PRICE VOLATILITY AND FOOD INSECURITY
THE CASE OF ETHIOPIA

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Abstract

Ethiopia is one of the food insecure countries in the world and it relies on food aid. To make up the shortage of cereal supplies, the country imported cereals (i.e. it is import dependent for three cereals: wheat, sorghum, and maize). As a result, Ethiopia is prone to price volatility in the international market.

This study explores the domestic and international price situation of the three cereals (price trends and price volatilities) over the past eighteen years (2000-2018). In order to evaluate the state of price in domestic and international markets, this paper employed different measures. The trend in price is analysed using price index and regression analysis, while different volatility measures such as the coefficient of variation, corrected coefficient of variation and standard deviation in logarithmic price differences were used to measure the extent of price variability. In addition, the effectiveness of the country's latest major food security programme has been reviewed.

The results of the study show that in terms of food security, the most prominent change in Ethiopia's cereal price is related to price volatility, not price increase. In fact, during the study period, the real domestic prices of two cereals (maize and sorghum) fell. Although the country has adopted a new food security programme (the productive safety net programme, PSNP), it has only shown limited success due to various reasons. PSNP is different from food aid because it links food security and development projects. Implementation issues (including targeting problem and transfer methods, i.e. only cash transfers or food transfers with/without cash component) and lack of synergy with complementary policies were factors that hindered the effectiveness of the food security programme. Furthermore, in terms of coverage, PSNP is mainly limited to four regions.

Key words: food insecurity, price volatility, productive safety net programme

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List of abbreviations

AB - Afrobarometer

CCV - Corrected Coefficient of Variation

CPI - Consumer Price Index

CV - Coefficient of Variation

DiD - Difference in Difference

DS - Direct Support

FAO - Food and Agriculture Organization

FAOSTAT - Food and Agriculture Organization Corporate Statistical Database

GARCH - Generalized Autoregressive Conditional Heteroscedasticity

GDP - Gross Domestic Product

GIEWS - Global Information and Early Warning System

GTP - Growth and Transformation Plan

IFAD - International Fund for Agricultural Development

IMF - International Monetary Fund

IPCC - Intergovernmental Panel on Climate Change

PoU - Prevalence of Undernourishment

PSNP - Productive Safety Net Programme

PW PSNP - Public Work Productive Safety Net Programme

REALISE - Realising Sustainable Agricultural Livelihood Security

RPP - Ratio of Production to Population

SDD - Standard Deviation of the first Difference in logarithmic prices

SNNPR - Southern Nations, Nationalities, and People's Region

UNCTAD - United Nations Conference on Trade and Development

UNICEF - United Nations International Children’s Emergency Fund

USA - United States of America

USD - United States Dollar

WFP - World Food Programme

WHO - World Health Organization

Chapter 1: Introduction

1.1 Background

The poverty rate in East Africa is high. Food insecurity and degradation of natural resources are other characteristics of the region **(**Heshmati, 2016; Simelton and Ostwald, 2020). According to the most widely accepted definition, "Food insecurity exists when people do not have adequate physical, social or economic access to food" (FAO, 2009, pp.8). Though food security has three components: food availability, food access and food utilization (Webb et al., 2006), this paper mainly focuses on food access. In Connolly-Boutin and Smit (2016), food access is understood as the affordability, allocation and preference of food which can be influenced by income level, the cost of food and government and trade policies, among others.

To start with, the amount of food available is critical to meeting food security. Onyutha (2016) analysed African future food supply and its per capita availability. Forecasts for 2050 show that food insecurity will prevail. In most of the cases, in about 80% of countries, cereal production increased and the ratio of production to population (RPP) declined. The changes in crop production is attributed to area cultivated while high population growth have resulted in low RPP. The inability to meet local food needs suggests that Africa is dependent on food imports and that international food prices can affect Africa's food security. Like other sub-Saharan African countries, Ethiopia has a multi-dimensional poverty, including food insecurity. For instance, in 2016 alone 10.2 million people were food insecure (FAO, 2016). Ethiopia relies on food aid, which accounts for 9% of its cereal supply between 1994 and 2006 (Tadesse and Shively, 2009).

1.1.1 Socio-economic context

Ethiopia is one of the countries in the horn of Africa. Being a landlocked country, it shares borders with six countries in the region. Ethiopia has nine states and two city administrations: Addis Ababa and Dire Dawa.

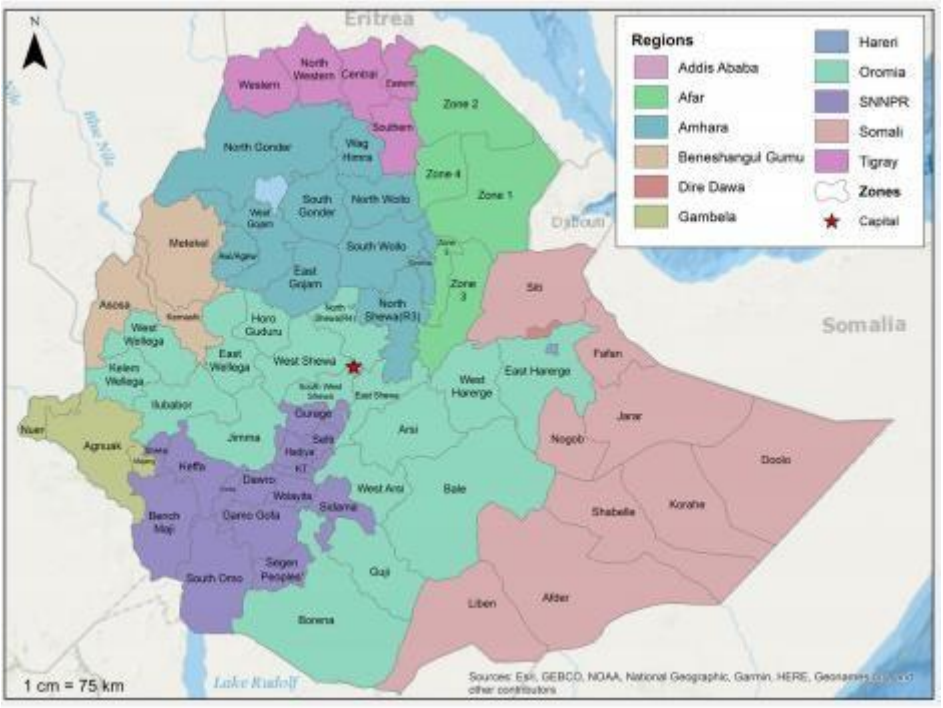


Figure 1. Location map of Ethiopia, adopted from Degarege and Lovelock (2019)

Ethiopia's per capita GDP is calculated at a purchasing power parity of $1,794 and is classified as a low-income country (see Table 1). Petrikova (2019) summarized the main economic and social indicators of Ethiopia. As shown in Table 1, on average the country achieved economic growth of about 8% over the past 20 years. Income inequality is measured by the Gini index. In the case of perfect equality, the index will take a value of zero, and for a perfectly unequal distribution, it will be 100. According to this measure, income inequality in Ethiopia has worsened since 2004. In terms of population size, Ethiopia is a country with a large population, with a population over 99 million. Besides, its population is growing at an alarming rate. Most of the population (about 80%) live in rural areas, and agriculture employs more than two-thirds of the workforce. Ethiopia grows crops such as barley and millet, but also staples (wheat, maize, teff and sorghum). Even under the current leadership of the ruling party, the country's political system is not democratic (Petrikova, 2019).

Table 1: Economic and social indicators

Per capita GDP at purchasing power parity (constant 2011 $) for 2018*	1,794
Average annual percentage growth rate of real GDP (% 1997- 2018) *	7.96
Gini Index (2004, 2010, 2015) *	29.8, 33.2, 35
Population (in millions)	99.3
Population growth (%)	2.5
Rural population (% of total)	80.5
Agriculture (% of labor employed)	72.7
Staple grains	Teff, Wheat, White maize, Sorghum
Political regime	Authoritarian

Source: Petrikova (2019), with records in asterisk (*) updated from World Bank

1.1.2 Scientific relevance

Agricultural commodity price volatility is of concern due to its impact on resource allocation. For example, in the case of high volatility, governments in poor countries will intervene in the market to provide basic commodities by subsidizing the price of inputs, which will affect the allocation of financial resources (Galtier,2009). During the period of high agricultural product prices, governments adopt various measures in order to make prices affordable for consumers. Governments attempt to increase supply of agricultural commodities by subsidizing import costs or supporting local production costs. Price volatility is an important issue that need to be explored, because subsidy can be costly in the face of high prices, especially for poor economies. For instance, the cost of fertilizer subsidy in Africa account for about 30% to 80% of the value of the fertilizers (Bates, 2014).

In addition, price volatility is an interesting subject for its impact on consumers and producer's welfare. Rising prices will increase consumer spending and drain income (Huchet-

Bourdon, 2011). A significant portion of the poor's income is used to buy food, and they are the ones most affected by price fluctuations (Ivanic, Martin and Mattoo 2011). On the other hand, downward fluctuations worry producers since it reduces their revenue (Huchet- Bourdon, 2011). Besides, food price instability can affect food security and may even interfere with production decision by stimulating or inhibiting producers (Galtier, 2009). There was a dramatic rise in international food prices since 2000. During the food crises in 2007/08 and later in 2010, prices have increased tremendously. The wheat price on the international market increased by 118 % between January 2007 and March 2008. Similarly, the price of maize increased by 77 % in June 2008 as compared to its price level in January 2007. In the second half of 2010, when international food prices started to rise again, the international food price index surpassed the 2007/08 level (Swaminathan, 2011).

Food insecure low-income countries like Ethiopia are susceptible to shocks in the international market since they fill the production gap through food imports (Matz, Kalkuhl and Abegaz, 2015). A study of Ethiopian wheat by Haile, Kalkuhl, Algieri and Gebreselassie (2017) showed that domestic wheat prices are affected by world prices. As a result, the turmoil in the international market has been transferred to the domestic economy to counteract food security. Specifically, global economic conditions and changes in oil prices are factors that affect demand for agricultural products, which in turn affect price trends (see Taghizadeh-Hesary, Rasoulinezhad, and Yoshino 2019; Swaminathan, 2011). In addition, even food aid has caused price volatility in the past.

According to a study by Tadesse and Shively (2008), in addition to the price transmission from the international market through purchased food imports, food aid has also depressed prices and hindered production. Therefore, both international and domestic price volatilities may have an impact on food security.

This paper attempts to assess the relationship between agricultural product price volatility and food security. The rest of the paper discusses price volatility and food security at different levels. Furthermore, as a climate study master's student, I am interested in food security issues since it involves climate change. According to the fifth report of the Intergovernmental Panel on Climate Change (IPCC), climate change affects different aspects of food security in tropical and temperate regions. For example, in the absence of adaptation, a rise in

temperature can negatively affect yields of wheat, rice, and maize. As yields decline, climate change worsens the incomes of the rural poor, which adversely affects access to food (Pachauri et al., 2014).

Figure 2 shows the effect of climate change on food security through different channels. At the bottom, Figure 2 presents the connection of various food security aspects (such as availability, access, and utilization) and other livelihood attributes with natural resources. Climate change and the resulting adaptation strategies (responses) have an outcome on livelihood and natural resources that are interdependent. For instance, according to Connolly- Boutin and Smit (2016), an adaptation strategy that may increase income, such as the selling of livestock can deplete soil fertility by reducing manure, but at the same time it can promote biodiversity by reducing overgrazing.

At the top of Figure 2, biophysical and socioeconomic factors that determine vulnerability are represented. Besides, it is shown that the adaptive capacity depends on financial, social, natural, human, and physical capitals that are generally called assets.

Finally, in the middle of Figure 2, we find the responses to climate change that can be either through adaptation strategies or by the transformation of institutional structures or processes.

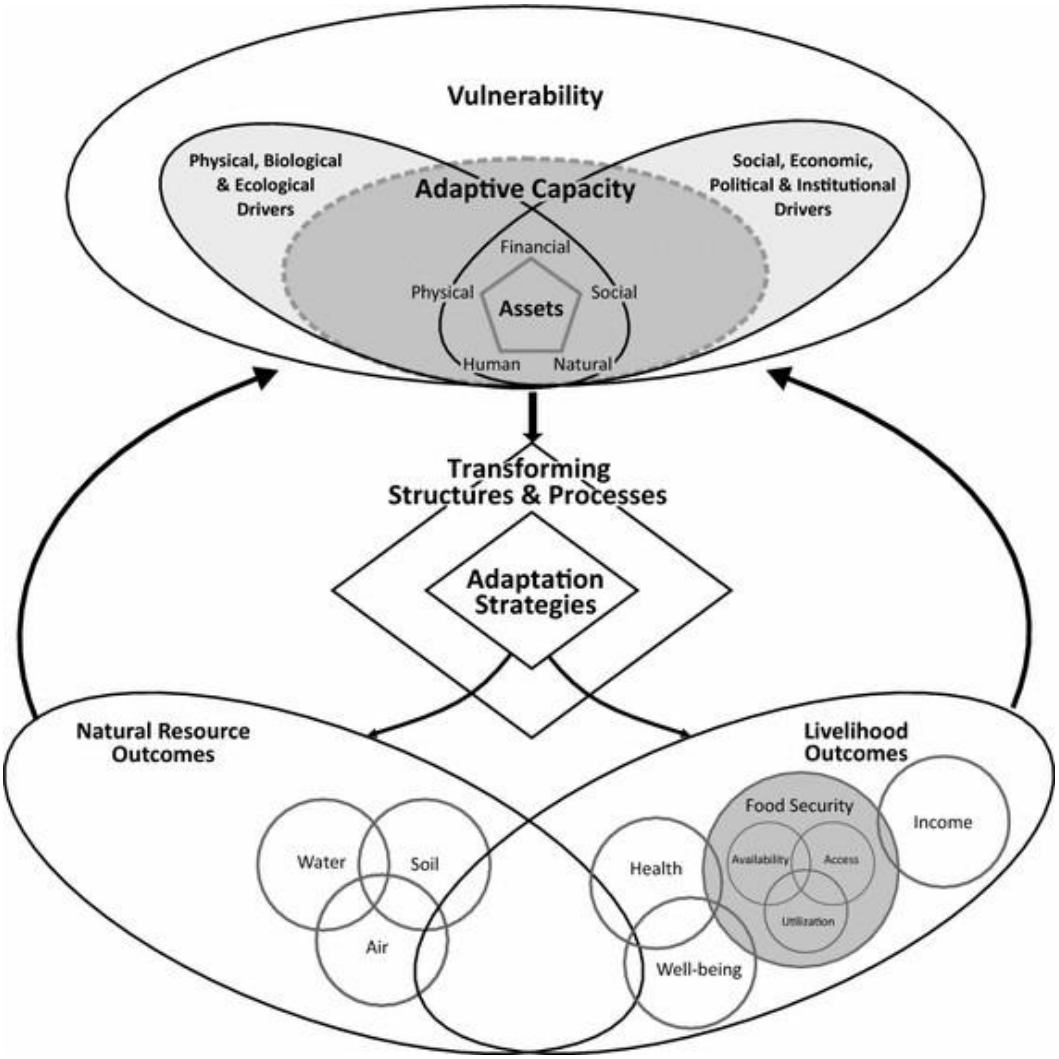


Figure 2. Climate change, food security, and livelihood framework (Connolly-Boutin and Smit, 2016).

Sub-Saharan Africa is vulnerable to the impacts of climate change (Connolly-Boutin and Smit, 2016; Kotir, 2011). According to Kotir (2011), SSA is the most vulnerable region because it relies on agriculture, which is highly sensitive to weather and climate variables. Climate change has adversely affected agricultural production in sub-Saharan Africa, affecting areas suitable for agriculture, the length of the growing season and yield potential, which in turn has affected food security. Hoffman, Kemanian and Forest (2018) identified climate signals for maize, sorghum, and groundnut yields in SSA. They pointed out that due to warming climate and dryness, the expected increase in future crop yields from technological advances may gradually decrease.

1.2 Conceptual framework and research questions

In order to understand the relationship between global food markets and the domestic economy and specify the scope of domestic food security policy, a conceptual framework is adopted from Smith (1998). Figure 3 shows the channels through which world food supply relate to national food availability and food security. Global food supply i.e. the amount of food available to feed the world's population, contributes to the national food supply through food imports. In addition, the national food supply also consists of domestic production. However, from a household or individual perspective, food prices (shown as food access) and consumer income are the immediate determinants of food security.

In face of volatile prices, in order to attain food security, governments may either target stabilization of prices or preservation of income (Cohen and Garrett, 2010). In line with this, this paper reviews the food security measures taken by the Ethiopian government. As far as I know, research on food security in Ethiopia either addresses price volatility or studies issues from a policy perspective (Woldehanna and Tafere, 2015; Tadesse, Algieri, Kalkuhl, and Von Braun, 2014). In this thesis, I am trying to combine volatility analysis with policy review.

