Price Transmission in the Era of Global Food Market Turmoil: The Case of Maize and Wheat Commodities in Ethiopia

By

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Submitted in partial fulfilment of the requirement for the degree of

PhD Agricultural Economics

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DEDICATION

This work is dedicated to my late father, Yami Gurmu, and my brother, Tesfaye Yami.

DECLARATION

I declare that this thesis hereby submitted for the degree of PhD in Agricultural Economics at the University of Pretoria is entirely my own work and has not been submitted or considered anywhere else for the award of a degree or otherwise.

Parts of the thesis have been published and submitted for publications in journals.

All errors in thinking and omission are entirely my own responsibility.

Signed: …………………

Name: Mesay Yami Gurmu

Date: 03 July 2017

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ABSTRACT

PRICE TRANSMISSION IN THE ERA OF GLOBAL FOOD MARKET TURMOIL: THE CASE OF MAIZE AND WHEAT COMMODITIES IN ETHIOPIA

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This study pursued the following three objectives: (1) to test the presence of Asymmetric Price Transmission (APT) among integrated wholesale maize markets during the post-agricultural market liberalisation period from July 2004 to March 2016; (2) to understand the influence of government interventions on the performance of maize and wheat grain markets; and (3) to examine the effect of domestic supply and demand dynamics on the maize market using a partial equilibrium modelling framework. In pursuit of the first objective, this study estimated an Asymmetric Vector Error Correction Model (AVECM). Findings from the inter-regional maize market integration analysis indicated that all maize market pairs considered in this study were cointegrated with the central Addis Ababa wholesale maize market. Spatial maize market integration has not only improved, but there has been an improved complete pass-through of price signals, with no evidence of positive APT in the regional wholesale maize markets in Ethiopia. Despite the widely held belief by consumers and government that traders' inappropriate price adjustment contributes to the persistence of soaring food prices in Ethiopia, we found no evidence to support this argument. Instead, wholesale maize traders tend to adjust

homogenously to increases and decreases in maize price deviations from the central Addis Ababa maize market. Hence, the widely held perception that considers traders as constituting a main contributor to the recent soaring food price situation in Ethiopia is just a misconception. In this study, it is argued that the recent surge in grain prices in Ethiopia has little to do with APT in maize markets.

The second objective employed a regime-dependent Vector Error Correction (VECM) model to examine the extent of the integration of Ethiopian wheat and maize markets with the world market and the effect of policy interventions on the spatial integration of food markets. Findings of the cointegration analysis indicate that domestic wheat and maize markets are strongly integrated with the world market during a period in which the government intervenes, as opposed to periods of low intervention. Despite the presence of a long-run relationship and absence of APT, domestic wheat prices are distorted by the government's secretive and unplanned interventions. Domestic wheat prices have surpassed the ceiling price during periods of heavy government interventions (i.e. since 2008). We argue that the increasing price gap between domestic and world wheat markets since 2008 is due to trade flow restrictions caused by foreign exchange rationing and subsidised wheat distribution.

A single commodity partial equilibrium approach was used to investigate the maize price formation and a likely impact of a bumper harvest and drought shocks on the maize market. Findings from the behavioural equations reveal that farmers respond very little to price in planning their maize acreage. Rather, the analysis demonstrated that rainfall and technological progress were relatively more important for higher maize acreage growth. Regarding the supply side shocks (a bumper harvest and drought) on maize prices, we found that a 20 per cent increase in maize yield could reduce nominal maize price by 81 per cent. This implies a decrease in maize price level of 238 per cent (110 USD/t) below the export parity price. This makes maize exports profitable, and shifts the trade regime from autarky to an export parity regime. On the other hand, the effect of drought could increase maize prices by 61 per cent in the short run (within the year). The effect could result in the domestic wholesale maize price moving over the upper threshold import parity price by 46 per cent (126 USD/t). As a result, maize imports would become profitable.

The policy implication is that, in order to improve access to affordable food by lowering food prices, greater attention should be given to creating space for the private sector to effectively carry out arbitrage operations. The government should continue to create a conducive market environment by playing a regulatory and facilitator role in the grain market. This should be accompanied by minimising a state trading enterprise direct involvement in the grain market.

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LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
AECM	Asymmetric Error Correction Model
APT	Asymmetric Price Transmission
PBM	Parity Bound Model
BFAP	Bureau for Food and Agricultural Policy
CEEPA	Centre for Environmental Economics and Policy in Africa
CGE	Computable General Equilibrium
CSA	Central Statistical Agency
DOLS	Dynamic Ordinary Least Square
ECM	Error Correction Model
ECX	Ethiopia Commodity Exchange
EGTE	Ethiopian Grain Trade Enterprise
EPP	Export Parity Price
EPRDF	Ethiopian People's Revolutionary Democratic Front
ETB	Ethiopian Birr
FAPDA	Food and Agriculture Policy Decision Analysis
GIEWS	Global Information and Early Warning Systems
IPP	Import Parity Price
LOP	Law of One Price
MoA	Ministry of Agriculture
SAP	Structural Adjustment Program
SSR	Self-Sufficiency Ratio
TAR	Threshold Autoregressive
VCR	Value Cost Ratio
VECM	Vector Error Correction Model

CHAPTER 1:

1.1 INTRODUCTION

After the commodity price turmoil of 2008, the topic of price transmission has attracted renewed interest, from both academics and policy makers. One of the fundamental key premises of the Law of One Price (LOP) in a competitive and efficient market is that integrated markets allow for price signals to be transmitted both spatially and vertically along the commodity value chain. Of course, the theory holds in a free market economy in the absence of government intervention.

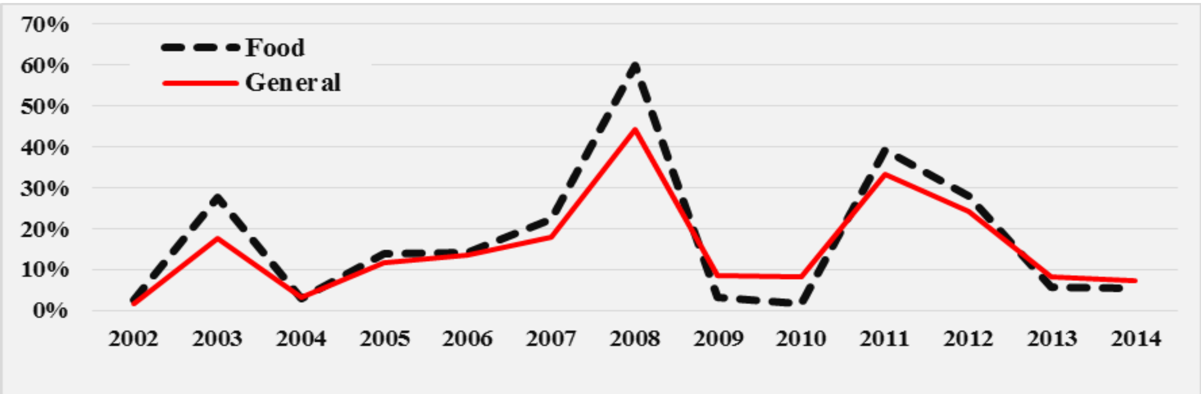
The degree of price signal transmission may broadly indicate whether efficient arbitrage is present or not among spatial markets. The strong assumption of LOP indicates that arbitrage opportunities prevent spatial market prices from drifting too far apart. Whenever there is deviation in prices for a homogenous product among spatial integrated markets, there is an opportunity for profit. Therefore, spatial arbitrage involvement restores price differentials to the equilibrium position. Thus, the error correction mechanism in LOP is arbitrage process. In principle, the involvement of arbitrage would eventually lead markets to converge and follow the same price for a homogenous good. Under such circumstances, if price shocks originated from one market are transmitted fully without any time lag to other spatial markets, then the markets are linked and spatial arbitrage conditions hold contemporaneously. On the other hand, the complete absence of price shock transmission indicates market segmentation or isolation. Therefore, investigating the degree of price transmission among spatial markets can paint a picture of the extent to which markets are spatially linked. Thus, it is of interest to policy makers who strive to maximise the welfare of consumers and the margins of producers.

The liberalisation of agricultural products has especially increased since the Marrakesh Agreement in 1994. As markets become increasingly integrated around the world, economic shocks in the international market are transmitted quicker than before. In this context, domestic prices may now experience volatility, which agricultural producers and consumers did not face in the past, with low-income countries suffering the most in this regard (Bourdon, 2011). Commodity prices have recently experienced dramatic increases in international markets, climbing to historic levels in mid-2008 (Minot, 2011).

There has been much speculation among scientists on what really caused the surge in commodity prices in international markets. A combination of factors is blamed for the rising global food prices. Some of the named culprits in the price escalations are the diversion of major agricultural commodities (maize and sugar) for biofuel production, poor harvests in certain major crop-producing countries, short-term export restrictions imposed by main exporter countries, excessive speculative behaviour by both governments and commercial agents, escalation of oil prices, and the depreciation of the US dollar. There has been an ongoing debate about the relative importance of each factor at the global level, but the net effect has translated into sharply higher world food prices (Benson *et al.*, 2008; Dawe, 2008).

Being a net importer of food crops, Ethiopia's domestic grain markets are considered vulnerable to price instability in international commodity markets. What is of concern is the domestic food prices have been rising at a higher rate than the international prices since 2003. Since 2003, food price inflation has surpassed 20 per cent five times (Figure 1.1 below). The year-on-year change in food price inflation reached an unprecedented all-time high level of 60 per cent in 2008. Moreover, in 2009 and 2010 food prices began to show signs of stabilisation and decline, but this was temporary, as food price inflation rose to 39 per cent and 28 per cent in 2011 and 2012, respectively. The persistence of high food price inflation poses a considerable threat for net food buyers in Ethiopia (CSA, 2015).

Figure 1.1: Inflation in Ethiopia (2001=100): year on year changes (2001-2014)



Source: Yami *et al*. (2017)

In order to contain the soaring food price situation after 2008, the Ethiopian government began to get involved in commercial wheat importation and distribution to vulnerable poor consumers at subsidised prices. Moreover, the government has imposed export bans on maize, sorghum, teff, and wheat. A new policy in food market regulation was introduced by the government in 2011. With the aim of mitigating unlawful food pricing practices, the Ethiopian government issued price caps on 17 basic food items. However, this intervention instead worsened the problem by reducing the availability of some of the food items on the market (Minten *et al*., 2012). Most traders reacted by hoarding commodities and consumers had difficulty in accessing some basic food items like sugar and cooking oil. As a result, the government reversed the decision for most commodities in June 2011.

The two new policy instruments that proved the Ethiopian government's commitment to long-term grain price stabilisation were: (1) the introduction of weather index insurance in drought prone crop producing areas; and (2) establishment of the Ethiopia Commodity Exchange (ECX). These interventions have largely been praised for reducing production risks and bringing transparency in the grain market. However, these programmes are still in the early stages and their role with regard to grain price stabilisation is limited. For instance, ECX commenced its activity in April 2008. Since then, trading has been limited to high value exportable crops like coffee, sesame and white beans (Yami *et al*., 2017).

Despite the policy responses and increases in domestic crop production, grain prices have remained high in Ethiopia. Cereal production has been increasing in Ethiopia since 2004. During periods between 1995-2003 and 2004-2015, the growth rate in domestic production of food crops was somewhat higher than the growth in total consumption. The coexistence of high crop prices with drastic increase in domestic crop production raises three key questions about the spatial integration of domestic grain markets, grain market pricing practices, and it casts doubts on the effectiveness of government policy interventions in the domestic grain market.

One possible culprit in relation to the persistence of food price hikes in the presence of high domestic crop production could be the existence of imperfect price transmission.[1] That is, traders' price adjustments may differ according to positive and negative price shocks. Despite production increases in surplus markets, where traders are hesitant to reduce prices or when the cost reduction is not fully transmitted, Asymmetric Price Transmission (APT) will contribute to the persistence of high food prices in deficit markets (Wondemu, 2015).

[1] In this study, the terms 'incomplete price adjustment', 'asymmetry' and 'imperfect price adjustment' are used interchangeably.

Production reallocations from surplus to deficit markets will therefore have little impact on reducing prices in deficit markets. This kind of domination in grain market structure could create price 'stickiness' (what goes up does not come down). The presence of APT has important policy implications for welfare distribution. APT implies that some role players in commodity marketing are not benefiting from a price reduction (consumers) or increase (producers).

The coexistence of high food crop production and soaring food prices in Ethiopia makes it necessary to empirically investigate traders' grain market price adjustments. In this thesis, we challenge a widely held perception that the inappropriate price adjustment by traders contributes to the persistence of soaring food prices in Ethiopia, by examining the case of maize and wheat commodities. This thesis has three main objectives. First, we test grain traders' pricing practices in the inter-regional maize markets and domestic to the world wheat and maize spatial market linkages with large datasets and more detailed analysis. The second objective examines the effect of the Ethiopian government policy interventions and counter measures concerning the world-to-domestic wheat and maize spatial market integration. Finally, we simulate the effect of domestic supply and demand dynamics on the maize market with a partial equilibrium modelling framework.

1.2 EVOLUTION OF CEREAL PRODUCTION IN ETHIOPIA

Agriculture continues to be the backbone of the Ethiopian economy. Within the agricultural sector, cereal production is the leading sub-sector for its share of the total cropped area (80 per cent), rural employment generation (60 per cent), and contribution to agricultural sector GDP (62 per cent). Cereals also account for over 40 per cent of the total expenditure on food and 60 per cent of the total calories consumed by households (Worako, 2012).

In Ethiopia, five major crops, namely teff, wheat, maize, sorghum, and barley, dominate cereal production. These crops account for over 95 per cent of cereal acreage and 49 per cent of calorie intake per day (FAO, 2015). The focus of this section is to provide an overview of the output, yield and area trends of major cereals in Ethiopia.[2] Emphasis is placed on the analysis of acreage allocation, production, and export and import trends of maize and wheat crops. In order to examine the influence of marketing policy reforms on crop production, the period of analysis is divided into two periods. The 1970 to 1990 period represents the socialism period, whereas the period from 1990 to date refers to a market-oriented economic system.

1.2.1 Trends in cereal acreage

Ethiopia's agricultural production system is generally characterised as comprising a low-input and low-output rainfed mixed farming system. Smallholder farmers with average landholdings of less than one hectare constitute about 95 per cent of the total area sown, and supply over 90 per cent of agricultural output (MEDAC, 1999). The intensity of cereal production, as measured by cultivated land and corresponding growth rates for the five major crops, is presented in Table 1.1 below. Overall, cereal cultivation during the one-price command economy (1974-1990) had shown a stagnant growth trend. On average, wheat area harvested declined by 1.1 per cent annually between 1970 and 1990. The market-based economic system seems to have encouraged farmers to allocate a larger proportion of land for wheat and maize production. As illustrated in Table 1.1, maize and wheat cultivated land increased by 8 per cent and 12 per cent annually between 1991 and 2000, respectively. The national increase in cultivated land since the 1990s can be attributed to two reasons. Firstly, the expansion of crop production at the expense of forest, pastures, and lands which are unsuitable for farming. Forests covered 40 per cent of the land area at the turn of the century, but less than 4 per cent today (Alemu, 2005). Furthermore, the introduction of wheat production to irrigated areas may also have partly contributed to the area expansion (Yami *et al.*, 2013). Secondly, the reform to a market-oriented economic system has given farmers an incentive to change the crop mix in favour of the production of staple crops such as maize and wheat.

[2] Due to data limitations of USDA sources, teff consumption and production trends are not reported here. Detailed analysis and explanation on the evolution of teff using the Central Statistical Agency (CSA) survey results are presented by different authors (see Taffesse *et al.*, 2011)..

Table 1.1: Evolution of cereal areal allocation by crop, (1970-2015)

Crops	Av. Area cultivated ('000 ha)				* Growth Rate (%)		
	1970's	1991-1995	1996-2003	2004-2015	1970's	1991-2000	2001-2015
Wheat	682	870	1 457	1 576	-1.1	12	2.6
Maize	864	1 187	1 718	1 970	1	8.3	4.1
Sorghum	901	922	1 499	1 653	-0.1	10	2.9
Barley	868	1 085	1 247	1 071	0.3	5.5	1.1
Millet	245	257	414	400	-2.3	10.5	2.0

Source: Author's calculation using USDA data (2015).
*the growth rate stands for annual growth rate measured by exponential growth rate. To save space, the period for the 1970s was used to denote the average for 1970-1990; henceforth, the study follows this convention.

1.2.2 Production and yield trends of major cereals

From 2000 onwards, the production of all five cereals has increased drastically. Compared with the 1990s, the percentage change in cereal production in 2000s ranges from 16–116 per cent. The highest growth was registered for sorghum (116 per cent), followed by wheat (103 per cent), maize (99 per cent), and millet (89 per cent). The smallest percentage change was recorded by barley (16 per cent), due to the lowest change in barley acreage.

The reason behind the recent dramatic increase in domestic crop production is yield enhancement, rather than areal expansion. In the past decades, crop production growth has been associated mainly with an increase in cultivated area. Acreage growth rate has shown a declining trend in the 2000s, while the converse is true for yield growth rate. Yield improvement is more pronounced in maize and wheat crops. The average annual yield growth rates for maize, wheat, sorghum, and barley are 2.3, 1.8, 1.7, and 1.4 per cent, respectively.

Owing to productivity improvement, maize and wheat production has increased recently. Wheat production doubled (to 103 per cent) between the periods 1991–2000 and 2001–2015 (Table 1.2 below). This was mainly attributed to productivity growth. Wheat productivity, on average, increased by 58 per cent between 1991–2000 and 2001–2015. It is believed that the wider adoption of high-yielding, end-use quality, and rust-tolerant wheat varieties after the 2010 yellow rust epidemics has brought about a dramatic change in wheat production in Ethiopia (Yami *et al.*, 2013). Likewise, maize has also registered a high average production growth (99 per cent) between 1991–2000 and 2001–2015. As it was the case for wheat, the increase in maize production was mainly driven by yield improvement (54 per cent), rather than an increase in cultivated area (28 per cent).

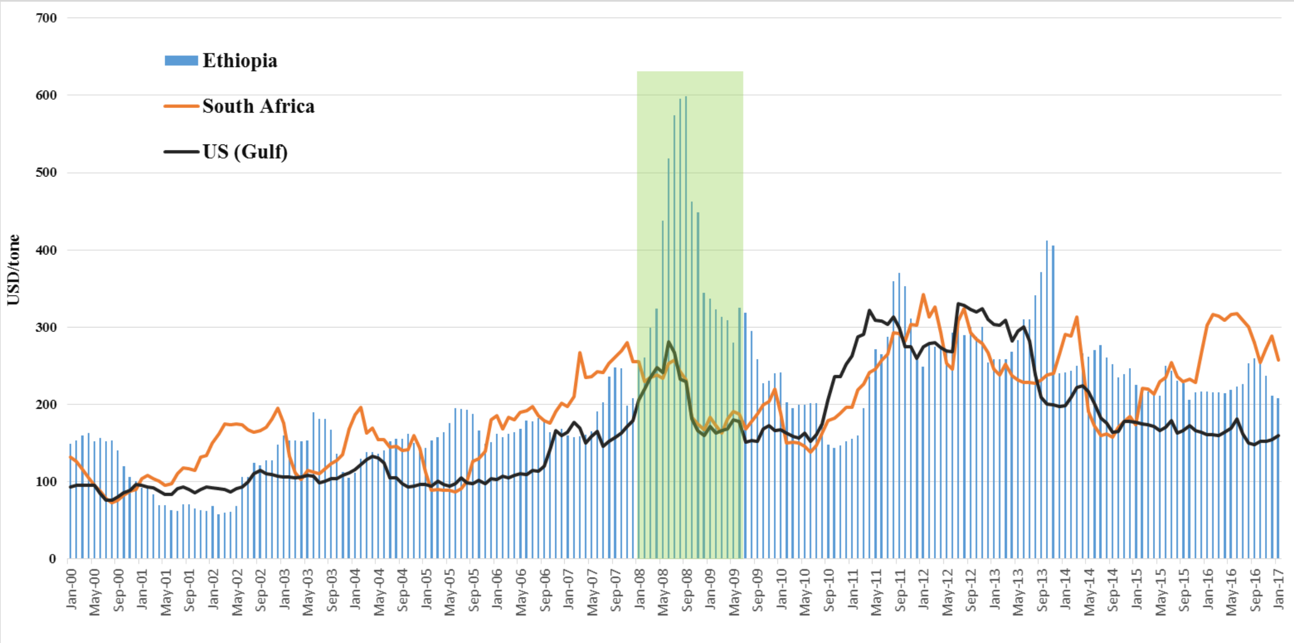
Table 1.2: Evolution of cereal production by crop, (1970–2015)

Crops	Av. Production ('000 tons)				* Growth Rate (%)		
	1970's	1991-95	1996-2003	2004-15	1970's	1991-2000	2001-2015
Wheat	707	1 008	1 639	3 081	1.2	9.9	8
Maize	1 291	1 742	2 670	4 969	3.4	7.8	8.8
Sorghum	1 017	1 046	1 569	3 174	0.5	7.2	8.5
Barley	927	1 225	1 297	1 650	2.1	3.2	5.3
Millet	193	207	369	599	-0.5	11	6.8

Source: Author's calculation using USDA data (2015).
*****the growth rate stands for annual growth rate measured by exponential growth rate.

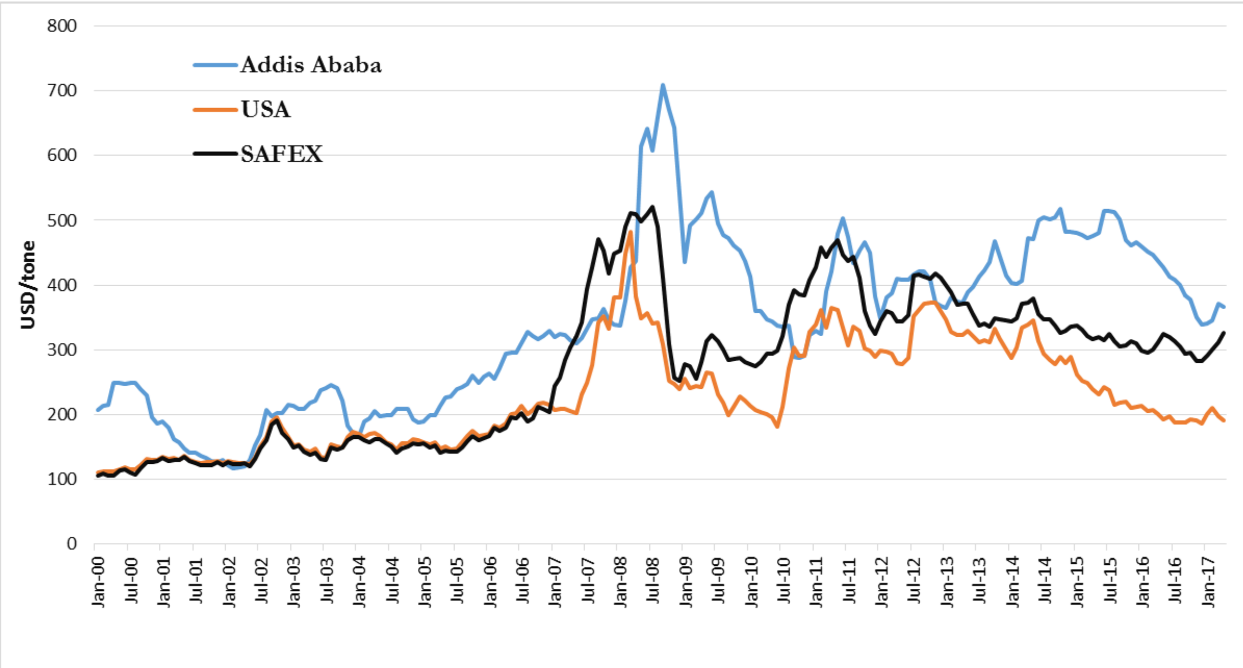
Despite the increase in maize and wheat production, grain prices in Ethiopia have remained high. As illustrated in Figures 1.2 and 1.3 below, maize and wheat domestic grain prices skyrocketed in 2008. The price spreads between domestic and international wheat and maize prices have been increasing since 2008. The price gap is more evident on the wheat crop than white maize. The increasing price spreads between domestic and international maize and wheat prices in the presence of double domestic crop production growth is puzzling.

Figure 1.2.2: Domestic and international maize prices, (Jan 2000 – Jan 2017)



Source: FAO (2015); International – USA: Gulf, Maize (US No. 2, Yellow); SAFEX - Randfontein, Maize (white) – Wholesale; Domestic – Ethiopia, Addis Ababa, white maize (Wholesale)

Figure 1.3: Domestic and international wheat prices (Jan 2000 – Apr 2017)



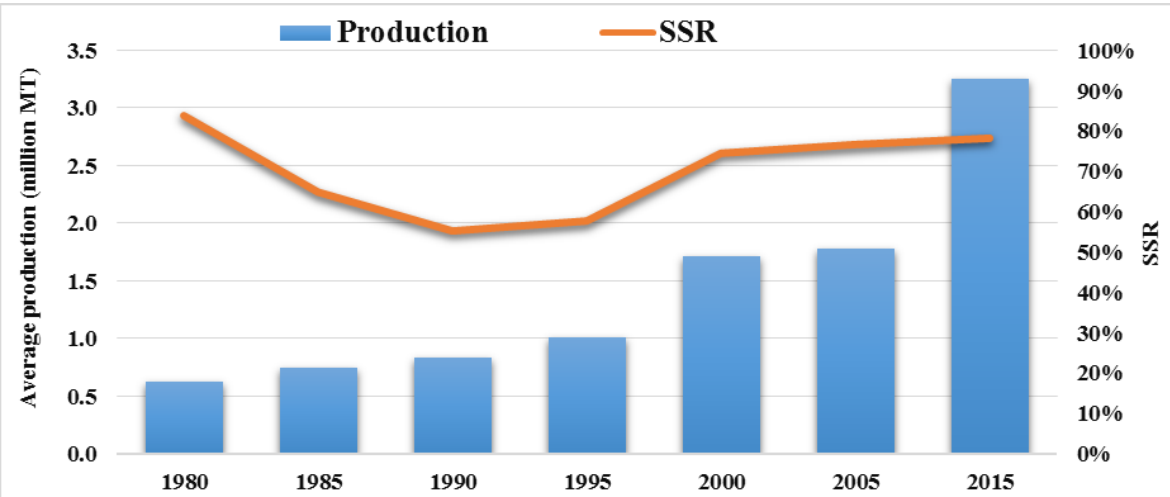
Source: FAO (2015); International – USA: Gulf, Wheat (No. 2 Hard Red Winter) and SAFEX - Randfontein, wheat – Wholesale; Domestic – Ethiopia, Addis Ababa, wheat (Wholesale)

1.2.3 Wheat and maize price discovery

Maize and wheat are the most important productive crops grown by a large number of farming households in Ethiopia. The crops are among the main staple food crops grown for both household consumption and sale. Despite the enormous role of the two crops for food security and export potential, consumers and producers have been seriously affected by the high prices of the two commodities in the domestic market. Through substitution effects, the crops are also dictating the price formation of other non-tradable food crops in Ethiopia (Rashid, 2011).

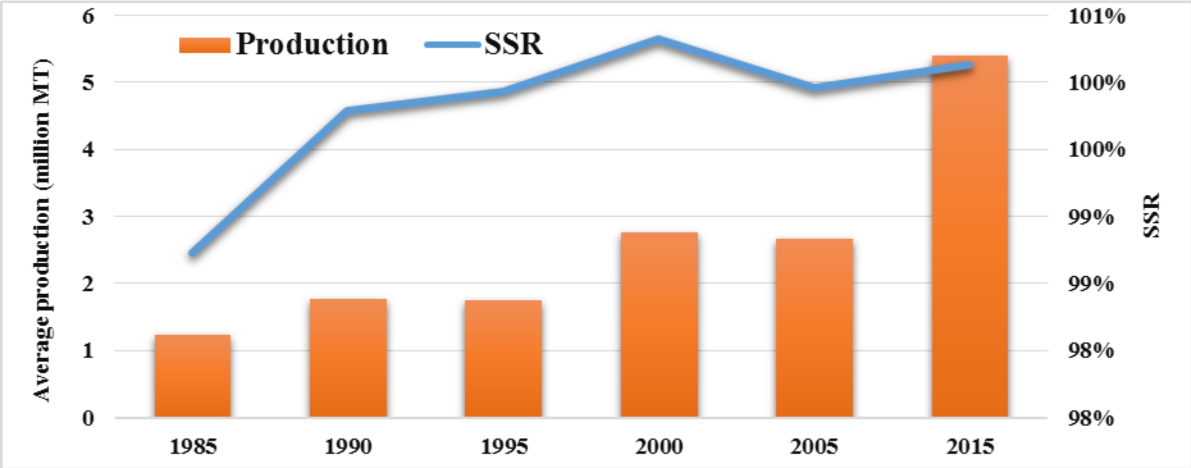
Figures 1.4 and 1.5 below indicate the average wheat and maize Self-Sufficiency Ratio (SSR) of Ethiopia from 1980 to 2015. Ethiopia is the largest wheat producer in Sub-Saharan Africa. Wheat production reached 3.8 million MT in 2016 and the wheat is produced mainly by smallholder farmers (USDA, 2016). As discussed above, wheat production has almost doubled over the past ten years in Ethiopia. Despite the increase, Ethiopia is still heavily dependent on wheat imports. About 24 per cent of domestic wheat consumption has been met through imports. On the other hand, the country is self-sufficient in maize production. The SSR for maize has fluctuated between 94 per cent and 102 per cent implying that the country is trading in an autarky trade regime (Yami *et al*., 2017). In an autarky trade regime, one would expect that the dynamics of domestic supply and demand factors, apart from government policies, would determine maize price formation and instability. It is important to mention that Ethiopia imports maize in times of drought. According to USDA (2015), a total of 25 000 tons of maize were imported during 2007, 2013, 2014, and 2015.

Figure 1.4: Average trends of wheat SSR, (1980–2015)



Source: Author’s calculation using USDA data (2015)

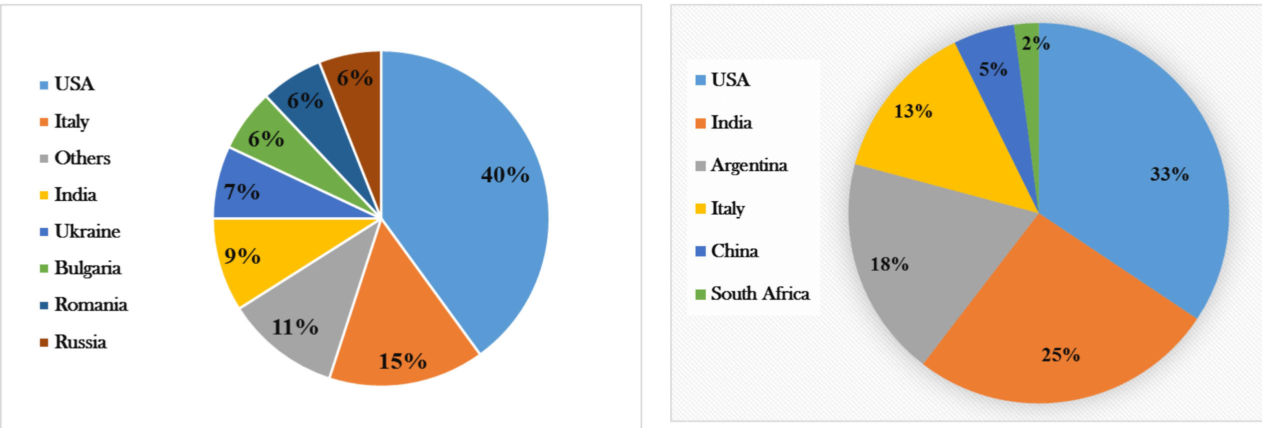
Figure 1.5: Average trends of maize SSR, (1980–2015)



Source: Author's calculation using USDA data (2015)

Figure 1.6 below outlines the major trading partner countries for wheat and white maize grain imports over the period 2001–2014. Individually, the USA was by far the single largest wheat import source for Ethiopia. Ethiopia has sourced almost half of its total wheat imports from the USA. The trend was the same for white maize, with one-third of the white maize imports being sourced from the USA. Italy was the second largest wheat exporter to Ethiopia, accounting for 15 per cent of overall wheat imports. The Black Sea region (Russia and Ukraine) also served as major wheat import origins for Ethiopia. Following India, the deficit in the domestic white maize production during drought season was filled through imports originating from Argentina (18 per cent), Italy (13 per cent), China (5 per cent), and South Africa (2 per cent).

