestic markets is undertaken using Linseed and Rapeseed prices in the two markets. The unconditional price volatility comparison over different periods between 1999 and 2012 shows that over the entire period the unconditional price volatilities of oilseed items is higher in the domestic market than the World market. However, the unconditional price volatility tracks the World market situation when we examine it periodically. During the commodity market crisis the World oilseeds price volatility exceeded the domestic level in the case of Linseed oil, and approached and narrowed the difference with the domestic price volatility in the case of Rapeseed. This reveals two characteristics of the domestic oilseeds market. The first is that the domestic oilseeds market is less integrated to the World market, as it appear insulated from the external price shocks, especially during the 2007/08 commodity boom. The second is related to the decline in the ratio of export to domestic production, indicating that the increased domestic consumption insulated the domestic market from the volatility that would have been permeated into the domestic market and amplify the higher domestic oilseeds price volatility.

Further, the results show that in the domestic market there is no problem of volatility persistence where as volatility persistence appears the characteristic of the World market. Nevertheless, volatility clustering is a problem both markets have in common.

It is worth investigating the producer`s perception of the observed volatilities and how they react in regard to the production decisions they make in every season. Further, the welfare implication of such price volatilities on poor farmers and households is also a possible future research direction. In a primary commodity exporting country, a limited number of primary commodities may constitute larger share of export revenue. Hence, volatility of prices of these commodities may have an implication on government revenue and the overall economic growth. For this reason, investigating the implications of oilseeds price volatility on government revenue is worth considering.

The fifth chapter reviews policies pertinent to the agricultural sector, and their implications on productivity. The review exercise indicated that the input market: fertilizer and improved seed market, which is state led, appear inefficient in terms of improving access for agricultural technologies and increasing agricultural yield. The inefficiency is, particularly, manifested by lack of competition in the fertilizer market, delays in distribution of fertilizer at the optimal planting time, quality deterioration due to lack of appropriate storage facilities at the last mile distribution points, and low incentive for the last mile distributors, primary cooperatives, which is 2% of the price of fertilizers. Studies have shown that the low profit margin is insufficient to cover annual administrative expenses of the primary cooperatives and hence they are not capable to undertake the distribution and storage properly.

The seed sector shares all the inefficiencies in the fertilizer sector. In addition, it has the following problems, particularly associated with the seed market, that affect the performance of the sector. First, the low profit margin received by the state enterprise, which is 5%, appears an entry barrier for private firms to involve in the seed market. Second, lack of qualified experts in the research institutes that innovate improved high yielding seeds and supply pre-basic and basic seed for multiplication together with low technical expertise of farmers in the seed multiplication have been the constraints holding back the sector`s performance. Thus, we observe that the subsidized seed supply by the public enterprise and the high investment that firms required to make to release new cultivars and fulfil the regulatory requirements have been discouraging competition in the sector. Lack of competition in the seed market may seriously hamper the efforts to increase adoption of improved seed varieties, which are resilient to weather shocks that result from climate change and contribute towards enhancing agricultural productivity and growth. For this reason, reforming the seed sector and fostering competition and innovation, and capacity building in the research institutes would help in expanding coverage of improved seed adoption, intensity, and ensure sustainability.

With regard to the output market, the Ethiopian Grain Enterprise has been responsible for price stabilization, export promotion, facilitating emergency food security reserve, and helping the disaster prevention and preparedness programs. However, we have seen that the enterprise has been required to alternate its responsibilities that differ in action. In one instance, it has been required to procure maize in the domestic market, as there was bumper stock resulting from increased maize productivity. On the other, it has been required to procure wheat from the international market and supply in selected domestic markets, especially in urban areas, at a subsidized price to protect urban consumers from the soaring food prices in 2008. These changing roles and responsibilities may have hampered the roles of the enterprise.

The Ethiopian financial service is characterized by low inclusion and outreach. This mainly relates to the low financial sector development in the country hat in recent years has shown remarkable growth. The country has one of the lowest financial inclusions in East Africa region, only 1% of the rural households hold bank accounts, and the rural financial inclusion is shown to be nearly 3%. At the national level, the financial inclusion reached 14%, which is by far lower than the neighboring Kenya, which has a financial inclusion of 41%. The loan approved and dispersed to the agricultural sector, mainly to the large commercial farms, stood at only 14.6%. These results indicate that in contrast to the significant share of the agricultural sector in the economy, the sector has been underserved in terms of access to finance. Thus, further innovative financial services that serve the small holders who are known for financial liquidity constraints in their efforts to increase productivity and transform their farms into commercial farms are crucial. In this regard, the contribution of micro finance institutions (MFIs) and saving and credit cooperatives (SACCOs), though not sufficient, have been helpful in improving the outreach of the financial services to the smallholder farmers.