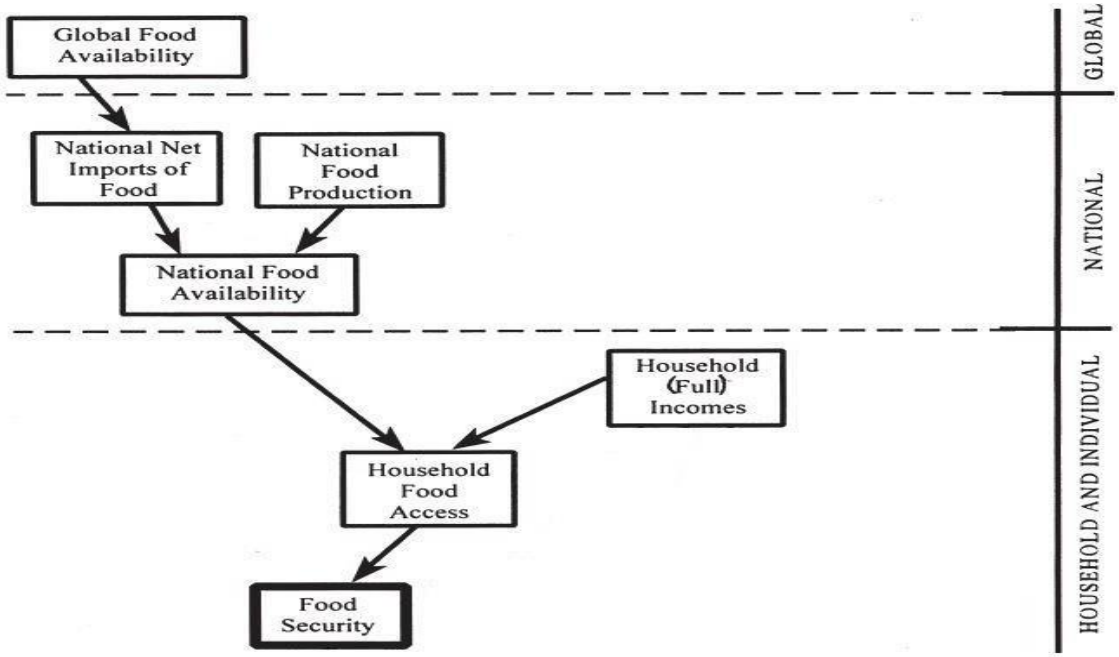


Figure 3. Conceptual framework (modified and adopted from Smith,1998)

In short, the main objective of this paper is to study trends in cereal prices and their volatility related to food security. Thus, the paper identifies the most prominent aspects of the state of

cereal prices and reviews the target of Ethiopia's food security policy in the past two decades. To achieve this goal, this study attempts to answer the following four research questions.
Research question 1. What are the price trends for the three grains (maize, sorghum, and wheat) in Ethiopia's domestic and international markets?

Research question 2. How volatile are the domestic and international prices of the three cereals (in the past two decades)?

Research question 3. What food security measures have been adopted by the Ethiopian government in different volatility conditions over the past two decades?

Research question 4. Are the food security measures taken by the Ethiopian government comply with the most prominent cereal price situation (observed in the past two decades)?

In addressing the first question, the trend in prices will be assessed graphically, by constructing indices and through regression analysis. From this we can examine if the price pattern in the international market corresponds to the domestic price evolution. For the second question, the price volatilities in the domestic and international market will be computed by using simple coefficient of variation i.e. uncorrected for trend in the price series (Naylor and Falcon, 2010), corrected coefficient of variation (Cuddy and Valle, 1978; Houchet-Bourdon, 2011) and standard deviation of the difference in logarithm of prices (Dawe, Morales-Opazo, Balie and Pierre, 2015; Gilbert and Morgan , 2010; Houchet-Bourdon, 2011; Mittal, Hariharan, and Subash, 2018).

If there is a correspondence between domestic and international price volatilities, this indicates the international market has an impact on the country's food security. Furthermore, the most prominent component of domestic price change has to be identified to better address Ethiopia's food insecurity.

Evaluating Ethiopian food security policy over the past two decades helps to know whether, the most prominent price component is targeted or not. For instance, if high prices are more critical than price fluctuations then, given the low income in developing countries, food insecurity may not be addressed through price stabilization measures (such as subsidy) alone. On the other hand, if price volatility is more relevant, enhancing domestic production can be an option to insulate from price volatility in the international market.

1.3 Outline of the thesis

The thesis will be organised into eight chapters. The second chapter, following this introductory chapter, describes the state of food security in Ethiopia and around the world. Chapter three will review the empirical evidence on the relationship between price volatility and food security. This chapter concludes with an overview of the drivers of agricultural price volatility. Chapter four introduces research methods and discusses volatility measures, procedures (assumptions) and data sources in more detail. The fifth chapter provides cereal price trends and identifies Ethiopia's cereal import partners. Then, in chapter six domestic and international price volatilities are computed. This is followed by the review of food security policies adopted by the Ethiopian government over 2000-2018, which is discussed in chapter seven. Finally, chapter eight summarizes the research by introducing the main findings, and then presents conclusions and recommendations.

Chapter 2: Overview of food insecurity

This chapter outlines the state of food insecurity in the world and Ethiopia, measured by the prevalence of undernourishment (PoU). Additionally, Ethiopia's main domestic cereal supply is discussed.

2.1 Global food security

Table 2 shows the state of food insecurity as measured by the percentage of undernourished people. The population below minimum level of dietary energy consumption (prevalence of undernourshment) captures the fraction of the population lacking enough diet energy for a healthy and active life. According to this measure, food insecurity is most prevalent in Africa.. Besides, within Africa there is a disparity in the percentage of the underfed. Eastern Africa is the most dietary deficient region while the southern part of Africa is the least underfed. In the latter case, the PoU is below 10 percent during 2005-2018 period whereas in the former case about 30 percent.

Table 2: Prevalence of undernourishment (percent of population) in the world, 2005-2018

	Prevalence of undernourishment (%)					
	2005	2010	2015	2016	2017	2018*
WORLD	**14.5**	**11.8**	**10.6**	**10.7**	**10.8**	**10.8**
AFRICA	**21.2**	**19.1**	**18.3**	**19.2**	**19.8**	**19.9**
Northern Africa	6.2	5.0	6.9	7.0	7.0	7.1
Sub-Saharan Africa	24.3	21.7	20.9	22.0	22.7	22.8
Eastern Africa	34.3	31.2	29.9	31.0	30.8	30.8
Middle Africa	32.4	27.8	24.7	25.9	26.4	26.5
Southern Africa	6.5	7.1	7.8	8.5	8.3	8.0
Western Africa	12.3	10.4	11.4	12.4	14.4	14.7
ASIA	**17.4**	**13.6**	**11.7**	**11.5**	**11.4**	**11.3**
Central Asia	11.1	7.3	5.5	5.5	5.7	5.7
Eastern Asia	14.1	11.2	8.4	8.4	8.4	8.3
South-eastern Asia	18.5	12.7	9.8	9.6	9.4	9.2
Southern Asia	21.5	17.2	15.7	15.1	14.8	14.7
Western Asia	9.4	8.6	11.2	11.6	12.2	12.4
Western Asia and Northern Africa	*8.0*	*7.1*	*9.2*	*9.5*	*9.8*	*9.9*
LATIN AMERICA AND THE CARIBBEAN	**9.1**	**6.8**	**6.2**	**6.3**	**6.5**	**6.5**
Caribbean	23.3	19.8	18.3	18.0	18.0	18.4
Latin America	8.1	5.9	5.3	5.5	5.7	5.7
Central America	8.4	7.2	6.3	6.1	6.1	6.1
South America	7.9	5.3	4.9	5.3	5.5	5.5
OCEANIA	**5.5**	**5.2**	**5.9**	**6.0**	**6.1**	**6.2**
NORTHERN AMERICA AND EUROPE	**< 2.5**	**< 2.5**	**< 2.5**	**< 2.5**	**< 2.5**	**< 2.5**

Source: FAO, IFAD, UNICEF, WFP and WHO (2019)

2.2 Food insecurity in Ethiopia and domestic food supply

The PoU (a food insecurity indicator) used in the previous section will also be used to measure the state of food security in Ethiopia. As shown in Figure 4, the percentage of undernourished people persistently declined in the last two decades. The blue line represents the undernourishment rate in Ethiopia, and the purple and green lines represent the PoU of low-income and sub-Saharan African countries, respectively. Starting with severe food insecurity; Ethiopia's PoU is used to be higher than the average of both low-income countries and sub-Saharan Africa, and great progress has been made to catch up with continued progress. Ethiopia achieved the average PoU in low-income countries by 2013 and has since fallen far below the average of low-income countries. Similarly, in 2016, Ethiopia managed to reach levels in sub-Saharan Africa, and even reached a lower PoU in 2017: lower than the average incidence of undernourishment in sub-Saharan Africa.

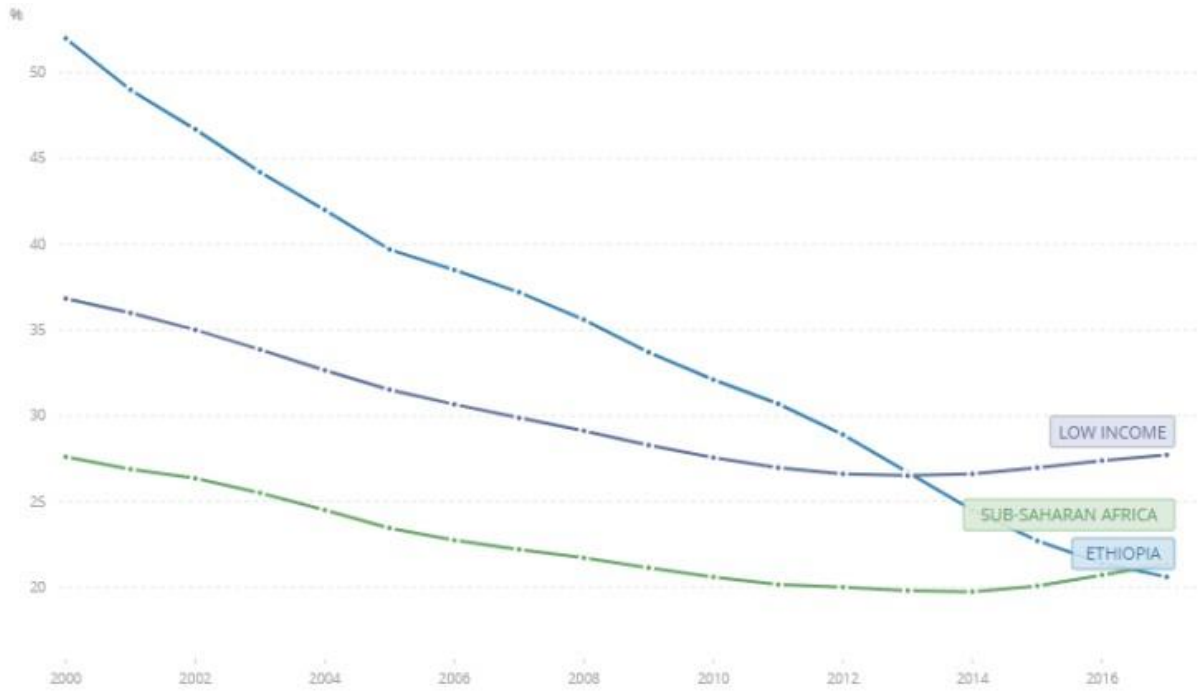


Figure 4. Prevalence of undernourishment (% of population) (World Bank)

Food availability is one of the factors that determine food security of a country. Domestic supply is comprised of domestic production and the amount of food imports. According to Otero, Pechlaner and Gurcan (2013), pp.276 "domestic supply is made up by the sum of already existing stocks, plus new domestic production, plus imports, minus exports".

2.2.1. Annual production of major cereals

Wheat, maize, and sorghum are the three most consumed cereals in Ethiopia and hence are important for food security. As can be inferred from Figure 5 the production of the three grains has increased overtime. Corn is the highest yield crop, and sorghum is the second highest crop. Of the three cereal types, wheat was the crop with the lowest yield during the study period.

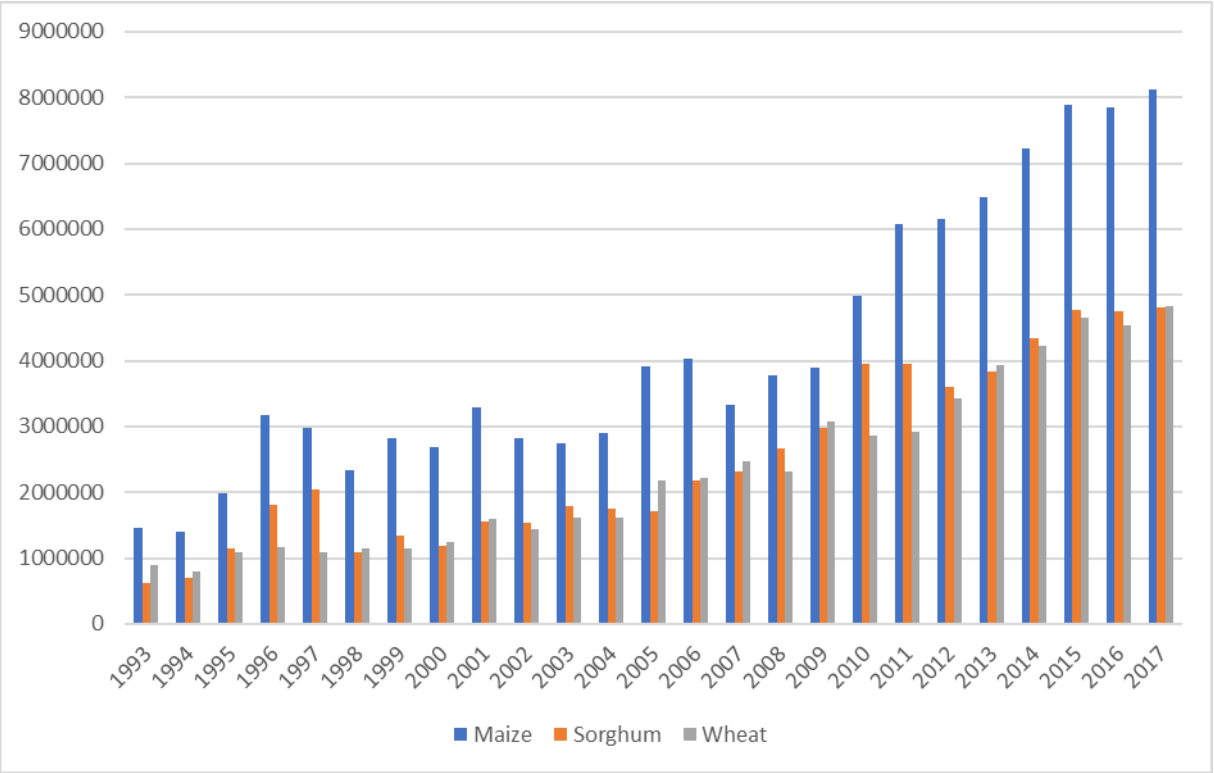


Figure 5. Quantities of maize, sorghum and wheat production in tonnes (constructed based on data from FAOSTAT)

2.2.2. Import- export balance of three main cereals

As can be seen in Figure 6 Ethiopia has been a net importer of wheat and wheat products. There is a huge import - export gap for wheat and wheat products. During 2007-2011 and between 1993 & 1996 sorghum and sorghum products import also exceeded export quantities. However, the deficit is not as high as for wheat and wheat products that covered the entire period. On the other hand, maize and maize products import is only slightly higher than its export, except in the post 2010 when maize export surpassed import.

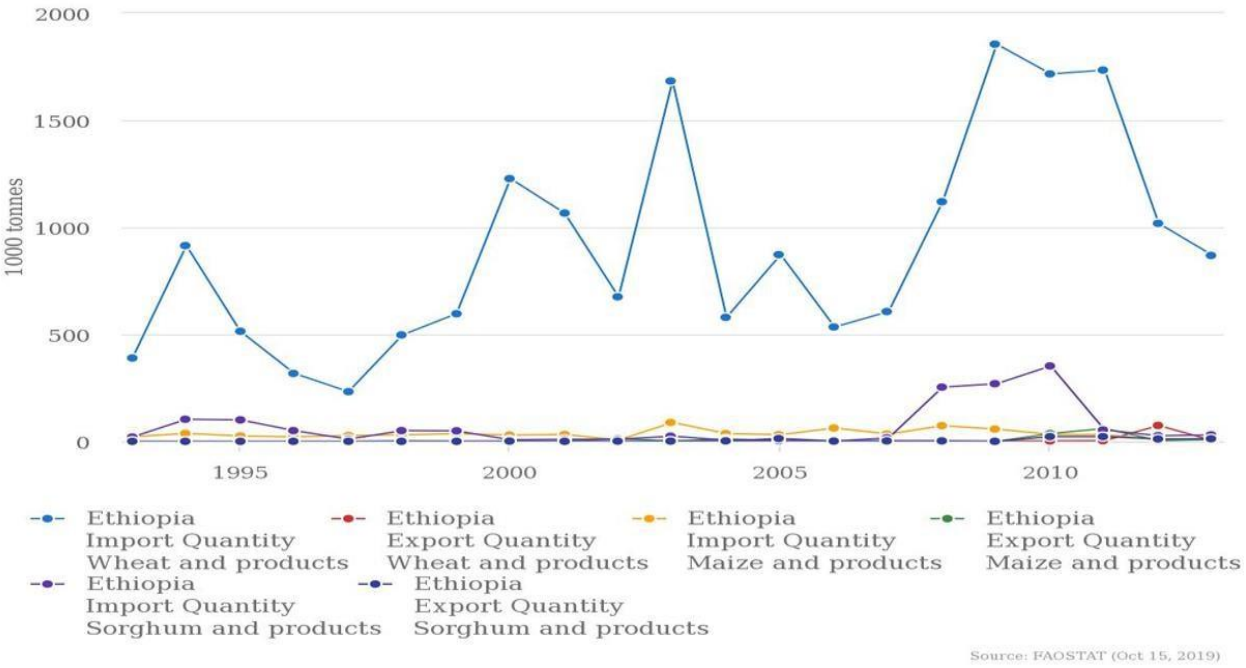


Figure 6. Import-export food balance of wheat, maize and sorghum, quantity in 1,000 tonnes (FAO STAT)

The production and import-export trend show that wheat, which is the least domestically produced amongst the three cereals, is the most imported grain. By the same token, the unmet domestic demand for the other two crops at different points in time when the domestic supply is insufficient is managed through import.

2.3 Conclusions

Two important conclusions can be drawn from this review. Firstly, as indicated by the undernourishment rate, Ethiopia is a food insecure country. Secondly, the import-export food balance of the three grains (wheat, maize, and sorghum) in Ethiopia indicates that the country is a net food importer. As a result, the country is linked to the international cereal market and it is important to study international price volatilities.

Chapter 3: Empirical literature review

This section starts with overview of prices in three major staples and empirical review on the impact of international food price volatility on food security in developing countries follow. In addition, this section covers the disparity in food security between urban and rural areas during food price crisis (period of high global food price volatility). It then continues to review the causes of international food price volatility, ranging from short-term events (such as droughts, sudden changes in energy prices, financial crises and the resulting speculative activities in commodity markets) to lasting measures (such as trade policies).