Figure 1.6: Wheat and maize import trade partner for Ethiopia, (2001–2014)



(a): Wheat and meslin import sources (%)   (b): Maize import sources (%)

Source: Author's calculation using International Trade Center (ITC) data (2016)

1.3 RESEARCH PROBLEM

The Ethiopian grain markets have shown a high degree of instability in recent years. Since 2008, the persistence of high food price inflation has been more severe in Ethiopia, as compared with other net food importing east African countries (Table 1.3 below). The year-on-year change in food price inflation in 2008 reached the 60 per cent level, which was the highest recorded. Moreover, in 2009 and 2010 food prices began to show signs of stabilisation and decline, but this was temporary as food price inflation rose to 39 per cent and 28 per cent in 2011 and 2012, respectively. The high and persistent food price inflation affected Ethiopia the most as compared with other selected countries specified in Table 1.3. The persistent high food prices in Ethiopia defied the conventional wisdom that considers high food prices to be temporary state.

Table 1.3: Comparison of food price inflation of Ethiopia with the rest of the world, (2000–2014)

Year on year change in food inflation (%), (2000=100)					
Year	**Ethiopia (2001=100)**	**Uganda**	**Tanzania**	**RSA**	**USA**
2001	-	-3 %	6 %	5 %	3 %
2002	3 %	-4 %	4 %	16 %	2 %
2003	**28 %**	15 %	4 %	8 %	2 %
2004	3 %	4 %	15 %	2 %	3 %
2005	14 %	13 %	5 %	2 %	2 %
2006	14 %	10 %	7 %	7 %	2 %
2007	**22 %**	2 %	7 %	10 %	4 %
2008	**60 %**	**20 %**	13 %	-39 %	6 %
2009	3 %	**25 %**	17 %	10 %	2 %
2010	1 %	2 %	-52 %	1 %	1 %
2011	**39 %**	**32 %**	16 %	7 %	4 %
2012	**28 %**	8 %	**20 %**	7 %	3 %
2013	6 %	3 %	8 %	6 %	1 %
2014	5 %	5 %	7 %	8 %	2 %
Average	**17 %**	**9 %**	**6 %**	**4 %**	**3 %**

Source: Author's calculation using FAO data (2015)

Despite the increase in domestic crop production over total consumption, grain prices in Ethiopia have remained high. The growth in cereal production has been drastic since 2004. The domestic production growth rate of food crops was recorded to be higher than total consumption growth during periods between 1995–2003 and 2004–2015, as shown in Table 1.4 below. The coexistence of high crop prices with the drastic increase in domestic crop production raises three key questions about the spatial integration of domestic grain markets and grain market pricing practices, and it casts doubts on the effectiveness of government policy interventions in the domestic grain market.

Table 1.4: Average change in production and consumption of major food crops in Ethiopia (1995-2003 to 2004-2015)

Crops	Avg. production ('000 tons)			Avg. total consumption ('000 tons)[3]			Trade regimes
	1995-2003	2004-2015	% Δ	1995-2003	2004-2015	% Δ	
Wheat	1,629	3,056	88	2,224	3,857	73	IPP*
Maize	2,637	4,886	85	2,632	4,849	84	Autarky
Sorghum	1,572	3,157	101	1,601	3,160	97	Autarky
Millet	359	595	66	359	592	65	Autarky

*IPP denotes Import Parity Price
Source: Yami *et al*., (2017)

There are two schools of thought with regard to the causes of persistent food price inflation in Ethiopia. The first school of thought favours domestic policy as the cause of soaring grain prices in Ethiopia. Dorosh and Ahmed (2009) and Admassie (2013) argue that the foreign exchange rationing policy of the Ethiopian government is the most important contributing factor for the escalation of food prices in Ethiopia.

The second school of thought blames price shock diffusion from international commodity markets for causing domestic commodity price increases. A number of studies have attempted to examine whether domestic grain markets follow international market prices (Conforti, 2004; Loening *et al*., 2009; Ulimwengu *et al*., 2009; Minot, 2011; Kelbore, 2013). The conclusions were, however, mixed. Ulimwengu *et al*. (2009) and Minot (2011) argue that the isolated (landlocked) nature of Ethiopia and the limited international food trade combine to limit the influence of international market shocks on domestic markets. In contrast, Conforti (2004), Loening *et al*. (2009), and Kelbore (2013) found a long-run integration between the Ethiopian and international grain prices. The conflicting evidence with regard to international price shock transmission presents policy challenges for the Ethiopian government in terms of adopting informed trade policies to cushion the adverse consequences of high food price shocks.

[3] Total consumption includes household food consumption, seed and industrial use. It is based on USDA and CSA classification of grain use in Ethiopia.

One possible culprit in relation to the persistence of food price hikes in the presence of high domestic crop production might be the existence of imperfect price transmission. That is, traders' price adjustments may vary with positive and negative price shocks, which could lead to imperfect price transmission. Imperfect price transmission could arise in inter-regional as well as world to domestic spatial grain market integration. In spite of production increases in surplus markets, if traders are hesitant to reduce prices, or when the cost reduction is not fully transmitted, APT will contribute to the persistence of high food prices in deficit markets (Wondemu, 2015). In such a situation, production increases and reallocations from surplus markets would not have much effect on reducing prices in deficit markets (Assefa *et al*., 2014). This also applies to world to domestic spatial grain market integration. For instance, if traders adjust more quickly to negative price shocks (high international prices) than to positive price shocks (low international prices), then the domestic grain prices for tradable commodities will be characterised by high price persistency. APT implies that some role players in commodity marketing are not benefiting from price reduction (consumers) or increase (producers). As a result, the distribution of welfare is quite different from what would be obtained under symmetry (traders respond homogeneously to increases and decreases in price deviation from equilibrium) scenario, because APT alters the timing and the size of the welfare changes that are associated with price changes (Ngare *et al*., 2013).

The Ethiopian government fully liberalised the grain market in March 1990 (Gabre-Madhin, 2001). Since then, studies conducted on market integration have indicated that market liberalisation has led to better integration of grain markets than in the pre-liberalisation period (Negassa and Jayne, 1997; Negassa and Myers, 2007; Tamru, 2013). Evidently, there is also some improvement in the number of grain market participants in Ethiopia. During the period 2001-2011, the number of market intermediaries, especially traders and brokers, rose by 140 per cent and 252 per cent, respectively, in the wholesale grain markets in Ethiopia. Moreover, the progress in road infrastructure development, coupled with increased private sector participation in the transport sector, is expected to improve food production reallocations from production to consumption areas (Minten *et al*., 2012).

On the other hand, there is evidence of unfair price fixing and market allocation in the food market. These have become an important policy issue with the pricing practices in the food market being called into question by the Ethiopian government in 2011. In an effort to curb unfair pricing, the government in 2011 imposed price caps on 17 basic food items. However, this intervention worsened the problem and resulted in a reduction in the availability of some food items in the market. Because of that, the government reversed the decision for most crops in June 2011 (Minten *et al*., 2012). Therefore, progress in the number of participants in the grain market, together with the mobility of agricultural products, may not be a sufficient indicator to reach sufficient conclusions on the structure and competitive behaviour of grain markets. The pricing practices of traders need to be examined as an additional indicator in order to fully reflect the performance of the grain market.

In spite of the above good reason to suspect the presence of unhealthy price setting in the grain market, the majority of available studies on spatial grain market integration have ignored the influence of grain traders' pricing practices on grain prices in Ethiopia. In general, two shortcomings are identified in the inter-regional and world to the domestic spatial grain market integration studies in Ethiopia. Firstly, the majority of studies that examined inter-regional grain market integration failed to test for the possible presence of uncompetitive grain pricing practices or asymmetric price adjustment that might be induced by a particular market structure (Negassa *et al*., 2004; Getnet *et al*., 2005; Negassa and Myers, 2007; Jaleta and Gebremedhin, 2009; Ulimwengu *et al*., 2009; Rashid, 2011; Tamru, 2013). Previous studies predominately relied on the Engel-Granger (EG) and the Johansen (1988) multivariate Vector Error Correction Model (VECM). These models have been criticised for their assumption of symmetric price adjustment. Implicit in this assumption is that a market will do the job by correcting price discrepancies from a long-run equilibrium position (Alemu and Ogundeji, 2010). If traders, however, exert some degree of market power owing to imperfect market competition, the 'rockets and feathers'[4] price phenomena will prevail. In this case, price adjustment may not be symmetrical and traders may adjust prices quickly for an increase in costs, and then be reluctant to reduce prices, or may reduce them slowly, following a decline in costs (Tappata, 2009). Worako *et al*. (2008) and Wondemu (2015) are the only authors who have attempted to examine market integration in Ethiopia by focusing on the influence of traders' market power through using the spatial price asymmetry approach. The analysis by

[4] The 'rockets and feathers' price pattern has been used interchangeably with the term 'asymmetric pricing'. Bacon (1991) used the term for the first time to describe the pattern of retail gasoline prices in the UK. Later, Tappata (2009) provided a theoretical explanation of this pattern and examined drivers of asymmetric pricing in a highly competitive market. The rockets and feathers pattern takes two forms; namely, asymmetries in the immediate adjustment to a cost change, and the number of periods required to eliminate an increase and decrease in price difference from a long-run equilibrium position. The focus of this study is on the latter form of asymmetry.

Worako *et al*. (2008) was, however, limited to the coffee sub-sector, while Wondemu (2015) only used three wholesale grain market locations, so this limited scope makes the generalisation of their results difficult. On top of that, Wondemu's study was limited to inter-regional grain markets and did not consider world to domestic spatial grain market integration.

Secondly, studies on world to domestic spatial grain market integration have not taken into account the effects of policy interventions by the Ethiopian government on spatial grain market integration (Conforti, 2004; Loening *et al*., 2009; Ulimwengu, *et al*., 2009; Minot, 2011; Kelbore, 2013). Policy interventions can influence spatial price transmission significantly (Yang *et al*., 2015). Following the unusually high domestic food prices of 2008, the Ethiopian government pursued a wide range of policy interventions to insulate the domestic market from international price shocks, and to stabilise domestic commodity prices. The major counter measures include restriction of foreign exchange for private traders, an export ban of major food crops, and involvement in commercial grain imports. These interventions may have resulted in international and domestic prices becoming unrelated to each other or related in a non-linear manner. When these types of interventions occur, a conventional full sample cointegration analysis may lead to misleading estimates of international to domestic market adjustment dynamics because of aggregation bias. Allowing for policy regime changes may therefore lead to different conclusions (Myers and Jayne, 2011). It is therefore crucial to consider policy interventions while investigating spatial price transmission in the Ethiopian grain market.

In the light of the above discussions, this study contributes to the debate on the causes of high grain prices and grain price transmission in the literature on Ethiopia: (i) by testing the presence of APT in the inter-regional and the world to domestic wheat and white maize spatial market integration with large datasets and more detailed analysis; (ii) by providing answers as to whether the recent unprecedented increase in domestic grain prices is the result of uncompetitive grain pricing practices; and (iii) by examining the effects of the Ethiopian government policy interventions on the world to domestic spatial grain market integration.

Since Ethiopia is self-sufficient in maize production, maize price formation depends on domestic supply and demand factors. For this reason, the study augmented the price transmission analysis by modelling the dynamics of domestic supply and demand for maize commodities using a partial equilibrium analysis. To the best of our knowledge, no study has tested for the presence of uncompetitive grain pricing practices and the effects of government policies on spatial grain market integration in Ethiopia.

Knowledge of how traders adjust prices to both local and international grain price shocks will provide valuable information to policymakers for redressing the soaring food prices and combating unlawful tendencies and inequitable welfare distribution among grain market actors. Of equal importance is the point that the results will provide insight into the Ethiopian grain market structure and make clearer the roles and additional objectives, if any, to be incorporated by the Ethiopian government in maize and wheat grain market price stabilisation policies. Given the pivotal role of maize and wheat for food security, a better understanding of the root causes of soaring domestic food prices and of the effectiveness of policy interventions could assist policymakers in devising suitable price stabilisation policies to provide a buffer for poor consumers and farmers against adverse price shocks. Knowledge of the causes of soaring food prices, therefore, provides a significant policy standpoint for agricultural policies aiming to improve food security for low-income groups through food affordability.

1.4 RESEARCH OBJECTIVES

As described above, following the soaring food prices of 2008, there is a widely held belief by the Ethiopian government and consumers that the inappropriate price adjustments of traders contribute to the persistence of soaring food prices in Ethiopia. This resulted in a new policy in food market regulation and became a justification for direct government intervention in commercial grain import and distribution at subsidised prices for selected crops. The main purpose of this study is, therefore, to investigate the contribution of traders' pricing practices to high maize and wheat prices in the domestic market. Furthermore, the study examines the effect of the Ethiopian government policy instruments on spatial price transmission of wheat and white maize grain prices.

The specific objectives of the study include:

1. To test the presence of asymmetric price adjustment in the inter-regional (maize) and world to domestic (wheat and maize) spatial market integration;

2. To determine whether positive or negative asymmetric price transmission characterises the white maize and wheat grain markets;

3. To examine the implications of government policy interventions on spatial grain market integration; and

4. To investigate the effects of domestic commodity supply and demand factors on maize price formation and dynamics with a partial equilibrium modelling framework.

1.5 HYPOTHESIS

In this study, the following hypotheses were tested:

1. Positive asymmetric price transmission characterises the Ethiopian grain markets, i.e. a previous month positive departure from a long-run equilibrium position persists for longer periods than the negative ones do. In other words, a negative price difference from a long-run equilibrium position is eliminated more quickly than a positive price difference is.

2. Positive APT contributes to the persistence of high white maize and wheat prices as traders lack the incentive to respond to price decreases from a previous month long-run disequilibrium. Instead, they tend to react more quickly when their margin is squeezed than when it is stretched.

3. The Ethiopian government policy reforms, such as allowing a state trading enterprise to be involved in grain import and distribution at subsidised prices below market prices, foreign exchange restriction to private traders, and frequent imposition and lifting of an export ban, would limit spatial and inter-temporal arbitrage operations of private traders. This would decrease the extent of market integration between the domestic and world market.

4. Maize grain price instability in Ethiopia is mainly driven by domestic commodity supply and demand dynamics, rather than by international price shocks.

1.6 LIMITATIONS OF THE STUDY

Certain limitations of this study should be borne in mind. The main purpose of this study is to understand the market-related causes of soaring domestic maize and wheat grain prices in Ethiopia. Obviously, the analysis employed in this study is not a panacea to provide complete details for causes of soaring food prices in Ethiopia. This is because there are other non-market-related factors that may contribute to grain price instability in Ethiopia. The macroeconomic policy impacts of money supply and the economic boom in the country are also mentioned by many authors as being major contributors to the recent Ethiopian food price inflation. These aspects are not addressed in this thesis, and we acknowledge the point that leaving out these effects is a major limitation to our study. However, attempts were made to theoretically and empirically capture the effects of the macroeconomic policy of foreign exchange rationing on equilibrium maize and wheat market prices in Chapter 5.

Furthermore, the short-run and long-run linkages and the influence of the energy sector and exchange rate fluctuations have not been addressed in this thesis. Since Ethiopia is a landlocked and non-oil producing country, shocks in oil prices in the world market may influence the domestic commodity prices through transportation costs and input prices such as fertiliser costs. However, because of the subsidisation of the transport sector by the government, the domestic commodity price is expected to be insulated from oil price shock effects from the world market. Even when the oil price skyrocketed in 2008 and reached USD147 a barrel, gasoline prices in Ethiopia remained unaffected because of government subsidies. These subsidy bills reached close to USD700 million (Rashid and Minot, 2010). This huge subsidy may have insulated Ethiopia's grain market from oil price shocks stemming from the world market. Moreover, the appreciation and depreciation of the Ethiopian Birr (ETB) to the US dollar is expected to influence the domestic commodity prices. However, Kelbore (2014) argued that there is little connection between the exchange rate movement and commodity price spikes in Ethiopia. The exchange rates remained constant between June 2007 and June 2008. On the other hand, commodity prices were rising during the same period. The Ethiopian exchange rate depreciated significantly after 2008; between 2009 and 2011, the exchange rate depreciated substantially by 66 per cent while commodity prices were falling during these periods. Due to the above-mentioned factors, the effects of exchange rate misalignment and oil price shocks on the domestic commodity prices were not considered further in this thesis.

1.7 ORGANISATION OF THE THESIS

The rest of this thesis is structured as follows. Chapter 2 documents the theoretical and empirical approaches to understand market-related causes of soaring food prices in a net importing and an open economy country context. Chapter 3 is an overview of the agricultural sector performance in Ethiopia. This chapter critically reviews the input and output agricultural commodity markets, performance of support service institutions, and agricultural policies designed to promote cereal intensification in Ethiopia during the three political regimes (the imperial regime, the Derg regime, and the Ethiopian People's Revolutionary Democratic Front (EPRDF)). Chapter 4 provides empirical evidence on the inter-regional spatial maize market integration and tests for APT among integrated wholesale maize markets in Ethiopia. The results from this chapter were published in the journal of Agricultural Economics Research, Policy and Practice in Southern Africa (Agrekon) on April 26, 2017. Chapter 5 examines the effect of the Ethiopian government policy responses to soaring food prices on agricultural commodity market performance. In this chapter, we endeavour to examine the impacts of the government policy responses to manage price risks, such as commercial wheat imports and distribution at subsidised prices, the maize export ban, and foreign exchange rationing, on the spatial equilibrium market performance on maize and wheat commodities. Chapter 6 investigates maize price formation and the impacts of production shocks (a bumper harvest and drought) on maize market and the trade regime in Ethiopia. An article extracted from this chapter has been accepted for publication in the Journal of Agricultural Science and Technology, and will be published in Vol. 19, supplementary issue, December 2017. The last chapter provides a summary, conclusions, and policy implications drawn from the thesis results.

CHAPTER 2:
UNDERSTANDING MARKET-RELATED CAUSES OF HIGH GRAIN PRICES

2.1 INTRODUCTION

In this chapter, we discuss the theoretical and empirical estimation of spatial market integration. In the first section, market-related sources of high domestic grain prices, including imperfect competition, international price shocks, and domestic commodity supply and demand dynamics, are presented. This is followed by describing the prominent drivers that hinder or speed up the diffusion of international price shocks to domestic grain markets. At the end, estimation approaches for spatial market integration are discussed.

2.2 MARKET-RELATED CAUSES OF HIGH FOOD PRICES

Since 2003, grain markets in Ethiopia have been experiencing unprecedented price spikes. Commodity prices have shot-up and the growth rate in food price inflation has been much higher than the world standard. An interesting follow-up question is, therefore, what explains Ethiopia's soaring food price? To answer this, the first step is to isolate the possible market-related causes of soaring food prices. There are two potential candidates for this: (1) price shock diffusion from international markets and (2) domestic supply and demand dynamics. Figure 2.1 below is schematic diagram demonstrating the possible market-related causes of high domestic grain prices.

Suppose there is market integration between international and domestic grain markets. Owing to the assumption of 'small-economy', price signals direction are expected to be unidirectional, running from world to the domestic grain market. Overall, openness in trade and allowing international arbitrage involvement increase market integration between domestic and world markets. There are different factors that can speed-up or impede the transmission of price shocks from international to domestic grain markets. These include:

i. Tradability of a commodity: Transmission from world to domestic grain markets occurs when a commodity is traded on international markets. The price for a non-tradable commodity is influenced by domestic supply and demand dynamics and government policies.

ii. The other factor comprises trade position or trade regimes where domestic commodity price formation depends on these. Depending on a country's production potential and consumption pattern, domestic commodity price formation depends on either of the three trade regimes: autarky, Import Parity Price (IPP), or Export Parity Price (EPP). If a country is a net importer of a commodity, then domestic price formation depends on IPP. In this case, domestic prices should then be a function of exchange rate, transportation costs, and possible import tax (Meyer *et al*. 2006). In an IPP trade regime, one would expect a high degree of price transmission from world to domestic grain markets. On the other hand, if a country is a net exporter of a commodity, then the trade regime switches to EPP. Under such conditions, the extent of transmission of price shocks from world to domestic markets becomes high. When a country reaches a self-sufficient position, domestic price formation will lie within the price band of IPP and EPP. In the autarky trade regime, aside from government policies, domestic prices are determined by the interaction of domestic supply and demand conditions and are unrelated to international price shocks.

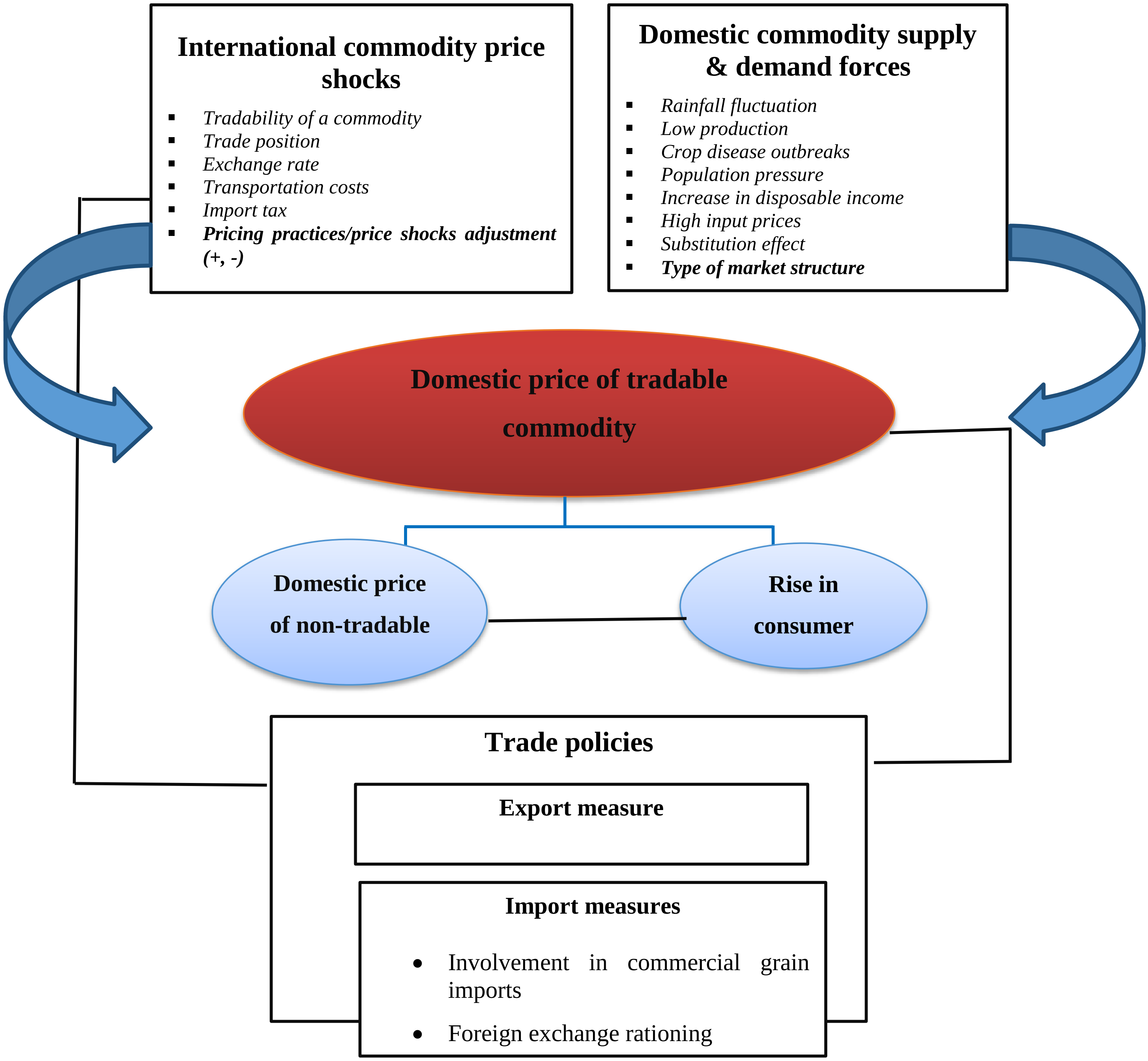
iii. Trade policies: Government trade policies also influence price shock transmission from international to domestic grain markets. In most cases, the implicit motive of government policy instruments is to either block or reduce the pass-through of price signals from international to domestic markets. For instance, policies like foreign exchange rationing impede the participation of traders on the international grain market. Even if imports become profitable, traders will not freely become involved in international grain trade to exploit profitable import opportunities. As a result, domestic prices for tradable commodity will drift over the upper threshold IPP. This will have direct implications on the domestic prices of tradable commodities and consumer welfare.

In general, high price shock diffusion from international to domestic markets will influence domestic prices of a tradable commodity. Through substitution effects, this will in turn influence prices of non-tradable commodities in domestic markets. The combined effect will raise food price inflation. In fact, this depends on the weight of a commodity in a consumer basket. In a developing country setting, expenditure for food constitutes the largest weight in the consumer basket. Soaring prices in the food market will therefore translate into high food price inflation.

When a country is in a self-sufficient position, domestic demand and supply dynamics determine price formation and instability of a commodity. Some of the factors that might lead to price instability in domestic grain markets include rainfall fluctuation, production stagnation, and population growth. Of particular interest to us is the type of market structure that characterises the grain industry (performance of grain markets). If the grain market is characterised by high market power, then middlemen will dominate the pricing of a commodity. In this case, traders tend to react quickly to adjust to high price shocks. However, they will become reluctant to pass-through price reductions to end-users. This kind of domination in the grain market structure could create price stickiness (what goes up does not come down), which benefits only middlemen at the expense of producers and end-users. Thus, further disrupting government agricultural policies aimed at increasing agricultural supply and promoting regional production specialisation.

Understanding the market-related causes of high grain prices requires a holistic analysis by modelling grain price formation, market structure, international price shock transmission, and trade policy shifts. An in-depth analysis for explaining the possible causes of high grain price persistency by incorporating price formation, market structure, and policy interventions in the grain industry has not been carried out in Ethiopia. The novelty of this study is that we employed a holistic approach to help us understand the causes of high grain prices in Ethiopia by examining the effects of international price shocks, policy effects, commodity demand and supply dynamics, and by testing the performance of grain markets. Knowledge of the causes of high grain prices in the domestic commodity market is, therefore, critical for designing sound policy responses to manage price risks. Consequently, this has important policy implications for improving the affordability of food commodities and promoting the welfare of grain producers and consumers alike.

Figure 2.1: Conceptual framework for understanding soaring domestic grain prices instability



Source: Author's own elaboration

2.3 METHODS OF MARKET INTEGRATION

The fundamental theoretical foundation for market integration is the LOP (Fackler and Goodwin, 2001). The premise of LOP indicates that the price gap between two spatial integrated markets should never be greater than transaction costs. The LOP can be written as:

$$|P^d - P^w| \leq t \quad (2.1)$$

where P^w and P^d are the world and domestic commodity prices, respectively, and t represents the transfer costs related with transporting a commodity. Based on Equation (2.1), the price difference between the two markets should never be greater than the transaction costs. When this is not the case, it would create an incentive for arbitrage[5] involvement. Spatial arbitrage condition is the starting point for any model of spatial price integration. Actual price may diverge from this relationship, but the arbitrage process in a well-functioning market will restore the price spread towards transfer costs.

Consider the price difference between two spatial markets

$$d_t = P_t^d - P_t^w \quad (2.2)$$

where P_t^j market prices in *j (j = d, w)* at time *t*, d_t is the price difference between markets *d* and *w* at time *t*.

The two spatial separated markets are said to have a long-run relationship when the previous period price difference (d_{t-1}) between the two markets is transmitted to the current period.

$$\Delta d_t = \rho d_{t-1} + \varepsilon_t \quad (2.3)$$

where ρ is the speed of adjustment and ε_t is the error term. The coefficient for the speed of adjustment lies between 0 and 1, where 0 indicates no price adjustment while 1 denotes full price adjustment. The sign of the term should be negative as an indication of the tendency to

[5] Arbitrage is the involvement in transaction for generating an immediate profit by taking advantage of price fluctuation among spatial markets.

correct price discrepancy from the previous period disequilibrium. A positive sign indicates a drift from the long-run equilibrium position with no sign of short-run adjustment.

The analysis for the presence of a long-run relationship in Equation 2.3 is estimated based on different approaches. The most common spatial market integration approaches include correlation analysis, regression-based models, and cointegration models of the Engle–Granger (1987) and Johansen and Juselius maximum likelihood procedures (Johansen and Juselius, 1990). None of these approaches are, however, free from criticism. The Engle–Granger (1987) and Johansen and Juselius VECM models are criticised for ruling out the impact of transaction costs on market integration. These approaches build on the Augmented Dickey Fuller (ADF) test to check for a long-run relationship. The alternative hypothesis of this test implicitly assumes symmetric price adjustment (Alemu and Ogundeji, 2010). Economic agents may not, however, adjust homogenously to upward and downward price deviations from the previous year disequilibrium. If economic agents tend to correct differently to an increase or decrease price deviation from previous year disequilibrium value, the assumption of symmetric price adjustment can lead to wrong inferences being drawn. Moreover, these price transmission models rely on a linearity assumption. That is, the cointegration relationship does not change over the entire sample period. This assumption will be violated if structural breaks and regime switching behaviour presents. In response, two models have recently been proposed to handle transaction costs and the non-linearity of market integration analysis, viz. the Parity Bounds Model (PBM) and the Threshold Autoregressive Approach (TAR).

Baulch (1997) proposed PBM to account for transaction costs and regime switching behaviour. In this model, the extent of market integration is treated as the frequency of spatial price relationships in the three regimes (no profitable trade, efficient trade, and unexploited profitable trade opportunity). This approach is an improvement over the above error correction models as it takes into consideration transaction costs, trade reversals, and discontinuity (Barrett, 1996). The approach is, however, criticised for its static nature and data limitation on observable transfer costs, especially in a developing country setting.

In recent years, the TAR model has been used for analysing market integration. The non-linear model of TAR is a significant improvement through estimating the dynamics of spatial market integration without requiring observable transaction costs, which makes it handier for analysis.

Furthermore, TAR and its family of alternative non-linear approaches, including Momentum Threshold Autoregressive (M-TAR) and Momentum Consistent TAR (MC-TAR), allow for asymmetric price adjustment tests. These approaches have been used by many authors in the analysis of African commodity markets integration (see, Abdulai, 2000; Sanogo and Amadou, 2010; Ndibongo *et al*., 2010; Yeboah, 2012; Fiamohe *et al*., 2013; Tamru, 2013; Yang *et al*., 2015).

The TAR model is a type of regime switching model where the regime shifter is considered to be transfer costs. For instance, in the case of three regimes, the first regime is above threshold ($d_{t-1} > \mathrm{TC}_{wd}$), which occurs when price difference exceeds transfer costs. Regime 2 is below threshold value, when the price differential is below threshold value ($d_{t-1} < \mathrm{TC}_{wd}$). In the first two regimes, unexploited profitable arbitrage exists that can be exploited by shipping a commodity from market *w* to *d* (*d* to *w*). Whereas the third regime ($|d_{t-1}| \leq \mathrm{TC}_{wd}$) corresponds to Equation (2.4) below and is regarded as the state of efficient arbitrage. It consists of both situations in which trade occurs and arbitrage is efficient, and situations in which no profitable trade occurs (Dercon and Van Campenhout, 1999). The degree of market integration and price adjustment can therefore vary depending on the size of the price difference and transaction costs. These price bands can be expressed as:

$$= \begin{cases} \rho^{out} d_{t-1} + \varepsilon_t^{out} & d_{t-1} > \mathrm{TC}_{wd} \\ \rho^{in} d_{t-1} + \varepsilon_t^{in} & d_{t-1} \leq \mathrm{TC}_{wd} \\ \rho^{out} d_{t-1} + \varepsilon_t^{out} & d_{t-1} < \mathrm{TC}_{wd} \end{cases} \quad (2.4)$$

where ε_t is the white noise, i.e. ε_t^{out} is $N(0,\ \sigma_{out}^2)$ and ε_t^{in} is $N(0,\ \sigma_{in}^2)$; ρ is the speed of adjustment of d_t towards the band $[-\mathrm{TC}_{wd}, \mathrm{TC}_{wd}]$. Arbitrage opportunity occurs outside the band until the threshold values on the band are reached, TC_{wd}. Within the inner band, there is no profitable arbitrage opportunity for traders to involve in trade, as the transaction costs of moving a commodity are higher than the price difference.