The Agricultural extension service has been offered aiming at increasing production and productivity of smallholder farmers. The service as been provided in the form of packages that include fertilizer, improved seed, pesticides and better cultural practices, improved post-harvest technologies, agro-forestry, soil and water conservation and beekeeping, all developed for different agro-ecological zones. These services, extended based on research generated information and technologies, plan to empower farmers to participate actively in the development process, increase the level of food self sufficiency and increase the supply of industrial and export crops while ensuring the rehabilitation and conservation of the natural resource base of the country. As of 2013, the program employs more than 70,000 extension workers across the country, and provides trainings for farmers in more than 15,000 Farmers Training Centres (FTCs) located across the country. As several studies show, the extension service is credit for increased income, increased household food security, reduction in poverty rates, and increased household consumption. However, these results have been contested. For instance, some studies indicate that farmers dis-adopted extension packages after a trial for a certain period due mainly to the high cost of inputs, which makes the appropriateness, profitability, and sustainability of the extension packages questionable. Moreover, extension workers were overtaken by other roles such as input distribution and ignored provision of advice to improve technical efficiency of farmers, and accorded high attention to numeric targets and coverage than the technical issues that need to be resolved. Thus, improving the capacity of the extension agents and clearly defining their duties and responsibilities tied to measurable outcomes may help in further improving the extension service.

The most contentious policy in the Ethiopian agricultural sector is land policy. Enshrined in the country`s constitution, land is the property of the people administered by the state on their behalf, and cannot be sold, exchanged or mortgaged. Thus, land is state property and farmers have only use rights over plots they have in their possession. The government believes that tenure security can be ensured by land registration and certification and currently most of the rural farmers received land certificates. However, the implication of property rights (land rights) on agricultural productivity has not been well researched in the Ethiopian context. The results from the available studies in this regard appear mixed. Some studies show that farmers, despite the certification, consider land redistribution likely to occur, while others indicate they are more concerned with the development of other factors such as population pressure and the ensuing land fragmentation than the issues of land right. One recent study, using panel data from the Tigray region in northern part of the country show that land certification has resulted in improved food security and improved child nutrition measured by body mass index (BMI). The evaluation, therefore, is inconclusive and the results indicated above cannot be used to widely infer the implications of land certification in the country.

6.2. Future Research Areas

On the process of developing this thesis, we have identified future research directions that are worth noting to advance the understanding of the constraints and challenges of the agricultural sector in Ethiopian agriculture in particular and in the developing world in general.

We note that in the analysis of the climate change the results obtained could be improved by including the temperature variable. We have not been able to do this because the data available for temperate in the study areas we considered was irregular and contains substantial missing values that we considered interpolation for a long period may be inaccurate in capturing the temperature variability. Further, the relative importance of climatic variables and non-climatic variables on average crop yield and yield variability can be an important research point. This is essential to identify whether climatic variables are unreasonably considered as reasons for lower productivity in the agricultural sector, and provide better insight into which factors are the key constraints in the agricltural sector.

Based on the study on the transmission of world food prices to domestic markets, we identify the following research directions. We have shown that the Ethiopian market is linked to the international food markets that are geographically close to the country. Further, the integration of the domestic wheat market with the international market, Paris wheat market, reveals the importance of the Ethiopian market in the evolution of the international wheat market in Paris. This, as we argued, is related to the wheat procurement of the Ethiopian governemnt for its price stabilization and the local food aid purchase scheme introduced since 1996. Therefore, examining the role of local food aid purchases on the degree of integration of the Ethiopian market to the world market is helpful in further explaining the mechanism of the linkage.

In relation to the study that compares oilseeds volatilities in the domestic and the world market, we suggest that measuring the impacts of oilseeds price volatilities on oilseeds producing households would better illustrate the implied risk of the price volatility. Further, it would be important to investigate whether there are price co-movements between the domestic oilseeds markets and the grain markets. From the review of the agricultural policies over the last two decades, we suggest that developing agricultural policy indicators that enable the policy makers evaluate the impacts of agricultural policies as an important future research area.