3.1 Prices of three widely traded cereals

Wheat, maize and rice are globally important crops whose volatility is analyzed by different authors (Cohen and Smale, 2011; Dawe, Morales-Opazo, Balie and Pierre, 2015; Gilbert, 2010; Gilbert and Morgan, 2010; Houchet-Bourdon, 2011; Naylor and Falcon, 2010; Otero, Pechlaner and Gurcan, 2013). Based on monthly data and coefficient of variation measure, wheat and maize prices fluctuate almost identically, but rice is the most volatile grain (Naylor and Falcon ,2010). According to Naylor and Falcon (2010), rice prices have become more volatile due to the absence of well-functioning futures market for rice, which is not the case for the other two crops. Their results are contrary to those of Dawe, Morales-Opazo, Balie and Pierre (2015), which found that corn prices were more volatile. The study period is different but, they also used different volatility measure, standard deviation of logarithmic price changes. On a global scale, a serious price increase is observed every 30 years. The impact of price increase in the 21st century is relatively small due to economic growth. Besides, every time the price rises, the reasons for price fluctuations are different. The root cause of the sharp price increase during the last century has been related to world wars and the oil crisis since 1970s. The reasons for the recent price volatility will be discussed in the section ‘‘Drivers of Agricultural Price Volatility’’.

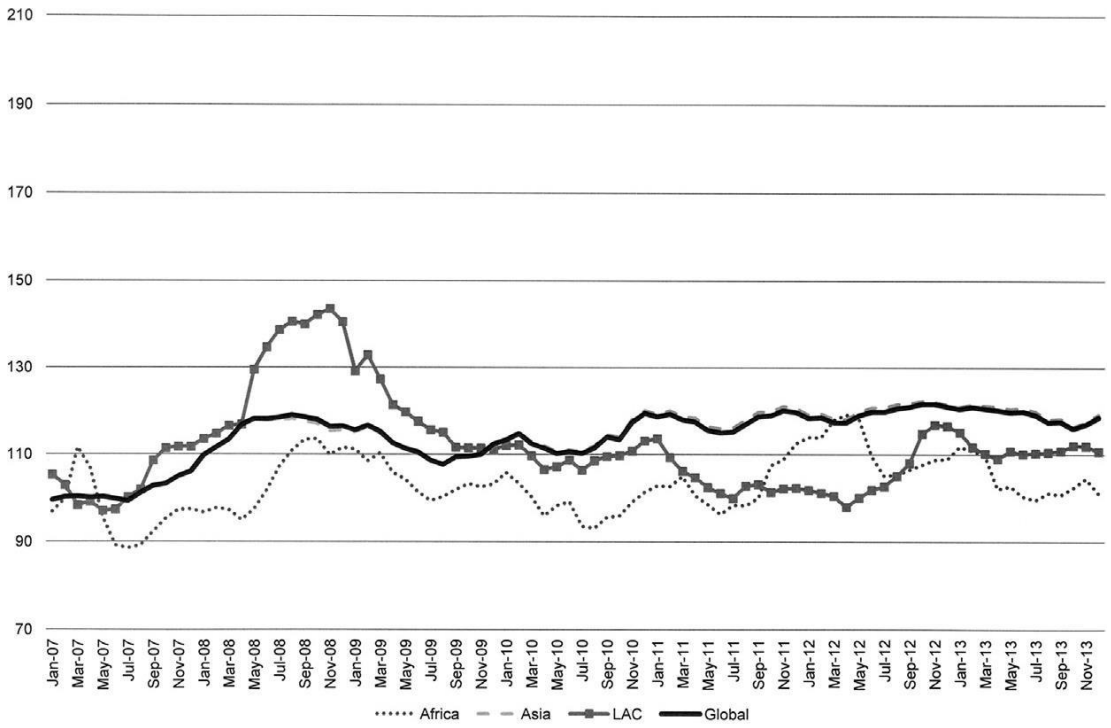
As shown in Figure 7 (a, b and c), prices increased for the three cereals during the 2007-2008 financial crisis that hit the global economy. As can be seen from Figure 7, in all cases (i.e. in Africa, Asia, Latin America and globally), the prices of the maize, rice and wheat rose sharply in 2008. According to Clapp (2009) the changes in cereal prices were due to the collapse of world financial market and the speculation that spread to the grain market. In addition, Clapp (2009) mentioned that rising oil price have contributed to the sharp rise in agricultural price. Oil prices have increased the prices of agricultural inputs such as pesticides and fertilizers

used in the production of agricultural products, thereby affecting cereal prices. Conversely, the price of wheat and maize in Latin America from 2007 to 2013 reached its lowest level around July 2010. In terms of magnitude (January-June 2007=100 as a base year), for the study period, the price index was highest for maize than for wheat and rice. As to Dawe, Morales-Opazo, Balie and Pierre (2015), price volatility measure also confirm that maize is more volatile than the other two crops. Besides, the price index for maize is highest for Africa than the other two regions and even well above the global price index for most of the period. On the other hand, the price index of rice is lowest for Africa except for a while when the lowest index is recorded in Latin America. In line with this observation, Dawe, Morales- Opazo, Balie and Pierre (2015) find out that cereal prices are more volatile in Africa than in Asia or Latin America.

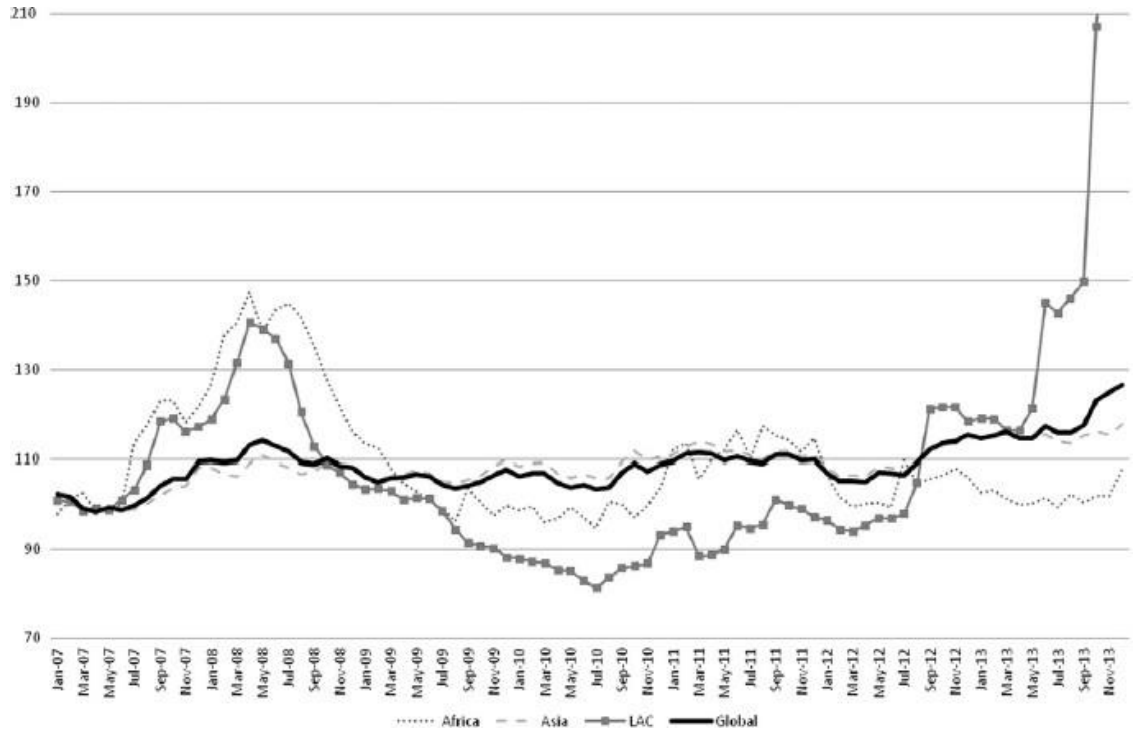
Another point that can be inferred from Figure 7 (a, b and c) is the unprecedented increase of wheat prices in Latin American in 2013, following a sharp drop in production in Argentina (Dawe, Morales-Opazo, Balie and Pierre, 2015).

Finally, it is worth mentioning the correspondence of price changes that exists between regions and the global trend except for Latin America. The co-movement of the regional price levels with the global trend suggests the presence of possible price volatility transmission i.e. world prices enter domestic economy through cereal imports.

a) Rice price index (January-June 2007=100)



b) Wheat price index (January-June 2007=100)



c) Maize price index (January-June 2007=100)

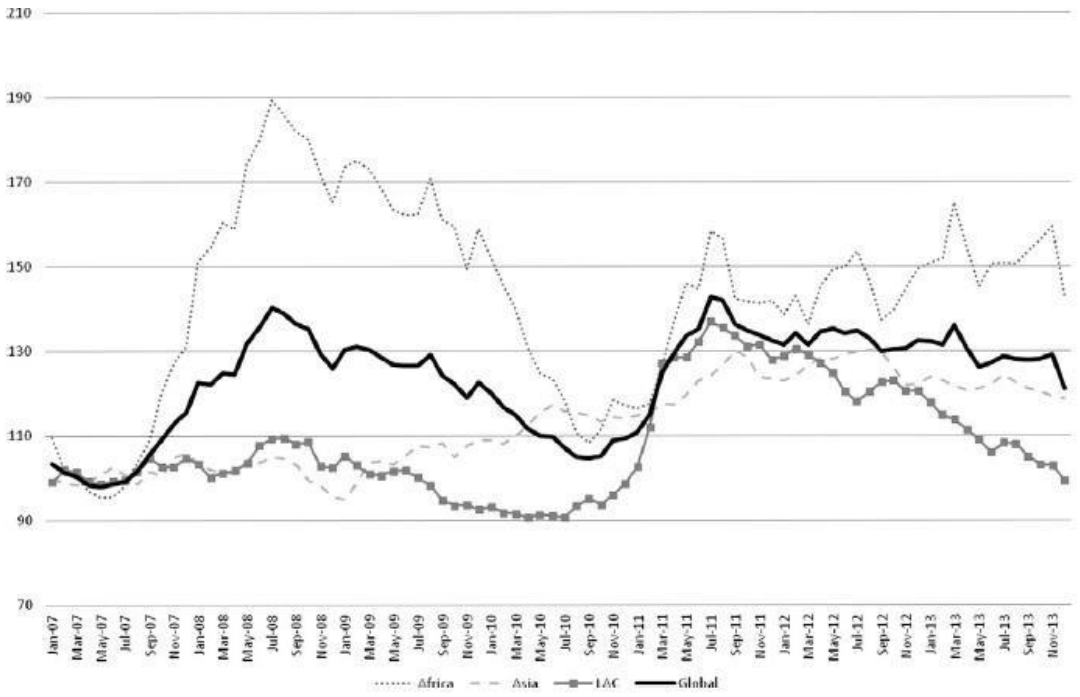


Figure 7. Price indices of rice, wheat, and maize at regional and global markets (Dawe, Morales-Opazo, Balie and Pierre, 2015).

3.2 Food security during the 2007-08 food price crisis

According to Huchet-Bourdon (2011), volatility refers to the variability of price around its mean value and it is often the high deviations that are often referred in volatility studies. Price volatility in the international market mainly affects developing countries that heavily depend on food imports (Clapp, 2009; Otero, Pechlaner and Gurcan, 2013). As countries involve more in international trade in agricultural markets, they import world price of food commodities. This has increased food security risks in developing countries through price inflation. In contrast, according to Clapp (2009) cheap imports discourage domestic production and acts as a dis incentive to improve the agricultural system of poor countries. Thus, price volatility in face of either too high or too low prices affect developing countries food security. Otero, Pechlaner and Gurcan (2013) find that the effect of agricultural commodity price volatility on food security differs significantly across countries according to their income levels. Developed countries like Canada and the United states import more of luxury foods while developing countries became dependent on advanced countries for their basic foods. Besides, in terms of magnitude, imports of former countries constitute less than 5 percent of food intake whereas for developing countries like Mexico basic food imports account over 50 percent of the average daily intake.

The impact of rising global agricultural prices, especially that of the 2007-2008 price increase (referred as the global food crisis throughout the paper) on food security in developing countries is discussed in the following paragraphs. As shown in Table 3, the studies cover rural and urban households of developing countries mainly Africa. A study by Naylor and Falcon (2010) showed that the poorest rural households are more vulnerable to food security risks. The extremely poor households are mainly farmers who sale small surplus produce on the market and as a result could not benefit from price increase.

Another study conducted by Hadley et al., (2011) on the effect of the 2007-2008 global food crisis on Ethiopian rural-urban food insecurity reasserted Naylor and Falcon (2010) finding. Ethiopia has experienced the global food crisis through the rising domestic food prices. However, this effect is not uniform in rural and urban areas. The global food crisis has led to a more visible food insecurity in rural Ethiopia. Urban households are more immune to food insecurity since they are richer on average. Nonetheless, they also have more wealth to protect them at high food prices. Additionally, due to the small scale of production, farmers are unable to take advantage of the benefits of rising agricultural prices.

Though minimal, as it only reduces dietary diversity, evidence from Ouagadougou showed the impact of rising global food prices on urban dwellers (Martin-Prevel et al., 2012). Basic foods such as grains, which have the largest price increases, continue to be consumed by most households. Still, the number of people who purchase foods that are considered less important in traditional diets has decreased (Martin-Prevel et al., 2012). Therefore, even in urban households, the impact of price volatility on food security is there, but they are insulated by converting their wealth into cash or eating less diverse food.

In terms of who is specifically affected by price variability, poverty is a crucial factor. Kumar and Quisumbing (2013) pointed out that poverty is a major factor in determining food insecurity than the urban-rural location differences. In Ethiopia, between 2007 and 2008, female-headed households were more susceptible to changes in food prices and food price shocks. Usually female-headed households are relatively poor, and their food gap (i.e. the number of months they are unable to meet food needs) is greater than that of male-headed households. The coping mechanisms utilized during price increase and shocks include reducing the number of meals offered to households and eating less preferred varieties.

However, according to self-reported food insecurity measures Verpoorten, Arora, Stoop and Swinnen (2013) discovered conflicting results with Ethiopia and Burkina Faso cases. The

authors point out that given the self-reporting indicators used to measure food insecurity, their results should be interpreted with caution. Their self-reported food security from Afrobarometer (AB) surveys measure the incidence and depth of food insecurity. On average, food security in rural households improved in 18 sub-Saharan African countries between 2005 and 2008. On the other hand, during the same period, the average level of urban food security deteriorated.

The incidence of food insecurity is used to measure whether individuals have experienced food shortages. On the other hand, the frequency of hunger is used to grasp the severity of food insecurity. Overall, Verpoorten, Arora, Stoop and Swinnen (2013) found a slight increase in the incidence of food insecurity and a reduction in the depth of food insecurity for the sample of sub-Saharan African countries considered. Which means, the number of people of food insecure people shows only a modest growth, but the number of people who often have food shortages has decreased. The authors provide multiple explanations for the slight impact of rising international food prices on sub-Saharan Africa. First, poor farmers may benefit from price increases through high product prices. Second, there can be slight transmission of international prices to the domestic market and, third, self-reported food security measures are less sensitive to changes in household food consumption. In addition, the region has already experienced drought in 2005. As a result, the impact of the 2008 food price hike is not easily recognized.

On top of that, it is worth mentioning that Verpoorten, Arora, Stoop and Swinnen (2013) have shown a positive correlation between food security and GDP per capita growth.

Figure 8 (a), taken from Verpoorten, Arora, Stoop and Swinnen (2013), measures the overall relationship between food insecurity (measured by percentage change in food insecure population i.e. the percentage of respondents without food at least once observed over the period 2005-2008) and economic growth (the average annual growth of GDP is measured). The plot shows the inverse relationship between the variables. As the economy grows, food insecurity will ease. Confidence intervals are built around the fitted line and points represent countries. Points above the line show a level of food insecurity that is higher than the average established by the fitted line. Figures 8 (b) and (c) provide a more categorized food insecurity measure, the incidence and depth of food insecurity. Food insecurity2 and foodinsecurity3 shows percentage changes in food security indicators. The state of food insecurity2 measures the percentage of respondents that have experienced food shortages more than once or twice

over 2005-2008), and on the other hand, the state of food insecurity3 measures a more severe condition, which represents the percentage of respondents with no food security many times or always during 2005-2008. Comparing the relationships in Figures 8 (b) and (c), (b) is stronger than the relationship in (c), which means that economic growth is strongly correlated to the incidence than the depth of food insecurity.