Since the band TAR approach is dynamic, the error correction models can be specified by re-writing Equation (2.5) below as (2.1):

$$\begin{cases} \Delta P_t^d = P_t^w + \rho.\left(P_{t-1}^d - P_{t-1}^w - T_{wd}\right) + \varepsilon_t^{out} & P_t^d - P_t^w > T_{wd} \\ \Delta P_t^d = \Delta P_t^w + \varepsilon_t^{in} & P_t^d - P_t^w \leq T_{wd} \\ \Delta P_t^w = \Delta P_t^d + \rho.\left(P_{t-1}^w - P_{t-1}^d - T_{wd}\right) + \varepsilon_t^{out} & P_t^w - P_t^d > T_{wd} \end{cases} \quad (2.5)$$

In the inner band, since there is an efficient arbitrage, there is no profitable trade, implying no adjustment. Outside the band, however, adjustment is present, resulting from the presence of unexploited profitable trade opportunity. As a result, an error correction will take place for the previous period price difference. This error correction mechanism continues in the long run until the price difference reaches the threshold of an efficient arbitrage condition.

In general, the TAR model is criticised on three grounds. The first major limitation of threshold approach is the assumption that price adjustment should be triggered only by transaction costs. However, following the 2008 global food price crisis, most governments pursued a wide range of policy instruments to insulate domestic grain markets from international price shocks. These interventions may impede spatial market price transmission. As a result, the assumption that only transaction costs act as a trigger for price adjustment undermines the influence of government policy on spatial price transmission (Yang *et al*., 2015). Like those in any of the other net food importing countries, the Ethiopian grain markets have been affected by global food price instability since 2003. Following the unusually high food prices, the government of Ethiopia implemented various policy interventions to manage soaring food price risks. Some of these interventions have been in effect since 2008, such as the export ban on major food crops and the government involvement in commercial grain imports. These trade policy interventions and countermeasures may affect spatial market integration between domestic and world grain markets. To account for this limitation in the threshold model, this study used the policy intervention period as a regime shifter. In this study, we modify the standard cointegration models to allow for trade policy reforms and examine the effects of policy regimes on spatial grain market integration, using a regime dependent VECM model (more on this in Chapter 5).

TAR models are also criticised for relying solely on price analysis. In other words, TAR models assume that adjustment will only be triggered if the price difference exceeds the threshold value, i.e. transaction costs. However, economic theory suggests that the volume of trade would be an important element of spatial market integration. By acknowledging this fact, Myers and

Jayne (2011) analysed spatial maize price transmission between South Africa and Zambia, using an extended multiple regime threshold model. The authors used the volume of trade flows between the two countries instead of the price differential as a regime shifter, and they found no cointegration during periods of heavy imports by the government and cointegration during periods of low imports by the government. Several studies have extended the conventional TAR model by using trade flows as a regime shifter (see, for example, Ndibongo *et al*., 2010; Yang *et al*., 2015).

The third drawback of the TAR model is the assumption of time-invariant transaction costs. Although the TAR model estimates asymmetric price transmission without requiring actual transaction costs, it is based on the restrictive assumption of constant transaction costs. This assumption is unrealistic in the real world and can be violated if transaction costs vary over time. Transaction costs can differ depending on the status of road infrastructure over time and seasons. In developing countries, such as Ethiopia, grain production movement during rainy seasons is formidable because of poor road infrastructure. This leads to higher costs in a rainy season than in a dry season. Transaction costs can also vary depending on fuel costs, import duty, and working capital. In response, Acosta (2012) and Acosta *et al*. (2014) have proposed the use of the Asymmetric Vector Error Correction Model (AVECM) as a good alternative econometric approach for analysing spatial price transmission. The advantage of this approach is that it avoids the restrictive assumption of constant transaction costs. The approach also allows for testing asymmetric price transmission. For this reason, we investigate inter-regional spatial maize price transmission using an Asymmetric Vector Error Correction Model (more on this in Chapter 4).

2.4 CHAPTER SUMMARY

This chapter discusses market-related causes of soaring food prices, such as domestic supply and demand dynamics, structure of grain markets, and price shocks risks from international markets. It also explains approaches of market integration analysis. Different approaches have been used to analyse market integration including the conventional linear models of Engle–Granger (1987) and the Johansen and Juselius VECM models. However, these approaches have been criticised for ignoring transaction costs and asymmetric price adjustment in market integration analysis. In recent years, the TAR model has been preferred for analysing market integration. This is because the model incorporates transaction costs and allows asymmetric price adjustment tests without requiring actual transaction costs. However, this approach is also not free from criticism. The TAR model is criticised for ignoring policy interventions. In this model, the trigger for price adjustment is transaction costs. However, government intervention in a commodity market can block price signals transmission. In other words, even when the price difference between markets exceeds the threshold value, i.e. transfer costs, economic agents may not correct prices in the presence of government interventions. One approach to address this issue is a regime dependent VECM model. This approach overcomes the linearity assumption of conventional time series models by accounting for non-linearity through sub-sample analysis. Unlike the TAR model, the trigger for regime switches in this approach is imposed exogenously. We employed this approach in Chapter 5 to examine the effect of policy interventions on spatial market integration. The second shortcoming of the TAR model is the assumption of constant transaction costs. This assumption is unrealistic in the grain market setting in developing countries such as Ethiopia, where transaction costs vary depending on seasons (rainy and dry seasons). To account for this limitation of the TAR model, we used AVECM in Chapter 4 to test asymmetric price transmission among regional wholesale maize markets.

CHAPTER 3:
A REVIEW OF THE ETHIOPIAN AGRICULTURAL SECTOR

3.1 INTRODUCTION

Despite holding enormous potential for agricultural production, the agricultural sector in Ethiopia has not registered any convincing structural changes in productivity, which has thus consequently delayed transformation of the economy. Because of this sluggish growth of the agriculture sector, the country is unable to feed its rapidly growing population. Food insecurity is becoming a common trend in Ethiopia, despite the favourable and diverse natural resource base of the country for agricultural production. Several factors have been contributing in hindering the structural transformation of the agricultural sector in Ethiopia. Low adoption of agricultural technologies (such as improved seed and agro-chemicals), output-oriented agricultural extension service, the presence of market failure that has resulted from the low status of market fundamentals, and the absence of risk management institutions are the most cited factors for the poor performance of the agricultural sector in Ethiopia. The aim of this chapter is to provide a comprehensive review of agricultural development strategies and agricultural policies adopted by various government regimes in Ethiopia. We are particularly interested in reviewing the input and output markets, farm technology promotion, provision of road, information and market institution development, and public support service institutions and policies that either hold back or prompt the growth of the agricultural sector in Ethiopia.

This chapter is organised as follows, section 2 describes the input market. In this section, we examine the experience and challenge of promoting fertiliser and improved seed among smallholder farmers in Ethiopia. Sections three and four document the status of agricultural support service provision, such as agricultural extension and credit service provisions. Section five describes the output market performance in Ethiopia. Section six highlights the status and performance of market fundamentals. The final section provides a summary of the chapter.

3.2 INPUT SECTOR POLICIES

Given the acute land scarcity in the country, especially in the highland areas, the application of appropriate yield-enhancing technologies, such as commercial fertiliser and improved seed, can play an important role in boosting cereal productivity and food production in Ethiopia. In this section, we highlight the fertiliser marketing and consumption trends, and the different policy reforms implemented to boost fertiliser consumption at the smallholder level in Ethiopia. In the seed section, we examine the performance of formal and informal seed systems, and the factors that influence seed demand and supply in Ethiopia. In doing so, we critically examine the challenges the country has encountered in its effort in promoting the use of farm-enhancing technologies, especially chemical fertiliser and improved seed distribution and utilisation, at smallholder level.

3.2.1 Fertiliser market

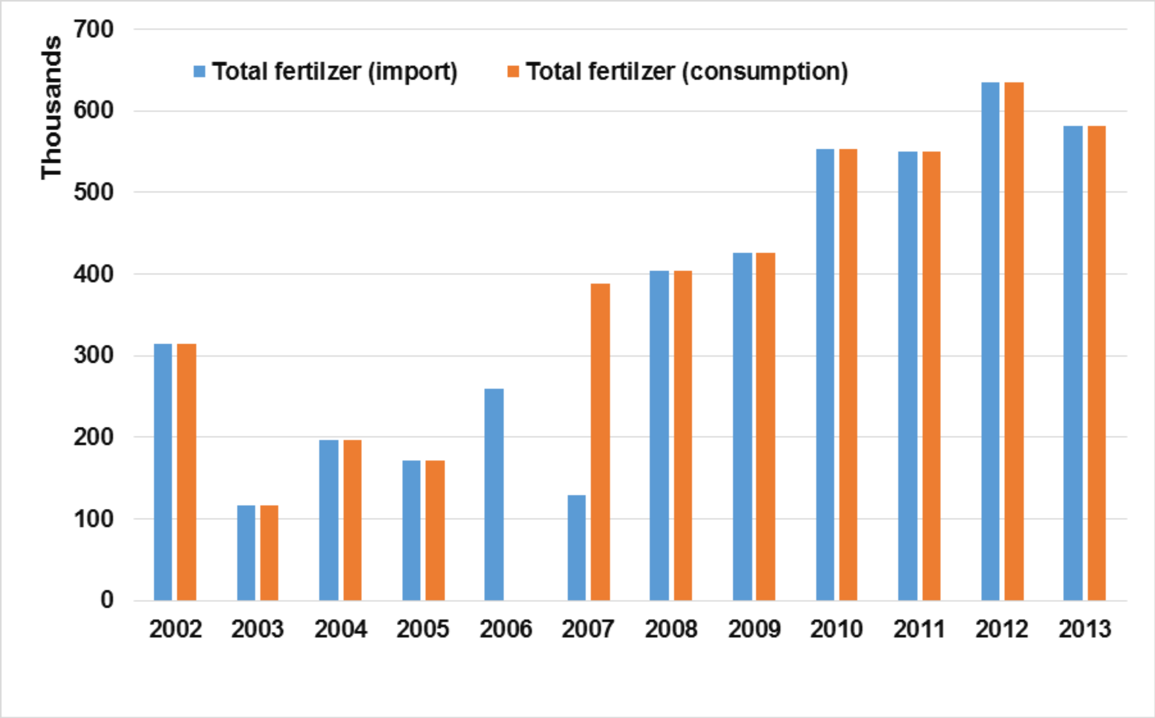
During the initial stage of market liberalisation in Ethiopia, positive signs of private-sector participation in fertiliser import and distribution were witnessed. Following the introduction of liberalisation in 1990, about 67 private wholesalers and 2300 retailers were involved in fertiliser importation and distribution (Spielman *et al*., 2011). Since Ethiopia imports all agro-chemicals, the participation of the private sector in fertiliser importation and distribution was envisaged to improve the input market. However, this changed when the government allowed ruling-party-affiliated companies to become involved in fertiliser importation, in parallel with the private sector. This move created an uneven playing ground in the fertiliser market and consequently led to the exit of prominent private fertiliser companies from the market, such as Ethiopia Amalgamated Limited Company. The number of private firms participating in fertiliser imports dwindled from 33 per cent in 1995 to nil in 1999. Although the partial involvement of the state in the input market is advisable[6] during the initial stage of market liberalisation, the complete monopolisation by parastatals in the fertiliser market has posed a serious concern for input market efficiency in Ethiopia. Currently, the Agricultural Inputs Supply Enterprise (AISE) is the sole importer of fertiliser in Ethiopia.

[6] Several factors are presented as compelling reasons for the continued intervention of the State in the input market in the early stage of fertiliser market development. Liquidity constraints, economies of size in international procurement and shipping, and marketing problems, such as wide dispersion of smallholders and variability of demand leading to high carryover stocks, dominate the justification for government intervention in input markets in agrarian economies such as Ethiopia (Byerlee *et al*., 2007)..

Regional governments play an important role in fertiliser supply and distribution to farmers in Ethiopia. They support farmers to get fertiliser on credit by providing guarantees for farmers' fertiliser purchases (Spielman *et al*., 2011 as quoted by Kelbore, 2014). Official estimates of fertiliser demand are compiled at regional level and aggregated to the national level. In rainfed farming, changes in fertiliser demand are more common and this has led to large carryover stocks. For instance, fertiliser carryover stocks averaged 33 per cent of imports between 2002 and 2011, with a high of 61 per cent in 2002, and a low of 12 per cent in 2007 (IFDC, 2012). Fertiliser distribution has been managed by cooperatives and regional agricultural bureaus. At the district level, fertiliser distribution has been the mandate of primary cooperatives and district agricultural bureaus.

Fertiliser prices in Ethiopia are competitive, as compared with other African countries. A comparison of fertiliser prices from port to farm gate indicates that marketing margins in Ethiopia are somewhat lower than the margins in other African countries that have relatively dynamic fertiliser industries, including South Africa and Kenya (see Rashid *et al*., 2013). The low price in Ethiopia is attributed to the subsidy in the retail market, which is not incorporated in the price build-up. It should be noted that we are not advocating public-sector participation in the fertiliser market to provide fertiliser at more affordable price to farmers than in the private sectors. This comparison has not been made in Ethiopia. In fact, providing fertiliser at higher prices might not hinder fertiliser use by smallholders. Ariga *et al*. (2006) show that a dynamic private-sector involvement in the fertiliser market promotes fertiliser consumption even when prices are provided at higher levels.

Figure 3.1: Fertiliser import and consumption trends in Ethiopia, 2002-2013



Source: Author's calculation based on FAOSTAT data (2015)

Figure 3.1 above reveals the trends in commercial fertiliser imports and utilisation in Ethiopia. During the past 12 years, total fertiliser imports increased rapidly, with imports increasing by almost 85 per cent from 314 799 MT in 2002 to 582 134 MT in 2013. Commercial fertiliser is used mainly in cereal production in Ethiopia. Region-wise comparisons have indicated that the Oromia and Amhara regions are the leading fertiliser users (Rashid *et al*., 2013). The percentages of fertilised crop area and commercial fertiliser application rate per hectare for major cereal crops are reported in Table 3.1 below. It appears that the teff *(Eragrostis Abyssinica)* crop cultivated area has received more fertiliser than those for major cereals have. This is because teff is the largest cereal crop in terms of land allocation in Ethiopia. However, this figure does not translate into percentage of fertilised hectare and intensity of fertiliser application per hectare. Following wheat, the teff crop stood second in percentage of area covered by fertiliser. As compared with the 2010/11 production year, cereal fertiliser applications per hectare improved considerably in the 2014/15 crop season. Relatively, wheat and maize have the highest fertiliser consumption rates per hectare than the rest of the cereal crops have.

Table 3.1: Fertilised area and application rate for major cereals

Cereals	2010/11			2014/15		
	Fertilised (ha)	Fertilised ha (%)	kg/ha	Fertilised (ha)	Fertilised ha (%)	kg/ha
Teff	1 866 446	68 %	79.66	2 343 816	78 %	106.5
Barley	566 046	54 %	59.08	592 589	60 %	85.73
Wheat	1 182 095	76 %	104.75	1 358 438	82 %	140.33
Maize	1 269 419	65 %	99.75	1 573 635	75 %	141.35
Sorghum	476 450	25 %	22.44	508 064	28 %	55.06
Finger Millet	233 039	57 %	56.43	303 544	67 %	83.62
Rice	7 296	24 %	46.52	26 482	57 %	82.39

Source: Author's calculations based on CSA data

Although fertiliser consumption has improved at a national level, the improvement in fertiliser application per hectare is much below that in Asian countries which have successfully experienced a green revolution. Different factors have jointly contributed to the sub-optimal application of commercial fertiliser at household levels in Ethiopia. The most-cited factors include distribution inefficiencies, low diversification in both alternatives (only two fertilisers, namely Diammonium Phosphate (DAP) and urea, are available for use), quantity of distribution (only in 50 kg bags), and the lack of competition in the fertiliser market. Late delivery, underweight bags, and poor quality are also some of the common problems reported by farmers. A study conducted by Bonger *et al*. (2004) revealed that about 40 per cent of surveyed farmers complained about the late arrival of fertiliser. Delays in the delivery of fertiliser are costly in a rainfed farming system, as these can cause delayed planting, which could make farming unprofitable.

There is a general belief among agricultural researchers and decision makers that increasing the application of fertiliser in small-scale farming might not be feasible. Given the subsistence nature of crop production in Ethiopia, it is reasonable to raise a question whether using the recommended fertiliser application rate by farmers is viable in a crop production system farming less than one hectare. From a policy perspective, addressing this question is very important for convincing farmers of the profitability of yield-enhancing production technologies and would further contribute to a wider adoption of improved technologies at smallholder level. Additionally, an understanding of the profitability of fertiliser use may also play a crucial role in bringing down the mismatch between fertiliser demand and imports by providing evidence on whether the mismatch is constrained by market failures (inadequate roads or absence of risk management institutions) or the low profitability of fertiliser.

A common method to carry out a profitability analysis is the Value Cost Ratio (VCR) approach, which is calculated as the extra yield sales value obtained from using an agricultural technology, divided by the cost of the technology. This analysis is mostly conducted on experimental field trials by comparing conventional farming with trials using a recommended fertiliser rate. As a result, it does not account for household and demographic heterogeneity, such as access to credit and output market, location factor, weather and disease shocks, managerial difference. Normally, a VCR of at least 2 is a sign of profitability.

Several studies have attempted to analyse the profitability of fertiliser use in cereals in Ethiopia. In general, these studies reported VCRs of fertiliser application in Ethiopia that varied across crops and regions. Their estimated VCRs varied from 1.7 to 4.2 for teff, 2.0 to 6.5 for wheat, and 1.7 to 5.3 for maize (see Rashid *et al*., 2013). Spielman *et al*. (2011) conducted a fertiliser profitability analysis in Ethiopia between 1992 and 2008, and found that a VCR of 2, suggesting profitable fertiliser utilisation. Nigussie *et al*. (2012, as quoted by Kelbore, 2014) also reinforced these findings, reporting a VCR of above 2 for major food crops in Ethiopia. However, they cautiously conclude that their results may have been inflated by the soaring food price situation in the output market at the time of their study. Rashid *et al*. (2013) reached a similar conclusion. The authors made a comprehensive analysis on the profitability of fertiliser use in Ethiopia by taking into account the shortcomings of experimental plot analysis. They addressed the limitation of experimental plot VCR analysis by using a household survey from four major cereal-producing regions in Ethiopia. Their VCR findings are much below the results obtained using experimental plots data. The estimated VCRs range from 1.4 to 2.17 for teff, 1.27 to 2.34 for wheat, and 2.34 to 2.03 for maize. The lowest VCR estimate they found was 1.27. This suggests that in the absence of weather and output-market-related risks, fertiliser use profitability would be 27 per cent within a period of six months. From these empirical findings, we can conclude that fertiliser application is profitable for the smallholder production system in Ethiopia.

3.2.2 Seed systems

Despite the reforms in the seed sector in 1991, the seed system in Ethiopia is still in the second stage of seed industry development, characterised by a low adoption of improved seed caused by a heavy reliance on farm-saved seed. According to CSA (2014/15), the improved seed coverage for cereals in Ethiopia is only at 12 per cent (Table 3.2 below). However, the same report has shown that improved seed coverage increased from 7 per cent in 2010/11 to 12 per cent in 2014/15. Although numerous studies have reported low adoption rates, the percentage of improved seed adoption rate varies from 3 to 12 per cent. This disparity might occur because farmers report only improved seed as the seed obtained from government or research organisations. These factors may underestimate the report on the adoption of improved seed in Ethiopia, especially for Open Pollinated Varieties (OPVs), where farmers use recycled seed.

Table 3.2: Improved seed coverage for major cereals in Ethiopia

	2010/11		2014/15	
	Improved seed ('000 ha)	Improved seed coverage (%)	Improved seed ('000 ha)	Improved seed coverage (%)
Cereals	704.599	7 %	1 186	12 %
Teff	39.972	1 %	76	3 %
Wheat	96.71	6 %	122	**7 %**
Maize	551.631	28 %	979	46 %
Sorghum	0.91	0 %	2	0.11 %

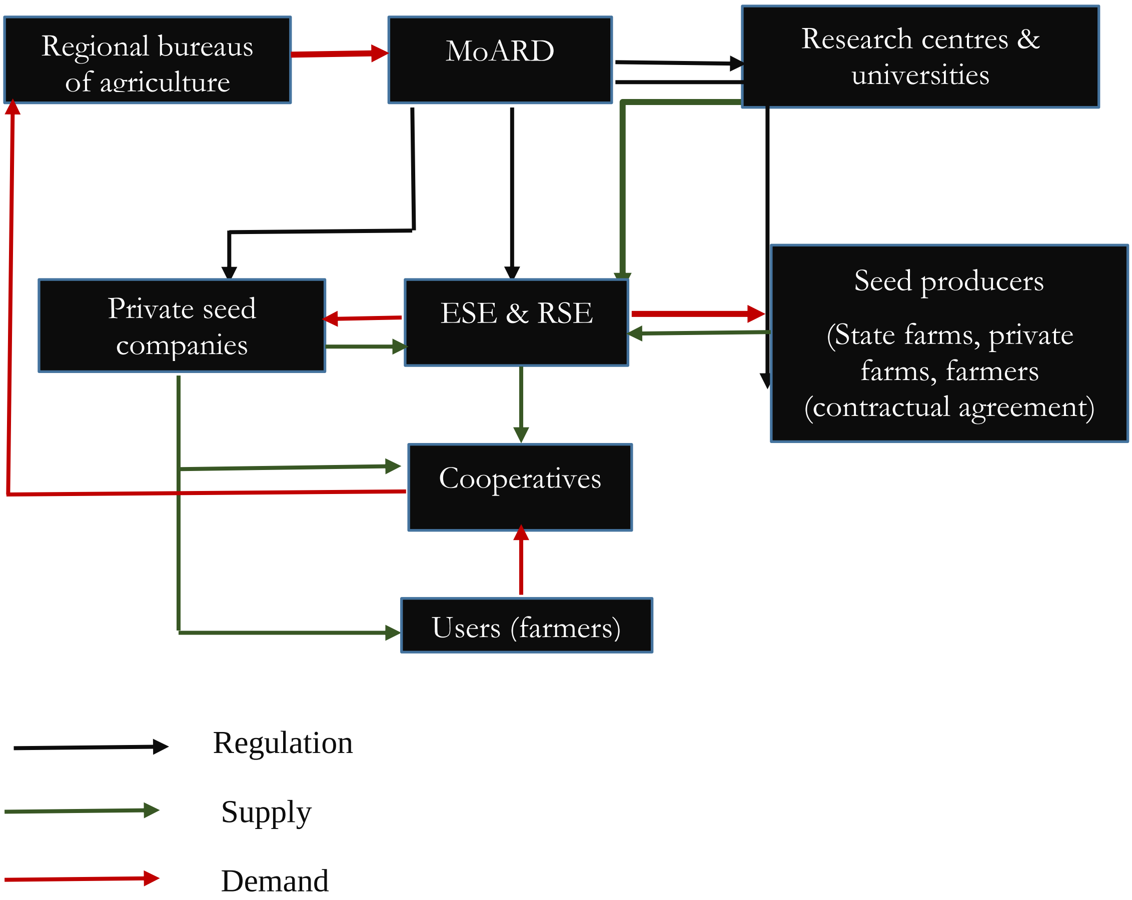
Source: Author's calculation based on CSA data

The seed system in Ethiopia consists of the formal sector and the informal (farmers') system, as well as the occasional emergency seed programmes. After almost five decades of operation, the formal seed sector could not adequately satisfy the seed demand of the vast majority of the nation's farmers who are smallholders and subsistence farmers (Zewdie *et al.*, 2008). The formal seed system covers between 10 and 20 % of the seed demand, while 80 to 90 % is satisfied by the informal seed system. Even though informal seed systems prove very valuable in supplying large quantities of seed, they appear to have neglected some quality aspects (Lipper *et al.*, 2005).

The formal seed sector in Ethiopia consists of actors including the Ethiopian Seed Enterprise (ESE), regional seed enterprises (RSE), the Ethiopia Institute of Agricultural Research (EIAR), the Ministry of Agriculture and Rural Development (MoARD), Regional Agricultural Research Institutes (RARIs), universities, and private firms. As shown in Figure 3.2 below, public sectors dominate the formal seed industry in Ethiopia. The national seed research is conducted mainly by the federal and regional agricultural research institutes under EIAR and by universities. These institutes supply basic (foundation) seed or breeding lines to seed multipliers. ESE and RSE, including Amhara, Oromia and SNNPR seed enterprises, are involved in the multiplication of seed, based on the seed demand projections of the regional bureaus of agriculture.

Unlike the fertiliser market, the seed industry in Ethiopia has allowed private sector participation. In 2004, there were 8 private seed companies involved in seed production. Their numbers jumped to 11 in 2008. Most of these private companies are involved in relatively profitable hybrid maize seed production. Some of these private firms have developed strong reputations and acceptance by farmers. For instance, Pioneer Hybrid International has established a strong market brand in some hybrid maize varieties. However, compared with other developing countries, the role of the private sector in the formal seed system is limited in Ethiopia. This limited role of the private sector is also witnessed in profitable hybrid maize seed production. According to Byerlee *et al*. (2007), as of 2004, about 70 per cent of hybrid maize seed was produced by ESE. The remaining 30 per cent was supplied by private firms, including Pioneer Hybrid International.

Figure 3.2: Structure of the seed system in Ethiopia



Source: Adapted from Byerlee *et al*. (2007)

The formal seed system has been criticised for poor seed quality and its timelines of delivery. Poor cleaning, mixed seeds, and low germination rates are also some of the common problems reported in the seed distributed by ESE. Furthermore, the seeds delivered by formal channels are not received on time and often fail to meet the planting times and seed quantity demand changes of farmers. Lack of capacity in meeting the seed demand requests is also a major concern in the formal seed system.

As has been the case for the fertiliser market, a mismatch between seed demand and supply is common in the formal seed industry in Ethiopia. For instance, during the 2004/05 crop production season, the formal seed system was only able to provide 27 per cent of the seed demand requirement (Byerlee *et al.*, 2007). This can partly be explained by the loose coordination among the actors involved in formal seed multiplication and distribution. The other cause for the mismatch is that farmers usually change their initial seed demands and variety preferences. As in the fertiliser sector, the effective demand estimation for improved seed is a challenging task, as farmers may alter their initial demands, based on rainfall expectation. This renders the involvement of the private sector in formal seed business more risky.

In the formal seed system, new varieties may take a long time to reach the farmers. Research institutes often claim that most of the new varieties produced by breeders have not been widely multiplied and disseminated to farmers. This is because of the failure of proper institutional linkages between research centres and seed enterprises. For the sake of reducing market promotion of new varieties, seed enterprises have become reluctant to widely multiply new varieties. Rather, they allocate much of their land for popularised varieties. This can reduce the variety mix available for farmers. As a result, farmers continue to grow the few popular varieties that have existed in the market for decades. Too much reliance on a few popular varieties can bring catastrophic impacts if those varieties become susceptible to disease outbreaks. This was witnessed in Ethiopia during the outbreak of the wheat yellow rust epidemic in 2010.

The extended rainfall all over the country and cool temperatures created conducive conditions for the stripe rust outbreak in 2010. The problem was exacerbated by the existence of susceptible wheat varieties, especially 'Kubsa' and 'Galema'[7] that were highly adopted all over the country. As result of this problem, wheat production in Ethiopia reduced by 8.03 per cent in 2010 (GAIN, 2012). This was a challenge for the country, which strives to ensure food security by doubling agricultural production and productivity. Since 2010, as a way out of the devastating danger of yellow rust epidemics, the National Wheat Program in collaboration with international organisations released 11 wheat varieties (Yami *et al*., 2013). Owing to problems in the formal seed supply system, farmers are still at risk, even if the new varieties are available for multiplication. When new varieties are popularised, the likelihood of them reaching farmers at the right time and quantity is not as anticipated, because the ESE and regional seed enterprises (RSE) seem reluctant to invest in marketing costs for the new varieties. Instead, they focus on the multiplication of popularised and established varieties. This is the major

[7] Kubsa' had an 82 per cent adoption level in Tigray, 56 per cent in Amhara, and 29 per cent in Oromia. 'Galema' was the most popular variety among wheat growers in the SNNPR, with an adoption level of 87 per cent (Yami *et al*., 2013).

bottleneck in providing improved seed varieties expeditiously to farmers through the formal seed system channel.

Given the critical role that improved seed varieties play in increasing agricultural production, a key question is how to facilitate the development of a seed system that is capable of generating, producing, and distributing improved seed varieties in a cost-effective way. One possible option would be to integrate informal and formal seed systems. Since both seed systems have their strengths and weaknesses, the integration of the two seed systems would stimulate the productivity and availability of improved seed varieties at the right time and quantity to smallholder farmers.

In an effort to foster the supply of improved seed varieties to smallholder farmers, EIAR in collaboration with different partners has been implementing different seed distribution schemes. The first initiative is the national pre-scaling up activity. The aim of the programme is providing improved seed varieties to undersupplied areas of Ethiopia. Later, community-based seed multiplication was adopted by various federal and regional agricultural research institutes. Although the scope is limited in terms of area and participant farmers, the launching of these seed multiplication and distribution schemes has benefited smallholder farmers in many ways. Firstly, community seed multiplication schemes acknowledge the importance of the integration of formal and informal seed systems. As a result, farmers' long-time farm experiences and different mechanisms of seed exchange further improve the dissemination of improved seed technology. Second, most of the crops that are included in this community seed multiplication activity are not widely multiplied by seed enterprises. This is because they are OPVs, and are considered unprofitable for seed business. Third, the schemes have favoured female household heads who are mostly excluded from development initiatives. In every community-based seed scheme, at least 10 per cent of the participants are female household heads, which further empowers marginalised segments of the population.

Various actors are involved in community seed production, including federal and regional research institutes, district bureaus of agriculture, universities, developmental organisations, and farmers. Participant farmers receive improved seeds from research institutes on a revolving basis. Training sessions for farmers on crop production and management, agricultural mechanisation, and environmental safeguard measures are provided by multidisciplinary teams composed from federal and regional agricultural research centres. Meanwhile, farmers use their long-time experience for growing the varieties. In some community-based seed production ventures, farmers have already linked with the output market. For instance, in collaboration with the Kulumsa Agricultural Research Institute, pulse seed producers in Arsi and West Arsi areas have established a link with the national pre-scaling up activity of EIAR. As a result, farmers supply their pulse seed for the pre-scaling up activity, which is further distributed to other unaddressed areas as improved seed.

3.2.3 Agricultural extension service

In this section, we examine the history of various national and development organisations' extension approaches that have been implemented to transform subsistence farming into a market-oriented agricultural production system in Ethiopia. The section places more emphasis on highlighting the success and challenges of six decades of experience in the provision of agricultural extension services in Ethiopia.

The extension service system plays an instrumental role in improving the livelihoods of smallholders through technology and information transfer. This ultimately improves the decision-making of smallholders on the production, management, and marketing of agricultural products. It also enables smallholder farmers to become more technically efficient and productive by improving their managerial ability and planting decisions. Agricultural extension services can serve as a bridge between technology generators, policy makers, and technology end users, since extension services involve technology dissemination and provide appropriate feedback to researchers in the introduced technologies. Therefore, the design and performance of appropriate agricultural extension services will have broader implications on speeding-up the transfer of technology and information to farmers.

Ethiopia's modern agricultural extension service dates back to the early 1950s. The Imperial Ethiopian College of Agriculture and Mechanical Arts (IECAMA, Alemaya University, since renamed as Hararmaya University) laid the foundation for the development of modern agricultural extension service in Ethiopia. As from the initial recruitment of extension agents, efforts were made to hire extension professionals with good knowledge of Ethiopia's agricultural system. The role of extension agents was in advising farmers with regard to livestock husbandry, crop production, crop protection, and improved farm machinery. They were also involved in community mobilisation through organising field days and holding adult and youth educational meetings (Kassa, 2003).

In August 1963, the imperial government shifted the mandate for agricultural extension from the College to the Ministry of Agriculture (MoA). Since then, the MoA has been coordinating the national agricultural extension service.[8] Following the transfer of the coordination of national extension service, the MoA decentralised the extension service delivery across the provinces. As far as performance of extension service delivery is concerned, the 1960s extension service was characterised by limited coverage and was biased against smallholder farmers (Stommes and Sisaye, 1979). According to Kassa (2003), the extension service delivery during the feudal regime managed to serve farmers around highways and favoured big landlords and influential farmers at the expense of smallholder farmers who lived in remote and inaccessible areas. As a result of this skewed service, the majority of smallholder farmers did not benefit much from the extension agents' support.