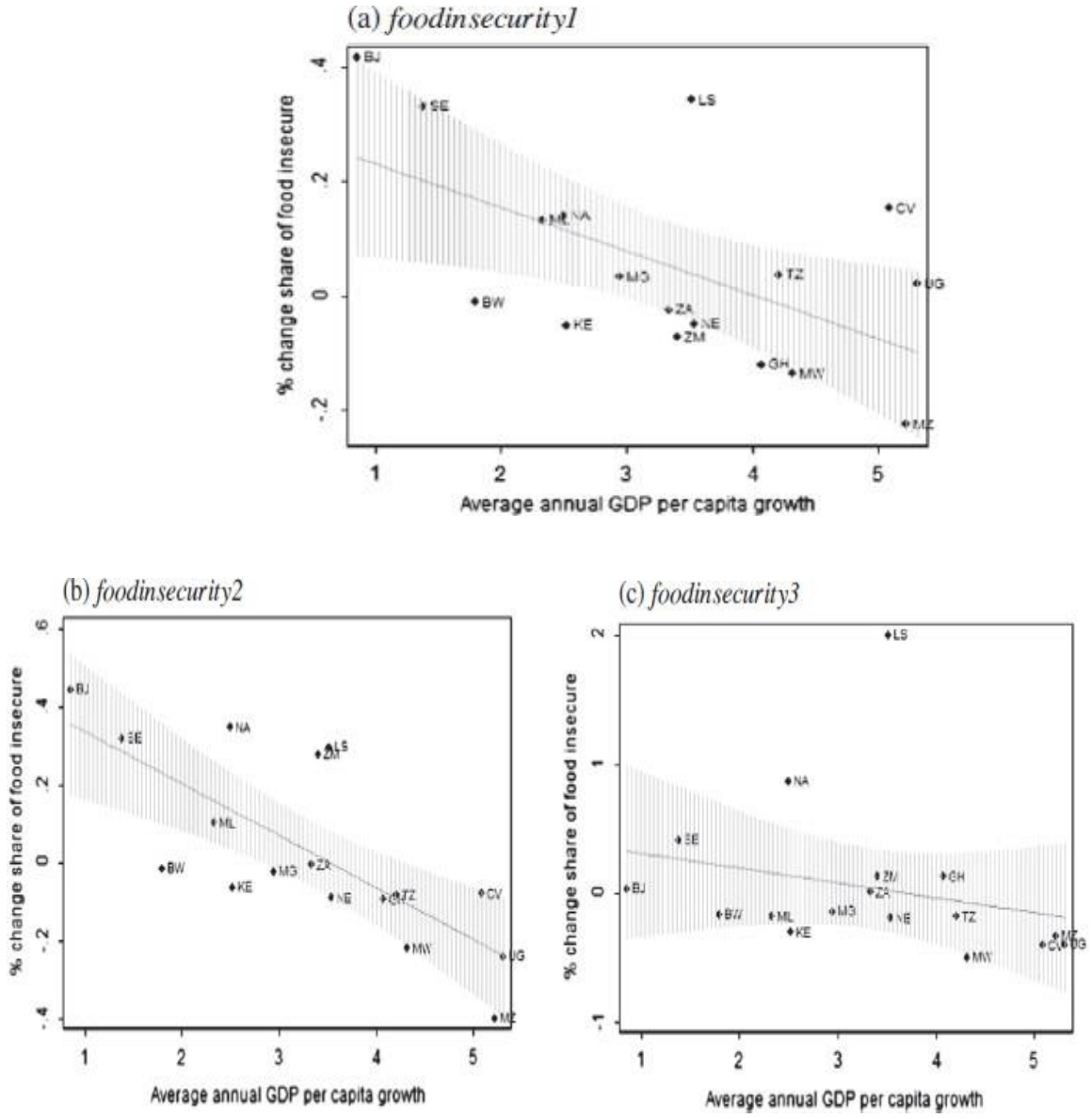


Figure 8. GDP per capita and food insecurity (Verpoorten, Arora, Stoop and Swinnen, 2013)

Verpoorten, Arora, Stoop and Swinnen (2013) also analyzed food insecurity by gender. Their results are consistent with the finding of Kumar and Quisumbing (2013). In a female-headed household, food insecurity is more prevalent than their male households.

In general, price volatility in the world market affects food security in developing countries, but even in developing countries, its impact varies with household poverty levels.

Table 3. Summary of the impact of 2008 food price crisis studies on food security

Author	Case study	Food security measure	Main findings
Hadley et al., (2011)	Ethiopia	Self-reported food security indicator	the poor in the rural areas are the most affected group by the 2008 food price shock
Kumar and Quisumbing (2013)	Rural Ethiopia and gender impact	Self-reported food security indicator	female-headed households were more food insecure during the 2007-2008 food price shock
Martin-Prevel et al., (2012)	Urban Burkina Faso	Self-reported food security indicator	food price increased during the 2008 food price crisis and though food expenditure increased, households were not only more food insecure but also consumed less diversified food
Verpoorten, Arora, Stoop and Swinnen (2013)	18 sub-Saharan African countries	Self-reported food security indicator	self-reported food security improved on average in rural households, while it worsened in urban households (farmers who may have benefited from the high food prices and price transmission was limited to urban areas)
Naylor and Falcon (2010)	Rural areas of Ghana, Guatemala, Malawi, and Uganda	household surveys-percentage of household expenditures on food	the poorest rural households are more vulnerable to food security risks.

Source: Author's compilation

3.3 Drivers of agricultural price volatility

Clapp (2009) believes that the reasons for agricultural product price volatility have exceeded the conventional demand and supply sources. In contrast, in the 2008 food price crisis, the

depreciation of the dollar, speculative activities in the commodity futures market and trade measures have had a major impact on food price volatility. Since the international market trades in USD, the depreciation of USD means that agricultural products become cheaper. Consequently, increased foreign demand for US grains has led to higher food prices. On the other hand, with the depreciation of the dollar, speculation in agricultural products has increased, which may be another reason for price volatility. Besides, agricultural export restrictions in developing economies; originally designed to protect the domestic economy from international price shocks, but it further exacerbated international price volatility.

Similarly, Naylor and Falcon (2010) point to external factors that contribute to increased food insecurity in developing countries. These factors are increased demand for biofuels, changes in exchange rates and energy prices, and excessive accumulation of cereals when high cereal prices are expected (speculation). As for Clapp (2009), rising oil prices have increased investment in biofuels, which has led to higher cereal prices. The increase in demand for biofuels affects the price of cereals since biofuel production uses cereals such as maize. Naylor and Falcon (2010) have also shown that food prices vary with oil prices and exchange rates. As noted by Rosset (2008), trade liberalization measures by international agencies such as the International Monetary Fund (IMF) and the World Bank, as well as droughts and other climate events, are other factors that contribute to international price volatility. According to Clapp (2009), developing countries cannot subsidize farmers after opening their economies to international trade. As a result, agricultural subsidies in industrialized countries, coupled with trade liberalization in developing countries as recommended by international organizations, have led to dumping of agricultural products, which discourages investment in domestic agriculture due to low prices. Not only that, but as the World bank’s loans to agriculture have decreased, agricultural investment in developing countries has also decreased. Generally, all these factors have contributed to the 2008 food crisis in developing countries.

3.4 Conclusions

The following conclusions can be drawn from the reviewed literature in this chapter. First, price volatilities vary by commodity and region. Grain prices were found to be more volatile in Africa than in Asia or Latin America. Additionally, volatility varies with the volatility measure used. For instance, with monthly data and coefficient of variation, Naylor, and Falcon (2010) found higher volatility for rice than for wheat and maize. On the other hand, Dawe, Morales-Opazo, Balie and Pierre (2015) using standard deviation of monthly logarithmic price differences had a higher volatility for maize compared to the other two grains.

Second, changes in price indices correspond to their volatilities. In the post 2007-08 food price crisis, maize, which has a higher price index than wheat and rice, recorded a higher price volatility than the rest.

Third, the 2007-08 global food crisis has affected domestic food security in developing countries. In addition to the effects of food price changes in the international market, poverty is critical to food insecurity in developing countries.

Chapter 4: Research methodology

4.1 Volatility measures

Gilbert and Morgan (2010) pp.3023 define volatility as "a directionless measure of the extent of the variability of a price or quantity." Volatility has different components**.** As to Naylor and Falcon (2010), total price volatility can be measured using the simple measure such as the coefficient of variation. However, removing the time trend in price movement yields a more precise estimate of volatility.

According to Huchet-Bourdon (2011) price volatility can also be measured by the standard deviation of prices from the average price. However, a measure like the coefficient of variation is more advantageous because it is unitless. The coefficient of variation (CV) is found by dividing the standard deviation by the mean. For low variability, CV and the logarithmic standard deviation give the same results (Gilbert and Morgan, 2010; Huchet- Bourdon, 2011).

Besides, a more advanced measure of volatility in the literature is the generalized autoregressive conditional heteroscedasticity (GARCH) model. This volatility model considers differences in volatility overtime (Gilbert and Morgan, 2010). But for my purposes, in this paper I will use two of the volatility measures mentioned earlier; the coefficient of variation or the corrected coefficient of variation (CCV) and standard deviation of the first difference in log prices (SDD). SDD is the conventional measure of price instability (Gilbert and Morgan, 2010), but other volatility measures used in the literature include CV and CCV. CCV is used when the price series has a trend.

When examining price volatility, price trends will first be evaluated. Rising prices constitute part of price fluctuations that mainly affects poor consumers (Naylor and Falcon, 2010). Since Ethiopia is a net importer of cereals, international prices can affect domestic prices, so analysis of trends in the international and domestic markets is important. In order to identify the evolution of price in domestic and international markets, regression analysis is used.

Price volatility can be computed with non- detrended or detrended data series. If there is a statistically significant trend, a simple measure of price instability (such as the coefficient of variation) will overestimate price fluctuations (Naylor and Falcon, 2010; Cuddy and Valle, 1978). Naylor and Falcon (2010) fitted the price equation in logarithmic form and computed

the variations along the trend, which is equivalent to the standard error of the estimate calculated from deviations about the following equation:

Log y = a + b * t .....(1)

Equation 1 is a formula for fitting the trend line of a price series, where the logarithmic real price 'Log y', is the dependent variable and 't' represents the trend variable. Whereas, 'b' is the coefficient of time, which indicates how much the logarithmic real price will change (the percentage change in real price) as time increases by one unit. Besides, the intercept of the regression equation is 'a'.

Similarly, Cuddy and Valle (1978), used both linear and logarithmic prices and derived the CCV from simple regression equation. They computed CCV from the standard error of the estimate (see appendix 1).

Thus, first a linear and log-linear trend lines are fitted to choose the line that fits the price series better. If there is a significant trend in the regression, then the corrected coefficient of variation is utilized to compute price volatility. CCV is superior to CV when calculating price fluctuations because it considers the trend in the price series. CCV adopted from Cuddy and Valle (1978) is mathematically,

$$CCV = CV\sqrt{1 - \tilde{R}^2} \qquad \text{.....(2)}$$

$R^{\tilde{}2}$ stands for the adjusted coefficient of determination from equation 1. When $R^{\tilde{}2} = 0$, there is no trend in the price overtime and as compared to CV, CCV does not add extra information about the price fluctuation around the trend. On the other extreme, when $R^{\tilde{}2} = 1$, prices have strong time trend and there is no volatility with respect to time. Thus, CCV is zero.

Generally, the higher is the $R^{\tilde{}2,}$ the less the prices vary with respect to time and the lower is CCV. In practice, $R^{\tilde{}2}$ is between zero and one. Cuddy and Valle (1978) pointed out that in rare cases where $R^{\tilde{}2}$ is less than zero, this is due to the very low R^2. In this case, CCV is equal to CV.

Similarly, Cuddy and Valle (1978) computed CV from a simple regression equation, which is in percent expressed in equation (3) below (see appendix 1 for the derivation).

$$CV = \frac{100}{\bar{y}}\sqrt{\frac{\sum(y - \bar{y})^2}{N - 1}} \qquad \text{.....(3)}$$

where, y represents price; N, the number of observations in terms of years/months and $\bar{y}$ is the average price.

On the other hand, Dawe, Morales-Opazo, Balie and Pierre, 2015; Gilbert and Morgan, 2010; Houchet-Bourdon, 2011; Mittal, Hariharan, and Subash, 2018, all used SDD in computing price volatility. These studies used different SDD formulations, but as in Houchet-Bourdon (2011) and Dawe, Morales-Opazo, Balie and Pierre (2015), it is basically defined as:

$$SDD = \sqrt{variance\left(ln\frac{p_t}{p_{t-1}}\right)} \quad \text{or} \quad \text{standard deviation of ln } (p_t/p_{t-1}) \ldots\ldots\ldots\ldots (4)$$

Where, p_t and p_{t-1} are prices at time t and t-1 respectively, and ln (p_t/p_{t-1}), stands for the logarithmic difference in prices.

In summary, as shown in Table 4, first a linear and log-linear trends are fitted to commodity prices and if the regression equation prove the presence of trend in the price series, then the use of detrended measure of price instability (i.e. the corrected CV which is comparable with standard deviation of differences in log prices- Huchet-Bourdon (2011) is justified. Otherwise, (if the commodity price does not exhibit a trend) non-detrended CV can be used to measure price volatility. The different metrics employed in this study are summarized in Table 4.

Table 4. Summary of methodology

Variable of interest	**measurement**	**Outcome**
Trend	Graphs, price indices, regression analysis	Evolution of agricultural commodities price over time
Aggregate volatility (Non-detrended)	coefficient of variation	Overall volatility (trends, and variability around the trend)
Detrended volatility	corrected coefficient of variation or standard deviation of difference in log prices	Fluctuations around the trend

Source: author's design

Regarding the use of real or nominal prices, deflating a series introduces uncertainty in the measurement of volatility (Huche-Bourdon, 2011). Besides, there is no consensus as to the best deflator in case of agricultural commodity prices. Gilbert and Morgan (2010) deflated nominal prices using Producer Price Index (PPI); Naylor and Falcon (2010) used GDP index whereas, Dawe, Morales-Opazo, Balie and Pierre (2015) used CPI. Naylor and Falcon (2010) argue real prices are important because they capture the welfare effects of price changes. However, in their study, volatility does not change with real or nominal prices. Dawe, Morales-Opazo, Balie and Pierre (2015) propose real prices when inflation is too high (over 10 % per year). They suggest a CPI that excludes the commodity in question, but this conversion factor is rarely available. In this paper, I work with real prices by using CPI as a conversion factor.

Beside the real-nominal price issue, it is controversial whether to choose a single average price or moving average price in volatility measurement. According to Gilbert and Morgan (2010) volatility itself can change significantly over time, and periods of high volatility tend to bunch together. This is what makes the use of a single average price problematic. To this end, Huchet-Bourdon (2011) proposed a 12-months moving average with a monthly data. He used 12 months mean price in calculating the annual volatility from a monthly data. Considering the change of volatility overtime, I will compute volatility statistics for different sub- periods.

Last but not least, volatility can be calculated using monthly or annual data, however monthly volatilities can be annualized multiplying by a factor, which does not affect the result as it is multiplication by a constant factor (Huchet-Bourdon, 2011). Several studies (see table 5) used monthly data and coefficient of variation and standard deviation in logarithmic price differences in their volatility analysis. In this paper, I will compute domestic and international volatilities of maize, sorghum and wheat with monthly data and corrected/coefficient of variation and standard deviation in logarithmic price differences.

Table 5. Studies on agricultural price volatility

Authors	Data frequency	Commodity prices	Volatility statistics
Dawe, Morales-Opazo, Balie and Pierre (2015)	Monthly data	Real prices	Standard deviations of logarithmic price changes
Gilbert and Morgan (2010)	Monthly data	Real prices	Standard deviations of logarithmic price changes
Houchet-Bourdon, (2011)	Monthly data	Nominal prices	Standard deviations of logarithmic price changes and coefficient of variation
Naylor and Falcon (2010)	Monthly data	Real prices	Coefficient of variation and root mean square error (de-trended volatility)

Source: Author's compilation

4.2 Data sources

National and international cereal price data will be collected from the FAO (Food and Agriculture Organization) database. Domestic prices in FAO's database come from Ethiopian Grain Enterprise, and they are mostly available from the year 1997. These are monthly data from January 2000 to September 2019.

In addition to FAO GIEWS (Global Information and Early Warning System) data on wholesale cereal prices and cereal imports, CPI data from UNCTAD (United Nations Conference on Trade and Development) are used to convert foreign prices into real prices. In the next chapter, the data collected will be presented and the scene will be set for analyzing price volatility. Besides, major import partners for the three cereals will be identified to examine the price volatilities in the relevant international markets related to Ethiopia.

Chapter 5: Description of data and Ethiopia's cereal import partners

This section outlines domestic wholesale and international prices for the three commodities: maize, sorghum, and wheat. It consists of summary statistics in the table, the evolution of prices in graph, and the sources of import in a pareto chart.

5.1 Ethiopian domestic cereal market prices

Table 6. Wholesale price of maize, sorghum, and wheat at different Ethiopian domestic market locations

Monthly wholesale price in different domestic markets in nominal USD/tonne	Average Price	Min Price	Min Date	Max Price	Max Date	Price Range
Addis Ababa, Maize	221.24	57.5	Feb-02	599.2	Sep-08	541.7
Bahirdar, Maize	214.38	50.7	Oct-01	591.7	Jul-08	541
Diredawa, Maize	251.5	97.3	May-02	740.5	Jul-08	643.2
Mekele, Maize	246.7	83.5	Oct-01	690.3	Jul-08	606.8
Addis Ababa, Sorghum (white)	379.28	133.1	May-02	852.4	Aug-08	719.3
Addis Ababa, Wheat (white)	360.12	117.4	Feb-02	708.7	Sep-08	591.3
Bale Robe, Wheat (white)	377.19	222.4	Oct-10	593.8	Aug-19	371.4
Debre Marcos, Wheat (white)	396.19	219.1	Sep-10	562.6	Sep-19	343.5
Diredawa, Wheat (white)	473.99	294	Oct-10	621.3	Sep-15	327.3
Jimma, Wheat (white)	462.14	279.3	Nov-10	587.2	May-18	307.9
Shashemene, Wheat (white)	412.34	231.3	Sep-10	612.5	Sep-19	381.2

Source: FAO GIEWS

Based on the average price data in Table 6, maize was the cheapest of the three grains throughout the study period. In most domestic markets, the average price of wheat is higher than the average price of sorghum, while the highest price range for sorghum, followed by maize.

The wholesale prices of maize, sorghum and wheat (in all markets) peaked in 2008, except for markets established in subsequent years (Bale Robe, Debre Marcos, Diredawa (for white wheat), Jimma and Shashemene, which were established in 2010) (see Table 6). The period of the highest cereal price corresponds to the period of the international food price crisis. Besides, the lowest prices were recorded in the pre-crisis period.

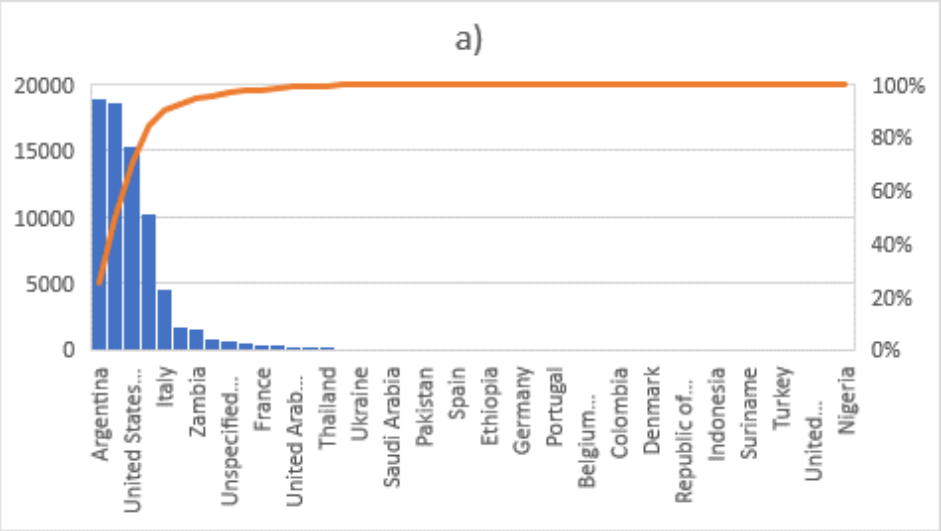
As mentioned under section 2.2.2, Ethiopia is a net importer of cereals and thus, it is necessary to identify the country's import partners to analyse cereal price trends on the international market.