Initially, the military regime (1974–1991) implemented the Minimum Package Approach as the focus of agricultural extension. Like its predecessor, the military government neglected smallholder farmers and gave primacy to cooperatives and state farms. Smallholder farmers faced problems in accessing credit and farm-enhancing inputs. Extension workers were overburdened with different assignments beyond their primary duties. In addition, the extension approach adopted by the military regime failed to achieve its stated objectives because of limited number of extension agents, and lack of adequate facilities and logistical support (Degife and Nega, 2000; Kassa, 2003).

Following the change in government in 1991, the Training and Visit (T & V) extension approach was adopted as a national extension system. The T & V extension approach was replaced by the Participatory Demonstration and Training Extension System (PADETES) in

[8] As of today, the agricultural extension service has been solely provided by the public sector. Apart from a few developmental organisations who offer capacity building support to farmers, MoA has been the single most important provider of national agricultural extension service to farmers. Recently, the Assela malt factory established its own extension system to facilitate the inspection of malt barley farmers' fields and the procurement of malt barley production from farmers in Arsi and West Arsi zones of Oromia regional state..

1995. PADETES was adopted from the SaSakawa Global 2000 (SG-2000) extension strategy.[9] The system placed more emphasis on a package approach to agricultural development. Initially, PADETES promoted cereal production packages and the beneficiaries were mainly from high-potential areas. Over the years, however, the packages diversified into livestock, high-value crops, improved post-harvest technologies, agro-forestry, soil and water conservation, and beekeeping, developed for different agro-ecological zones (Kassa, 2003).

PADETES used the Extension Management Training Plot (EMTP)[10] approach to diffuse technology to participant and non-participant farmers. The major responsibilities of extension agents were in organising demonstration trials, helping farmers to obtain farm-enhancing inputs, and channelling farmers' feedback to different stakeholders. Since farmers are unable to get credit service from formal sources such as banks due to collateral problems, PADETES facilitated in-kind input credit service provision to farmers. As a result of the PADETES integrated extension approach, the average yields of maize, sorghum, teff, wheat, and barley for EMTP participant farmers in the Oromia and the Southern Nations, Nationalities and Peoples Regional State were above the conventional farming averages (Quinones and Takele, 1996; Kassa 2003).

Despite the observed yield difference of PADETES, the agricultural extension service delivery has faced many challenges. According to Kassa (2003), some of the common problems of the agricultural extension system in Ethiopia are poor linkages and synergy between research and extension service, thus leading to repetition of tasks and wastage of resources. In most cases, the planning of extension programmes and policies left out consideration of farmers' circumstances, opinions, and the traditional knowledge system. The current extension system is also blamed for focusing too much on cereal production. The livestock sub-sector and marketing aspect have received less attention from the extension system. The involvement of extension agents in other duties beyond their advisory role has also impacted on the relationship and frequency of contact between extension agents and farmers.

[9] The SG-2000 extension programme was aimed at supporting Ethiopia's efforts to boost agricultural growth through a modern technology transfer programme; building the capacity of extension service providers; fostering the linkages between research and extension service in technology generation and dissemination; and promoting post-harvest and value addition (Quinones and Takele, 1996 cited in Kassa, 2003).

[10] According to Takele (1997), EMTPs are on-farm technology demonstration plots managed by participating farmers. The extension agents play a facilitating role in the management of the plots. The agents also use the EMTPs to practically train on the advantages of applying recommended practices to non-participant farmers.

The current government has made efforts to address some of the above-stated critical problems in agricultural extension service delivery in Ethiopia. Increasing the number of extension service personnel and revitalising the coordination mechanism among various stakeholders in extension service provision are some of the major steps taken by the Ethiopian government. Over the past ten years, the Ethiopian government has given priority to improving the accessibility of modern agricultural extension services to farmers. In every district, the government has assigned three professional agricultural extension workers to help farmers with crop technology, livestock husbandry and sustainable land management. This move has increased the extension agent-to-farmer ratio: Ethiopia's extension agent-to-farmer ratio is estimated at 1:476, compared with 1:1000 for Kenya, 1:1603 for Malawi, and 1:2500 for Tanzania (Kassie *et al*., 2015).

The poor linkage between research and agricultural extension agents has continued to affect the growth of the agricultural sector in Ethiopia. In an effort to invigorate the research-extension-farmer linkage and coordination, the government established the Agriculture and Rural Development Partners Linkage Advisory Council (ARDPLAC) in 2008 with the financial support of the World Bank. Following the name change of the former Ministry of Agriculture and Rural Development to the Ministry of Agriculture, ARDPLAC was renamed to ADPLAC.

ADPLAC has been basically established as a formal linking mechanism between research and extension activities at National, Regional, Zonal, and District levels. It also incorporates development organisations that assist farmers in capacity building and development activities. The principal aim of the forum is to bring together all stakeholders working with farmers and address common structural problems identified by farmers and the advisory council. This is also expected to reduce the duplication of efforts and the misuse of resources. The members include research institutes, universities, NGOs, and Bureau of Agriculture and Rural Development (BoARD), extension agents, and model farmers. The directors of BoARD and research institutes are ADPLAC chairpersons. The core members of the committee are expected to meet twice a year. However, they usually meet once a year. In the annual meeting, members present their ongoing and completed research and development activities related to the tasks assigned by the advisory council. The views and reflections of farmers and extension agents are incorporated in problem identification and the planning of new research activities.

3.2.4 Access to agricultural credit

Adequate access to agricultural credit is one of the essential drivers for the transformation of smallholder system from a subsistence to a market-oriented agricultural production system. Farmers' access to formal financial resources is very important for agricultural development, as this enables them to become involved in input markets to buy improved technologies, which can improve productivity. Adequate financial institutions help farmers by relaxing their cash requirements during a lean season, which they might otherwise meet by borrowing from local traders, which will be paid through crop supply during harvesting time when prices reach low levels. Thus, the availability of a reliable and accessible financial sector that is capable of providing tailor-made services for smallholder farmers' credit requirements could play a crucial role in breaking the vicious circle of poverty. So, the effort to develop agriculture as the leading sector of the economy could suffer huge setbacks in the absence of strong financial institutions. The following section discusses the history of agricultural financial sector development in Ethiopia during the three political regimes (the imperial regime, the Derg regime, and that of the Ethiopian People's Revolutionary Democratic Front (EPRDF)). We highlight the financial resource flows to the agricultural sector in relation to other sectors of the economy.

The imperial government's plan for allocation of financial resources had explicitly indicated a priority of credit flow that was supposed to be given to productive sectors and projects. Hence, credit flow among different competing sectors was to be facilitated according to their contribution to the economy. For instance, the flow of bank credit was supposed to be based on priorities stated in the plan, which recognised the agricultural sector as being the main economic sector. Likewise, priority was placed in the plan to support agricultural production (subsistence, large-scale and mechanised agriculture) through the provision of agricultural finance. These efforts were envisaged to raise productivity and speed-up the transformation process of smallholder peasant agriculture from subsistence to commercialised agriculture. In practice, credit service provision was not executed as stated in the plan; the industrial sector was the main beneficiary of the credit flow. For instance, between 1951 and 1969, of the total loans disbursed by the Development Bank of Ethiopia (DBE), the industrial sector took the lion's share of the loans, 58 per cent, while the reminder went to the agriculture sector (Admassie, 2004).

In general, efforts to promote smallholder agriculture production through the provision of credit during the imperial regime were ended, with the limited success being attributed to numerous reasons such as collateral requirements usually in terms of property, the landlord–tenant relationship which made it difficult to attach ownership to execute on collateral, and the use of credit for non-productive purposes (Admassie, 2004). Following the 1974 revolution, the financial system in Ethiopia was nationalised. As a result, all financial institutions enjoyed public monopoly. Credit policy gave preference to public sectors such as state farms and cooperatives, while small-scale farmers and private sectors were left out of the picture. Over a ten-year period between 1981 and 1990, the private sectors' share of the total loans and advances made by the banking system was only 8.3 per cent. The marginalisation of the private sector went beyond credit access. It was also reflected in the interest rates charged by the National Bank of Ethiopia (NBE) to the private sector. As illustrated in Table 3.3 below, the lending rates set by the NBE vary depending on the type of ownership, where, in most cases, the private sector is discriminated against.

Table 3.3: Lending rates on loans and advances by ownership (percentage per annum)

Sectors	Cooperatives	Gov. owned organisations	Private sector
Agriculture	5	6	7
Industry, mining, power & water resources	6	8	9
Domestic trade	6	8	9.5
Transport & communication	6	8	8
Export trade	6	8	9.5
Imports	5	6	7
Hotel & tourism	6	8	9
Construction	6	8	9
Housing			
- Construction	4.5	4.5	7
- Purchase	6	6	8

Source: NBE (1986, cited in Admassie, 2004)

Following the downfall of the Derg regime, the EPRDF adopted a Structural Adjustment Program (SAP). The programme requires the abolition of any distortion in the financial sector and the developing of a flexible and liberalised monetary policy. With the introduction of liberalisation, lending rates, which were between 4.5 and 9.5 per cent, were raised; discrimination of access to credit and interest rates by type of ownership were eliminated; and the domestic establishment of private financial institutions was allowed (NBE, 1992).

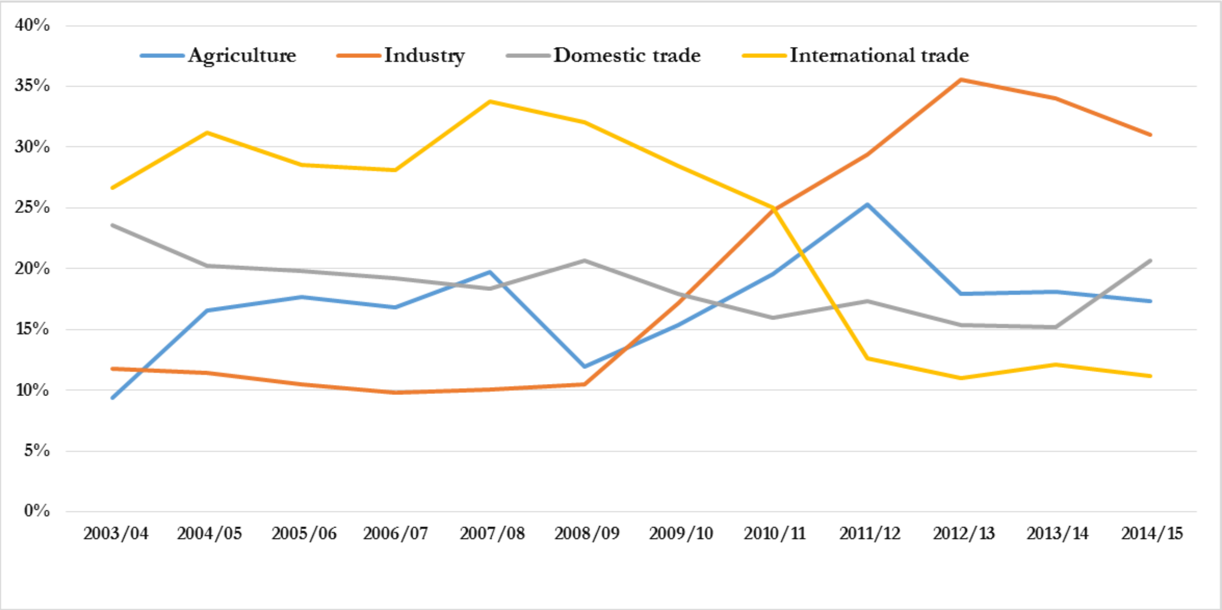
Although the financial liberalisation has registered success in shifting the flow of credit services from public to private organisations, it has failed to bring about meaningful change in credit utilisation and flows to the agricultural sector. This is evidenced by the low share of the agricultural sector in the total credit disbursed by banks, which is below 20 per cent (see Figure 3.3 below). Table 3.4 below provides the trends of loan disbursements, disaggregated by sectors. The results from Table 3.4 reveal that, over the past twelve years, the international trade and industry sectors have received the largest share of loans, while financial flows to the agricultural sector have been marginal. For instance, between the period 2003/04 and 2013/14, international trade absorbed, on average, 23 per cent of the credit flows from banks, followed by the industry sector (20 per cent), domestic trade (19 per cent), and the agricultural sector (17 per cent). while the balance was absorbed by other sectors. In general, given the importance of the agricultural sector in terms of employment creation, contribution to national income and poverty alleviation, the flow of financial resources to the sector has been negligible.

Table 3.4: Trends of credit disbursement across sectors (millions ETB)

Sectors	2007	2008	2009	2010	2011	2012	2013	2014
Agriculture	5 372	3 037	4 437	8 248	14 175	9 709	10 867	13 077
Industry	2 739	2 668	4 958	10 465	16 512	19 298	20 391	23 437
Domestic trade	5 012	5 265	5 169	6 733	9 701	8 325	9 104	15 589
International trade	9 210	8 165	8 217	10 570	7 061	5 974	7 281	8 415
Export	3 116	2 858	5 279	5 921	2 659	2 569	2 973	3 780
Import	6 094	5 307	2 938	4 648	4 402	3 700	4 307	4 635
Hotels & Tourism	244	275	320	395	456	883	1 191	1 620
Transport & Communication	1 338	903	966	1 851	1 917	1 576	1 555	3 625
Housing & Construction	2 017	4 040	3 916	2 901	5 083	6 323	6 696	6 720
Mines, Power & Water resources	59	-	7.2	7.3	16	82	266	165
Others	1 263	1 123	914	1 037	1 180	2 082	2 614	2 831
Total	27 254	25 477	28 905	42 208	56 102	54 251	59 965	75 481

Source: Author's compilation from NBE annual reports

Figure 3.3: Share of loans disbursement, by major economic sectors



Source: Author's compilation from NBE annual reports

Banks lend to target beneficiaries, either directly to the end-user or through other bodies such as cooperatives and peasant associations. In the former approach, banks provide credit directly to an individual person or an organisation which has legal entity status. In the latter approach, intermediaries such as cooperatives sign a loan contract with banks and channel the borrowed funds to their members. In rural Ethiopia, since smallholder farmers do not meet the collateral requirements of banks, regional governments serve as intermediaries between banks and farmers by using their federally allocated budget as collateral. Regional governments borrow from banks and lend to farmers through cooperatives for the purchase of agricultural inputs. In case of default, the budget allocated to regional government will be used for repayment of outstanding credit.

In spite of the success in the liberalisation of the formal financial institutions, the majority of the credit demand of smallholder farmers is still being satisfied by the informal sector such as friends and moneylenders. Kelbore (2014) has enumerated the factors that have contributed to limited access to formal finance for the rural poor in Ethiopia: (1) the formal financial institutions consider only standardised agricultural machinery and equipment for collateralising agricultural loans. Since land belongs to the state, farmers have no property rights. In the face of no land ownership and limited mechanised farming (where farming is practised with traditional farm implements), it is difficult for smallholder and poor farmers to acquire formal credit as a main source of finance for agricultural-related investment. (2) Weather and disease-related risks are prevalent in both rainfed and moisture-stressed farming typologies, making the agricultural sector costly for financial institutions to expand their credit service to the rural poor who do not have access to risk smoothing institutions such as the insurance market. (3) The high transaction costs that result from the small amounts of the loans required by farmers appear to be unprofitable for the banking sector.

With the aim of reaching out in rural areas to help smallholder farmers' gain access to credit service, the Ethiopian government has established Microfinance Institutions (MFIs). In 2014/15, the number of MFIs reached 35. Their total capital and total assets reached Birr 7.2 billion and Birr 30.5 billion, respectively. The five largest MFIs, namely Amhara, Dedebit, Oromiya, Omo, and Addis Credit and Savings accounted for 84.2 per cent of the total capital, 93.4 per cent of the savings, 89.3 per cent of the credit, and 89.7 per cent of the total assets of MFIs at the end of 2014/15 (NBE, 2014). MFIs have been targeting the rural poor farmers by allocating two-thirds of their overall loan portfolio to the agricultural sector. However, the loans are not suited to the needs of smallholder farmers, as they provide for 6 to 12 months maturity periods. Additionally, the loan size offered is too small (on average USD170) (Wolday and Peck, 2010, cited in Kelbore, 2014).

3.3 AGRICULTURAL OUTPUT MARKET

Given the importance of the cereal sub-sector in employment creation, agricultural GDP, and cultivated land, all the three political regimes, despite their differing political ideologies, placed strong priority on cereal production and marketing components. Consequently, the sector has witnessed many policy reforms since the 1960s. This section examines the agricultural marketing policies that were implemented by the three different regimes. In doing so, different cereal marketing policy reforms that target production and output markets are discussed.

Cereal markets under the imperial regime (1960–1974) were characterised by modest government intervention, relatively high marketed output, and very high transport costs owing to inadequate infrastructure and communication services. It is important to note that the high marketed surplus, which was estimated at between 25–30 per cent of production, was not the result of market-oriented production or surplus production systems. The majority of farmers were classified under subsistence farming. Instead, the high marketable output was the result of the feudal-tenant relationship, which required small farmers to pay rents in kind to landlords, higher officials and churches who leased most of the land to smallholder farmers.

Government interventions in the cereal market were conducted through the Ethiopian Grain Board (EGB), which was established in 1950 to undertake export licensing for oilseeds and pulses, quality control, supervision of marketing intelligence, and the regulation of domestic and export purchases and sales. With the aim of achieving better domestic grain price stabilisation through holding and releasing stocks, the EGB was reformed and renamed as the Ethiopian Grain Council (EGC) in 1960. Like its predecessor, the EGC failed to achieve its stated objectives because of the limited coverage of production regions and concentration in urban areas, thereby neglecting remote rural producing regions. As a result of this, the restructuring in public grain market intervention did not improve inter-regional grain market integration (Holmberg, 1977, cited in Rashid and Negassa, 2011).

The socialist government (1975–1990) implemented strict controls over all grain production and marketing. These included determination of annual quotas, restrictions on grain movement, determination of marketing days, and rationing of grain to urban consumers. The main focus of these interventions was to serve urban consumers and public institutions, at the expense of smallholder farmers. Smallholder farmers were obliged to meet the quota requirements by abandoning consumption or through purchase from local markets, which further deprived their well-being. According to Franzel *et al*. (1989), the rationale for controlling grain marketing was both ideological and pragmatic. On the ideological side, there was a strong belief that middlemen exploited the peasantry and consumers, and that state interventions was required to curtail the exploitation. The pragmatic reasons were associated with the post-revolutionary land reform that brought an end to the share tenancy. This reform led to an increase in on-farm consumption in surplus areas. Thus, the share of peasant production that was marketed declined from 25 per cent to 10 per cent between 1974 and 1978. As a result, grain prices were higher in urban areas.

To serve its main purpose of supplying urban consumers, the government established the Agricultural Marketing Corporation (AMC) in 1976. The AMC was involved in almost all areas of agricultural input and output markets. The state control in grain production and marketing had a negative influence on the performance of cereal production and marketing. The fixed quota requirement did not consider smallholder farmers' consumption demands, where farmers were forced to meet the quota by abandoning consumption. The restriction in regional grain movement contributed to market segmentation and affected the efficiency of spatial grain market integration by impeding arbitrage processes. Moreover, traders were forced to sell much of their output to AMC at prices even below open market prices.

In March 1990, the socialist government attempted to relax some of the above-stated restrictions in the grain market. The government undertook major grain marketing policy reforms, which included the removal of grain movement restriction, abolition of forced quota delivery, and the elimination of the AMC's monopoly power (Rashid and Negassa, 2011). However, these reforms did not last long, as the EPRDF government toppled the Derg regime in 1991.

Following the overthrowing of the Derg regime in May 1991, the incumbent government introduced numerous economic reforms in the cereal market. As stipulated in the SAP, the government's first move was to restructure government parastatal organisations. To this end, the government replaced the AMC with the Ethiopian Grain Trade Enterprise (EGTE). The EGTE was allowed to operate side by side with private sectors in order to foster competition and efficiency in the grain market. Particularly, the EGTE was mandated to stabilise grain prices, generate foreign exchange through grain exports, and maintain a strategic food reserve for disaster response and emergency food security operations.

During the initial years of the reform period, the EGTE faced shortages of capital to undertake grain procurement. The restructuring limited the role played by the EGTE in grain procurement and price stabilisation by reducing collection centres and branch offices. The eight zonal offices were closed, the branch offices were reduced from 27 to 11, and the grain purchase centres shrank from 2 013 to 80. As a result of this downsizing, the EGTE played only a minor role in procuring grain. The EGTE's annual average grain purchase from smallholder farmers and traders declined from 258 719 tons during the 1984/85 to 1989/90 period to 50 608 tons during the 1990/91 to 1995/96 period (Negassa and Jayne, 1997).

A series of proclamations and regulations from 1999–2000 substantially revised the EGTE's mandates. These proclamations required the EGTE to gradually move away from price stabilisation and to focus on promoting exports, facilitating emergency food security reserves, and helping in the national disaster prevention and preparedness programme. Owing to these reforms, the share of state involvement in the domestic grain market diminished from 40 per cent in the 1980s to about 3 per cent in 2000s (Rashid and Negassa, 2011).

Although it was no longer its duty, the EGTE has been returned to its price stabilisation role in two contrasting situations. Firstly, in 2002, to curb the maize price plunge caused by two consecutive years of bumper harvests. Following the two years of bumper harvests, maize prices dropped by about 80 per cent. With the aim of stabilising the maize price plunge, the EGTE became involved in the maize market and procured 18 000 MT of maize, of which 11,000 MT were exported. Secondly, it intervened to tame the soaring food price surge of 2008. As stated in the introduction part, grain prices started to swing upwards after 2008. In order to manage the high grain price in the domestic grain market, the Ethiopian government ordered the EGTE to become involved in wheat importation and distribution at subsidised prices to millers and to vulnerable urban consumers.

3.4 STATUS OF MARKET FUNDAMENTALS

The concept of market integration is very much interrelated with the status of market fundamentals, especially the three I's, namely information, infrastructure, and institutional development. Here, we briefly discuss the status and trends of road infrastructure and information communication service development in Ethiopia.

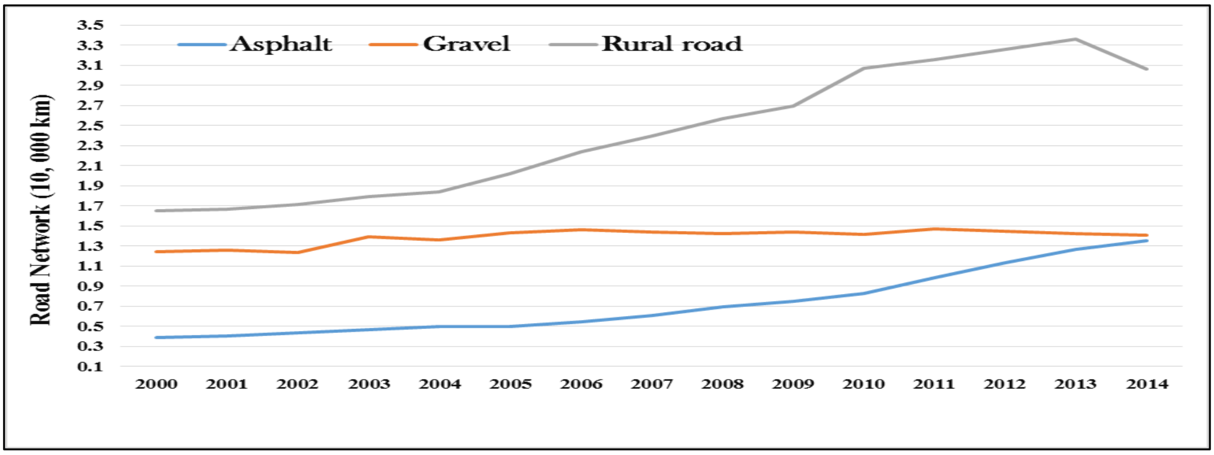
3.4.1 Road network development

The Ethiopian agricultural production system is characterised by widely dispersed production and consumption areas. Quality markets and physical infrastructural development would therefore play a crucial role for food production reallocations from major producing regions to deficit consumption areas. In the absence of adequate physical infrastructure, reliable market information, and marketing institutions, it is more likely to have market segmentation and regional grain price variability. This would ultimately worsen the food security status, as deficit areas could not access food at affordable prices. This was the case for Ethiopia in the 1980s and early 1990s, where poor infrastructure facilities hindered agricultural production reallocations among grain production and consumption regions. It is believed that the inadequate physical infrastructure had contributed to the famines of the mid-1980s by limiting the reallocations of food in times of drought from surplus-producing regions to drought-affected deficit areas.

Public investment in roads, the communication sector, and marketing institutions was limited and non-existent for a long time. For instance, in the 1980s, more than 90 per cent of the country's population lived at a distance requiring more than 48 hours to walk to a paved road (WFP, 1989). To address this problem, the current Ethiopian government has shifted its focus on road infrastructure development. Figure 3.4 below presents road development trends in Ethiopia. The progress in road development has been encouraging, and asphalt and rural road development, especially, has increased remarkably over the past 14 years. The length of rural roads jumped from 16 480 km in 2000 to 30 641 km by 2014. This expansion in rural roads shows a remarkable growth rate of 86 per cent. In 2008, Ethiopia had 25 640 km of rural roads, almost three times the length of rural roads that existed in the 1990s. Likewise, the asphalt road development increased threefold from 3 924 km in 2000 to 13 551 km in 2014. In 2014, the total road network reached 110 414 km, which showed an annual expansion of 11 per cent, as compared with 2013 (ERA, 2015). It is widely believed that such expansion in road infrastructure development would contribute to timely mobility of agricultural products.

Trends in physical road infrastructure development are not the only indicator for road development. The quality of existing roads also matters in influencing grain movement and transaction costs in developing countries. As far as road quality is concerned, about 70 per cent of the total road network was in good condition in 2014. More specifically, 73 per cent of the asphalt roads, 59 per cent of the gravel roads and 55 per cent of the rural roads were in good condition in 2014 (ERA, 2015).

Figure 3.4: Road development trends in Ethiopia, (2000–2014)



Source: Author's calculation using Ethiopian Road Authority (ERA) data

Given the inadequate rural infrastructural facilities, the focus on rural road construction is pragmatic. Despite the aggressive move by the incumbent government in rural road development, the cereal market is still expected to face some challenges if the existing rural roads are not transformed into tarmac roads. Rashid and Negassa (2011) have mentioned three reasons why these issues will continue to be points of concern in the cereal market: (1) with rural and gravel roads being the dominant road types across the country, the majority of grain transport from surplus to consumption centres can only take place during the dry season. This prevents producers and grain traders from taking advantage of the seasonality of grain prices. (2) With the shortened time period available for road access, there is increased pressure on the limited marketing infrastructure to transport grain, which might increase the demand for marketing services and hence increase marketing costs. (3) The cost of operating trucks on gravel and rural roads is also higher than operating them on all-weather roads, which increases transportation costs. Therefore, the long-term strategy should focus on upgrading rural roads into all-weather roads.

3.4.2 Trucks and transport services

Following the introduction of liberalisation in the grain market, the private sector's participation in transport services has improved significantly. As illustrated in Table 3.5 below, the number of small trucks with the capacity of up to seven tons has increased by more than four times, from 10 420 in 1993 to 48 197 in 2008. Likewise, the number of bigger trucks, with 8 to 18 tons capacity, increased by 11 per cent (from 10 630 trucks to 11 756). Owing to this shift from traditional transport to motorised transport, the movement of grain from surplus to deficit areas has shown some improvement (Minten *et al*., 2012).

Table 3.5: Number of trucks in Ethiopia in thousands, (1993–2008)

Year	Number of trucks by size		
	3-7 tons	8-18 tons	Trailers
Average 1993-1999	**10.42**	**10.67**	**4.81**
2000	24.42	10.11	5.6
2001	27.07	10.52	5.67
2002	25.33	12.91	5.65
2003	25.39	13.82	6.13
2004	32.52	10.72	6.01
2005	32.6	11.28	7.13
2006	39.72	11.38	6.89
2007	43.96	11.57	7.31
2008	48.2	11.76	7.73
Average 2000-2008	33.25	11.56	6.46
Average annual growth rate since 2000	**9 %**	**2.6 %**	**4.3 %**

Source: Rashid and Negassa (2011)

3.4.3 Telecommunication service

Information flow plays a significant role in the performance of markets by improving the selling and buying decisions of market participants. For this reason, increasing the means of information communication, and hence enhancing access for it, is fundamental in achieving efficient market integration across regions. The telecommunication service is one of the means by which market information could be transmitted between buyers and sellers, and thus allow prices to be possibly negotiated between trading partners (Kelbore, 2013). In Ethiopia, telecommunication services have rapidly expanded since 2000. Since 2000, mobile subscription has increased, on average, at an annual rate of 75 per cent (Table 3.6 below). Likewise, fixed telephone subscriptions have been growing annually by 10 per cent since 2000. In 2015, about 43 per cent of Ethiopia's population had access to mobile services.

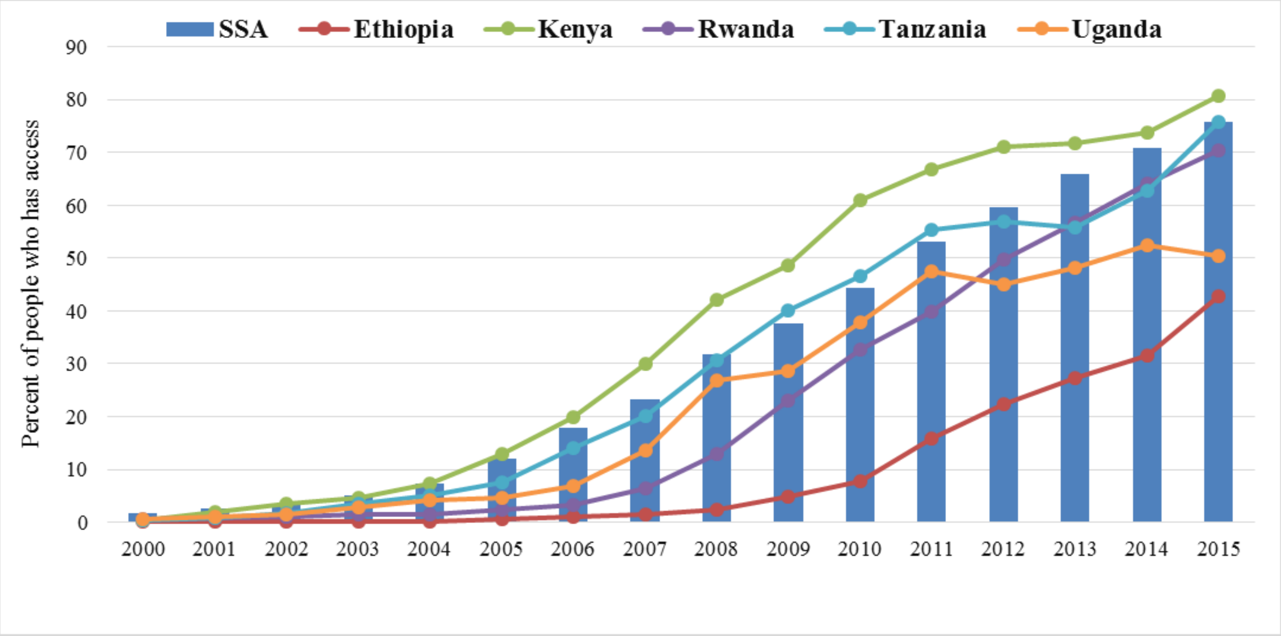
Table 3.6: Mobile and landline subscriptions in Ethiopia, (1995–2014)

Years	Mobile subscriptions ('000)	Mobile subscriptions (per 100 people)	Fixed telephone subscriptions ('000)	Fixed telephone subscriptions (per 100 people)
Average (1995-1999)	1.35	0.00	161.27	0.27
2000	17.76	0.03	231.94	0.35
2001	27.5	0.04	283.68	0.42
2002	50.40	0.07	353.82	0.51
2003	51.32	0.07	404.79	0.56
2004	155.53	0.21	484.37	0.65
2005	410.63	0.54	610.35	0.80
2006	866.7	1.11	725.05	0.93
2007	1208.50	1.50	880.09	1.09
2008	1954.53	2.37	897.29	1.09
2009	4051.70	4.78	915.06	1.08
2010	6854	7.87	908.88	1.04
2011	14 126.66	15.80	829.01	0.93
2012	20 523.89	22.37	797.50	0.87
2013	25 646.86	27.25	761.45	0.81
2014	30490	31.59	820	0.85
2015	42 311.63	42.76	890.64	0.90
Average (2000-2015)	**9296.72**	**9.90**	**674.62**	**0.80**
Average annual growth rate since 2000	**75 %**	**70 %**	**10 %**	**7 %**

Source: World Development Indicators, The World Bank Database (2016)

Despite the impressive achievement in mobile phone ownership, the coverage in cellular phone provision is still far below the Sub-Saharan Africa (SSA) standard. Figure 3.5 below illustrates the trends in mobile ownership in Ethiopia and other neighbouring countries (Kenya, Uganda, Tanzania, and Rwanda). The figure indicates that about eight out of ten people had access to mobile service provision in SSA in 2015. This country-wise comparison indicates that the neighbouring countries, Kenya, Rwanda, Tanzania and Uganda, where more than 50 per cent of their population have mobile services, have managed to provide the service much better than Ethiopia has. About 43 out of 100 people owned mobile phones in Ethiopia in 2015. As stated earlier, unlike the rest of the African countries, the telecommunication service sector in Ethiopia is under a public monopoly. Until recently, a mobile SIM card was obtained through a formal application, which had a long waiting time. However, the situation has improved recently, where like many other African countries, SIM cards can be obtained in any kiosk on the street corners.