5.1.1 Ethiopian import partners

Ethiopian's cereal import partners are identified using the pareto chart. The left axis shows the value of cumulative imports (in 1,000 USD), and the right axis shows the percentage of total imports over the period 1998-2017.

Figure 9 shows that between 1998 and 2017, more than 80% of Ethiopian maize was imported from five countries: Argentina, South Africa, the United States of America, India, and Italy. Similarly, 60 percent of Ethiopia's sorghum imports come from the United States, Sudan (former), Italy and India. The United States alone contributed two-thirds (about 40%) of Ethiopia's sorghum imports.

About 90% of the most imported cereal (wheat) originates from the United States, India, Italy, and East European countries: Ukraine, Russian Federation, Romania, and Bulgaria.



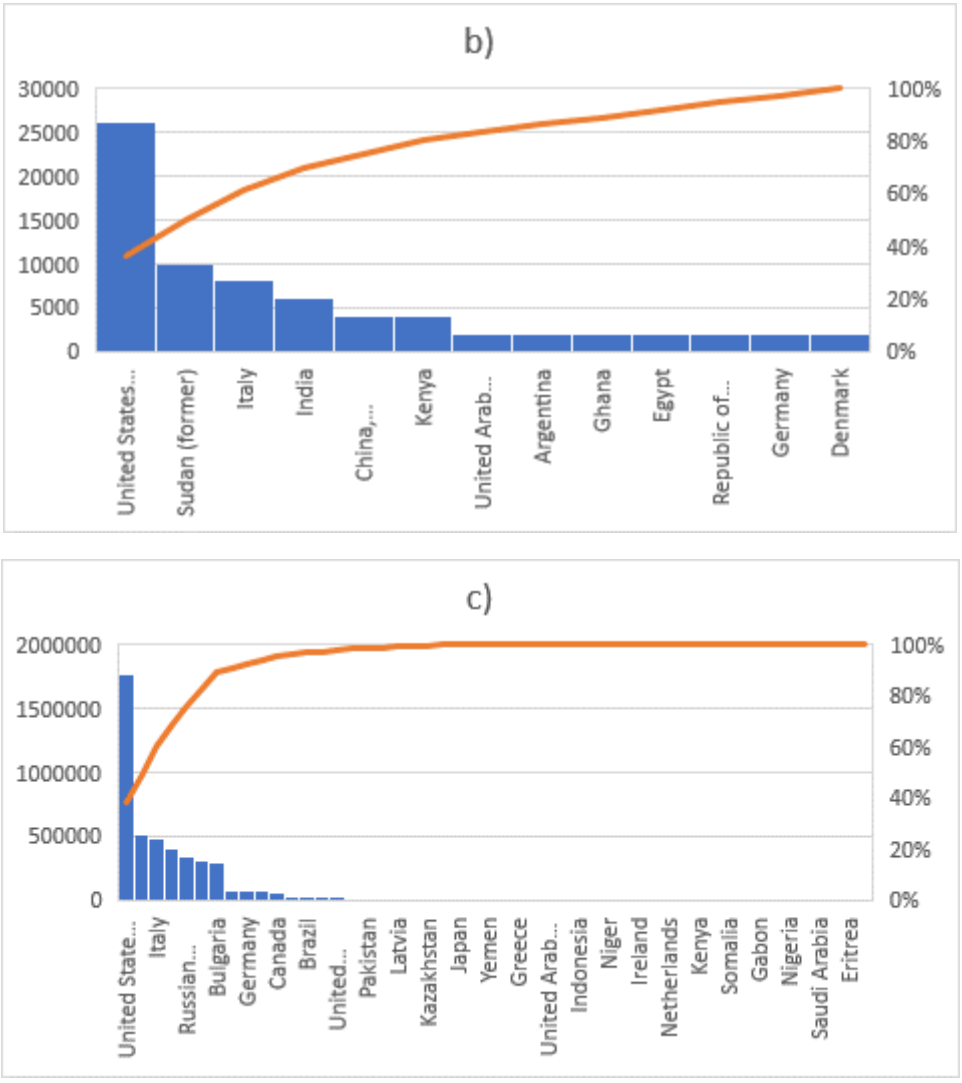


Figure 9. Origin of Ethiopian cereal imports a) maize b) sorghum c) wheat (constructed with data from FAO GIEWS)

In a nutshell, the bulk of Ethiopian wheat, maize and sorghum imports come from the United States, India, and Italy. At the same time, the country has commodity-specific import partners; Argentina and South Africa for maize, East European countries (such as Ukraine, Russian Federation, Romania, and Bulgaria**)** for wheat and Sudan (former) for sorghum (see Figure 9).

5.2 Evolution of cereal prices

The evolution of the three cereal prices (maize, sorghum and wheat) in the domestic and international market is shown in Figures 10, 11 and 12. In order to compare cereal price trends in the domestic and international markets, the Addis Ababa wholesale market was chosen to represent the domestic market. The Addis Ababa wholesale market represents the domestic prices of three grains for the following reasons. First, the average wholesale price of wheat and maize in Addis Ababa is almost equal to the average domestic price of both

cereals. Besides, the Addis Ababa wholesale market is the only wholesale sorghum market in Ethiopia.

Secondly, the Addis Ababa wholesale market was the only domestic cereal wholesale market for which data is available for the study period. Therefore, it is used for comparison with international prices.

Table 7 shows the correlation between domestic prices of maize (USD/tonne, January 2010 to September 2019) by region and with the central market. addism stands for Addis Ababa maize wholesale market price, whereas bahirm, direm and mekelem stand for Bahirdar, Diredawa, and Mekele maize wholesale market prices, respectively.

As can be seen from Table 7 and Table 8, there is a statistically significant positive correlation between the different maize and white wheat markets. Besides, the domestic market for these cereals is strongly correlated with Addis Ababa central market for each cereal. Except for Jimma wheat, the correlation coefficient between the central and the regional market is generally above 0.8.

Table 7. Correlation between prices in domestic maize markets (nominal USD/tonne), January 2010 - September 2019

	addism	bahirm	direm	mekelem
addism	1.0000			
	117			
bahirm	0.9099*	1.0000		
	0.0000			
	117	117		
direm	0.8105*	0.8397*	1.0000	
	0.0000	0.0000		
	117	117	117	
mekelem	0.9048*	0.9223*	0.8466*	1.0000
	0.0000	0.0000	0.0000	
	117	117	117	117

* 5% level of significance

Source: Author's computation based on FAO GIEWS data

Table 8. Correlation between prices in domestic wheat markets (nominal USD/tonne), January 2010 - September 2019

	addisww	baleww	direww	jimmaww	shasheww
addisww	1.0000				
	117				
baleww	0.9106*	1.0000			
	0.0000				
	116	116			
direww	0.8514*	0.7707*	1.0000		
	0.0000	0.0000			
	117	116	117		
jimmaww	0.6806*	0.6752*	0.8082*	1.0000	
	0.0000	0.0000	0.0000		
	115	114	115	115	
shasheww	0.9204*	0.9325*	0.7892*	0.7272*	1.0000
	0.0000	0.0000	0.0000	0.0000	
	117	116	117	115	117

* 5% level of significance

Source: Author's computation based on FAO GIEWS data

On the other hand, as shown in Figure 10, maize is the only crop with multiple international markets due to data constraints. In the following sections, price trends for each grain between international and domestic markets are presented.

5.2.1 Maize

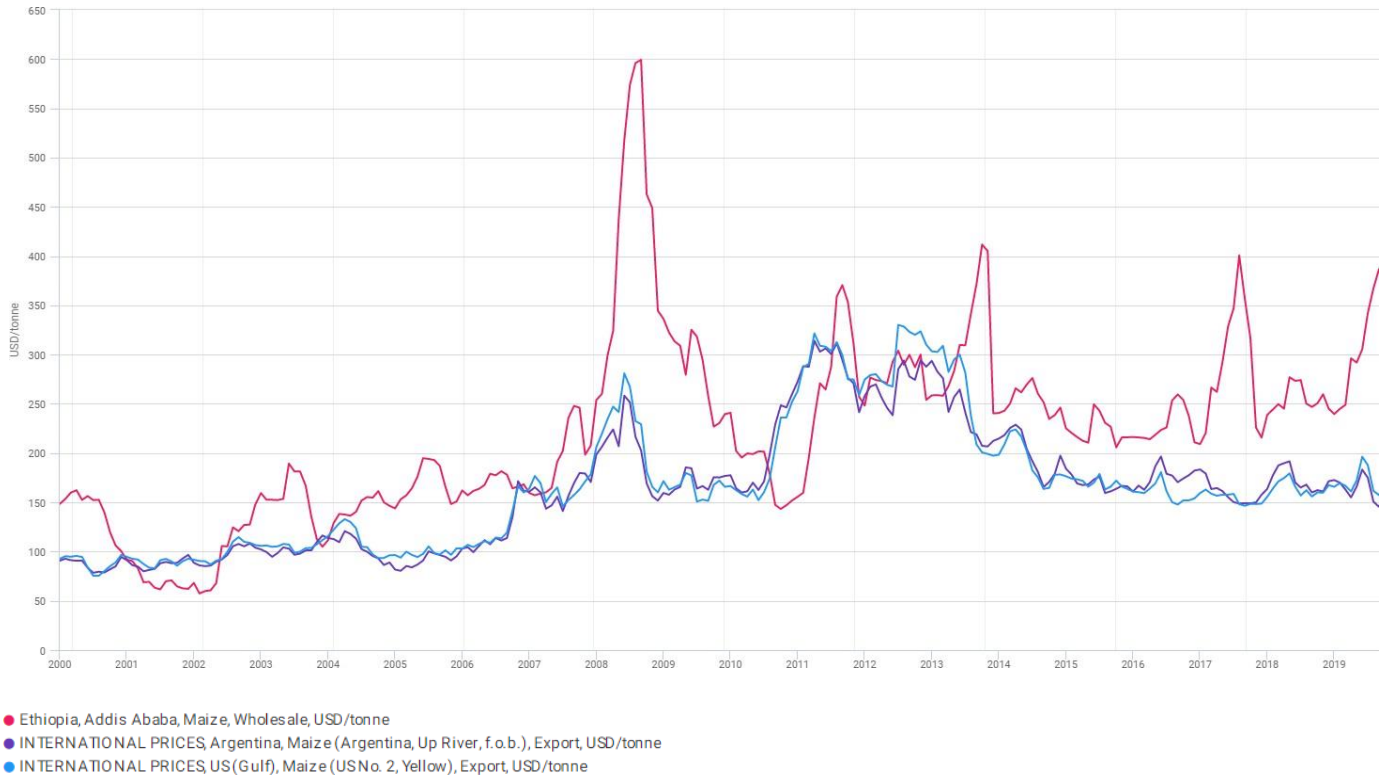


Figure 10. Monthly maize price at Addis Ababa wholesale market and international markets (in nominal USD/tonne) (FAO GIEWS)

International prices of maize are nearly identical in the two foreign markets, Argentina, and USA. However, the domestic price of maize is mostly higher than the international price. This can be due to the additional costs incurred on maize imports such as transportation cost. In addition, it can be seen from Figure 10, the world price of corn has increased until 2014 and levelled off afterwards. The domestic price of maize for maize show the same pattern. Especially the domestic price of maize has shown a dramatic increase in 2008-2009 period. The pattern of domestic and international markets indicates that maize prices have been higher in recent years compared to their level at the beginning of the millennium.

5.2.2 Wheat

As shown in Figure 11, the domestic price of wheat basically follows the international wheat price pattern, but with a time lag. Throughout the period, domestic wheat prices have risen relatively since 2000s, but international wheat prices were largely less expensive.

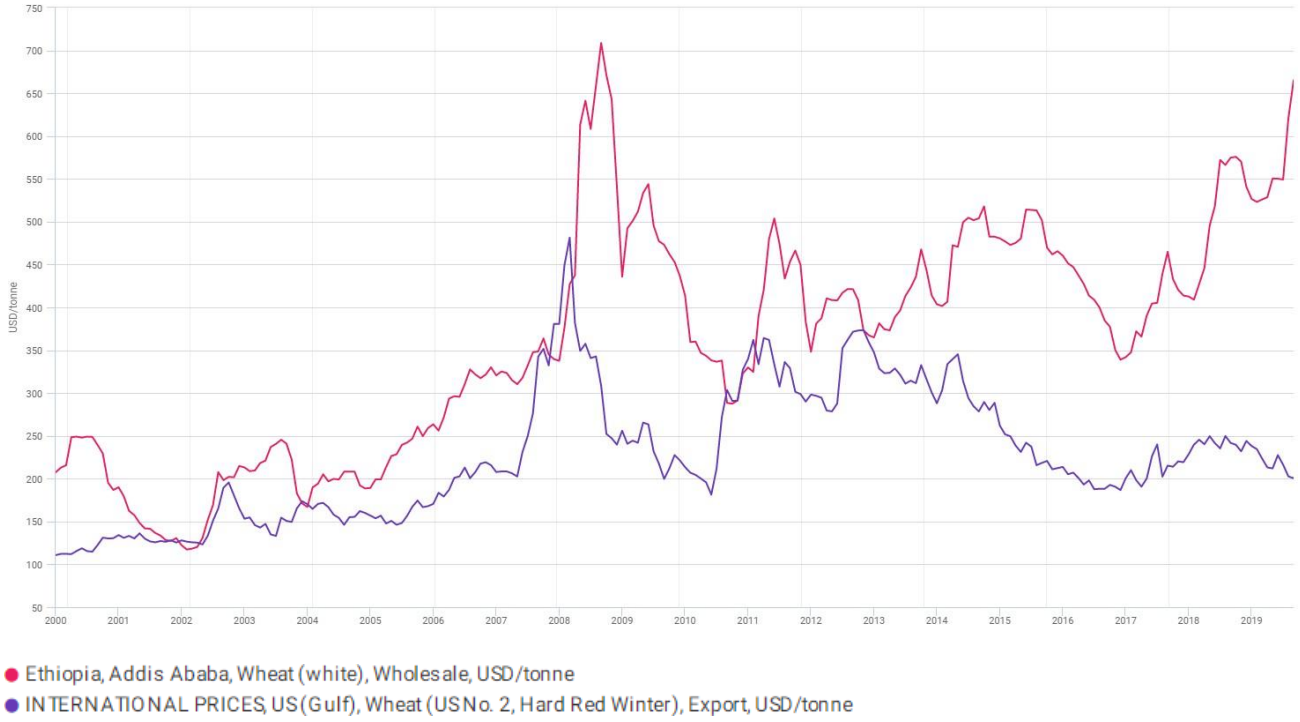


Figure 11. Monthly wheat price at Addis Ababa wholesale market and international market (in nominal USD/tonne) (FAO GIEWS)

5.2.3 Sorghum

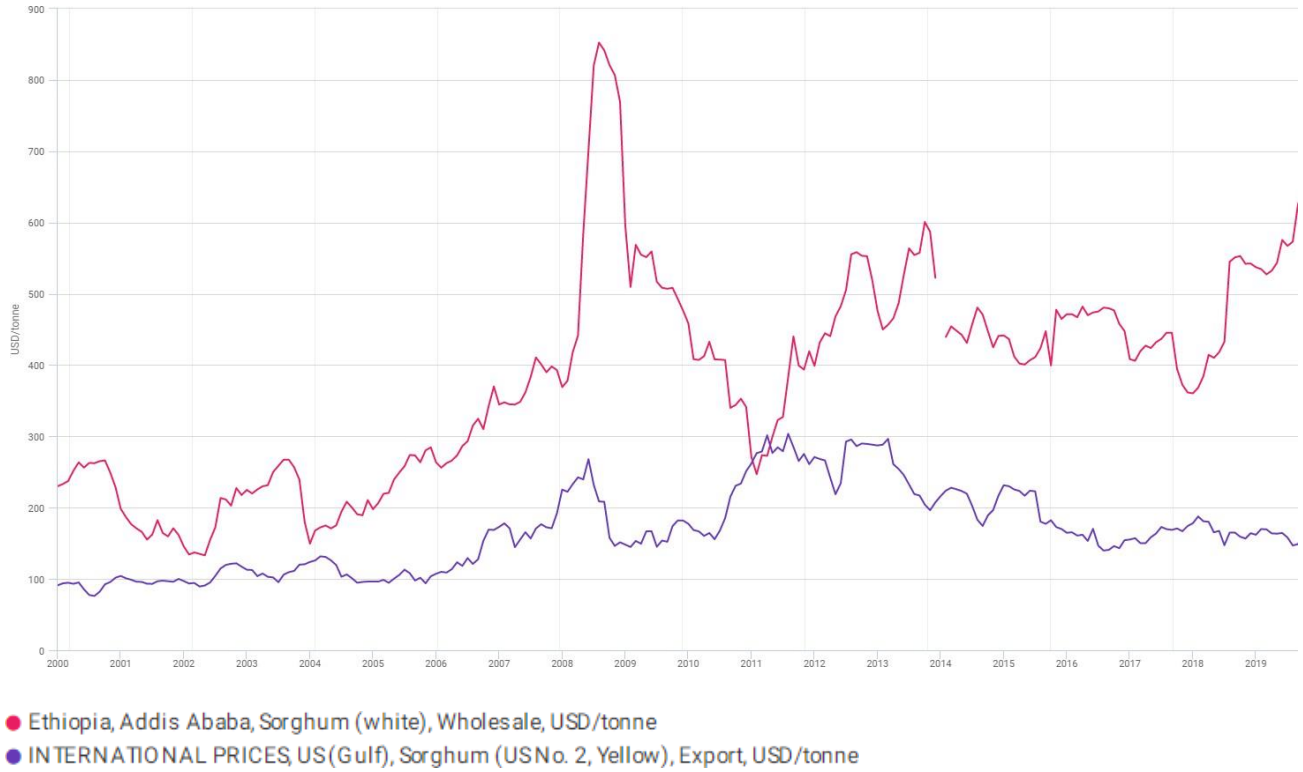


Figure 12. Monthly sorghum price at Addis Ababa wholesale market and international market (in nominal USD/tonne) (FAO GIEWS)

As with the other two grains, the price of sorghum on the domestic market is higher than the world market price, and there is a huge price gap between the two markets. However, the domestic market price has risen sharply.