Figure 3.5: Mobile cellular subscriptions (per 100 people), (1999–2015)



Source: World Development Indicators, The World Bank Database (2016)

3.5 CHAPTER SUMMARY

In this chapter, we critically reviewed the input and output agricultural commodity markets, the performance of support service institutions, and the agricultural policies that have been put in place to promote cereal intensification in Ethiopia. Although there have been different attempts and policy reforms in the input and output markets to boost cereal productivity and improve the contribution of cereals to poverty reduction, the progress so far in cereal intensification in Ethiopia has not been satisfactory. The review pointed out that seed and chemical fertiliser adoption rates are much below the recommended rates. Although fertiliser consumption has improved at national level, the improvement in fertiliser application per hectare has been marginal. Different factors have jointly contributed to the sub-optimal application of commercial fertiliser, such as late delivery, inflexible distribution systems providing only two types of fertilisers in 50 kg bags, and lack of competition in the fertiliser market.

Although the partial involvement of the state in the input market is advisable during the initial stage of market liberalisation, the complete monopoly of a parastatal in the fertiliser market has posed a serious concern regarding input market efficiency in Ethiopia. Although the state-led importation and distribution of agro-chemicals has resulted in increased fertiliser consumption in Ethiopia, it does not accommodate private-sector participation and lacks competitiveness in that it offers only limited fertiliser options and quantities for farmers. Moreover, the inefficient demand estimation and distribution system of the state-dominated fertiliser market in Ethiopia has resulted in large carry-over stocks of chemical fertiliser. Several studies have confirmed that fertiliser application at the household level is profitable in Ethiopia, suggesting that the cause for low application rates could be institutional inefficiencies.

Unlike the fertiliser market, the seed industry in Ethiopia has allowed private-sector participation. However, compared with other developing countries, the role of the private sector in the formal seed system is limited in Ethiopia. As has been the case for the fertiliser market, the seed sector is confronted with many problems. The formal seed system has been criticised because of poor seed quality and timelines of delivery. Poor cleaning, mixed seeds, and low germination rates are also some of the common problems reported on the seed distributed by ESE.

From the review of the input sector (fertiliser and improved seed), we can conclude that the low adoption of improved technology is only one aspect of the problem of the low productivity of the agricultural sector in Ethiopia. Institutional inefficiency in the input sectors has played a large part in the stagnation of the agricultural sector in Ethiopia. While technology is important, the market structure and distribution system of the input sector should be revisited to attain the much-needed cereal intensification in Ethiopia.

Ethiopia has an admirable six decades of experience in agricultural extension service provision to farmers. However, the history of extension approaches has been biased against the livestock sub-sector. Furthermore, extension workers are overloaded with different assignments, which in most cases are not their primary responsibility. The current government has given priority to improve the accessibility of modern agricultural extension service to farmers. In every district, the government has assigned three professional agricultural extension workers to help farmers with crop technology, livestock husbandry, and sustainable land management. This has improved the accessibility of extension services, as evidenced by the low extension agent-to-farmer ratio in Ethiopia, which is estimated at 1:476, compared with 1:1000 for Kenya, 1:1603 for Malawi, and 1:2500 for Tanzania.

Although the financial liberalisation has registered success in shifting the flow of credit services from public to private organisations, it has failed to bring meaningful change in credit utilisation and flows to the agricultural sector. Despite the importance of the agricultural sector in terms of employment creation, contribution to national income, and poverty alleviation, the flow of financial resources to the sector has been negligible. For instance, between the period 2003/04 and 2013/14, the international trade sector absorbed, on average, 23 per cent of the credit flows from banks, followed by the industry sector (20 per cent), domestic trade (19 per cent), and the agricultural sector (17 per cent).

The review concludes that the performance of the Ethiopian agricultural sector, especially the input and output sectors, provides mixed outcomes. All agricultural policies that have been designed by the different regimes were aimed at accelerating the transformation of the hand-to-mouth production system to a more market-oriented production system. However, the state-led input service provisions are inefficient in terms of providing a tailor-made service to suit the smallholder demand. Despite the growth in the number of personnel, the agricultural extension service still needs improvement in distinguishing the roles and responsibilities of extension workers. Because of their involvement in different tasks, extensions service providers are viewed by farmers as government spokesmen rather than as professionals. Furthermore, the review concludes that the designed agricultural policies tend to ignore input–output market linkages. For instance, the extension service is skewed towards the production aspect. This poor coordination constitutes a major structural bottleneck, affecting the performance of the agricultural sector in Ethiopia. A case in point is the performance of the maize sub-sector. Through the strong promotion of agricultural inputs (improved seed and fertiliser), coupled with favourable weather conditions, Ethiopia has managed to boost maize yields to 3 tons per hectare. However, because of the skewed policies targeting the output sector, these blessings have not been translated into welfare gains to farmers. The subsequent bumper harvests led to a price plunge, which made maize farming unprofitable. Therefore, policies that promote agricultural production and productivity should also prioritise market development to realise the target of transforming small-scale farming to market-based agriculture. Thus, further reform to invigorate the linkages between the input and output markets is crucial to the success of the agricultural sector in Ethiopia.

CHAPTER 4:
SPATIAL MARKET INTEGRATION AND ASYMMETRY IN THE ETHIOPIAN MAIZE MARKET

4.1 INTRODUCTION

Ethiopia is an agrarian country, hence the efficiency and effectiveness of the agricultural commodity markets are listed as a top priority issue for the government. The efficiency of agricultural marketing affects agricultural production, income, and the overall welfare of participants along the commodity chain. Thus, any improvement in the agricultural marketing system will stimulate agricultural and economic development at the national and regional levels.

In the presence of efficient spatial market integration, production reallocations from production to consumption areas stabilise prices in deficit areas. In doing so, integrated markets enable consumers in a deficit market to pay a reasonable price for a commodity, which thereby contributes to food security, while producers in surplus markets would get the right market prices. Thus, market integration contributes to regional production specialisations, which is an engine of economic growth in agriculture-based developing countries. On the other hand, the absence of efficient spatial market integration would lead to food price spikes in a deficit market. Hence, regional price disparity would exist because of market segmentation. Therefore, a better understanding of the degree of spatial market integration is important for designing relevant policy responses for improving the functioning of grain markets.

The purpose of this chapter is two-fold: firstly, to analyse whether inter-regional maize market prices in Ethiopia are spatially integrated, and secondly, to assess the speed and symmetry of spatial maize price transmission. The remainder of the chapter is structured as follows. Section two briefly describes the maize market structure in Ethiopia. Section three documents the theoretical and empirical literature on asymmetric price transmission. Sections four and five present the data and specification of the econometric models. Section six presents the findings of the study. The last section sets out a chapter summary.

4.2 MAIZE MARKET STRUCTURE IN ETHIOPIA

Maize is grown predominantly by smallholder farmers in Ethiopia. About 95 per cent of maize production is supplied by smallholders. For the most part, Ethiopia relies on domestic maize production to meet domestic demand. As shown in Appendix Figure 1(a), maize production and consumption centres are widely dispersed. For instance, a surplus producing area, Nekemete, is located at a 318 km driving distance from the central Addis Ababa market. Likewise, the distance from the deficit Mek'ele town to the central Addis Ababa market is more than 750 km. The geographical dispersion necessitates the availability of good infrastructure and better functioning markets in order to facilitate maize production reallocations from production to consumption areas. The following section briefly describes the main characteristics of the white maize value chain from production to consumption stages. Describing the main role players at each point of the value chain would enable us to better understand the maize industry in Ethiopia.

4.2.1 Production

Maize is Ethiopia's largest cereal commodity in terms of total production, yield, and number of producers. About 8.6 million smallholder farmers cultivate white maize, while 5.4 million for Teff and 4.1 million farmers for wheat. Maize production is predominantly dominated by smallholder farmers. Smallholder farmers with average land holdings of less than 1 ha supply about 95 per cent of maize production, whereas commercial and state farms supply 5 per cent (CSA, 2015).

Maize production reached 6.3 MT in 2016 (USDA, 2016). This figure is 25 per cent and 26 per cent higher than wheat and sorghum production in Ethiopia, respectively. At 2.86 tons per hectare, the maize yield is the highest among cereals in Ethiopia. By comparison, in Sub-Saharan Africa (SSA), Ethiopia is ranked fifth in terms of area devoted for maize production, but is second to South Africa in maize yields and third after South Africa and Nigeria in production (Abate *et al*., 2015). Ethiopia has been largely self-sufficient in maize production.

The SSR for maize has fluctuated between 94 per cent and 102 per cent, implying that Ethiopia is trading in an autarky trade regime (see Table 4.1 below).

Table 4.1: White maize production and SSR in Ethiopia, (2010-2016)

Year	2010	2011	2012	2013	2014	2015	2016
Production (1000 MT)	4 895	6 069	6 158	6 492	6 580	5 050	6 300
Area Harvested (1000 HA)	1 963	2 055	2 013	1 995	2 230	2 150	2 200
Yield (MT/HA)	2.49	2.95	3.06	3.25	2.95	2.35	2.86
Imports (1000 MT)	0	0	0	5	5	5	0
Exports (1000 MT)	65	10	5	0	0	0	0
SSR	**101 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

Source: Author's calculation using USDA data (2016)

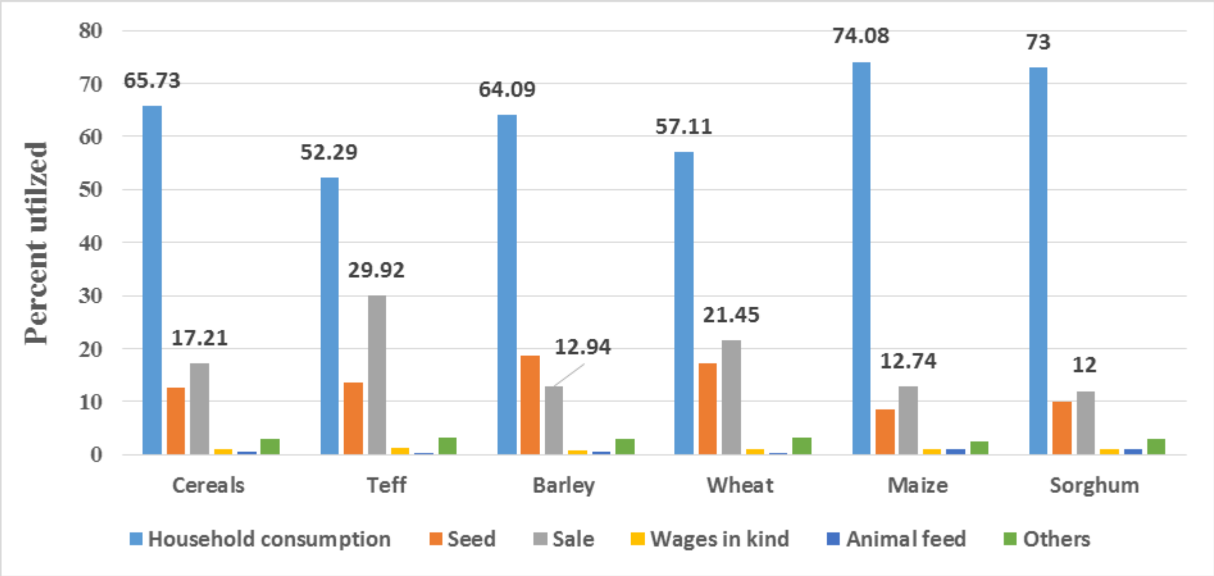
4.2.2 Marketing

In Ethiopia, nearly 66 per cent of cereal produced is used for household consumption, while 17 per cent and 12 per cent is for sale and seed, respectively. The remaining 5 per cent of cereals produced is used for other purposes like wages, animal feed, etc. As far as marketing is concerned, teff is the highest marketed crop in Ethiopia. About 30 per cent of teff production is supplied for the markets (see Figure 4.1 below).

Maize production is mainly used for home consumption. Based on the Central Statistical Agency's crop utilisation report (CSA, 2015), 74 per cent of maize production is consumed at household level. Available data shows that the maize commercialisation rate is low, with only 13 per cent being supplied to the market. The majority of maize production is marketed during the peak season when prices are low. Rashid *et al*. (2010) have indicated that about 60 per cent of maize is marketed during the first three months after harvesting. Farmers are forced to sell maize immediately after harvest owing to fear of storage losses and to settle outstanding loans for agricultural inputs.

Similar to other staple food crops in Ethiopia, maize is marketed through negotiation and mutual agreement between traders and farmers. Buyers and sellers meet personally, negotiate prices, inspect the grain on the spot, and complete the transaction (Demeke, 2012). Since there is no organised market information and exchange system, farmers rely on their negotiation skills and information from relatives.

Figure 4.1: Grain crops utilisation in Ethiopia, 2015



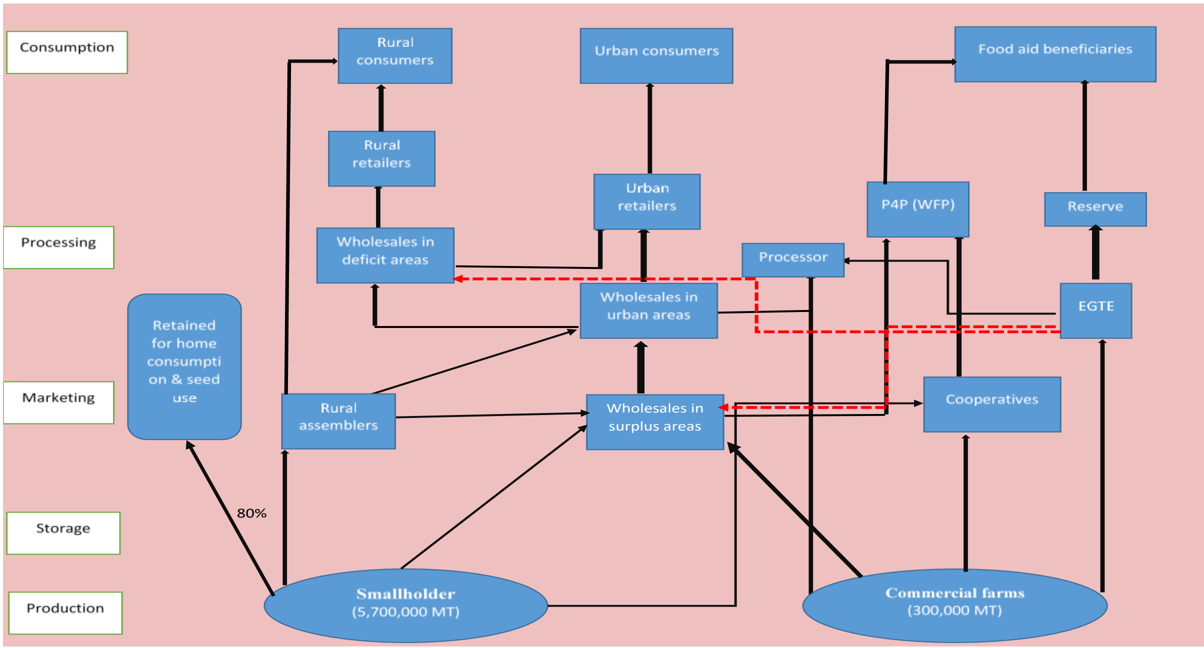
Source: Author's calculation using CSA data (2015)

Figure 4.2 below shows the maize crop marketing channel, from production to consumption stages. The maize value chain in Ethiopia consists of multiple actors and channels. A range of actors, that include smallholder farmers, wholesalers, retailers, cooperatives, traders, brokers, processors, Non-Governmental Organisations (NGOs), the parastatal organisation, and private consumers, take part in maize value chain. Typically, smallholder farmers sell surplus maize production to local small-scale traders. Local traders assemble the product and sell it to regional traders. Regional traders either supply the product to cooperatives or transport and sell the product in Addis Ababa to wholesalers and processors via brokers. In most cases, regional wholesalers do not have the financial strength to store maize for long periods and for supply during lean seasons. They own or rent grain storage, but usually do not store for more than one month. They also have limited scale in product reallocations – transactions are on the basis of one truckload (about 5 tons) and trade is conducted on 4 market days a month (Rashid *et al*., 2010, cited in Woldegiorgis, 2011).

Cooperatives collect maize from their member farmers and supply it to the local food procurement programme of World Food Program (WFP) or sell it to the EGTE. The EGTE is the only parastatal organisation involving in grain purchases for the food security reserve and emergency distribution. Although the EGTE was initially mandated to generate foreign exchange through the export of pulses and oilseeds, it is also involved in the maize market for price stabilisation purpose.

Wholesalers are the dominant role players in the maize marketing channel. In fact, Rashid *et al*. (2010) reveal that wholesalers command about 70 per cent of the marketed volume of maize. Regional wholesalers supply to Addis Ababa or wholesalers in deficit areas through brokers. Wholesalers in the central market mainly supply to processors and retailers. Few commercial farms are involved in maize production and marketing. They are mechanised and operate at a large scale, with > 50 ha of land. They mainly sell to wholesalers, the EGTE, the Purchase For Progress (P4P) programme, and cooperatives. Despite the long marketing channels and relatively large number of actors involved, value addition in maize is minimal. The only significant value addition is in storage and transportation.

Figure 4.2: Maize marketing chain in Ethiopia



Note: Broken red lines are rarely used channels in case of price stabilisation action by the EGTE.
2014/15 denotes marketing year, October 2014 to September 2015.
Source: Adapted with some modification from Rashid *et al*. (2010)

4.2.3 Milling industry

In general, the practice of purchasing processed cereals for consumption is not common in Ethiopia. This is evidenced by the low share of processed cereals in the per capita calorie intake in Ethiopia that is less than 2 per cent. As discussed above, the majority of cereal production in Ethiopia is consumed at household level. In the remote rural areas of Ethiopia, cereals are processed at household level manually, using mortar and pestle or grinding stones, or both. In relatively accessible rural areas, small-scale water mills, diesel-powered flour mills, and small-scale flour mills are used to process cereals. Rural households take grains to millers and pay a processing fee, based on the weight of grain processed (Woldegiorgis, 2011).

Until the early 1990s, the government owned all commercial flour mills. There were no private-sector owned flour mills until the mid-1990s. This started changing rapidly in the early 2000s. Presently, there are 69 commercial privately owned flour mills in the country, with a total capacity of around 7 300 tons per day. The industrial mills are mainly located in and around Addis Ababa and Nazareth area. About 75 per cent of the grain supply (hard and soft wheat) is from domestic production. The remaining balance is filled through imports by the government and private sector.

Medium or large scale milling and processing in Ethiopia is largely limited to wheat with very few companies involved in maize processing (Rashid *et al*., 2010). According to RATES study (2003), millers allocate only 4 per cent of their milling capacity for maize processing. For instance, from the 2000/01 production amounted to 132 000 MT and its components were 57 per cent wheat flour, 21 per cent biscuits, 19 per cent pasta/macaroni, 2 per cent bread, and 1 per cent maize flour. Despite having the largest number of livestock in Africa, the use of maize grain and residue for poultry and livestock production is very limited in Ethiopia (Demeke, 2012).

4.2.4 Consumption

Maize is an important staple food crop in Ethiopia. It accounts for 17 per cent of the per capita calorie intake, followed by sorghum (14 per cent) and teff (11 per cent) (Table 4.2 below). The per capita maize consumption is expected to reach 62.3 kg/person in 2025, which is 39 per cent higher than the average per capita maize consumption of 42.63 kg/person during 2001–2015 (more detail will be given later in Chapter 6).

On the consumption side, three types of maize consumers can be categorised in Ethiopia. The main consumers for maize production are rural consumers. Rural consumers get maize either from their own harvests or from local markets. Rural households consume more maize (436 per capita calories) than those in urban areas do (107 per capita calories) (Berhane *et al*., 2011). In urban areas, maize is the least preferred crop for consumption, where wheat and teff crops are the most preferred. The third category of maize consumers comprises food aid beneficiaries. Every year, about 6 to 7 million people are food insecure in Ethiopia. As a result, various development organisations, including FAO and WFP, have been involved in purchasing and distributing maize from the surplus to the drought-prone areas of Ethiopia.

Table 4.2: Per capita calorie consumption of food items in Ethiopia, (2004/05)

Cereals	**Per capita calories**			
	Urban	**Rural**	**National**	**%**
Teff	601.70	196.69	254.13	10.91
Wheat	200.59	309.79	294.30	12.63
Barley	38.16	144.58	129.48	5.56
Maize	107.53	435.99	389.40	16.71
Sorghum	94.72	366.21	327.70	14.06
Other cereals	25.21	53.29	49.31	2.12
Processed cereals	195.15	17.10	42.35	1.81
Enset/kocho/bulla	27.18	215.15	188.49	8.09
Total cereals & enset	1290.24	1738.79	1675.17	71.90
Non cereals	697.72	647.67	654.77	28.10
Total (National)	**1987.96**	**2386.46**	**2329.94**	**100.00**

Source: Berhane *et al*., (2011)

4.3 ASYMMETRIC PRICE TRANSMISSION: THEORETICAL AND EMPIRICAL CONSIDERATIONS

Spatial price transmission is an issue that has been widely analysed in the context of the LOP, which assumes that if two markets are linked by trade and are efficient, the price differential between them is equal to the transaction costs (Fackler and Goodwin, 2001). If the price differential exceeds transaction costs, it creates a profitable trade opportunity for arbitrage processes. Consequently, an arbitrage process exploits the profitable trade opportunity by shipping a commodity from low-price to high-price grain markets. Therefore, the error correction mechanism in spatial market integration is the LOP.

Markets are said to be integrated if they are connected by arbitrage processes (Ngare *et al*., 2013). Price integration could be short run, or instantaneous, or long term. Short-term market integration implies that a price change in one agricultural commodity market is immediately and fully reflected in the price level of the other market. In this case, the two markets are said to be integrated contemporaneously. On the other hand, long-term market integration occurs when the price adjustment takes a long run to reach an equilibrium position.

According to Rapsomanikis *et al*. (2003), the notion of price transmission can be better understood as being based on three main components: co-movement of price signals, speed of adjustment, and asymmetry of response. 'Co-movement of price signal' means that a change in the price of an agricultural commodity in one market is reflected in the price change of a homogenous commodity in other markets; 'dynamics and speed of adjustment' signifies the rate at which changes in the prices in one market are transmitted to other markets; and 'asymmetry of response'[11] signifies the nature of the price adjustment process in which a price transmission differs according to whether prices are increasing or decreasing (Prakash, 1999; Balcombe and Morrison, 2002; Rapsomanikis *et al*., 2003; Meyer and von Cramon-Taubadel, 2004).

Depending on the structure of spatially integrated markets, the price transmission process can be complete or partial, or linear or non-linear (Ihle *et al*., 2009). Perfect price transmission assumes that a price decrease or increase in one market leads to the same price change in another integrated market. The idea of perfect price transmission is analogous to a standard competition model, where a seller charges a price close to the marginal cost. Different factors constrain the complete pass-through of price signal movement among integrated spatial

[11] APT can be categorised as positive and negative APT. For this study, we classify positive and negative APT based on the definition of Meyer and von Cramon-Taubadel (2004). They define positive APT as price movements that squeeze the margin, while negative APT is defined as price movements that stretch the margin. In this context, we generalise this definition as being that positive APT occurs when regional wholesale maize prices react more rapidly to an increase from the central Addis Ababa wholesale maize market price than to a decrease. As a result, a high maize price persists in regional wholesale maize markets, which has implications on welfare distribution as consumers pay artificially high prices. Conversely, negative APT presents when regional wholesale maize prices react more quickly to a decrease in the central wholesale maize price than to an increase.

markets. Among the most-cited factors include the status of market fundamentals, especially the three I's: road infrastructure, information communication service development, and market institutions. Other factors that constrain price signal transmission from one market to other include government trade policy interventions and imperfect competition.

In the absence of adequate market fundamentals, transaction costs will be high. If transaction costs are prohibitively high, price changes will not transmit instantaneously. In extreme cases, price signals will not transmit at all because of market segmentation (Abdulai, 2000; Conforti, 2004). Trade policies of the government, such as import tariffs, an export ban and macroeconomic policy interventions related to exchange rates, may diminish or block spatial price signal transmission among markets. The higher the tariff levels are, the closer domestic prices will be to autarky and the less international price changes will transmit to national markets (Rapsomanikis *et al*., 2003; Conforti, 2004). Exchange rates play a significant role in influencing the domestic prices of a country. Exchange rate appreciation would tend to insulate domestic prices from rising world prices, whereas depreciation would diminish the pass-through of declining world prices to domestic market prices (Kelbore, 2013).

The presence of imperfect competition also hinders the full transmission of price signals (Abdulai, 2000; Rapsomanikis *et al*., 2003). According to Meyer and von Cramon-Taubadel (2004), the main culprit for the imperfect price transmission is market power. In rural agricultural markets, imperfect competition allows oligopolists to react more quickly and collusively to shocks that squeeze their marketing margins than to shocks that raise their marketing margins, resulting in APT (Ngare *et al*., 2013). Thus, the presence of imperfect competition obstructs the full transmission of price signals.

It is, however, important to mention that concentration is probably a necessary but certainly not a sufficient condition for the exercise of market power. The conclusion for market power being a cause of APT is not conclusive. Borenstein *et al*. (1997), in their study of vertical price transmission for crude oil to gasoline prices, conclude that the downward stickiness of retail prices for gasoline in an oligopolistic environment will lead to positive asymmetry. Conversely, Ward (1982) finds that market power can lead to negative asymmetry if oligopolists are hesitant to risk losing market share by increasing output prices. Hence, it is not clear a priori whether market power will lead to positive or negative asymmetry (Bailey and Brorsen, 1989, cited in Acquah and Dadzi, 2010).

Recent empirical market integration studies have given more attention to assessing the performance of agricultural commodity markets. The extension of standard cointegration approaches by examining the nature of adjustment to the previous year long-run deviation as symmetric or asymmetric has improved the policy use of agricultural market integration studies. The early and pioneering work on testing APT by modifying the error correction representation was done by von Cramon-Taubadel and Fahlbusch (1997). In his study of vertical pork price integration, von Cramon-Taubadel (1998) found that price transmission between producer and wholesale pork prices in Northern Germany was asymmetric.

The prevalence of uncompetitive pricing practices in the agricultural food markets continues to be an important policy concern for most countries in Africa. The underdeveloped infrastructural service and information asymmetry could be the possible causes of APT. Despite good reasons for the possible presence of uncompetitive pricing practices in the agricultural sector, the empirical analysis of testing APT is not extensive in Africa. Until 2004, only 40 publications in major journals were available on the estimation of APT. One-third of these studies focused on the USA markets (Meyer and von Cramon-Taubadel, 2004). The lack of extensive empirical study in investigating the presence of APT and the possible causes for it in the African agricultural food market is worrisome. Very few studies have attempted to test for the presence of APT in the African commodity markets (Abdulai, 2000; Cutts and Kirsten, 2006; Alemu and Ogundeji, 2010; Acquah and Dadzi, 2010; Acosta, 2012; Yeboah, 2012; Fiamohe *et al*., 2013; Ngare *et al*., 2013). These authors make an important contribution to the literature on food price transmission in African food markets by incorporating APT into their analyses. The next section summarises the existing empirical analyses on APT which have been conducted in African commodity markets.

Abdulai (2000) employed a threshold cointegration model to examine maize price linkages in Ghana. He found that the major maize markets in Ghana are well interconnected. His results, however, supported the presence of APT in maize markets. Different studies in Ghanaian spatial maize market integration also found similar results (Acquah and Dadzi, 2010; Yeboah, 2012). Using the wholesale grain price data from 2002–2012, Yeboah (2012) examined regional maize market integration in Ghana. He used consistent a Threshold Autoregressive model to analyse the extent of integration and performance of regional maize markets. The results showed that all four maize market pairings are integrated. The results, however, confirmed the presence of heterogeneity for price adjustment responses between maize market pairs. With the exception of Brongo Ahafo and Greater Accra market pairings, the remaining integrated maize markets were characterised by asymmetric price adjustment, where traders are quicker to adjust when their market margins are squeezed than when they are stretched. Similar conclusions were reached in the South African and Kenyan agricultural food markets.

Following the high retail food prices of 2002 and 2003, Cutts and Kirsten (2006) examined the market concentration power of agro-food processing industries in the South African food market chain. Their results showed that retail food prices in South Africa were characterised by a high level of asymmetry, although the level did decrease for perishable products. The high degree of asymmetry was associated mainly with the market power of the food processing industries. Using relatively high frequency data covering the period from 2003 to 2008, Alemu and Ogundeji (2010) studied the nature of price asymmetry (positive and negative) in the South African food market. They found that the positive price difference between retail and producer food prices persists for longer periods than the negative deviation does. This is not surprising, given the fact that the five main supermarket chains controlled 66 per cent of the food retail market in South Africa.

Using weekly retail market prices, Ngare *et al* (2013) investigated the spatial integration of maize and beans market prices in Kenya. Their findings indicate that the maize and beans retail markets are integrated. Not every price deviation from the previous year long-run equilibrium position was, however, adjusted homogenously. Retail prices adjusted more quickly to an increase than decrease prices did, suggesting the presence of positive APT.

Acosta (2012) assesses the spatial transmission of white maize prices between South Africa and Mozambique. The author used an asymmetric error correction model to estimate the speed and symmetry of white maize price transmission. He found that the white maize prices between South Africa and Mozambique markets are cointegrated. However, the speeds with which prices are corrected for an increase and decrease are asymmetric. The author suggests that among the barriers that impede efficient price transmission are the presence of high import tariffs and the structure of value-added tax.

It should be noted that presence of APT does not necessarily mean the existence of high market power and concentration in the food market. Tappata (2009) highlights the point that, in a highly competitive market environment, the lack of incentive by consumers to incur search costs can play an important role in explaining the rockets and feathers price pattern. Since the market is competitive, the cost of being informed constitutes search costs. In such markets, sellers take advantage of uninformed buyers by setting their prices above marginal cost. As more consumers become informed, however, the market become more competitive and firms start to compete more fiercely for the increasing mass of informed consumers by setting prices closer to marginal cost.

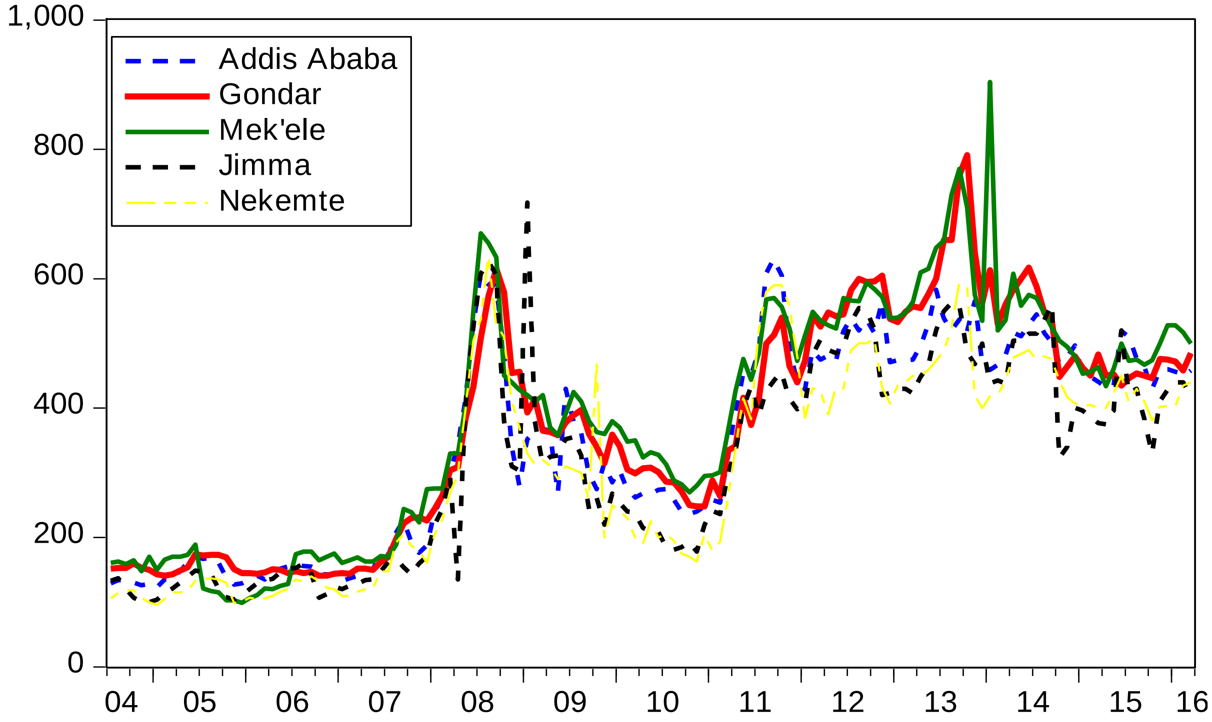
To summarise, the prevalence of uncompetitive pricing practices in agricultural food markets continues to be an important policy concern for most countries in Africa. The underdeveloped infrastructural service and information asymmetry are believed to be the possible causes of APT. Despite good reasons for the possible presence of uncompetitive pricing practices in the agricultural sector, the empirical analysis of APT is not extensive in Africa. Very few studies have attempted to analyse the presence of APT in the African commodity markets (Abdulai, 2000; Cutts and Kirsten, 2006; Alemu and Ogundeji, 2010; Acquah and Dadzi, 2010; Acosta, 2012; Yeboah, 2012; Fiamohe *et al*., 2013; Ngare *et al*., 2013). These empirical studies, however, did not go beyond simply finding APT (or not) in the food market: little attention has been devoted to explaining the possible causes of APT in relation to the institutional features of the market being studied. Additionally, the scope and focus of these studies were limited to inter-regional APT by disregarding the effects of world-to-domestic food price transmission. For a net food importing continent like Africa, another possible cause of APT is domestic tradable food price adjustment to changes in world food market prices.

4.4 DATA

The study used the Ethiopian Grain Trade Enterprise (EGTE) monthly wholesale maize price data. The EGTE collects cereal prices from major producing and consumer markets. Prices are collected three times a day (early morning, late morning, and afternoon) and average prices are reported. Wholesale and retail monthly price data are available for public use, aggregated to a monthly frequency for each of the market areas. Owing to the excessive missing values in retail maize market prices, this study only considers wholesale maize prices. There are some missing observations in the wholesale maize prices too. Markets such as Dire-Dawa and Mettu, which have more than five consecutive missing values, were dropped from the analysis. The missing observations for the rest of the markets are interpolated. The dataset incorporates fifteen maize market locations in Ethiopia: the central market (Addis Ababa Ehel-Berenda market) and regional maize markets (Ambo, Bahir-Dar, Debre-Birhan, Dese, Debre-Markos, Gondar, Hosaena, Jimma, Mek'ele, Nazareth, Nekemete, Shashemene, Woliso, and Ziway). Maize markets are selected based on their representativeness of crop production, consumption areas, importance to the national grain trade flow, and data availability. The price series is from July 2004 to March 2016 (141 months).

Major regional surplus and deficit maize markets price trends are plotted in Figure 4.3 below. It is clear that in 2007/08 the domestic wholesale maize prices rose sharply in all markets. The wholesale maize prices also rose substantially at the end of 2013, especially in Mek'ele and Gondar markets. From the visual observation from the graph, the nominal maize prices for Mek'ele and Gondar markets have been consistently higher than the Addis Ababa maize market prices. Higher prices could be attributed to the supply deficiencies in these two markets. In addition, the two markets are located relatively farther away from Addis Ababa market. Mek'ele market is located in the Northern part of Ethiopia with 762 km away from Addis Ababa, while the Northern market, Gondar, is located at the distance of 732 km from Addis Ababa. The nearest markets to the central Addis Ababa market are Nazareth, Woliso, and Ambo. The higher mean maize price in Mek'ele and Gondar markets, therefore, may have something to do with the isolation and deficiencies of maize production in these two markets.

Figure 4.3: Nominal monthly wholesale maize prices in surplus and deficit maize markets in Ethiopia, July 2004 to March 2016 (ETB/100 kg)



The descriptive results for the wholesale maize prices are presented in Table 4.3 below. The spatial maize price differences and fluctuations provide a reasonable reflection of reality. Not surprisingly, the maximum maize price was obtained in deficit Mek'ele market. The minimum price was noticed in the western region surplus producing market of Nekemete. The variation of maize prices reveals that major producing markets such as Hosaena, Shashemene, and Debre-Markos have more variation than the rest maize markets. This variation in maize prices could be attributed to the seasonality of maize production in main producing regions, where prices typically decline at harvesting times and start to swing upwards during lean months.

Table 4.3: Descriptive results of the nominal wholesale maize market prices, July 2004 to March 2016 (ETB /100 kg)

Markets	Mean	Std. Dev.	Max	Min	Driving distance from Addis Ababa (km)	Types of road[12]	Market type
Addis Ababa	347.46	157.28	631	123	-	-	Surplus
Ambo	330.38	154.85	696	110	119	Asphalt	Surplus
Bahir Dar	343.93	169.82	770	112	552	Asphalt	Surplus
Debre-Birhan	356.44	164.87	663	123	132	Asphalt	Surplus
DM*	361.74	180.87	774	116	306	Asphalt	Surplus
Gondar	370.40	171.10	791	141	732	Asphalt	Surplus
Hosaena	376.68	182.01	801	127	228	Asphalt	Surplus
Jimma	316.61	157.59	718	100	352	Asphalt	Surplus
Nazareth	348.92	163.31	680	120	86.5	Asphalt	Surplus
Nekemete	312.28	155.94	635	96	318	Asphalt	Surplus
Shashemene	358.01	180.97	770	107	251	Asphalt	Surplus
Woliso	344.57	162.63	718	107	111	Asphalt	Surplus
Ziway	345.43	167.69	718	106	163	Asphalt	Surplus
Dese	358.07	160.01	690	129	388	Asphalt	Deficit
Mek'ele	385.17	179.46	904	99	762	Asphalt	Deficit

Note: *DM denotes Debre-Markos

4.5 ECONOMETRIC FRAMEWORKS

4.5.1 Testing time series properties

According to Gujarati (2003), before one pursues formal testing, it is always advisable to make a visual inspection of the series by plotting the data. Such a plot and corresponding correlogram give an initial clue about the likely nature of the time series (the existence of trend and deterministic components). The correlogram plot will roughly tell us about the existence of a unit root in the Data Generating Process (DGP). Furthermore, we can also detect the presence of seasonality behaviour. However, these tests have little power to distinguish between true unit root process and near unit root process. The problem is difficult because a near unit root process will have the same-shaped Autocorrelation Function (ACF) as a unit root process (Enders, 1995). Therefore, to be statistically confident for the presence of non-stationarity behaviour, formal empirical tests using unit root tests are necessary.

[12] The types of road infrastructure that connect the regional markets to the central Addis Ababa market.

4.5.1.1 Unit root tests

The estimation of a standard regression model using Ordinary Least Squares (OLS) is based on the assumption that the mean and variance of variables are time invariant. Variables their mean and variance change over time are known as non-stationary variables. Therefore, the results generated from non-stationary variables using the OLS method lead to spurious regression or nonsense regression. For non-stationary variables, the estimation of a long-run relationship among variables should be based on cointegration methods. Cointegration methods require variables to have the same order of integration. Thus, this study starts by testing the order of integration using ADF regression (Dickey and Fuller, 1979). The unit root test is estimated following the procedure proposed by Doldado *et al*. (1990).

The ADF test equation, having random walk with drift and time trend, is specified as:

$$\Delta\gamma_t = \alpha + \beta t + \delta\gamma_{t-1} + \sum_{i=1}^{k} \beta_i \, \Delta\gamma_{t-i} + u_t \qquad (4.1)$$

where Δ denotes the number of differences required to make the γ_t variable stationary, α is the drift parameter, t is the time trend, and K is the number of lags required to whiten the residuals u_t. The optimum lag length is selected using the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC). In Equation (4.1), we test the null hypothesis of a unit root $(\delta = 0)$ against the alternative of stationarity $(\delta < 0)$. The value δ has to lie between $(-1 \leq \delta \leq 1)$. For robustness, the Phillips-Perron (PP)[13] and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test were also estimated. The null hypothesis of ADF and PP test is that the variable has a unit root (non-stationary). On the other hand, the KPSS test is the reverse of the two tests (the variable is stationary against the alternative of a unit root). Thus, the KPSS test is used to complement and substantiate the results of ADF and PP tests.

[13] For the sake of brevity, the mathematical specifications for the PP test is not specified here. Interested reader can get a detailed explanation in the EViews user guide.

4.5.2 Bai and Perron structural break test

Since all maize market prices are integrated of the same order, we can proceed to the cointegration test (see Table 4.4 below). The cointegration test is performed using the Johansen Maximum Likelihood (ML) method. However, conventional cointegration techniques, such as Johansen's approach, may lead to misleading inferences if structural breaks persist in the data series (Rafailidis and Katrakilidis, 2014).

A gradual and sudden shift in the properties of a price series questions the parameter constancy assumption over the entire sample period. Using the same dataset of Nelsson and Plosser (1982), Perron (1989) empirically proved that, in the presence of a structural break, the variables in fact deemed to be non-stationary become trend stationary, and concluded that, without allowing for a break in the unit root tests, the researcher would mistakenly infer a stationary variable as non-stationary. This in turn has consequences on cointegration tests, specification of VAR, and the results of the Granger Causality tests. Therefore, ignoring a break where there is switch in the parameter value is quite perilous.

To overcome the bias of traditional unit root tests, Perron (1989) proposed a modified Dickey-Fuller (DF) unit root test that includes dummy variables using one known (exogenous) structural break. However, a known assumption of break date is criticised as it violates the distribution assumption. Moreover, treating break data as exogenous requires applying certain personal judgment, and that hardly qualifies as serious analysis. Then, a number of studies attempted to tackle this problem by endogenously estimating the break date (Zivot and Andrews, 1992; Perron and Vogelsang, 1992; Perron, 1997; Lumsdaine and Papell, 1997; Bai and Perron, 1998). The common feature of this approach is that they reduced the bias arising from the Perron known breakpoint by endogenously estimating the structural break date. In this approach, the selection of the break date is treated as the outcome of the estimation procedure, rather than identifying it exogenously.

Testing cointegration by considering the possible presence of a structural break has at least two advantages. First, it avoids the bias towards the non-rejection of the null hypothesis of no cointegration. Second, since this procedure can identify when the structural breaks occurred, it would then provide valuable information for analysing whether a structural break on a certain variable is associated with a particular government policy, economic crisis, war, regime shift, or other factors.

Given the fact that domestic commodity prices rose sharply following the global commodity price crises of 2008 and 2011, dealing with structural breaks seems to be a necessary condition. Beyond the output price fluctuations, the policy reforms made by the Ethiopian government to stabilise the domestic grain prices are expected to shift the properties of grain prices abruptly or gradually. Against this backdrop, this study investigated the presence of structural breaks in wholesale maize market prices using the Bai and Perron (1998) multiple structural break test. The test uses the full sample and adopts a different dummy variable for each break.

The Bai and Perron (1998) structural break test is useful for testing unknown breaks in a price series. The test is conducted using the following model specification, set out in Equation (4.2), with *m* breaks (*m*+1 regimes).

$$Z_t = \chi_t' \beta + \varphi_t' \eta_j + u_t, \text{ for } t = T_{j-1} + 1, \ldots, T_j, \quad (4.2)$$

$$j = 1, \ldots m + 1$$

where Z_t is the dependent variable in period t, χ_t' and φ_t' are vectors of covariates, and β and η_j ($j = 1, \ldots m + 1$) are the corresponding vectors of coefficients, and u_t is the disturbance term (Bai and Perron, 1998). $T_{1,\ldots} T_m$ are indices that represent the breakpoints. m is the maximum number of breaks used for the test, and is set to five. The *supF* $(\iota + 1/\iota)$ test identifies the statistically optimum number of breaks. The null hypothesis is that the optimum number of breaks is ι while the alternative hypothesis states that the number of breaks is $\iota + 1$.

Z_t

4.5.3 A Stock-Watson Dynamic Ordinary Least Square Approach (DOLS)

Following Rafailidis and Katrakilidis (2014), we tested the presence of cointegration by accounting for the identified structural breaks using the Stock and Watson (1993) Dynamic Ordinary Least Square approach (DOLS).

Since the pioneering work of Engle and Granger (1987), the cointegrating of regressions has become one of the standard tools in analysing integrated variables. Although OLS estimator is consistent in the presence of serial correlation in the error term, it suffers from second-order bias (Hayakawa and Kurozumi, 2006). In response, Stock and Watson (1993) proposed an alternative DOLS approach to deal with the pitfalls of the OLS and the Johansen ML procedures. DOLS is an improvement on OLS as it copes with small samples and dynamic sources of biasness. The Johansen method, being a full information technique, is exposed to the problem that parameter estimates in one equation are affected by any misspecification in other equations (Azzam and Hawdon, 1999:7). In contrast, the Stock and Watson method is a robust single-equation approach, which overcomes the simultaneity bias by incorporating leads and lags of first differences of the regressors, and for serially correlated errors, by a Generalised Least Squares (GLS) procedure. Moreover, if the variables under investigation are integrated of order one I (1), DOLS will have the same asymptotic optimality properties as the Johansen distribution has.

We model the long-run relationship between two series γ_t and χ_t as:

$$\gamma_t = \delta_1 + \delta_2\chi_t + \sum_{j=-k}^{k} \beta\Delta\chi_{t-j} + \epsilon_t \tag{4.3}$$

where K is known as the lead-lag truncation parameter. The OLS estimator of δ_2 based on Equation (4.3) above does not suffer from from second-order bias and is efficient in a certain class of distributions (Saikkonen, 1991, as quoted by Hayakawa and Kurozumi, 2006).

4.5.4 Asymmetric Error Correction Model (AECM)

Here, we are primarily concerned in testing the price adjustment response of regional maize markets to positive and negative price deviations from previous year disequilibria. To analyse this, we have relaxed the standard two-step Engle and Granger (1987) cointegration model by decomposing the error correction term into positive and negative components.

Earlier studies on APT applied the Wolffram–Houck (W-H) (Wolffram, 1971; Houck, 1977) method to investigate the short-run and long-run asymmetric price transmissions. The W–H method for the response of market price p_t^i to changes in p_t^j market price is specified as follows:

$$\sum_{t=1}^{\iota} \Delta P_t^i = \beta_0 + \beta^+ \sum_{t=1}^{\iota} \Delta P_{j,t}^+ + \beta^- \sum_{t=1}^{\iota} \Delta P_{j,t}^- + \varepsilon_t \qquad (4.4)$$

where

$\Delta P^+ = \Delta P$ for all $\Delta P > 0$, and 0 otherwise

$\Delta P^- = \Delta P$ for all $\Delta P < 0$, and 0 otherwise;

$\Delta P_{i,t}$ = the first difference of the price on market i at time t, β_0, $\beta^+$and β^- are coefficients and ι is the current time period.

Detection of asymmetry is through testing whether $\beta^+ = \beta^-$. Short-run and long-run asymmetry can be tested by introducing lag terms in $\sum \Delta P_{j,t}^+$ and $\sum \Delta P_{j,t}^-$ into Equation (4.4) above. According to von Cramon-Taubadel (1998), the W–H specification suffers from first-order serial correlation, which is often indicative of spurious regression in the analysis of non-stationary series. The presence of spurious regression is corrected if the analysed variables are cointegrated. In his analysis on vertical APT in the German pork market, von Cramon-Taubadel (1998) has shown that the above W–H specification is inconsistent with cointegration.[14]In response, the author has proposed the use of Asymmetric Error Correction Model (AECM) for cointegrated variables. This approach combines cointegration and asymmetry based on the assumption that p_t^i and p_t^j are linked by a unique long-run relation, while the contemporaneous and short-run dynamics that correct departures from equilibrium relation are asymmetric (von Cramon-Taubadel and Fahlbusch, 1997).

According to Engle and Granger (1987), if two markets prices P_t^i and P_t^j are cointegrated, then they can be represented in the error correction form. The conventional Engle and Granger cointegration approach involves two steps. The first step is estimating the long-run equilibrium equation:

$$P_t^i = \alpha_0 + \alpha_1 P_t^j + u_t \qquad (4.5)$$

[14] See Von Cramon-Taubadel and Loy (1996) and von Cramon-Taubadel (1998) for detailed explanation on how re-parameterisation of the W-H specification in Equation (4.4) is incompatible with cointegration.

The OLS residuals from Equation (4.5) are a measure of disequilibrium: $\hat{u}_t = P_t^i - \hat{\alpha}_0 - \hat{\alpha}_1 P_t^j$. A test for cointegration is a test of whether $\hat{u}_t$ is stationary. This is determined by ADF tests on the residual, with the MacKinnon (1991) critical values. A long-run relationship exists when cointegration holds between the price series, P_t^i and P_t^j . Therefore, it is valid to proceed to the second stage that investigates the magnitude and speed of price adjustment.

The second step, which estimates the Error Correction Model (ECM), is specified as:

$$\Delta P_t^i = \varphi_0 + \sum_{k=1} \varphi_1 \, \Delta P_{t-k}^i + \sum_{h=0} \theta_h \, \Delta P_{t-h}^j + \alpha \, \hat{u}_{t-1} + \varepsilon_t \qquad (4.6)$$

Since Equation (4.6) has only I(0) variables, a standard hypothesis test using t-ratios and diagnostic testing of the error term is valid. The adjustment term α is the error correction term (ECT) and must be negative and significant to show adjustment to the previous year departure from an equilibrium position.

The Engle-Granger two-step method suffers from a number of problems. One of its major drawbacks is that it can estimate only up to one cointegrating relationship. As a result, it is appropriate to examine cointegration within the Johansen VAR framework (Brooks, 2008). Given the small sample properties and multivariate nature, the Johansen's ML method has better power than alternative methods of estimating and testing cointegrating relationships have (von Cramon-Taubadel, 1998:9).

After accounting for the structural breaks and taking into account the above limitation of Engle-Granger approach coupled with the existence of cointegration of all maize market pairs, this study estimated an Asymmetric Vector Error Correction Model (AVECM). We start by modifying the first stage of the Engle-Granger approach by estimating the long-run equilibrium relationship using Johansen's method. Trace and Maximal Eigenvalue test statistics are used to test for the presence of cointegration under the Johansen approach. Once cointegration is confirmed, then the second stage of Engle-Granger in Equation (4.6) is conducted to obtain the short-run dynamics and the error correction term (ECT). The ECT coefficient α indicates the speed at which regional wholesale maize markets correct price deviations from last year disequilibrium position. The lags of P_t^i and P_t^j quantify the short-run dynamics of regional and central prices on price movements of regional maize market prices. Lag length is selected using AIC and SBC.

Finally, the von Cramon-Taubadel (1998) approach is adopted to test for asymmetry in price adjustment. The AVECM is outlined in Equation (4.7) below and it is obtained by decomposing the lagged error correction term ($\hat{u}_{t-1}$) from Equation (4.6) into its positive (ECT^{+}_{t-1}) and negative parts (ECT^{-}_{t-1}). Splitting the error correction term[15] into positive and negative parts would enable us to observe whether the speed of price adjustment of regional wholesale maize markets to upward and downward price deviations from the equilibrium position are different. In other words, whether price transmission is asymmetric.

$$\Delta P^{i}_{t} = \beta_0 + \beta_1 \sum_{k=1} \Delta P^{i}_{t-k} + \beta_2 \Delta P^{j}_{t} + \beta_3 \sum_{h=1} \Delta P^{j}_{t-h} + \beta^{+}_{4} ECT^{+}_{t-1} + \beta^{-}_{4} ECT^{-}_{t-1} + \varepsilon_t \quad (4.7)$$

where $ECT = ECT^{+}_{t-1} + ECT^{-}_{t-1}$. An F-test can be used to test the null hypothesis of symmetric price adjustment ($\beta^{+}_{4} = \beta^{-}_{4}$).

Although Equation (4.7) resolves the issue of asymmetry and cointegration, it still suffers from simultaneity of prices at different spatial markets. We have attempted to address this problem by using the Toda and Yamamoto (1995) ('T-Y') Granger Causality approach. Moreover, the application of this approach can light on the central maize market hypothesis test in Ethiopia.[16]The novelty of T-Y approach is that first, unlike the conventional Granger Causality test, the researcher does not bother for the order of integration and cointegration. You can

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[15] It is also possible to segment the contemporaneous term of the right-hand side of the equation of the central maize market ΔP^{j}_{t} into positive and negative parts to test for asymmetric contemporaneous adjustment. This type of asymmetry is considered in Chapter 6. For a detailed explanation on the different means of introducing asymmetry into the Error Correction Regression, see von Cramon-Taubadel and Loy (1996).

[16] The other option of estimating price leadership is to use the Johansen multivariate VAR framework, as proposed by Asche *et al*., (2012). This approach has the advantage of addressing the simultaneity issue, which otherwise might be a problem in the Granger non-causality test. In their analysis of testing the central market hypothesis in nine sorghum maize markets in Tanzania, Asche *et al*. (2012) recommend the use of two steps for establishing the existence of a central market when the markets under consideration are relatively large. The first stage will estimate a full set of bivariate cointegration analyses for testing cointegration and exogeneity. In the second stage, multivariate cointegration analysis will be employed for those markets that have a common stochastic trend. Although we acknowledge the advantage of this approach, the large number of regional maize markets considered in our study makes it extremely difficult to adopt the application of this approach. For instance, to do the first test alone would require running bivariate cointegration tests in 105 maize market pairs.

estimate the VAR in level form and evaluate the relationships between variables using the modified Wald (MWALD) test. Thus, avoids the potential bias associated with unit roots and cointegration tests (Zapata and Rambaldi 1997; Clarke and Mirza 2006). Second, it proposes a causality testing in a possibly integrated and cointegrated system using an augmented level VAR modelling that gives allowance for the long-run information, which requires first differencing and pre-whitening. Third, inference from the MWALD test is valid as long as the order of integration of the process does not exceed the true lag length of the model (Toda and Yamamoto, 1995).

Toda and Yamamoto (1995) suggested that researchers could estimate a $(K+d_{max})^{th}$ order VAR. Therefore, prior to estimating the T-Y causality test, the test for order of integration and lag length selection criteria are the precondition to test maximal order of integration (d_{max}) and the true optimum lag length (K). To this end, optimum lag length is selected using AIC, adjusted Likelihood Ratio (LR) and Final Prediction Error (FPE) tests.

To illustrate the model specification steps, suppose we are interested in testing T-Y causality test in two maize markets. T-Y causality test of VAR ($K + d_{max}$) for two maize markets prices can be specified as:

$$y_t = a_0 + \sum_{i=1}^{p=k+d(\max)} \Phi_i y_{t-i} + u_t \tag{4.8}$$

where $y_t = \begin{bmatrix} Market\ A_t \\ Market\ B_t \end{bmatrix}$ $a_0 = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix}$ $\Phi_i = \begin{bmatrix} A_{11,i} & A_{12,i} \\ A_{21,i} & A_{22,i} \end{bmatrix}$ $y_{t-i} = \begin{bmatrix} Market\ A_{t-i} \\ Market\ B_{t-i} \end{bmatrix}$ $u_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$

where, 'd' is the first order difference operator. The order of p represents ($k + d_{\max}$) and y_{t-i} denotes lagged maize prices. The direction of causality can be confirmed by applying the standard Wald test to the first 'K' VAR coefficient matrix. For example, in the first equation $H_0: A_{12,1} = A_{12,2} = \cdots = A_{12,k} = 0$, implies that market B price does not granger cause market A maize price, and $H_0: A_{21,1} = A_{21,2} = \cdots = A_{21,k} = 0$, implies that market A wholesale maize price does not granger cause market B maize prices and so on.

4.6 RESULTS AND DISCUSSIONS

The results section begins by presenting the price leadership findings. Price leadership is tested separately for surplus and deficit maize markets. Once the central market is established, a cointegration test is conducted by pairing the rest of the regional maize markets with the identified central market. For robustness, the examination of the cointegration test takes into account the effects of structural breaks. The final results section discusses the findings from asymmetric price adjustment for cointegrated maize market pairs.

4.6.1 Maize price leadership

The central market hypothesis or price leadership role is an important concept of market integration, and it has relevant policy implications, especially for developing countries (Ravallion, 1986). Moreover, in market integration analysis, the existence of a central market is required to justify the econometric model. The validity of market integration tests rest on the appropriate identification of a central market. This assumption is, however, often made without any formal empirical testing. According to Asche *et al*., (2012), arbitrage process, the error correction mechanism in market integration, could work in both directions between two spatial integrated markets, and among markets when several integrated markets are considered. However, if price is determined in a central market, and transmitted to regional, satellite, or dependent markets, price shocks in the latter do not influence price movements in the former. Hence, price determination process at national level can be determined from investigating only the price determination process in the central market.

The existence of a central market makes it easier for governments to monitor and intervene price distortion in grain market. Thus, further reducing the costs of price stabilisation policy (Sadoulet and Janvry, 1995). Knowledge about the presence of a central market and its price dynamic effects on satellite markets will assist the effectiveness of food assistance and other humanitarian food price support interventions. This could be done by either targeting the central market or satellite grain markets that are exposed to price shocks from the central market (Asche *et al*., 2012). This is of particular interest to constant food aid recipients such as Ethiopia.

The extended VAR procedure of the Toda and Yamamoto (1995) causality test analyses the lead-lag price relationships among regional wholesale maize markets. The central market hypothesis test was conducted in two stages. Firstly, the wholesale maize market price relationship between Addis Ababa and major surplus maize markets is examined. Secondly, the deficit maize markets and the leadership role of the Addis Ababa maize market price are investigated. The classification of markets as deficit and surplus maize markets is based on the USAID maize production and market flow map – see Appendix Figure 1(a).

Before commencing the estimation of the T-Y causality test, one must identify the maximum order of integration (d_{max}) of the underlying variables as well as the optimal lag length (k) of the VAR system. To address this, Dickey and Fuller (1979) proposed a test to detect the non-stationarity of series using the ADF. Table 4.4 below depicts the results of unit root tests based on ADF, PP, and KPSS statistics in levels and first difference of the variables. With the exception of Jimma market prices, which follows a random walk process, all tests are conducted with a random walk with drift. It is very crucial to attempt to use an optimal number of lags of the dependent variable in unit root tests. According to Brooks (2008), including too few lags will not remove all of the autocorrelation, thus biasing the results, while using too many will increase the number of parameters and reduce the degrees of freedom. The frequency of the data and information criterion are suggested in determining the optimal number of lags of the dependent variable. In this study, the frequency of the data is used as lag length selection criteria to test for the presence of unit roots. Since the data is monthly, 12 lags were chosen to whiten the residual.

The results from all unit root tests correspond with each other. Table 4.4 below suggest that all variables are nonstationary in levels while they turn stationary in first difference. Therefore, d_{max} should be equal to one. Based on the information criterion (AIC, and Hannan-Quinn Information Criterion (HQ)), the optimal lag length of the VAR in the surplus and deficit maize markets equations is selected as eight and three, respectively. Thus, supporting the rational and validity of the T-Y approach of Granger causality, as the true lag length of the model is greater than the order of integration. In the next stage, we augment the VAR by the maximum order of integration of the series (d_{max}) and estimate VAR (9) and (4) for the surplus and deficit maize markets equations. Model adequacy tests for the residual series approved the robustness of the specifications. Diagnostics test was made using the Breusch-Godfrey (1978) test of serial correlation. The BG (8) test for the surplus maize market and BG (3) for the deficit maize market test has a *p*-value of 15.34 per cent and 21.41 per cent, so the test failed to reject the null of no serial correlation against the alternative of eight and third order autocorrelation.

Table 4.4: Unit root tests

	ADF	PP	KPSS
Level (constant, no trend)		**Test statistics**	
Addis Ababa	-1.63	-1.69	0.95***
Ambo	-1.82	-2.04	0.93***
Bahir Dar	-1.53	-1.59	0.91***
Debre-Birhan	-1.53	-1.46	0.96***
Debre-Markos	-1.62	-1.58	0.90***
Dese	-1.66	-1.72	0.92***
Gondar	-1.69	-1.54	0.91***
Hosaena	-1.42	-1.78	1.00***
Mek'ele	-1.64	-1.84	0.92***
Nazareth	-1.47	-1.64	0.98***
Nekemte	-1.93	-1.88	0.88***
Shashemene	-1.42	-1.67	0.99***
Woliso	-1.69	-1.78	0.93***
Ziway	-1.39	-1.54	0.99***
Level (no constant, no trend)			
Jimma	-0.08	-0.39	0.86***
First difference (constant, no trend)			
Addis Ababa	-2.88*	-9.98***	0.072
Ambo	-3.12**	-11.72***	0.069
Bahir Dar	-3.08**	-11.36***	0.082
Debre-Birhan	-2.95**	-10.20***	0.046
Debre-Markos	-2.81**	-10.69***	0.073
Dese	-2.93**	-10.28***	0.074
Gondar	-3.01**	-10.41***	0.076
Hosaena	-3.14**	-16.15***	0.061
Mek'ele	-3.33**	-15.59***	0.074
Nazareth	-3.25**	-9.70***	0.084
Nekemete	-3.36**	-13.12***	0.055
Shashemene	-3.45**	-8.93***	0.058
Woliso	-3.35**	-9.13***	0.066
Ziway	-2.93**	-8.21***	0.071
First difference (no constant, no trend)			
Jimma	-3.02***	-15.70***	0.058

Notes: ***, **, * reject the null hypothesis at 1 %, 5 %, and 10 % significance levels

Tables 4.5 and 4.6 below present the results of T-Y modified Wald test of causality among deficit and surplus regional maize markets in Ethiopia. The findings indicate that the Addis Ababa maize market price movement influences the surplus wholesale maize markets of Hosaena, Nekemete, and Nazareth. Likewise, the Addis Ababa maize market price dictates the determination of the maize price in all the deficit regional maize markets considered in this study. Therefore, the null hypothesis of no causality from the Addis Ababa maize price to the above-mentioned surplus and deficit maize markets has been rejected. In the majority of cases, the direction of causation is unidirectional, from the Addis Ababa price to the rest of the regional maize markets. The converse, however, does not hold, except for the deficit Dese maize market. Apart from this one case, the Addis Ababa maize price is exogenous to the rest of the regional maize markets. Thus, Addis Ababa's wholesale maize market is behaving as the dominant maize market in Ethiopia.

Unlike the deficit wholesale maize markets, the surplus maize markets, such as Bahir Dar, Debre-Markos, Gondar, and Jimma, are exogenous. In these markets, the local supply and demand dynamics are expected to determine maize price formation. It is worthwhile to mention that, aside from Addis Ababa maize market, a hierarchical maize market has started to emerge in maize price formation in Ethiopia. Following the introduction of market liberalisation, regional maize markets such as Debre-Markos have started to play an important role in maize price determination in Ethiopia, which has further implications for regional and local maize price stabilisation policies. The results of this study are in partial contradiction to the previous study conducted by Getnet *et al*. (2005). Those authors concluded that, following the introduction of agricultural market liberalisation policy in Ethiopia, the central Addis Ababa wholesale market had developed concentration of market power over the regional grain markets. As a result, the central wholesale market is a major short-run and long-run determinant of grain market prices in local supply markets. Although our results did not totally dismiss this finding, we also find that, apart from the central maize market, other regional maize markets, such as the Debre-Markos maize market, contribute substantially to maize price formation in Ethiopia. Two possible explanations could be raised for the development of other regional maize price leader markets in Ethiopia. Firstly, the recent impressive progress in market fundamentals, such as road infrastructure and telecommunication service facilities in Ethiopia, is expected to facilitate inter-regional maize market trade. Improvements in transportation networks would facilitate arbitrage processes among regional maize markets.

This development would make it easier for traders to acquire market information from nearby regional maize markets and exploit any profitable trade opportunity through efficient production reallocations.