5.3 conclusions

In general, domestic prices of the three grains are higher than international prices. Over the past two decades, domestic and international cereal prices have risen in nominal US dollars, but domestic prices have risen even more. Commodity wise, maize is the cheapest grain on the domestic market and has also shown a moderate price increase over the other two grains. Furthermore, there is no sign of cereal price convergence between global and domestic markets, especially over the past five years. In chapter 6, real prices are introduced, trends in real prices will be identified, and then volatility analysis follows from that.

Chapter 6: Results and discussion

In chapter 4, it is pointed out that the presence of trend affects volatility results and thus, before proceeding to volatility analysis, in the first section of chapter 6, the presence of trend is checked with price index and regression analysis. Thereafter, volatility computations follow in the subsequent sections. Different volatility measures such as the coefficient of variation, the corrected coefficient of variation and the standard deviation in logarithmic price differences are calculated in this chapter.

6.1 Price trends

In this section, after converting nominal prices into real prices, firstly, the trend in price is displayed graphically by constructing a price index. Secondly, through regression analysis, the statistical significance of the result from the price index is tested.

6.1.1 Trend check with price index

Before checking for the presence of trend in the price series, nominal prices are converted into real prices by using the consumer price index. According to Naylor and Falcon (2010), real prices are a better measure than nominal prices to explain the impact of prices on consumer welfare. Hence, price indices are computed for the three cereals: maize, sorghum, and wheat. The first year of the price series is used as a reference year. Thus, prices in 2000 (i.e. the base year) equals 100 and for the consequent years nominal prices are divided by the CPI in decimal to obtain real price indices. Domestic real prices in local currency are obtained from FAO GIEWS, while foreign prices in nominal US dollars are converted into real prices by using the CPI, which is obtained from the UNCTAD.

As can be seen from Figure 13, there is a peak around 2009, when the cereal price indices climbed to a high level. Real domestic commodity prices have appreciated during the 2008 food price crisis. Generally, cereal real prices have not change much compared to the nominal prices discussed earlier in chapter five. Thus, considering the inflation rate, Ethiopian domestic grain prices have been relatively stable for the first two decades of the 21st century. Note that the spike in sorghum price index in 2014 represents a missing data.

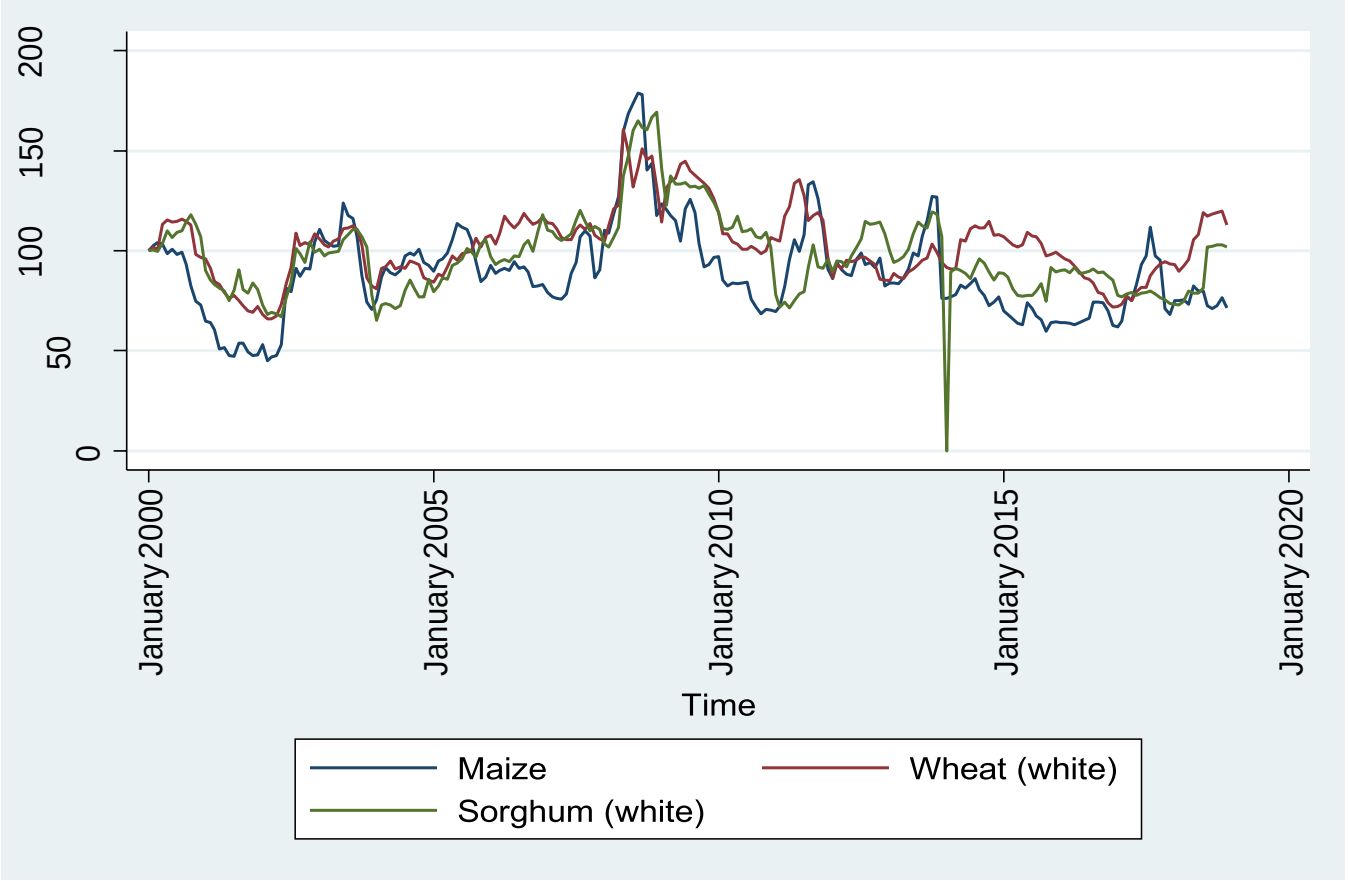


Figure 13. Real domestic cereal price indices, January 2000 – December 2018 (index, January 2000=100) (stata output based on FAO GIEWS domestic currency real price data, Ethiopian Birr/tonne)

Figure 14 shows the evolution of international monthly price of maize, wheat, and sorghum over 2000 – 2018. The Argentina maize price index is represented by ArgenM index, and correspondingly, USA prices of maize, wheat and sorghum are denoted by USAM, USAS and USAM, one after the other. It is portrayed in the same figure that the USA cereal price index generally increased for the three cereals until 2013 and decreased afterwards. Conversely, Argentina maize price index declined and there is an enormous decline especially since 2013.

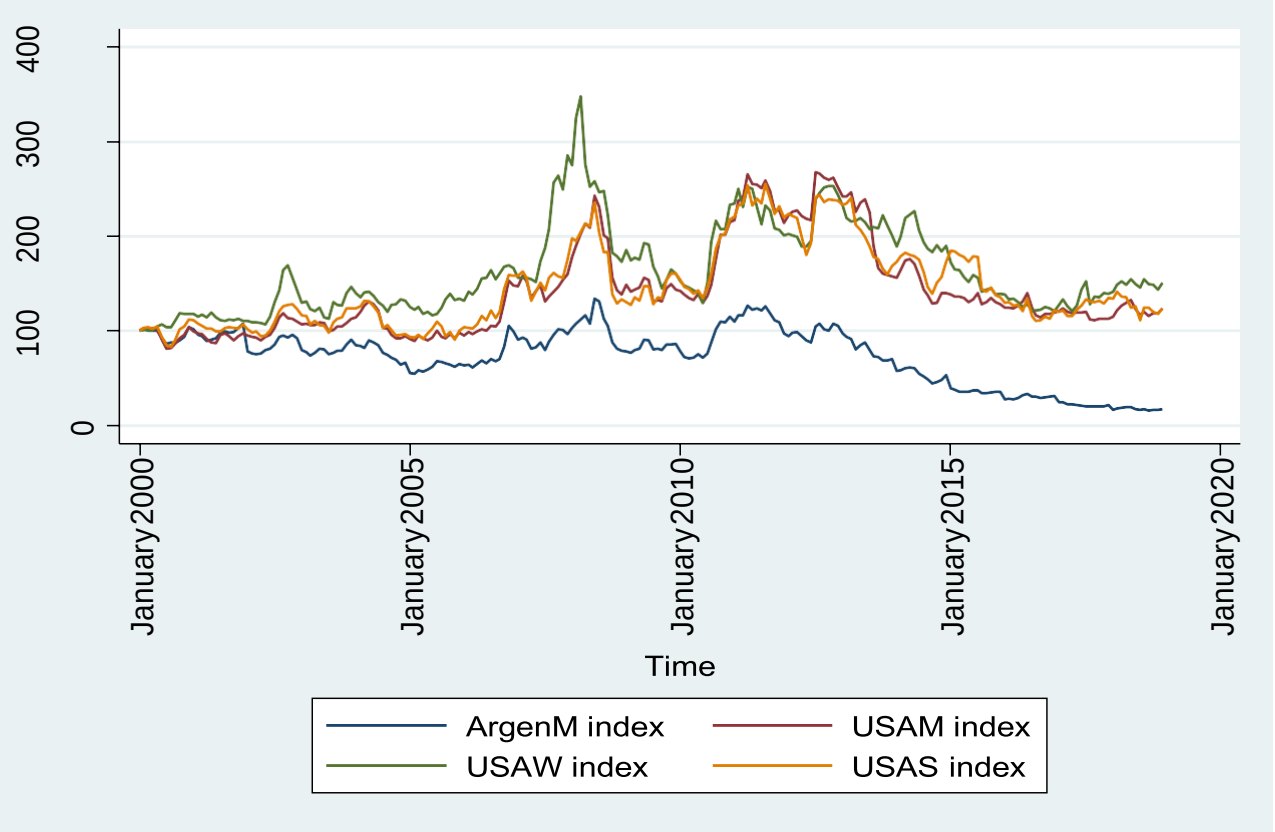


Figure 14. Real international cereal price indices, January 2000 - December 2018 (stata output based on real USD/tonne price)

6.1.2 Results from regression analysis

In order to identify whether a statistically significant trend exists, real price is regressed against time. Table 9 shows the non-transformed prices have a trend for Ethiopian maize and sorghum but only at 10 percent level of significance. On the other hand, for logarithmic prices, Ethiopian sorghum is the only cereal with a trend. In all cases (i.e. for the non- transformed and for the logarithmic prices), the coefficient of determination for the domestic price is very low, below 1 percent.

Table 9. Regression between real domestic cereal prices and time

	Ethiomaize	lnEthiomaize	Ethiowheat	lnEthiowheat	Ethio sorghum	ln Ethiosorghum
Coefficients						
Time	-1.3106*	-.0003	.0930	.0001	-1.6595*	-.0003*
constant	3070.2***	7.9846***	4696.461***	8.4365***	5177.092***	8.5328***
number of observations	228	228	228	228	227	227
Tests						
F-test	2.98	1.63	0.01	0.09	2.73	2.83
Prob>F	0.0854	0.2032	0.9089	0.7644	0.0999	0.0941
R-Square	0.0130	0.0072	0.0001	0.0004	0.0120	0.0124
Adjusted R-Square	0.0087	0.0028	-0.0044	-0.0040	0.0076	0.0080

***significant at 1%, ** significant at 5% *significant at 10%; in brackets values for logarithmic prices

Source: Author's computation based on FAO GIEWS monthly data in real prices, Ethiopian Birr/tonne

Table 10 presents the results of linear and log-linear trend fitted to the international price. As can be read from the table, there is a statistically significant positive trend for USA maize, wheat, and sorghum prices, which means every following month real logarithmic USA cereal price increased. Conversely, a negative trend is present in Argentina's maize price. These results are not strange as the same conclusion can be reached with the price index.

Table 10. Regression between real international cereal prices and time

	USA maize	lnUSA maize	USA wheat	lnUSA wheat	USA sorghum	lnUSA sorghum	Argen maize	lnArgen maize
Coefficients								
Time	.3298 *	.0021***	.3168***	.0015***	.3214***	.0020***	-.6210***	-.0057***
constant	128.3487 ***	4.8197***	193.173***	5.2216***	130.7236***	4.8467***	236.7495***	5.6403***
number of observations	228	228	228	228	228	228	228	228
Tests								
F-test	38.20	56.30	25.09	37.38	48.98	65.78	138.35	201.71
Prob>F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-Square	0.1446	0.1994	0.0999	0.1419	0.1781	0.2254	0.3797	0.4716
Adjusted R-Square	0.1408	0.1959	0.0959	0.1381	0.1745	0.2220	0.3770	0.4693

***significant at 1%, ** significant at 5% **significant at 10%; in brackets values for logarithmic prices

Source: Author's computation based on FAO GIEWS monthly data converted to (in) real prices

6.1.3 Conclusion

The price index showed that both domestic and foreign prices have fluctuated overtime and regression analysis is used to measure more precise price trends. The regression output indicates that domestic real prices of maize and sorghum were falling in contrary to the rising international cereal prices for the three commodities (other than Argentina maize). Real maize price has fallen in Argentina.

6.2 Volatility analysis

In the forthcoming sections, 6.2.1 and 6.2.2, price fluctuations are computed using three measures of volatility, CV, CCV and the standard deviation on logarithmic price differences.

6.2.1 Coefficient of variation and Corrected coefficient of variation results

Based on price index and the regression output, apart from Ethiopian domestic wheat price, trends are present in the price series of the three cereals. Accordingly, since there is no statistically significant trend for Ethiopia's domestic wheat price, CV is used to measure its volatility. For all the other cereal price series, both domestic and international prices, since a statistically significant trend is found, the CV is corrected for the trend and hence CCV is computed from CV. In Table 11, volatility results are shown for the domestic and international prices.

Table 11. Coefficient of Variation and corrected coefficient of variation volatility results (2000-2018)

Commodity	Linear	Log-linear	Presence of trend and justified volatility measure	Standard deviation	Mean price	CV in percent	CCV
	$\tilde{R}^2$	$\tilde{R}^2$					
Ethiomaize	0.0087*	0.0028	statistically significant linear trend in price, CCV	757.21	2920.13	25.93	25.82
Ethiowheat	-0.0044	-0.0044	no statistically significant trend in price, CV	805	4707.11	17.10	17.10
Ethiosorghum	0.0076*	0.0080*	statistically significant trend in price, CCV	1000.46	4987.48	20.06	19.98
USAmaize	0.1408***	0.1959***	logarithmic trend, CCV	57.21	166.11	34.44	30.88
USAwheat	0.0959***	0.1381***	logarithmic trend, CCV	66.11	229.45	28.81	26.75
USAsorghum	0.1745***	0.2220***	logarithmic trend, CCV	50.24	167.53	29.99	26.45
Argenmaize	0.3770***	0.4693***	logarithmic trend, CCV	66.48	165.64	40.13	29.23

***significant at 1%, **significant at 5%; *significant at 10% (results for the F-test)

Source: stata output (Author's computation based on FAO GIEWS monthly data converted to (in) real prices

By the corrected coefficient of variation measure of volatility, among the three cereals, maize is the most volatile grain, both in the domestic and international markets. This result is expected since through-out the study period, especially in the domestic market, maize price index fluctuated more than wheat and sorghum (it has shown more variation). In the literature, the volatility of maize is related to its multiple uses that include biofuel production, animal feed and its use in human consumption (Cohen and Smale, 2011; Naylor and Falcon, 2010).

6.2.2 Volatility as measured by standard deviation in logarithmic price difference

In the previous part (6.1.2), a statistically significant trend is found in the domestic prices for maize and sorghum, but the low R- square values indicate that time explains less than 1 percent of the variation in domestic price. As a result, the detrended and non-detrended measures yields about the same results in the domestic volatilities. Table 11 shows the CV and CCV that nearly assume similar values for domestic prices. Similarly, in the foreign market, except for maize, detrended and non-detrended volatility measures have slight differences. In the remaining sections, the most widely used volatility measure in literature (i.e. standard deviation of logarithmic price differences) is used to compute domestic and international volatilities for the entire period and for various sub- periods.

In the following Table, Table 12, domestic and international volatility of the three cereals is shown as measured by SDD. The first column measures the volatility for the entire period (2000 - 2018). The second column shows price volatility in the pre food crisis (2000 - 2006) and in the third column is shown the volatility during the international food price crisis until 2012. The last column measures the most recent volatility from 2013 until 2018.

Table 12. Volatility results measured by standard deviation of logarithmic price differences

Commodity	SDD			
	Whole period	2000-2006	2007-2012	2013-2018
Ethiomaize	0.091	0.0857	0.0932	0.0932
Ethiowheat	0.0531	0.0525	0.0644	0.0391
Ethiosorghum	0.0638	0.0690	0.0679	0.0519
USAmaize	0.0592	0.0536	0.0729	0.0473
USAwheat	0.0630	0.0488	0.0859	0.0477
USAsorghum	0.0646	0.0567	0.0782	0.0563
Argenmaize	0.0744	0.0692	0.0733	0.0784

Source: Author's computation based on FAO GIEWS monthly data converted to (in) real prices

As shown in Table 12, the volatility results with the SDD measure is different and lower than the results from the CV measures. This is not surprising as the SDD volatility measures the volatility in percentage price changes (i.e. the fluctuations in the growth rate of price). In the SDD volatility measure, the prices are in logarithmic differences, which is approximately percentage changes and hence, it is lower than CV or CCV. For the whole period, according to both measures (SDD or CVs) maize is the most volatile. The following bar chart (see Figure 15) demonstrates the domestic and international cereal price volatilities in percent.