Secondly, a geographical advantage may also contribute to the price leadership role of the Debre-Markos maize market in Ethiopia. Debre-Markos town is located in the maize-surplus northern part of Ethiopia. The market has a geographical advantage, as it is located in the middle of the Amhara regional state, which is one of the major maize-surplus producing regions in Ethiopia. Not only does the market have better access to surplus maize markets, it is also adjacent to maize deficit Northern and Eastern regional markets, such as the Weldiya, Dese, Mek'ele, and Asayita markets (see Appendix Figure 1(a)).

Table 4.5: T-Y causality test among deficit maize markets

Maize markets	Addis	Dese	Mek'ele
Addis Ababa		8.66 (0.034)**	10.64 (0.014)**
Dese	31.23 (0.00)***		20.59 (0.00)***
Mek'ele	5.39 (0.145)	12.50 (0.00)**	

Notes: Null hypothesis of non-causality: χ^2 (2) statistics
Probability values in parenthesis; ****, ** reject the null hypothesis at 1 % and 5 % significance levels

Table 4.6: T-Y causality test among surplus maize markets

Maize markets	Addis	Ambo	Bahir Dar	DB	DM	Gondar	Hosaena	Jimma	Nazareth	Nekemete	Shashemene	Woliso	Ziway
Addis Ababa		7.01 (0.54)	8.25 (0.41)	10.21 (0.25)	9.27 (0.32)	7.35 (0.50)	17.31 (0.03)**	6.68 (0.57)	16.02 (0.04)**	21.26 (0.00)***	7.13 (0.52)	10.05 (0.26)	11.53 (0.17)
Ambo	5.88 (0.66)		4.55 (0.80)	4.03 (0.85)	6.04 (0.64)	6.72 (0.57)	10.88 (0.21)	4.48 (0.81)	8.92 (0.35)	16.85 (0.03)**	11.14 (0.19)	14.11 (0.08)*	19.83 (0.01)**
Bahir Dar	5.49 (0.7)	3.52 (0.89)		3.94 (0.86)	4.19 (0.84)	3.84 (0.87)	8.16 (0.42)	12.35 (0.14)	13.09 (0.11)	16.45 (0.04)**	9.57 (0.30)	8.80 (0.36)	12.11 (0.15)
DB	9.93 (0.27)	7.14 (0.52)	6.77 (0.56)		9.74 (0.28)	9.35 (0.31)	15.98 (0.04)**	8.22 (0.41)	14.82 (0.06)*	12.03 (0.15)	11.29 (0.18)	13.61 (0.09)*	29.71 (0.00)***
DM	9.33 (0.31)	15.00 (0.06)*	13.23 (0.10)	14.69 (0.06)*		9.03 (0.34)	4.92 (0.77)	3.47 (0.90)	28.88 (0.00)***	19.72 (0.01)**	11.20 (0.19)	13.87 (0.08)*	12.33 (0.14)
Gondar	9.49 (0.30)	2.81 (0.94)	8.72 (0.36)	14.72 (0.06)*	6.51 (0.59)		9.00 (0.34)	6.85 (0.55)	8.67 (0.37)	8.70 (0.37)	8.75 (0.36)	15.77 (0.04)**	18.51 (0.02)**
Hosaena	12.32 (0.14)	8.53 (0.38)	6.73 (0.56)	8.04 (0.43)	10.25 (0.25)	9.55 (0.30)		4.40 (0.82)	5.74 (0.67)	21.64 (0.00)***	14.93 (0.06)*	20.82 (0.00)***	23.00 (0.00)**
Jimma	6.28 (0.61)	8.04 (0.43)	4.27 (0.83)	2.16 (0.98)	2.28 (0.97)	5.43 (0.71)	3.87 (0.87)		14.00 (0.08)*	5.93 (0.65)	7.38 (0.49)	10.72 (0.22)	6.06 (0.64)
Nazareth	11.05 (0.20)	7.09 (0.53)	9.36 (0.31)	6.27 (0.62)	7.62 (0.47)	5.53 (0.70)	7.31 (0.50)	4.19 (0.84)		21.74 (0.00)***	21.75 (0.00)***	5.62 (0.69)	19.69 (0.01)**
Nekemete	9.79 (0.28)	12.36 (0.14)	3.40 (0.91)	4.33 (0.83)	5.77 (0.67)	9.20 (0.32)	4.47 (0.81)	4.01 (0.86)	6.13 (0.63)		5.06 (0.75)	9.99 (0.26)	10.04 (0.26)
Shashemene	7.73 (0.46)	17.72 (0.02)**	4.52 (0.81)	2.88 (0.94)	4.92 (0.77)	7.24 (0.51)	8.28 (0.41)	2.60 (0.96)	11.90 (0.15)	19.75 (0.01)**		12.68 (0.12)	17.71 (0.02)**
Woliso	4.44 (0.81)	5.63 (0.68)	5.21 (0.73)	2.85 (0.94)	4.86 (0.77)	4.96 (0.76)	5.80 (0.67)	3.41 (0.91)	5.26 (0.73)	5.69 (0.68)	3.65 (0.89)		4.32 (0.83)
Ziway	8.22 (0.41)	7.83 (0.45)	5.86 (0.66)	2.62 (0.96)	4.00 (0.85)	7.94 (0.44)	5.25 (0.73)	4.13 (0.84)	2.54 (0.96)	4.00 (0.86)	3.26 (0.92)	9.63 (0.29)	

Notes: Null hypothesis of non-causality: χ^2 (2) statistics
Probability values in parenthesis; ***, **, * reject the null hypothesis at 1 %, 5 %, and 10 % significance levels
DB and DM stand for the Debre-Birhan and Debre-Markos markets, respectively

4.6.2 Long-run relationships

A set of variables is defined as cointegrated if a linear combination of them is stationary (Brooks, 2008). Cointegrated variables may also be seen as constituting a long-term relationship or equilibrium relationship. This is because market forces, such as the arbitrage process among integrated markets, are expected to bring a price difference to an equilibrium position. Therefore, in cointegrated variables, a short-run deviation from a long-run equilibrium position is possible, but in the long term, arbitrage processes would restore the price difference to an equilibrium position.

Results for the unit root test found that all 15 wholesale maize price series are I (1). Since the price series is non-stationary and integrated of the same order, cointegration analysis is therefore appropriate to investigate the long-run relation among maize market prices. Given the large number of maize markets, cointegration tests are conducted in a pairwise fashion. Following the result of the T-Y causality test, the Addis Ababa maize market is treated as an exogenous maize market.[17] Thus, in the subsequent cointegration and APT analysis, the regional wholesale maize markets are paired with the Addis Ababa maize market. The use of the Addis Ababa maize price as that of a central market is appropriate to this study because with 15 maize markets, there are 105 [$(n^2$-$n)/2$] possible market pairs.

Cointegration among maize market pairs are tested using Johansen's method (Johansen 1991). The results for the cointegrated maize market pairs are presented in Table 4.7 below. Trace and Maximal Eigenvalue test statistics provide no conflicting results. In both cases, the null of zero cointegrating vectors (r = 0) is rejected. However, the hypothesis of more than one cointegrating vector is rejected in both test statistics. The last column in Table 4.7 presents the lag length selected for long-run analysis of market pairs. Optimum lags were chosen using the information criterion (AIC, SBC, and Likelihood Ratio (LR)).

[17] In the context of market integration analysis, a market price is exogenous if it does not respond to changes in other commodity market prices. This market is also called a dominant market. In this case, the price relationship between a central and regional market will form a dominant–satellite price relationship. In the dominant market, price is determined outside of the system (group of markets) that is analysed. However, supply and demand shocks in this market feed through to other markets because of market linkage (Asche *et al*., 2012)..

Table 4.7: Johansen tests between cointegrated wholesale maize market pairs

Markets	Trace Ho	Trace statistic	Max Ho	Max-Eigen statistic	Lags
Addis – Ambo	$r = 0$	29.08***	r=0	29.00***	2
	$r \leq 1$	0.075	r=1	0.075	
Addis – BD*	$r = 0$	23.81***	r=0	20.09**	2
	$r \leq 1$	3.72	r=1	3.72	
Addis – DB*	$r = 0$	19.74***	r=0	19.64***	3
	$r \leq 1$	0.10	r=1	0.10	
Addis – Dese	$r = 0$	25.29***	r=0	25.20***	2
	$r \leq 1$	0.09	r=1	0.09	
Addis – Gondar	$r = 0$	20.38***	r=0	20.37***	2
	$r \leq 1$	0.008	r=1	0.009	
Addis – Jimma	$r = 0$	18.53***	r=0	18.47***	9
	$r \leq 1$	0.06	r=1	0.06	
Addis – Mek'ele	$r = 0$	13.71**	r=0	13.71**	3
	$r \leq 1$	0.003	r=1	0.003	
Addis – Nekemete	$r = 0$	22.44**	r=0	18.87**	8
	$r \leq 1$	3.57	r=1	3.57	
Addis – Woliso	$r = 0$	35.06***	r=0	34.91***	2
	$r \leq 1$	0.15	r=1	0.15	
Addis – Ziway	$r = 0$	27.01***	r=0	26.87***	2
	$r \leq 1$	0.15	r=1	0.15	

Notes: *BD and DB stand for Bahir Dar and Debre-Birhan markets, respectively[18]
***, ** significance levels at 1 and 5 %, respectively

Results from the Johansen cointegration tests show that no cointegration was found between Addis Ababa and the regional maize markets of Debre-Markos, Hosaena, Shashemene, and Nazareth market pairs. Given the proximity of Nazareth and Addis Ababa, the absence of cointegration between these two wholesale maize markets was not expected. The two markets are located within a radius of 86.5 km and are connected with good, all-weather roads. Therefore, transaction costs and costs for acquiring market information are expected to be low. This result may provide evidence that transportation costs and infrastructure facilities might not have that much influence on cointegration between these two adjacent markets. This remark is consistent with the finding of Getnet *et al.* (2005) of a low degree of market integration between the neighbouring Addis Ababa and Ambo markets (119 km). The presence of market segmentation between adjacent maize markets might be attributable to imperfect competition

[18] Cointegration test specifications for maize market pairs are mixed. Some market pairs are estimated with no deterministic trend (no intercept and no trend), while other pairs are estimated with no deterministic trend (intercept and no trend).

in the maize market structure, which further motivates us to investigate the phenomenon of APT in maize market structure in Ethiopia.

Another possible cause for the absence of cointegration between the Nazareth and Addis Ababa maize markets could be the presence of structural breaks, which may lead to misleading inferences being made from the cointegration results. It is widely accepted that the presence of structural breaks distorts the validity of conventional unit root and cointegration tests (Phillips, 1986; Perron, 1989). Therefore, tracing out the presence of breaks in our data series is crucial because of the Ethiopian government's intervention in the domestic grain market to mitigate the high domestic commodity prices of 2008 and 2011. Hence, ignoring a structural break test in a volatile commodity market environment, and with the presence of government intervention in an agricultural market, might falsely lead to non-rejection of the null hypothesis of no-cointegration. The Bai and Perron (1998) breakpoint test is used to analyse the effects of structural breaks on maize markets integration and the results are presented in Table 4.8 below.

The sequential Bai and Perron test results identified 15 breakpoints. Structural breaks were identified in the Gondar, Bahir-Dar, Mek'ele, Hosaena, Debre-Markos, Dese, Nazareth, Nekemete, Shashemene, and Ziway wholesale maize markets. The breakpoints are more pronounced in the Gondar wholesale maize market. In this market, we reject the null hypothesis of 0, 1, 2, 3, and 4 breakpoints, but we fail to reject the tests of 5 versus 4 breakpoints. The 2008 M07, M10, M11, and M12 structural breaks are likely associated with the Ethiopian government's macroeconomic intervention. In March 2008, the government restricted foreign exchange access for private traders. This intervention is expected to hinder private traders' involvement in international grain trade. Because of the restriction, although imports become profitable, traders do not freely get involved in international grain trade to exploit profitable import opportunities. As a result, the domestic grain prices for tradable commodities would drift over the upper threshold Import Parity Price (IPP). For instance, between June and July 2008, the domestic wheat grain price exceeded the IPP by USD200 (Rashid and Minot, 2010). Through substitution effects between maize and wheat, this might have contributed to the domestic maize price surge.

Table 4.8: Bai-Perron test results and break dates for regional markets with Addis Ababa's wholesale maize market

Markets	Gondar	BD	Mek'ele	Hosaena	DM	Dese	Nazareth	Nekemete	Shashemene	Ziway	Critical value
Tests	**Scaled F-statistics**										
sup-F(1|0)	41.49**	35.15**	14.09**	27.51**	27.03**	19.97**	45.19**	13.77**	52.37**	21.58**	11.47
sup-F(2|1)	41.32**	37.48**	22.41**	32.29**	10.32	9.23	7.80	10.47	9.89	5.39	12.95
sup-F(3|2)	32.11**	21.19**	17.11**	8.84							14.03
sup-F(4|3)	17.91**	3.38	14.39								14.85
sup-F(5|4)	0.00										15.29
Break dates	2007M01, 2008M11, 2012M01, 2014M07	2008M11, 2011M11, 2014M06	2008M11, 2012M01, 2014M05	2008M10, 2011M05	2012M12	2008M07	2008M12	2009M11	2013M01	2012M05	

Notes: BD and DM stand for Bahir Dar and Debre-Markos markets, respectively
** denotes rejection of the null hypothesis at 5 % significance level

In general, the results from the Bai and Perron test reveal that the presence of structural breaks is evident in maize market prices and that they might have an impact on cointegration tests. Therefore, it is important to retest cointegration among the maize markets by considering the effects of structural breaks. Following Rafailidis and Katrakilidis (2014), we estimated the Dynamic Ordinary Least Square approach (DOLS) to investigate cointegration tests by incorporating the identified structural breaks in the form of dummy variables. The results obtained using DOLS presented mixed results with the above-mentioned conventional Johansen's cointegration test. Indeed, the conclusion for the cointegration tests altered when breakpoints were considered in the analysis. The results from the cointegration test with structural breaks found that long-run relationships held, even when the effects of structural breaks are considered (see Appendix Tables A.1-A.3). However, analysing cointegration by taking into account breaks gives a different story for those maize markets considered as non-cointegrated in the Johansen's approach (Tables 4.9 and 4.10 below). Those regional maize markets (Shashemene, Nazareth, Debre-Markos, and Hosaena) found to have no-cointegration with Addis Ababa maize market became cointegrated when structural breaks were taken into account.

Table 4.9: DOLS estimation for Hosaena and Debre-Markos maize markets

Hosaena & Addis Ababa market pairs		
Variables	**Coefficients**	**t-Statistic**
Panel A. Long-run equilibrium results from DOLS		
ADDIS_ABABA	1.147***	44.531
Constant	-21.608**	-2.208
HOS08	-87.857*	-1.753
HOS11	62.917	1.339
Adj. R^2	0.949	
Panel B: Cointegration test for the market pairs		
U_t = -2.25**		
Debre-Markos & Addis Ababa market pairs		
Panel A. Long run equilibrium results from DOLS		
ADDIS_ABABA	1.146***	24.285
Constant	-35.641**	-1.989
DM12	46.975	0.549
Adj. R^2	0.941	
Panel B: Cointegration test for the market pairs		
U_t = -2.79***		

Notes: Leads and lags specifications are based on AIC criterion
U_t is the innovation series obtained by the dynamic ordinary least squares cointegration equation.
***, **, * denote rejection of the null hypothesis at 1 %, 5 %, and 10 % significance levels, respectively

Table 4.105: DOLS estimation for Nazareth and Shashemene maize markets

Variables	Coefficients	t-Statistic
Nazareth & Addis Ababa market pairs		
Panel A. Long run equilibrium results from DOLS		
ADDIS_ABABA	1.062***	33.781
Constant	-18.435	-1.532
NAZ08	40.479	0.684
Adj. R^2	0.95	
Panel B: Cointegration test for the market pairs		
U_t = -2.47**		
Shashemene & Addis Ababa market pairs		
Panel A. Long run equilibrium results from DOLS		
ADDIS_ABABA	1.109***	23.843
Constant	-29.214	-1.652
SHASH13	159.755*	1.893
Adj. R^2	0.916	
Panel B: Cointegration test for the market pairs		
U_t = -2.74**		

Notes: Leads and lags specifications are based on AIC criterion
U_t is the innovation series obtained by the dynamic ordinary least squares cointegration equation.
***, **, * denote rejection of the null hypothesis at 1 %, 5 %, and 10 % significance levels, respectively

In summary, the results from the Johansen tests indicate that out of 14 maize market pairs, a long-run relationship is confirmed in 10 market pairs. Nevertheless, the conclusions for the cointegration tests altered when breakpoints were considered in the analysis. When structural breaks were considered, all regional maize market pairs became cointegrated with the central maize market. Hence, in these cointegrated market pairs, maize prices could wander in the short run, but in the long run, maize prices will converge to the equilibrium position. This means that an Error Correction Model (ECM) can be estimated, as there is a linear combination of these market price pairs that would be stationary. In this case, the ECM would be the appropriate model to use to investigate the short-run and long-run relationships among the cointegrated maize market pairs. Therefore, in the subsequent discussion, an Asymmetric Error Correction approach, based on Equation (4.7) above, is estimated in order to examine the dynamics of maize prices and to test for the presence of asymmetric price adjustment.

4.6.3 Asymmetric Price Transmission

In this section, we discuss the findings from AECM obtained by segmenting the speed of adjustment for previous year disequilibria into positive and negative components. Estimates of AECM for regional maize markets as dependent variables are presented in Table 4.11 below. The results from Table 4.11 show that the contemporaneous changes in coefficients are significant at 1 per cent and less than one in all regional maize market equations. This implies that the regional wholesale maize markets do not respond fully within one month to the Addis Ababa wholesale price changes, and that monthly data is frequent enough for investigating the dynamics of maize price transmission. The results further demonstrate that out of 14 maize market pairs with the central Addis Ababa market, APT is confirmed in only two wholesale maize markets, those of Mek'ele and Nekemete. Contrary to our expectations, negative asymmetric price adjustment exhibits in both the Mek'ele and Nekemete wholesale maize markets. Since ECT_{t-1}^{+} indicates that regional wholesale maize prices are higher than the central Addis Ababa price, i.e. the margin is higher, compared with the long-run equilibrium value. In these markets, therefore, wholesalers respond more rapidly when the margin is stretched than when it is squeezed. In the Mek'ele market, wholesalers do not correct the negative price difference from previous year disequilibria, probably because through fear of losing market share.

Our AECM results are in line with the findings of Wondemu (2015) who found that there was no APT in the Dire-Dawa and Mek'ele maize market price adjustments to the central Addis Ababa wholesale maize market price shocks. However, this is in sharp contrast with many empirical price transmission analyses conducted on African food markets, which show that price increases are corrected and transmitted more quickly and fully than price decreases (positive APT) are (Abdulai, 2000; Cutts and Kirsten, 2006; Alemu and Ogundeji, 2010; Acquah and Dadzi, 2010; Acosta, 2012; Yeboah, 2012; Fiamohe *et al*., 2013; Ngare *et al*., 2013). The absence of positive asymmetric price adjustment in the maize market is good news for consumers.[19] Several factors may contribute to the absence of asymmetric price adjustment in wholesale maize market in Ethiopia. The active presence of the EGTE in the maize market may contribute to symmetric price transmission in the maize market in Ethiopia. The EGTE is

[19] This remark is based on the assumption that regional wholesalers supply maize grain directly to consumers. However, if wholesalers supply maize to retailers, the conclusion might change, depending on the nature of price transmission between retailers and consumers.

the only parastatal organisation involving in the procurement of maize from farmers, for three purposes: the national food reserve, school feeding, and the Productive Safety Net Programme (PSNP). In addition to these activities, the enterprise is also involved in maize price stabilisation. As stated earlier, in response to a maize price plunge, EGTE procured 180 000 tons from farmers, and exported about 11 000 tons of maize in 2002.

Besides the EGTE, other non-governmental organisations such as the World Food Programme (WFP) are also involved in the maize market in Ethiopia. The recent launch of the Purchase for Progress Program (P4P) and purchase from Africans to African (PAA) programmes of the WFP ought to play an important role in maize price determination by linking producers to output markets. Both programmes have targeted local procurement of white maize commodity from farmers for humanitarian assistance to other neighbouring countries. From 2010 to 2013, the P4P of the WFP purchased 26 212 tons of maize and beans, generating nearly USD8 million for Ethiopian smallholders. Close to 600 000 maize farmers, excluding large-scale maize traders, have benefited from the programme (Nogales and Fonseca, 2014). In general, these initiatives may contribute to stiff competition in wholesale maize markets. Hence, the active participation of these organisations in the maize market is expected to improve the competitive structure of the maize market in Ethiopia.

In summary, from the analysis of APT, we would conclude that asymmetric price adjustment has not contributed to the recent maize price surge in Ethiopia. Although further research is needed on this issue, the surge could partly be explained by the Ethiopian government's interventions in the grain market through the macroeconomic intervention of imposing foreign exchange restrictions and direct involvement in grain imports.

Table 4.11: Estimates of Asymmetric error correction for regional maize markets, July 2004 to March 2016

Coefficients	Regional maize markets (dependent variable)													
	Nazareth	**Dese**	**Jimma**	**Ambo**	**Mek'ele**	**DM**	**Ziway**	**Shashemene**	**Woliso**	**Hosaena**	**Nekemete**	**DB**	**BD**	**Gondar**
Constant	-3.421	1.278	6.229	0.284	11.06**	-2.907	0.748	-3.204	1.033	0.959	**6.794***	1.153	2.167	2.612
D(Addis)	**0.782*** **	**0.764*** **	**0.936*** **	**0.659*** **	**0.626*** **	**0.641*** **	**0.630*** **	**0.668*** **	**0.785*** **	**0.569*** **	**0.469*** **	**0.752*** **	**0.375*** **	**0.381*** **
ECT_{t-1}^{+}	**0.069**	**-0.39*** **	**-0.75*** **	**-0.66*** **	**-0.542*** **	**-0.161** **	**-0.53*** **	**-0.231** **	**-0.63*** **	**-0.717*** **	**-0.709*** **	**-0.42*** **	**-0.30*** **	**-0.219*** **
ECT_{t-1}^{-}	**-0.249***	**-0.381** **	**-0.423***	**-0.71*** **	**0.029**	**-0.359*** **	**-0.53*** **	**-0.407*** **	**-0.56*** **	**-0.775*** **	**-0.330** **	**-0.43*** **	**-0.275** **	**-0.263** **
P_{t-1}^{d}	**-0.390*** **	-0.160	-0.028	0.120	**-0.216** **	-0.103	**0.353*** **	**0.253*** **	**0.207** **	-0.051				
P_{t-2}^{d}	**-0.320** **	0.075	-0.077	-0.003	**-0.249*** **	0.142	-0.116	**-0.218** **						
P_{t-3}^{d}	**-0.499*** **	-0.072	-0.148	**0.206** **										
P_{t-4}^{d}	**-0.442*** **	-0.175	0.060	-0.055										
P_{t-5}^{d}	-0.080	-0.140	0.004											
P_{t-6}^{d}	**-0.375*** **	0.164	0.113											
P_{t-1}^{Addis}	**0.506*** **	0.103	-0.078	-0.108	0.049	0.024	-0.091	-0.044	-0.181	0.142				
P_{t-2}^{Addis}	**0.386*** **	0.013	-0.033	-0.090	0.232**	0.021	-0.022	0.088						
P_{t-3}^{Addis}	**0.313** **	0.045	-0.022	-0.080										
P_{t-4}^{Addis}	**0.348*** **	0.129	-0.041	-0.018										
P_{t-5}^{Addis}	0.128	-0.098	-0.285											
P_{t-6}^{Addis}	0.087	0.034	0.209											
Adj. R^2	0.569	0.425	0.463	0.468	0.415	0.505	0.389	0.454	0.456	0.490	0.502	0.426	0.297	0.363
LM test	0.279	0.246	0.249	0.516	0.290	0.113	0.881	0.379	0.254	0.221	0.718	0.556	0.803	0.599
Wald test of H_O: ECT_{t-1}^{+}= ECT_{t-1}^{-}	2.700	0.003	0.139	0.069	**7.173*** **	1.754	0.0003	1.203	0.117	0.083	**2.886***	0.0003	0.843	0.129

Notes: P_{t-k}^{d} represents lag length of the dependent regional maize markets; Lag length is selected using AIC and SBC criteria.
The Breusch-Godfrey (1978) (LM) test for higher-order serial correlation rejected the presence of autocorrelation in all equations. The values reported in the LM test are the probability values where the test failed to reject the null hypothesis of no serial correlation in the individual maize equations.
In the interest of space, the dummy variables that accounted for structural breaks in Bahir Dar, Dese, Gondar, Hosaena, Debre-Markos, Mek'ele, Nazareth, Nekemete, Shashemene, and Ziway equations are not reported; DM, DB, and BD stand for the Debre-Markos, Debre-Birhan and Bahir Dar markets, respectively
***, **, * denote rejection of the null hypothesis at 1 %, 5 %, and 10 % significance level, respectively.

4.7 CHAPTER SUMMARY

By overlooking the important role of grain traders in providing marketing services to smallholder farmers and in grain price stabilisation, policy makers have since 2008 consistently blamed traders for the persistence of soaring food prices in Ethiopia. This perception of policy decision makers has also been shared by consumers. This resulted in a new policy in food market regulation and direct government intervention in commercial grain imports for selected crops. Motivated by the coexistence of soaring food prices and high domestic food production, this chapter investigates the performance of white maize wholesale grain markets in Ethiopia during the post-agricultural market liberalisation period from July 2004 to March 2016. We tested the presence of APT between integrated wholesale regional maize markets by taking into account structural breaks. Findings from the cointegration tests indicate that 10 out of 14 maize market pairs confirm long-run relationships. Nevertheless, the conclusions of the cointegration tests altered when the breakpoints were considered in the analysis. When structural breaks are considered in the price series, all regional maize market pairs became cointegrated with the central Addis Ababa wholesale maize market. The cointegration of all the maize market pairs considered in this study is a reflection of better spatial maize market linkages experienced in Ethiopia after the introduction of the Structural Adjustment Program (SAP). Not only has spatial maize market integration improved, but the complete pass-through of price signals has also improved substantially, with no evidence of positive APT in the regional wholesale maize markets in Ethiopia.

Despite the widely held belief by consumers and government that traders' inappropriate price adjustment contributes to the persistence of soaring food prices in Ethiopia, we found no evidence to support this argument. Instead, wholesale maize traders tend to adjust homogenously to increase and decrease in accordance with maize price deviations from the central Addis Ababa maize market. Surprisingly, the regional wholesale maize markets of Mek'ele and Nekemete adjust their prices more quickly for decreases in prices stemming from the central Addis Ababa wholesale maize market than for increases in prices. Our findings are in sharp contrast with the findings of several other studies conducted in Southern, Western and Eastern Africa major food commodity markets (Abdulai, 2000; Cutts and Kirsten, 2006; Alemu and Ogundeji, 2010; Acquah and Dadzi, 2010; Acosta, 2012; Yeboah, 2012; Fiamohe *et al*., 2013; Ngare *et al*., 2013) which revealed that marketing intermediaries respond more quickly when their marketing margin is squeezed, rather than when they are stretched. The active presence of the EGTE and the involvement of non-governmental organisations such as the WFP in domestic maize markets may contribute to the absence of asymmetric price adjustment in the wholesale maize market in Ethiopia. The government state trading enterprise, the EGTE, interventions in the domestic maize market as a facilitator for the maize market through occasional buying and selling in times of soaring food prices and bumper harvests, is expected to improve the maize market structure. Furthermore, the involvement of other agencies such as the WFP in maize procurement from farmers has enabled farmers to organise themselves in group marketing. Group marketing can eliminate the possible exploitation of uninformed smallholder farmers by marketing intermediaries (Pokhrel and Thapa, 2007). We believe that these interventions have brought about healthy competition in the wholesale maize market in Ethiopia.

It should be noted that the improvements in spatial maize market integration have been achieved with strong government commitment to improve the rural road infrastructure. The progress in road development has been encouraging, and the development of especially asphalt and rural roads has increased remarkably over the past 14 years. The length of rural roads jumped from 16 480 km in 2000 to 30 641 km by 2014. The quality of existing roads also matters by influencing grain movement and transaction costs. As far as road quality is concerned, about 55 per cent of the rural roads were in good condition in 2014 (ERA, 2015). It is widely believed that such expansion in rural road infrastructure development would contribute to the timely mobility of agricultural products by reducing transaction costs. It will also increase the number of traders and improve competition among marketing intermediaries in local markets.

It is argued in this study that the recent surge in maize prices in Ethiopia has little to do with APT in maize markets. However, the government's implementation of half-market liberalisation in the agricultural commodity market, through the macroeconomic intervention of foreign exchange restriction to private traders and direct involvement in grain imports, could be blamed for the recent surge in maize prices in Ethiopia.

CHAPTER 5:
THE INFLUENCE OF POLICY INTERVENTION ON PRICE DISCOVERY IN THE ETHIOPIAN MAIZE AND WHEAT MARKETS

5.1 INTRODUCTION

African governments implemented a wide range of policy responses to cushion the impact of the 2007/08 food crisis. The major policy responses included consumer support measures (safety net programmes, reducing tariffs and domestic taxes, and releasing stocks), trade and price control measures (export bans, price controls, and foreign exchange restrictions) (Demeke *et al.*, 2014). However, most of these interventions were the result of panic and even worsened the situation in some African countries such as Malawi and Ethiopia. Minot (2011), in his comprehensive analysis, argued that although Africa is a net importer of rice, wheat, and maize, in most cases, it was African governments' 'fire-fighting' and ill-advised policy interventions that contributed more to the food price spikes of 2008, rather than the price shocks from international market did. Therefore, it is essential to have effective policy instruments in place in order to counteract any adverse price shocks stemming from international commodity markets.

The nature and extent of spatial grain price transmission has become an important policy issue in Ethiopia. There are two reasons for these, namely the status of market fundamentals such as road infrastructure and marketing institutions, and the fact that information communication services are at infant stages in Ethiopia. This has major implications for the reallocation of food production from surplus to consumption areas. Secondly, Ethiopia is a net importer of wheat. As a result, the domestic wheat price is expected to be impacted by world food price developments.

Following soaring world commodity prices, Ethiopia experienced the highest food price inflation in 2008. In response, the government of Ethiopia pursued a wide range of policy interventions to insulate the domestic market from international price shocks, and to stabilise domestic commodity prices. Major counter measures included the restriction of foreign exchange for private traders, an export ban of major food crops, and the state marketing parastatal involvement in commercial grain imports and distribution. However, the frequent and unpredictable Ethiopian government interventions in the grain market since 2008 have been blamed for creating mistrust between private sectors and government. The Ethiopian government often argues that private sector imports and trade are not sufficiently developed to undertake necessary imports in a timely manner, leading to severe price spikes in the domestic grain market. On the other hand, private traders are complaining of a lack of a level playing field for playing an effective role in grain price stabilisation in Ethiopia. In the domestic grain market, private traders are constrained to perform effective inter-temporal arbitrage operations because of subsidised wheat distribution, which is way below the market price. Similarly, in the international trade, the government is limiting the spatial arbitrage activities of private sector by imposing foreign exchange rationing and export bans on staple food crops.

Many experts believe that the Ethiopian government's policy of foreign exchange rationing, coupled with unannounced and sudden imports through its parastatal, the EGTE, have created excessive speculation and uncertainty in the domestic grain market (Dorosh and Ahmed, 2009; Admassie, 2013). This uncertainty in the grain market is expected to restrain traders from participating in the international market, even where there is an unexploited profitable import opportunity. This, in turn, creates disincentives for the private sector to play an effective role in grain imports, thus leading to inappropriate price transmission.

This chapter investigates how the Ethiopian government has responded to the food price crisis of 2007/08 and 2010, and the effect of government intervention on maize and wheat spatial equilibrium price relationships. Understanding the effectiveness of trade policy reforms on spatial grain markets is useful for assessing the impact of government intervention on the performance of grain markets in Ethiopia. This, in turn, will help to guide subsequent interventions aimed at improving the performance of the agricultural commodity market.