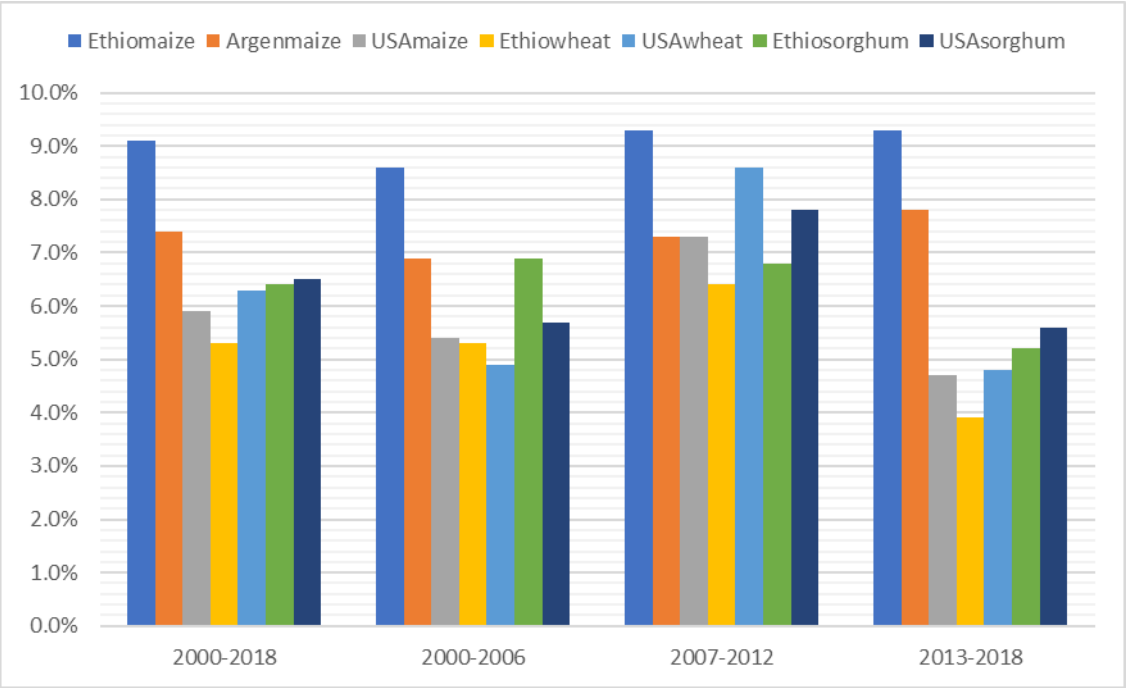


Figure 15. Volatility in standard deviation of logarithmic price changes (in percent)

Source: Author's computation based on FAO GIEWS monthly data converted to (in) real prices

In Figure 15, volatilities were computed for the whole period (2000 - 2018), but also for sub-periods. As to our expectation, volatilities were higher during the 2007-2012 food crisis period. Volatility during 2007 - 2012 is higher than the volatility for the whole period (2000- 2018), but also higher than volatility during the different sub-periods (before and after the food crisis periods), confirming the enormous price rise during the international food crisis. This is also evident from the changes in the price index as shown in Figures 13 and 14.

Except for Ethiopia and Argentina maize markets, volatilities have fallen in the post 2007- 2012 period. Besides, as can be seen form Figure 15, Ethiopia's domestic maize market is the most volatile market during the whole period and under all sub periods. In the following sections, domestic and international price volatilities are discussed by commodity.

6.2.3 Domestic and international maize price volatilities

Ethiopian maize market is always more volatile than Argentina and USA maize markets for all time periods considered. As can be seen from Figure 16, the most significant change in volatility is observed for USA maize market. The USA market volatility increased by about 2

percent during 2007-2012 sub-period compared to its volatility during 2000-2006 period. The higher market volatility in the USA maize during the second sub-period have fallen substantially in the following sub-period, during 2013-2018. On the other hand, Argentina's maize price volatility increased over time. Argentina's maize price is more volatile in the second sub-period than the first sub-period, but even became more volatile during 2013-2018. Ethiopia's maize market volatility does not correspond to any of the two international maize markets. Ethiopia's maize price volatility increased during the food crisis period and volatility remained the same in the post food crisis.

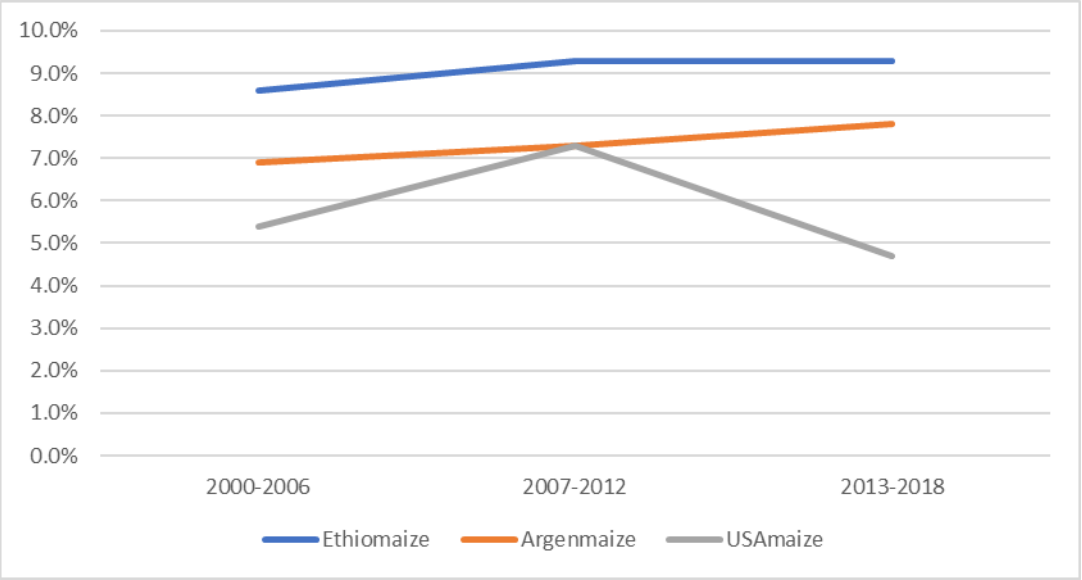


Figure 16. Domestic and international volatilities of maize for different sub-periods (volatility in standard deviation of logarithmic price changes (in percent))

Source: Author's computation based on FAO GIEWS monthly data converted to (in) real prices

6.2.4 Sorghum and wheat price volatilities

Except for 2000-2006 period, international wheat volatility is higher than the domestic volatility for the other two sub-periods. The same is true for the Ethiopian sorghum market, which was more volatile than the international market in the first sub-period and less volatile in the other two periods. Therefore, recently domestic wheat and sorghum market are less volatile than the international markets.

In 2007-2012, the USA wheat and sorghum markets were more volatile than the Ethiopian market. This can be related to the economic crisis that hit the global economy and which started in the USA. The 2007-08 economic crisis is believed to have an impact on the international agricultural market (Clapp, 2009).

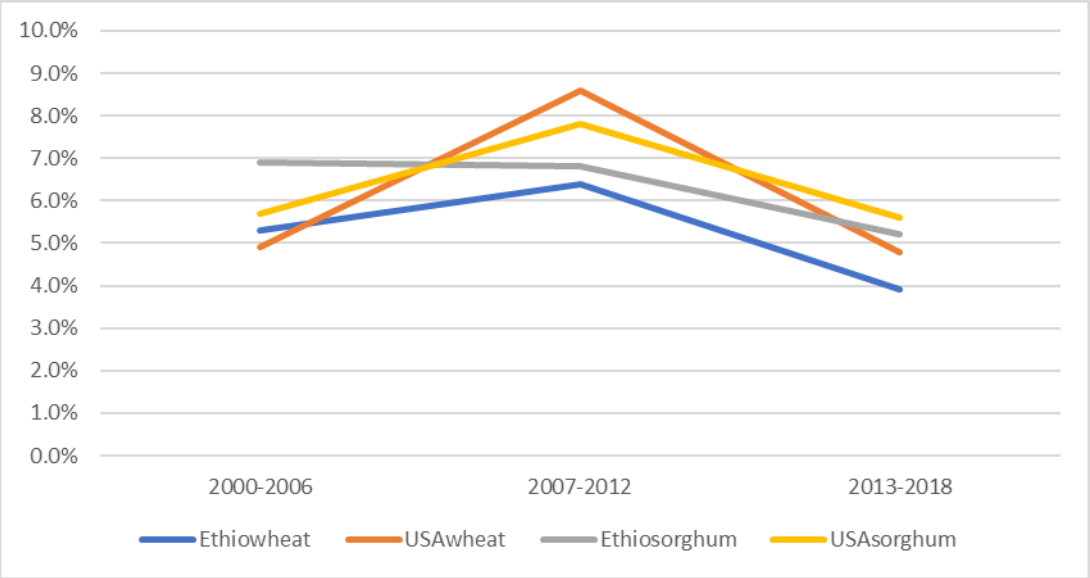


Figure 17. Domestic and international volatilities of wheat and sorghum for sub-periods (volatility in standard deviation of logarithmic price changes (in percent))

Source: Author's computation based on FAO GIEWS monthly data converted to (in) real prices

6.2.5 Conclusion

The relative volatility between domestic and international markets vary by period and commodity. Apart from maize, the domestic market (of sorghum and wheat) is less volatile than the international market since the 2007 global food crisis (i.e. lower domestic volatilities during 2007 - 2012 and 2013 - 2018 sub-periods). From January 2007 to December 2013, Dawe, Morales-Opazo, Balie and Pierre (2015) found that maize volatility exhibits a different trend from other cereals. According to their study, world prices of wheat and rice are more volatile than the domestic markets while maize is more volatile in the domestic market. The higher domestic volatility of maize can be associated with the thin world maize market and the less connection of domestic and foreign maize markets. Firstly, maize is domestically the most widely produced cereal. Secondly, maize imports are

relatively low (see also figures 5 and 6). Thirdly, they linked higher domestic maize price volatility to lower irrigation volumes in its production.

For maize, all three markets (Ethiopia, USA, and Argentina markets) have their own peculiar features at different sub-periods. During the food crisis period, maize price volatility increased in all three markets, but in the post food crisis, USA maize market became less volatile while the volatility of Ethiopia's maize market remained unchanged. Nevertheless, the volatility of Argentina's maize price increased. In general, the maize market in Ethiopia is the most volatile maize market in all sub-periods.

During the entire period (2000 – 2018) the domestic market for sorghum and wheat have shown less fluctuations than the international market, while corn has more fluctuations in the domestic market. This result conforms with the relative volatility of sorghum and wheat between domestic and international markets since the food crisis period (i.e. for 2007-2012 and 2013 – 2018 sub- periods).

The comparison across time shows that apart from Ethiopia's sorghum prices, which is almost equally volatile, both the local and international markets have become more volatile during 2007-2012 period relative to the pre-food crisis period.

Comparing 2000 - 2018 price volatilities of the three cereals in all markets (both domestic and international) before and after the food crisis, the volatilities in the post-food crisis period are at least as low as in the pre-food crisis period (excluding Ethiopia and Argentina maize price volatilities). This shows all markets have recovered from the high cereal price volatility during the food crisis.

Finally, turning to domestic price volatility, maize and wheat volatility increased during the food crisis. The impact of the global food crisis on domestic markets is also shown by other studies (Hadley et al., 2011; Kumar and Quisumbing, 2013; Martin-Prevel et al., 2012). After the food crisis period, maize volatility remained at a high level, but wheat volatility declined. Whereas, during 2007-2012, sorghum volatility declined slightly from its pre-food crisis level. However, like wheat, the volatility of sorghum decreased after the food crisis (see Table 13).

Table 13. Summary of domestic and international cereal price volatilities

	Pre food crisis	During food crisis		Post food crisis	Whole period
	Sorghum and wheat				
Domestic volatility compared to the preceding period		*Slightly decreased for sorghum*	*Increased for wheat*	Decreased for both	
Domestic volatility vs International volatility	higher	lower		lower	Lower
	maize				
Domestic volatility compared to the preceding period		*increased*		*Remained the same*	
Domestic volatility vs International volatility	higher	higher		higher	Higher

Source: Author's

So far, price trends and volatility in international and domestic markets have been identified. In chapter 7, Ethiopia's food security policy for the first two decades of the 21st century will be reviewed to check whether it is in line with the most compelling price factors.

Chapter 7: Ethiopia's Food security programme since 2000

7.1 The Productive Safety Net

In the past 20 years, Ethiopia's main food security programme is called the Productive Safety Net Programme (PSNP). The Ethiopian government adopted a new policy early this century to address emerging food security issues so that vulnerable people can cope with food shortages or price shocks. Until early 2000s when the PSNP is introduced, at times of food insecuity, the government of Ethiopia provided emergency assistance in form of food aid. However, this ad hoc response was not successful in averting further famine (Berhane, Gilligan, Hoddinott, Kumar and Taffesse, 2014; Gilligan, Hoddinott and Taffesse, 2009).

The newly introduced food security measure has an additional component in addition to food aid. PSNP departs from the tradition of emergency responses to food shortages since the 1980s as it intends to increase agricultural productivity in addition to providing transfers (Bishop and Hilhorst, 2010; Gilligan, Hoddinott, Kumar and Taffesse, 2014). PSNP is a cash and food-for-work programme. The criteria for public work PSNP are that the households are poor and food insecure but can provide labour for the public works. The poverty level of eligible household is measured by low cattle and/or land holdings (Berhane, Gilligan, Hoddinott, Kumar and Taffesse, 2014). On the other hand, a household is food insecure if it received food assistance for three consecutive years before participating in PSNP programme (Gilligan, Hoddinott and Taffesse, 2009). PSNP has various phases and currently the programme is in its fourth phase. Since the third phase that started in 2010, there is a growing shift from food to cash transfers (Ministry of Agriculture, 2014). In view of cereal price volatility this means households became more susceptible to price fluctuations.

Ethiopia's PSNP is second only to Africa's biggest safety net i.e. South Africa's safety net. In 2015, it covered more than 7 million people (Cochrane and Tamiru, 2016; Gilligan, Hoddinott and Taffesse, 2009), and started with an annual budget of 107 million USD (Bishop and Hilhorst, 2010).

In the first two phases (2005 – 2009), the objective of the PSNP was to provide food and/or cash transfers to chronically food insecure households (Ministry of Agriculture, 2014). However, in phase 3 (2010-2015), the programme has been expanded to contribute to the

Growth and Transformation Plan (GTP), which aims to upgrade the country to a middle- income economy by 2025. As a result, the PSNP becomes part of the GTP and aims to contribute to four policies. First, it helps to achieve social protection policy that bring social, economic, security and social justice to all Ethiopians. The policy target in the social protection policy is reached by increasing the number of safety nets. Increasing the number of safety nets is believed to reduce the proportion of the population living below poverty line. Second, reducing in distress sale of assets and the number of malnourished children through safety nets will contribute towards Disaster Risk Management Policy. Third, through public works, it is also part of a green economy policy to combat climate change. The course of action in this case includes watershed and pasture management projects and carbon dioxide sequestration in public works. Fourth, the PSNP is directly linked to the National Food Security Plan, which aims to reduce the percentage of stunted children under the age of five.

7.2 Components of the PSNP

The PSNP is implemented in two forms (Berhane, Gilligan, Hoddinott, Kumar and Taffesse, 2014). The first element is public work (PW), which involves able-bodied chronically food insecure individuals. The beneficiaries in this category supply their labor in exchange for wages. The second type of PSNP is called direct support (DS). Compared with PW, the proportion of beneficiaries in DS is smaller. The beneficiaries of DS have two characteristics: they are usually poorer and unable to provide labor. Elderly and disabled persons fall into this category. According to Cochrane and Tamiru (2016), there is a third type of target population that is pregnant or lactating women.

7.3 Effectiveness of the PSNP

In order to evaluate the effectiveness of PSNP, six papers are reviewed, as shown in Table 14. These papers assess the implementation process or impact of PSNP in relation to food security objective. The study area covers a range from a single location to the entire programme area that includes four regions: Tigray, Amhara, Oromiya and Southern Nations, Nationalities, and People's Region (SNNPR). The methods employed in these articles consist

of ethnographic research, focus group discussions, case studies, regression analysis and impact assessment methods such as difference in difference (DiD) and propensity score matching techniques. Whereas, in terms of the time span covered, the studies were distributed across different phases of PSNP, from its inception in 2004 until 2015.

During the initial phase of PSNP, according to Bishop and Hilhorst (2010), there was a targeting problem in two villages of the Amhara region, which has adversely affected the effectiveness of the food security programme. The beneficiaries of PSNP were selected based on their willingness to participate in a resettlement programme. A voluntary resettlement programme is another food security programme in which people are resettled from depleted highlands to lowland areas. Participation of people in to the PSNP is influenced by their willingness to resettle and not merely their food insecurity. As a result, the PSNP did not address the most vulnerable, but instead benefited relatively wealthy families. The relatively better off families are willing to settle to get food aid, but the most food insecure households are left out of PSNP. In this case, the influence of the adjacent policy invalidates the PSNP.

Lavers (2013) also studied complementarity between policies. Accordingly, the state land ownership, which is a form of social protection and the safety net programme as a part of food security policy are interrelated. The small land holdings that results from the land policy and the nature of agricultural production affected the effectiveness of PSNP. The study at Geblen, Tigray region showed that the land shortages have contributed to food insecurity and the PSNP is at most filling the gap in land policy rather than addressing food security problem. In this regard, Lavers (2013) emphasized the lack of synergy in existing policies. Through land policy, the government has the objective of limiting the rural urban migration and it is also used as a political means to control the rural population. However, small land holdings are less effective to apply the PSNP.

Another study by Cochrane and Tamiru (2016), revealed an implementation gap at lower administrative levels. PSNP is used to enforce political agenda. The food security programme has been used to maintain political power by involving elites, and on the other hand erode citizen participation. Consequently, the goals of the PSNP have not been fully achieved, leading to divergences between plans and practices. Assessing the implementation at local or lower administrative level, there was no community participation during the selection process

and hence it is not participatory. The selection is done by the community chairperson and the accountable unit from the Safety net programme. Besides, there is no clear graduation criteria for beneficiaries of the food security programme and once they graduate from PSNP, they become food insecure. Generally, beneficiaries were selected but also graduated based on political affiliation.

In a study covering four regions, Sabates-Wheeler and Devereux (2010) using regression analysis studied the relative effectiveness of cash and food transfers. They found that cash only transfers were less effective than food transfers with and without cash transfers. According to Sabates-Wheeler and Devereux (2010), cash transfers were less effective due to inflation in the country. As shown in Figure 18, rising food prices since 2002 have weakened the purchasing power of the poor and reduced the benefits of cash transfers.

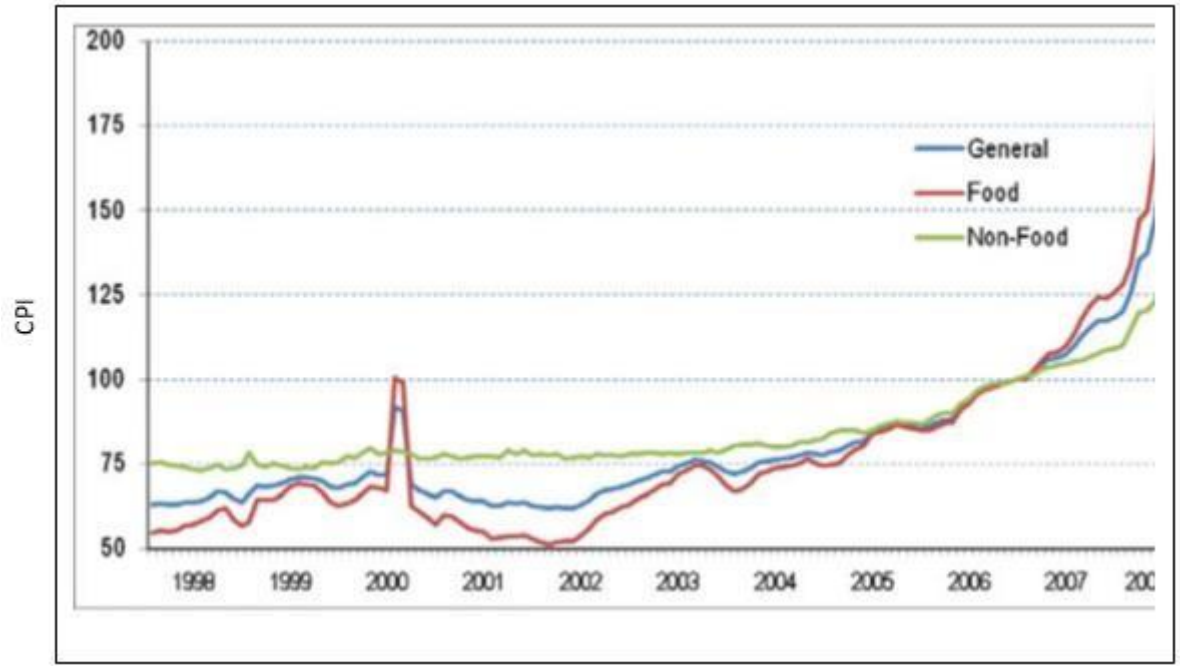


Figure 18. Inflation during 1998-2008 (Sabates-Wheeler and Devereux, 2010)

Two papers, Berhane, Gilligan, Hoddinott, Kumar and Taffesse (2014) and Gilligan, Hoddinott and Taffesse (2009) investigated the impact of PSNP on food security. The impact evaluation by Berhane, Gilligan, Hoddinott, Kumar and Taffesse (2014) employed DiD through a matching method based on a dose-response model of received transfers. They pointed out that comparing beneficiary households with non-beneficiary households is problematic since the beneficiaries are poorer on average and more food insecure. Hence, the

assessment is done among beneficiaries based on the number of years that households received PSNP payments. They compared the impact of five - year participation in food security programme with respondents who received only one year of PSNP benefits. High level of transfer or full participation is for those who received transfer for 5 years and the low level of transfer, only for one year. The impact of public work payments is measured by the changes in the number of months that the households report that they go food secure. PSNP only increased food security by 1.29 months while having PSNP and other food security programmes increased food security by 1.5 months.

Gilligan, Hoddinott and Taffesse (2009) found a comparable impact to that of Berhane, Gilligan, Hoddinott, Kumar and Taffesse (2014). In Tigray region, participants with PW PSNP and other food security programme (access to improved seeds, irrigation and water- harvesting schemes, soil and water conservation, credit, the provision of livestock or chicks, crop production extension services, or had contact with a development agent) have an impact of about 1.6 months as compared to those who did not receive these benefits or do not have access to it. Gilligan, Hoddinott and Taffesse (2009) used propensity score matching impact evaluation method to find out programme impact. The study is based on a survey of food insecure households in PSNP participating regions. Households with similar characteristics were chosen. This is done by propensity score (the probability of being in the programme) that matches beneficiaries with non-beneficiaries. Then, the impact is calculated from the average difference in outcome between the two groups. Gilligan, Hoddinott and Taffesse (2009) cited various reasons for the lack of a more significant programme impact, including lower levels of transfers or implementation deficit. The payment for involvement in PW PSNP is only 6 Birr (0.75 USD) per day. Besides, they believe that the assessment of programme impact is premature. The assessment is done at the outset of the first phase of PSNP in 2006 and a higher impact would be realised at the end of the third year in 2009 when the programme is fully implemented.

Table 14. Summary of studies on the effectiveness of PSNP in meeting food security

Authors	Study area	Feature and phase of PSNP evaluated	Methodology	Results	Why PSNP is (not) effective
Bishop and Hilhorst, 2010	2 villages of the Amhara region	effectiveness of targeting (during initial phase, the second half of 2004)	Ethnographic research and focus group discussions	benefits of the programme go to the more affluent households	influence of adjacent policy
Cochrane and Tamiru, 2016	3 administrative districts in southern Ethiopia	implementation process at the local level, 2015	Qualitative case study	systematic divergence between plan and practice	maintenance of political control
Lavers, 2013	Geblen, Tigray region	complementarity between agricultural and social protection policies, 2010	Case study	the PSNP and its complementary programmes can achieve food security	links between policies in practice
Sabates-Wheeler and Devereux, 2010	Tigray, Amhara, Oromiya and SNNPR	relative efficacy of cash transfers versus food aid, surveys in 2006 and 2008	Regression analysis	transfers with food component were better than cash only transfers	price inflation
Berhane, Gilligan, Hoddinott, Kumar and Taffesse ,2014	Tigray, Amhara, Oromiya, and SNNPR.	impact of the PSNP on food security, Survey in three rounds (2006, 2008 and 2010)	DiD	PSNP only improved food security by 1.29 months	comparison is made among the beneficiaries
Gilligan, Hoddinott and Taffesse, 2009	Tigray, Amhara, Oromiya, and SNNPR	impact on household food security, in 2006	Propensity score matching techniques	PSNP had little impact on participants	due to various reasons

Source: Author's compilation

7.4 PSNP and food prices

The relationship between PSNP and food prices can be understood in several ways. For instance, Public work PSNP helps stabilize domestic prices as the community investments can raise agricultural productivity. Furthermore, through increased income from off-farm employment or higher productivity, public work can improve the living standards of food insecure participants, which may help to withstand (counter) price volatility. According to the findings in chapter 6, international cereal prices are mostly more volatile than domestic ones. The other mechanism that links agricultural productivity to food security is through the cereal import dependence. If cereal imports decline due to increased domestic production, lower import dependence means that the impact of international cereal price volatility on the domestic market can be minimized.

On the other hand, non-PW PSNP i.e. the DS and maternity support feed the most vulnerable non - productive groups but it only grants short-term access to food with no consequence on long term food security. Thus, non-PW PSNP is not different from food aid. Moreover, if the transfers are in cash, it has a minimal impact on food security jeopardized by food price inflation (Sabates-Wheeler and Devereux, 2010).

In addition to its direct contribution to food security, the PW PSNP can also contribute to different policies. The community works can help to overcome the adverse effects of climate change and reduce GHG emissions. Besides, by safeguarding asset selling during shocks, it can strengthen resilience.

All in all, based on the literature reviewed, PW and cash transfers with food elements are useful since they contribute to income growth, but they can also address immediate food shortages. Generally, the PSNP is part of the country's development plan and has the potential to contribute to food security.

7.5 Conclusion

The food security approach prior to the implementation of the PSNP only met short term needs. However, especially in its latest stage, the PSNP has been linked to different policies and economic growth in general. Studies have shown the adverse effect of complementary policies in the implementation of the food security programme. In this case, the country's land policy encouraged small holdings which counteracted the food security programme.

Furthermore, there was a targeting problem. The most vulnerable people were not included in PSNP because of political patronage. On top of this, the small cash transfers were less effective by inflation that eroded the purchasing power. Finally, the PW PSNP is more important than the other two categories in meeting long- term food security. In the final chapter (Chapter 8), the main findings of this study will be revisited to draw conclusions and recommendations.

7.6 Critical reflection

The results of the study are based on the Standard deviation of the logarithmic price differences, which is the most widely used volatility measure in the literature. But using the Corrected coefficient of variation will produce different results. In volatility studies, different measures may lead to different results. Naylor and Falcon (2010) used different volatility measures and obtained different results. They used CV and detrended volatility measures to find the dissimilar results. On the contrary, Gilbert and Morgan (2010) and Houchet-Bourdon (2011) pointed out that in the case of low volatility, different measures may yield similar results. The two papers noted that the volatility measured by CCV and the standard deviation of the logarithmic price difference is the same.

Besides, Houchet-Bourdon (2011) used nominal and real prices, domestic and foreign prices to confirm volatility results. But the current research assesses food security. Hence, real price in domestic currency is deemed appropriate to investigate the effect of price on local consumers.

Data limitation also constrained the research in two ways. International cereal price data was not available for some of Ethiopian major cereal import partners. Due to lack of data, it was impossible to incorporate multiple international wheat and sorghum markets. Additionally, quarterly CPI data is not available. Consequently, the annual CPI is used to convert the monthly nominal price to real price. However, this may have a slight effect on the volatility results, which are derived from prices.

Regarding national cereal prices, the Addis Ababa central market is used to represent domestic market prices. In order to determine whether the Addis Ababa wholesale market is a representative market, its correlation with various local wholesale markets is computed. Alternatively, the average domestic wholesale price can be calculated from cereal prices in different local markets (Mittal and Subbash, 2018). For Ethiopian cereal market, since some of the regional wholesale markets were established lately, the Addis Ababa central market is used to represent domestic cereal prices.

Furthermore, this paper compares domestic cereal price volatility during 2007-08 global food crisis with the volatility before and after. As a result, the impact of price volatility is derived from this reference point. A more concrete conclusion could be drawn when the various

global food crises are included. However, the paper gives a good insight about the volatility around the most recent food crisis and reviews multiple aspects of Ethiopia's SafetyNet i.e. the implementation processes and its impact on food security.

It is shown that high cereal price volatility in world market is reflected in domestic cereal prices. During the global food crisis, compared to the pre 2007-08 global food crisis, the changes in the domestic volatility of wheat and maize corresponds to the volatility changes in the international market. The adverse impact of 2007- 08 global food crisis on Ethiopia's food security is also confirmed by several authors (Hadley et al., 2011; Kumar and Quisumbing, 2013; Martin-Prevel et al., 2012). However, when we consider all the different sub-periods (i.e. 2000-2006, 2007-2012 and 2013-2018), the changes in volatility between the domestic and international cereal market differs per grain. In the literature, grain price volatility difference between the international and domestic market is explained by the volume of domestic production and the amount of cereal imported (Dawe, Morales-Opazo, Balie and Pierre, 2015).

Generally, the study assessed the connection between domestic and international markets but, the magnitude of their relationship is missing. Therefore, the volatility transmission between the two markets should be investigated.

Finally, the effectiveness of PSNP is assessed with six papers that studied different aspects of the programme. These studies covered different phases of the safety net that were implemented in several target areas. Various factors that limited the effectiveness of the PSNP were identified. Apart from the weakness of instruments used by the safety net programme (for example, the small amount of cash transfer which is subject to inflation), the assessment showed that complementary land policy and the resettlement programme retarded the effectiveness of PSNP. Thus, the influence of complementary factors should be fully understood.

Chapter 8: Major findings, conclusion, and recommendation

8.1 Major findings and conclusion

Domestic and international prices of wheat, maize and sorghum have risen in nominal US dollars over the past two decades. Besides, the increase in the domestic price is more than the increase in the international market.

Regarding real prices, the price index of cereals on the domestic and international markets fluctuated overtime. However, the results of regression analysis showed a negative trend in real domestic prices of maize and sorghum whereas, international prices of the three cereals except for Argentina maize have increased. Thus, domestically cereals were becoming more affordable. From a food security perspective, lower prices are beneficial for consumers.

The relative volatility between domestic and international markets varies over time and from commodity to commodity. Compared to fluctuations in the period 2000- 2006, domestic real prices of maize and wheat fluctuated more during 2007- 2012. Thus, there was correspondence between international and domestic price volatilities. Literatures also confirm the presence of adverse impact on Ethiopian food security from the 2007-08 global food crisis.

Ethiopia's main food security programme for the past two decades is called PSNP. The ongoing food security programme, currently in its fourth phase, links food security and development. PSNP is mainly implemented in two forms: PW PSNP and DS. In terms of meeting long term food security objective, PW PSNP is superior to DS since it raises agricultural productivity. Besides, it promotes various development goals including mitigation of climate change.

However, there are several factors that have lessened the effectiveness of PSNP. First, the success of the safety net has been offset by a complementary land policy that promote smallholdings. Second, PSNP is used as an instrument to implement the resettlement programme. Beneficiaries of PSNP were selected based on their willingness to participate in resettlement programme. As a result, the PSNP cannot benefit the poorest people in the

society and rather relatively wealthy participants were selected to the food security programme based on political affiliation. Third, among the two forms of transfer used in the PSNP i.e. food transfer and cash transfer, the cash transfer is found less effective. Inflation eroded the purchasing power of the small cash transfers. Fourth, PSNP mainly involves four regions: Tigray, Amhara, Oromiya and Southern Nations, Nationalities, and People's Region (SNNPR) and did not cover the poor all over the country.

In general, compared with the food security approach before the implementation of the PSNP, PSNP has better addressed the domestic cereal market situation. PSNP is superior to ad hoc emergency food aid response to food insecurity for two reasons. On one hand, PSNP address food insecurity by providing food access (income support or food transfer) to the elderly and disabled. On the other hand, the public work component of the safety net is aimed at raising productivity, which can be considered a price stabilization measure. With the PSNP, there is an improvement in food security, but it has a limited effectiveness owing to the implementation problems and because of adverse effects from complementary land policy and the resettlement programme.

8.2 Recommendation

Based on this study, the following recommendations are made.

- Since price volatility is more pressing than price increases in Ethiopia, food security measures should target price volatility (stabilizing prices). Domestic real cereal price does not show an increasing trend while the impact of international price volatility is present. Thus, it is necessary to raise productivity in order to achieve long-term food security. In this regard, complementary projects like REALISE, that are aimed to raise agricultural productivity, should be encouraged to cover more food insecure areas.

- The domestic volatility has increased during the 2007-08 global food crisis. The country's food security is affected by international price fluctuations as international market price fluctuation transmits to the domestic economy. This should be minimized by importing cereals from less volatile markets (trade partners). For example, for Maize, USA market is preferred to Argentina as it is less volatile in the pre and post 2007-08 global food crisis.

In addition, the impact of international cereal market volatility on food security can be minimized by promoting domestic production. Once again, productivity-enhancing projects that can stabilize price by boosting production are suggested.

- On top of adopting food security measure, the framing of food security programme by the government is equally important. The review on the impact of PSNP on food security showed that the link between food security and neighbouring policies limit its effectiveness. Thus, understanding linkages with other policies and tracking (follow-up) implementation process is therefore critical to having effective food security programme.

- In the case of direct support, cash only transfers were found to be less effective in meeting food security owing to inflation. Thus, for DS beneficiaries, food security is best achieved through food transfer.

In summary, the amount of cash transfer should be large enough to purchase the minimum calorie requirements in order to meet food needs of disable persons and the elderly. Thus, the amount of cash transfer should be revised according to the prevailing inflation rate in the country. At the same time, programmes that are aimed to increase agricultural productivity are essential for long-term food security.

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Appendix 1

From a simple regression, the coefficient of multiple determination is given as:

$R^2 = 1- \sum(y-\hat{y})^2 / \sum(y-\bar{y})^2$ ..... (1)

$\hat{\mathbf{y}}$ is the predicted value of y from equation 1. Rearranging, equation (1) can formulated differently as in equation (2).

$\sum(y-\hat{y})^2 = (1- R^2) *\sum(y-\bar{y})^2$ ..... (2)

Multiplying the right-hand side of equation (2) by (N-k/ N-k) *(N-1//N-1),

$\sum(y-\hat{y})^2 = (N-k) *(1- R^2) *(N-1/N-k) *\sum(y-\bar{y})^2/(N-1)$ ..... (3)

Where, N is the total number of observations and k is the number of explanatory variables including the constant term.

Dividing both sides by N-k and taking the square root of the expression on the left-hand side of equation (3) gives the standard error of the regression estimate (SEE).

$SEE = \sqrt{\sum(y-\hat{y})^2/ N-k} =\sqrt{(1- R^2) *(N-1/N-k) *\sum(y-\bar{y})^2/(N-1)}$ ..... (4)

Whereas the last term on the right-hand side of equation (4) is the square of standard deviation (SD) of y, which is $\sum(y-\bar{y})^2/(N-1)$.

Thus,

$SEE = SD*\sqrt{(1- R^2) *(N-1/N-k)}$ ..... (5)

Multiplying both sides of equation (5) by $100/\bar{y}$, yields

$100*SEE/\bar{y} = 100*SD/\bar{y} *\sqrt{(1- R^2) *(N-1/N-k)}$ ..... (6)

$100*SD/\bar{y}$ is CV and similarly, $100*SEE/\bar{y}$ = CCV. Hence, equation (6) can berewritten as.

$CCV = CV*\sqrt{(1- R^2) *(N-1/N-k)}$

Finally, correcting R^2 for the degrees of freedom,

$CCV = CV*\sqrt{(1- \tilde{R}^2)}$ ..... (7)