5.2 THE RATIONALE FOR GOVERNMENT INTERVENTION: EVIDENCE FROM AFRICAN COMMODITY MARKETS

Africa mainly satisfies the domestic consumption of tradable commodities through imports from the international markets. Imports account for a large share of the supply of wheat (70 per cent), rice (43 per cent), and cooking oil (49 per cent) in Africa. Nevertheless, regional cross-border trade within Africa serves as the main source of maize imports for many African countries; imports account only 8 per cent of the African maize supply, 2 per cent of the sorghum supply, and 5 per cent of the supply of pulses (FAO, 2010, cited in Minot, 2014). In an open economy, the price formation of tradable commodities is largely determined by international markets, while price formation for non-tradable commodities is determined by domestic supply and demand interactions.

Price stabilisation and food security are major priorities for many African countries. This is not surprising, given the fact that the majority of households spend much of their expenditure on food items. As a result, the power of many African governments has been threatened by the instability of food prices and their inability to provide adequate food security for the poor. Under these conditions, a government have no option other than intervening in the domestic grain market. In many countries, governments take on the responsibility of mitigating food price instability risks (Smith, 1997). However, a challenging question concerns how government intervention reconciles with other stakeholders' interests, especially those in the private sector.

There are several compelling reasons, even in a well-developed private sector, for a government to bring adequate stability to the grain market. One form of government intervention in food price stabilisation is for poverty alleviation and income distribution purposes, which is beyond the responsibility of the private sector. Further justification for government intervention is seen when private sectors become reluctant to take risks in the absence of risk smoothing institutions. The private sector is unwilling to conduct spatial and inter-temporal arbitrage operations when the extent of instability in production results in prices becoming unpredictable (Smith, 1997). In these circumstances, government can step up to fill the gap left by the private sector. Broadly speaking, the presence of market failures, such as inadequate infrastructure, incomplete credit and insurance markets, and information asymmetry, are the causes for government intervention in food markets (Byerlee *et al*., 2006; Rashid and Negassa, 2011).

Africa's vulnerability to high food prices in international food markets was clearly evidenced by the recent global food market crisis of 2007/08. Following the global food price crisis of 2007/08, staple food market prices in Africa rose by 65 per cent, although there were considerable variations across countries. For example, food price increases were moderate (25–39 per cent) in South Africa, Ghana, and Cameroon. On the other hand, they were extreme in Ethiopia and Malawi (> 150 per cent)[20] (Minot, 2011). African governments implemented different policies to counteract the soaring food prices of 2008. A review of the cereal policy responses of 17 African countries is presented in Table 5.1 below. As illustrated in Table 5.1, consumer-support measures such as reduction in tariffs and VAT were the major policy responses during the crisis period (Dec 2007–Oct 2008). From the survey of the 17 countries, it is noted that 10 countries (59 per cent) implemented these interventions. Reductions in tariffs and VAT have also dominated the grain policy responses of African countries after the crisis period. All of the countries have used these interventions after the crisis period (Oct 2008–Jan 2017). Price interventions in staple commodities were implemented by 3 countries during the crisis, and by 13 countries after the crisis. Export bans were imposed by 3 countries (18 per cent) and 7 countries (41 per cent) during and after the crisis period, respectively. Zambia recently lifted its export ban on maize and maize products. Government domestic procurement and stock releases were implemented by 4 countries (24 per cent) and by 11 countries (65 per cent) before and after the crisis period, respectively.

Many experts believe that the policy responses of African governments to food crises have targeted consumers' protection at the expense of private sector investment in market and value chain development (Minot, 2011, 2014; Demeke *et al*., 2014). Policy measures, such as unexpected changes in import tariffs and stock policies, price controls, restriction of private grain trade, export bans, and foreign exchange controls, can discourage private investment in storage and marketing facilities. For instance, Kenya, Malawi, Ethiopia, and Zambia have allowed government marketing parastatals to control import and domestic buying and selling decisions to stabilise maize and wheat prices. These interventions are expected to inhibit

[20] We left Zimbabwe out because the country has been experiencing hyperinflation associated with social and political turmoil.

private traders from actively stabilising grain prices, which might otherwise reduce food insecurity through spatial arbitrage and inter-temporal arbitrage operations. This ultimately leads to severe price spikes in domestic food markets. The empirical findings by Minot (2014) supported the above assertion. Compared with other African countries that intervened less in their domestic markets, Kenya, Malawi, Zambia, and Ethiopia experienced soaring grain prices during 2008–2010.

There are only a few countries in Africa that have made policy reform a long-term market development strategy by implementing market-based risk management strategies. For instance, from the survey countries, Ghana is the only country that has started policy implementation in risk management strategies. It has been well documented that market-based intervention is the most advisable instrument for sustainably managing food price risks. Market-based approaches have a number of advantages over direct price stabilisation schemes (Larson *et al*., 2004). Firstly, participation is generally voluntary. Therefore, people participate only at a level that suits their particular situation (Byerlee *et al*., 2006). Secondly, the welfare gains to individuals using market-based risk management strategies may be substantial, particularly when risks are high (Anderson, 2001). Thirdly, unlike direct food price stabilisation intervention, market-based interventions reduce fiscal costs and contribute to macroeconomic stability. Finally, the most important advantage of market-based instruments is that they encourage the involvement of private sectors in the food system (Byerlee *et al*., 2006).

Table 5.1: Policy decisions on cereal commodities from selected African countries

Country	Before crisis (Dec 2007 – Oct 2008)				After crisis (Nov 2008 – Jan 2017)				
	Export ban	Tariff	Price controls	Strategic reserve	Export ban		Tariff	Price control	Strategic reserve*
	Imposed	Decreased			Imposed	Lifted	Decreased		
Burkina Faso		√	√	√			√	√	√
Burundi		√ 2008					√ 2010		
Cameroon		√ 03/2008					√	√ 2010	
Chad				√ 06/2008			√ 2009	√ 2010	√ 2009
Djibouti		√	√				√2009		
Egypt	√ 03/2008				√ 2015		√ 2009	√	√
Ethiopia	√	√		√	√		√	√	√
Ghana		√ 05/2008					√	√	√
Kenya	√	√	√				√	√	√
Malawi		√			√ 12/2011		√	√	√
Mozambique							√	√	
Nigeria		√					√	√	√
Rwanda							√	√	√
Tanzania	√	√		√	√ 05/2011		√	√	
Uganda					√ 08/2009		√		
Zambia					√ 02/2016	√ 04/2016	√	√	√
Zimbabwe					√ 02/2009		√	√	√

Notes: *Strategic reserve includes government domestic procurement from farmers, imports, and stock release
Source: Adapted from Demeke *et al*. (2014) with the author's modification from FAPDA data (2017)

5.3 POLICY RESPONSES TO HIGH FOOD PRICES IN ETHIOPIA

In this section, we discuss the major policy responses of the Ethiopian government to the soaring food price inflation of 2008. As discussed above, the Ethiopian government implemented various types of policy responses in order to tame the soaring food prices. These interventions and their potential impacts on domestic grain market prices are explained in detail below. Descriptions of the major policy decisions are presented in Table 5.4 below.

5.3.1 Commercial grain imports

After the reform of market liberalisation in March 1990, private traders became main actors in domestic and international grain trade in Ethiopia. The government's share in the domestic cereal markets fell from around 40 per cent in the 1980s to about 4 per cent by the end of the 1990s, and to less than 2 per cent from 2001 to 2007. More importantly, the government did not engage in any large-scale imports of cereals after the launch of the market liberalisation programme. However, in response to the high food price inflation of 2008, the Ethiopian government implemented various policy instruments to manage high price risks. Once again, the country's food logistic agency, the EGTE, has become a dominant actor in Ethiopia's cereal market (Rashid and Minot, 2010).

Since 2008, the EGTE has focused its intervention mainly on domestic cereal price stability. One of the intervention mechanisms has been wheat importation and distribution. This is not surprising, given the mismatch between domestic wheat demand and supply. For instance, flour mill factories annually demand about 2.5 to 3.5 million MT. However, the total domestic wheat production is around 3 million MT. Out of 3 million MT, only 20 per cent of wheat production is marketed. The rest is retained for seed (17 per cent) and household consumption (57 per cent). Because of this mismatch, Ethiopia has become a net importer of wheat. Until 2008, private traders filled the shortfalls through imports, mainly from the Black Sea areas such as Ukraine, Russia, Bulgaria, and Romania. However, following the foreign exchange rationing to private traders, the Ethiopian government has ordered the EGTE to become involved in wheat importation and distribution. Since 2008, the EGTE has imported more than 4 million tons of wheat (Table 5.2 below). From a discussion held with an expert,[21] Ethiopia imported more than 2 million MT of wheat in 2016 to mitigate the humanitarian crisis posed by El Nino. The EGTE imported 1 million MT, while the remainder 1 million MT was imported by the Disaster Prevention and Preparedness Agency (DPPA).

Table 5.2: Wheat imports and price subsidies

Year	Imported ('000 mt)	CIF_Djibouti ($/t)	Sales per quintal (ETB)	Market price (ETB/quintal)	Price support ($/ton)
2008	311.1	396.5	350.0	534.9	177
2009	227.6	259.3	370.0	569.7	155
2010	304.6	259.3	381.6	479.2	61
2011	258.0	252.8	503.3	720.0	125
2012	320.7	313.7	543.6	701.4	86
2013	298.5	292.8	545.9	758.9	112
2014	420.0	369.8	545.1	926.7	190
2015	389.6	294.3	550.0	1004.6	220
2016	1000.0	295.8	550.0	1054.0	232

Source: EGTE (2016)

The EGTE re-started the urban food-rationing programme in 2008, which continued in 2009 and 2010. The aim of this scheme was to provide food at a subsidised price to vulnerable urban consumers. The price support ranges from 61–232USD per ton (Table 5.2 above). Each household received 50 kg of wheat grain at a subsidised market price, which, however, changed at a later stage. The EGTE has started to distribute imported wheat at subsidised prices to wheat flour mill factories. Currently, about 300 small- and large-scale wheat flour mill factories in Ethiopia are benefiting from this programme. The EGTE distributed wheat at a constant subsidised price of 550 ETB/100 kg, while the market price was 1054 ETB/100 kg. Not all flour mill factories are benefiting from this scheme. Only those flour mill factories linked vertically to bread bakeries are benefiting from the subsidised wheat distribution. The other flour mill factories meet their wheat demand by procuring from large-scale traders, farmer unions, and commercial farms. Wheat flour mill factories that benefit from such subsidy agree

[21] Discussion with Mr Geberegziabher, the planning and marketing development directorate director of the EGTE, October 18, 2016.

to distribute wheat flour to bread bakeries at a fixed price, set by the government. Likewise, bread bakeries also agree to maintain the quality, weight and fixed selling price to consumers. In this way, all actors across the wheat value chain benefit from the programme. It is clear that private wheat flour millers and consumers are the main beneficiaries from the subsidised wheat distribution.

Table 5.3: Breakdown of wheat imports by type, (2001-2015)

Year	Durum wheat		Wheat & meslin		Total		From total import (mil.mt)	
	Qty(t)	Value	Qty(t)	Value	Qty (mil.mt)	Value	Food aid	Commercial
2001	310 879	48	762 671	136	1.07	184	0.65	0.42
2002	214 752	53	437 186	107	0.65	160	0.35	0.30
2003	875 947	189	1 603 103	363	2.48	552	1.39	1.09
2004	412 934	120	575 020	177	0.99	297	0.42	0.56
2005	730 539	187	862 146	225	1.59	412	0.88	0.71
2006	179 751	44	328 306	84	0.51	128	0.32	0.18
2007	198 888	58	384 128	134	0.58	192	0.39	0.20
2008	818 377	338	1 100 050	465	1.92	803	0.64	1.28
2009	803 771	220	1 111 522	322	1.92	542	0.92	0.99
2010	887 058	252	1 048 706	304	1.94	556	0.78	1.15
2011	602 011	224	1 078 302	403	1.68	627	0.59	1.09
2012	511 959	188	1 011 388	333	1.52	521	0.66	0.86
2013	510 240	212	1 393 265	528	1.90	739	0.18	1.72
2014	-	-	892, 384	339	0.89	339	0.18	0.71
2015	-	-	1 258 962	433	1.26	433	0.07	1.19

Source: Author's calculation from UN Comtrade & FAO database; trade value in USD million

The Ethiopian government is losing precious foreign exchange earnings by diverting money from other development activities to subsidised wheat imports and distribution. For instance, as compared with 2007, the total wheat import bills of the country rose by 318 per cent in 2008. In monetary value, the import expense increased from USD192 million to USD803 million (Table 5.3 above). Apart from the foreign exchange restriction, there are no new rules put in place to limit private traders' involvement in wheat imports. However, the participation of traders in wheat imports is expected to be affected by the recent heavy and unpredictable public intervention in the grain market.

5.3.2 Export ban

Besides wheat importation, the Ethiopian government has in addition imposed an export ban on major tradable crops, including maize. From a food security perspective, the ban is expected to improve domestic maize consumption. However, the export ban may also create a disincentive for production if domestic maize prices decline below the floor price of the EPP. Since maize is a major staple crop in Ethiopia, any maize price instability in the domestic market is expected to have an adverse effect on other domestic tradable and non-tradable commodities (Getnet, 2009; Rashid, 2011).

Nevertheless, the export ban may also distort maize food availability and food security in the eastern Africa region. Maize is the major staple crop consumed and traded in the region. It is the second most-traded commodity, next to sesame, in the east African cross-border area.[22] Owing to low yields, recurrent wars, and drought, several eastern Africa countries have relied on cross-border maize trade to fill their shortfalls. For instance, countries such as South Sudan, Kenya, Rwanda, and Somalia rely on formal and informal cross-border trade to import maize. These regional maize demands have been mainly met by imports from Uganda, Tanzania, and Ethiopia. However, maize production in Tanzania and Uganda does not exceed 3.5 million MT and is not enough to supply the regional demand. For instance, South Sudan alone imported more than 500 thousand tons in 2013 (Dorosh e*t al.*, 2016). Furthermore, Tanzania has tightened up on maize exports to the region, depending on domestic harvest conditions. The only country able to provide a sustainable maize supply to the regional maize market is Ethiopia. The Ethiopian maize market has the potential to supply affordable and quality white maize to eastern Africa countries. Several initiatives for maize exports to eastern Africa maize-deficit countries are being halted by the Ethiopian export ban. The World Food Program (WFP) initiative, the Purchase from Africans for Africans (PAA) programme, planned to procure maize from Ethiopian farmers for export to the rest of the eastern Africa countries. However, the frequent export ban has become the main roadblock to this initiative.

In response to bumper harvests, the government provisionally lifted the export ban on maize in the 2010 and 2014 production seasons. However, the lifting of the export ban was not widely

[22] Maize commodities have constituted about 18 per cent of the cross-border trade in the east Africa region (FEWS NET, 2016).

and repeatedly communicated so as to create confidence for stakeholders to seriously consider maize exports. The only official communication of the government's decision to lift the maize export ban was a letter from Ministry of Trade to Ministry of Agriculture. In the letter, the permission for farmer cooperatives to export was not made clear. However, this was later clarified by the Ministry of Trade to include farmer cooperatives. In late 2015, the maize export ban was imposed again, with the aim of mitigating the effects of El Nino. Yet again, the current export ban was put in place without stakeholder engagement and the decision itself was not communicated adequately, timely, and widely to help market actors plan their planting and marketing decisions.

5.3.3 Foreign exchange rationing

Ethiopia generates foreign exchange from the export of primary agricultural commodities such as coffee and pulse crops. The agricultural export sector is facing challenges of competitiveness and volatile prices in the international market. With foreign exchange reserves nearing zero, and the import demand in excess of supply of foreign exchange in 2008, the Ethiopian government was faced with two options to circumvent the situation;[23] (1) to devalue the domestic currency to reverse the real exchange rate appreciation, thus reducing demand for imports, stimulating the export sector, and restoring equilibrium in foreign exchange market; or (2) to control import by imposing foreign exchange restrictions and allow the exchange rate to remain overvalued. Instead of depreciating the Ethiopian Birr (ETB) to restore the balance between supply and demand for foreign exchange, the government adopted a policy of foreign exchange rationing (Dorosh and Ahmed, 2009).

Foreign exchange rationing is expected to impede traders' involvement in international markets.[24] In the absence of private trade, the speed of price transmission from international to domestic markets diminishes. This in turn creates direct implications for the domestic prices

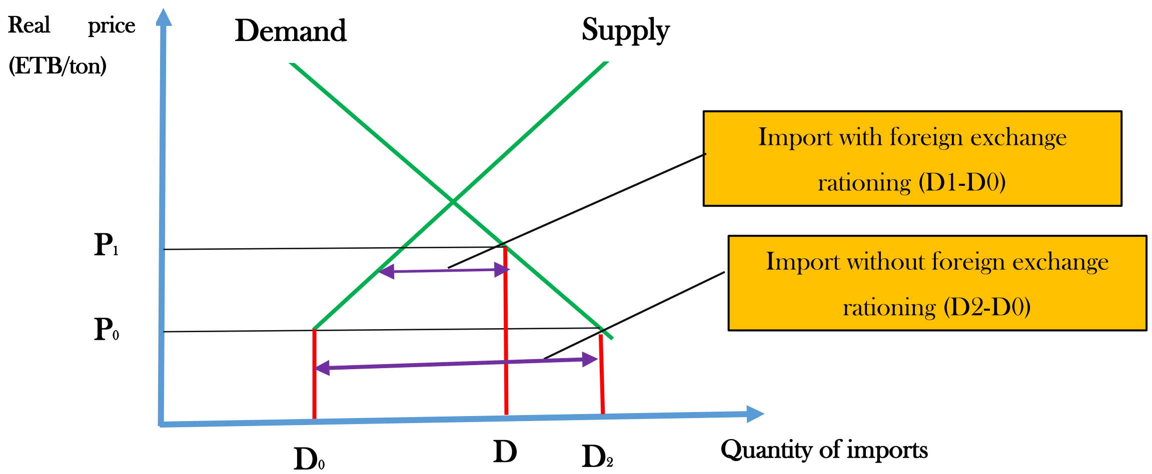
31 Ethiopia had been financing its current deficit through the drawdown of official foreign exchange reserves. From the end of June 2007 to the end of March 2008, foreign exchange reserves fell by USD381 million (equivalent to 13 per cent of the value of merchandise imports in that period). For 2007/08 as a whole, foreign exchange reserves fell by USD264 million (an amount equal to 5 per cent of merchandise imports in 2006/07(Dorosh and Ahmed, 2009).

[24] Foreign exchange rationing is a macroeconomic policy, which is expected to restrain the active participation of traders in international markets. It will have wider economic implications by limiting money movement during travelling abroad, borrowing limitations, remittances, and so on. We are interested in examining the impact of this control on spatial price transmission between domestic and international wheat and maize markets.

of tradable commodities. With foreign exchange restrictions, even though imports might become profitable, traders would not freely get involved in international grain trade to exploit a profitable import opportunity arising from the price discrepancy between the domestic and international grain markets. As a result, the domestic prices of tradable commodities will drift over the upper threshold IPP. Through a substitution effect, this will influence prices of non-tradable commodities in the domestic grain market.

According to Dorosh and Ahmed (2009), the precise effects of foreign exchange rationing on the market for importable goods depend not only on the overall rationing of foreign exchange, but also on the size of the ration of foreign exchange for an importable commodity. Figure 5.1 below demonstrates the effects of foreign exchange restrictions on the domestic prices of tradable commodities. In the absence of foreign exchange restrictions, the import quantity required to meet the domestic demand is D_2 minus D_0. Suppose the foreign exchange rationing limits the participation of traders in international grain trade. As a result, the quantity imported by private traders decreases by D_2 minus D_1. The deficit in imported goods leads to a rise in domestic prices from P_o to P_1. Thus, the restriction of foreign exchange has direct implications for the domestic prices of the tradable commodity.

Figure 5.1: Effects of foreign exchange restrictions on a tradable commodity



Source: Adapted from Dorosh and Ahmed (2009)

Apart from foreign exchange rationing, a limitation has been imposed on the transportation allowance from USD3000 to USD1000. Moreover, in an effort to efficiently utilise the limited foreign exchange, private traders are not allowed to apply for foreign currency for one commodity at more than one bank. The National Bank of Ethiopia (NBE) also issued a new transparency directive in February 2016. The directive is aimed at removing entry barriers for the allocation of foreign currency to private sectors. In this new directive, a foreign exchange request is evaluated on a first-come, first-served basis. From a discussion held with an expert,[25] we also noted that the procedure to get foreign exchange is that applicants from private sectors first have to fulfil the formal procedure and apply to banks. Finally, banks have a discretion to decide on whether to approve the foreign exchange request, depending on the amount allocated for the prioritised sectors.

[25] Discussion was held with Mr Dereje Shewangezaw, trade service management and special outlet of Commercial Bank of Ethiopia, October 28, 2016.

Table 5.4: Major policy reforms in the Ethiopian grain market since 2006

Date/year	Measures	Descriptions
01/12/2006	Export ban	The export of wheat, maize and sorghum was totally banned through the directive issued by the Ministry of Trade and Industry in December 2006.
March 2008	Foreign exchange restrictions	Access to foreign exchange for imports has been rationed to curb excessive drawdowns of foreign exchange reserves.[26]
01/04/2008	Government market intervention	Establishment of the Ethiopian Commodity Exchange (ECX) in order to improve the efficiency, coordination, and integration of the Ethiopian agricultural marketing system, together with reduction of transaction costs and risks.
01/06/2008	Export ban	In June 2008, the ban was extended to all cereals.
01/07/2008	Release of food stock	The Ethiopian government sold about 190 000 tons of wheat from its grain reserve to about 800 000 urban poor.
01/08/2008	Food subsidy	The government imported 150 000 tons of wheat for the state-subsidised distribution scheme, implemented since March 2008.
25/11/2008	Government procurement through imports	A new urban support programme, launched in 2007 and scaled up in 2008, has distributed subsidised grain to poor urban households with the additional aim of mitigating food price inflation. 300 000 tons of wheat were imported and sold in urban areas (the selling price was well below market price).
14/07/2010	Export ban	The government lifted the export ban on cereals, such as maize and sorghum, which was imposed in 2006. The ban came into force because of high grain prices, and was lifted owing to low prices in the domestic market.
2011	Food market regulation	Price caps imposed on 17 basic food items. In June 2011, price caps were lifted for most commodities, aside for some food items like sugar and edible oil.[27]
22/03/2011	Export ban	The government re-imposed the export ban (lifted in 2010) on maize owing to high and volatile domestic prices.
31/10/2015	Wheat imports	In response to the drought-induced food shortages (El Nino), the government significantly increased the country's commercial imports of wheat. At the end of October 2015, one of the biggest import tenders in recent years was launched, seeking 2 million tons of wheat. This figure compares with an average of about 420 000 tons of commercially imported wheat during the last five years, and well above the quantity of about 750 000 tons of wheat imported in 2011 during the latest drought in the Horn of Africa.

Source: Author's compilation from FAPDA data (2017)

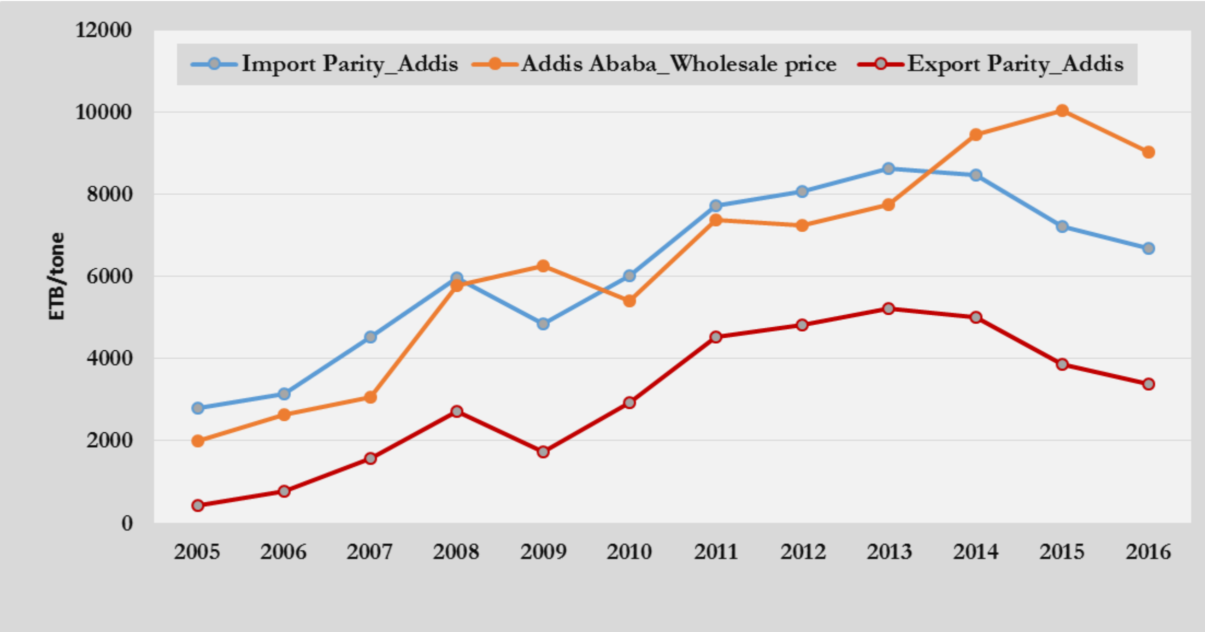
[26] See Rashid and Negassa (2011); Rashid and Lemma (2014).

[27] See Minten *et al*. (2012).

5.4 PARITY PRICE ANALYSIS

The following section illustrates the parity price analysis for wheat commodities. Computing parity prices would allow us to better understand the maize and wheat price structure and the influence of the aforementioned policy responses on the two commodities market prices. The assumptions and calculation of the white maize parity price analysis are discussed in Chapter 6. Here, we only illustrate the parity price analysis for wheat commodities (Figure 5.2 below). The complete cost breakdown and steps followed to estimate wheat IPP and EPP are reported in Appendix Table B2.1.

Figure 5.2: Parity price analysis for wheat, 2005–2016



Note: Import and export parity analyses are calculated using the FOB wheat price at the port of North West Pacific (NWP) region, U.S.
Source: Author's calculation

From the wheat parity price analysis, it can be seen that it was profitable for the private sector to import wheat during 2008 and 2009 (Figure 5.2 above). During 2005–2016, the Ethiopian wheat price, as represented by the Addis Ababa wholesale wheat price, followed two regimes: autarky and import parity regimes. Summaries of these trade regimes, along with possible explanations of regime switching, are discussed below.

From 2005 to 2008 – Autarky trade regime

- Wheat importation was not profitable as the domestic wheat price fluctuated between border prices.
- Domestic wheat price was determined by domestic supply and demand interaction.
- Except for wheat aid, government did not engage in wheat imports from overseas.

From 2008 to the beginning of 2010 – Import Parity Price

- There were incentives for private sectors to get involved in wheat imports.
- The divergence between the domestic wheat price and IPP was higher during 2009.
- Private wheat imports were constrained by foreign exchange rationing.
- The government parastatal agency, the EGTE, started to import wheat.
- The government re-started the urban food rationing programme by distributing the imported wheat to poor urban consumers at subsidised prices.

From 2010 to mid-2013 – Autarky trade regime

- The period was characterised by heavy government intervention in the domestic grain market.
- The government continued distributing subsidised wheat to flour mill factories that are vertically integrated to bakeries. This is expected to curb the upward pressure on the domestic wheat grain price.

From mid-2014 to present – Import Parity Price

- Domestic wheat price has been higher than the upper threshold IPP.
- There are incentives for the private sector to import wheat (of course, if other benefits that have been put in place for the EGTE wheat imports also applied to private importers such as lifting of surtax, withholding, and VAT).
- The gap between domestic wholesale price and IPP is widening.
- Weather-related shocks such as El Nino reduced domestic wheat production by 21 per cent in 2015. According to USDA (2017), domestic wheat production reduced from 4.2 mill MT in 2014 to 3.3 mill MT in 2015. This is followed by heavy government wheat imports to counteract the threat caused by El Nino. According to

expert discussion, Ethiopia imported more than 2 million MT of wheat in 2016 to mitigate the humanitarian crisis posed by El Nino. The expert stressed that the heavy government wheat importation might depress the domestic wheat price. He further reiterated that it has brought uncertainty and speculation into the domestic grain market, which is believed to influence the domestic wheat market price.

5.5 EMPIRICAL FRAMEWORK

Market integration has been analysed using a variety of methods including correlation analysis, regression-based approaches, and Error Correction Models (ECM). Among these alternative approaches, researchers prefer cointegration models as they account for non-stationarity and the dynamic nature of agricultural commodities. In recent years, the threshold autoregressive (TAR) approach has become popular for analysing agricultural commodity market integration. One merit of the TAR model is that it accounts for the effect of transaction costs in market integration. Furthermore, it allows for regime switching price relationships, and examines cointegration under different threshold values. However, this approach has been criticised on two grounds. Firstly, the TAR approach assumes constant transfer costs. Recent studies have attempted to overcome the constant transfer costs assumption by using trade flows as a regime shifter (see, for example, Myers and Jayne, 2011; Ndibongo *et al*. 2010; Yang *et al*., 2015). The use of trade flows, as a regime shifter, is also not free from criticisms. The absence of trade flows or of physical transfers of goods between two spatial markets does not necessarily mean no price integration is present; markets can be integrated through information flows about supply and demand dynamics.

Secondly, the TAR model assumes that price adjustment is only triggered when the price difference exceeds certain threshold values determined by transfer costs (Barrett and Li, 2002). However, government interventions may restrict trade flows and price signal transmissions between spatial markets. Following the global food price crisis of 2008, most governments pursued a wide range of policy instruments to insulate their domestic grain markets from international price shocks. These interventions are thus likely to hinder spatial market integration. Owing to this intervention, economic agents would not freely exploit profitable trade opportunities by transporting commodities from low-price to high-price areas. Therefore, the assumption of transaction costs as being the only trigger for price adjustment can undermine the influence of policy effects on spatial price transmission. It is important to mention here that threshold models rely on the assumption of LOP. LOP works very well in a free market economy in the absence of government intervention. Therefore, whenever there is government intervention, the assumption of a spatial grain market is questionable.

In the Ethiopian context, the state trading enterprise has been importing commercial wheat since 2008. Furthermore, the ability of grain traders to import wheat has been constrained by foreign exchange restrictions. Thus, we might expect spatial equilibrium price relationships to be different when the government is importing, versus when imports are undertaken by the private sector. Therefore, over time, the price transmission relationships could be altered owing to changes in the policy actions. In the presence of government intervention, estimating world-to-domestic spatial price relationships using a conventional full sample cointegration analysis may lead to misleading estimates because of aggregation bias (Myers and Jayne, 2011). This is because standard linear cointegration models such as the VECM are based on the restrictive assumption of linearity. Allowing for policy regime changes may therefore lead to different conclusions (Myers and Jayne, 2011; Yang *et al*., 2015). One option for overcoming the above-mentioned shortcomings of TAR model is to employ a regime-dependent VECM model. This approach is different from the standard VECM model as it accounts for non-linearity in price transmission analysis. In this study, we relax the standard cointegration model to allow for trade policy reforms, and to examine the effects of these policy shifts on spatial market integration between the domestic and international grain markets. To this end, we estimate world-to-domestic wheat and maize spatial market integration using the Johansen and Juselius (1990) cointegration approach with a full sample and sub-sample cointegration analysis. Several studies have employed a sub-sample cointegration approach to examine the impact of agricultural policy reform on food market integration (see, for example, Ismet *et al*., 1998; Gosh, 2011; Barassi and Ghoshray, 2007; Yang *et al*., 2015). The specification for Johansen's cointegration model is presented below.

Let P_t^D be the domestic wheat and maize prices, while P_t^W represents world prices. Suppose these variables are I(1) (integrated of order one) and cointegrated. A VAR with k lags containing these variables can be modelled as follows:

$$P_t = X_1 P_{t-1} + X_2 P_{t-2} + \cdots + X_k P_{t-k} + u_t \quad (5.1)$$

where P_t is a vector of endogenous prices, $P_t = \begin{pmatrix} P_t^D \\ P_t^W \end{pmatrix}$, X's are matrix of unknown coefficients, and u_t are white noise disturbance. A VECM of the above VAR (k) in difference form can be represented as:

$$\Delta P_t = \Pi\, P_{t-k} + \Gamma_1 \Delta\, P_{t-1} + \Gamma_2 \Delta\, P_{t-2} + \ldots\, \Gamma_{k-1} \Delta\, P_{t-(k-1)} + u_t \quad (5.2)$$

where $\Pi = \left(\sum_{i=1}^{k} X_i\right) - I_g$ and $\Gamma_i = \left(\sum_{j=1}^{i} X_j\right) - I_g$

The presence of cointegration between the domestic and international prices is obtained by looking at the rank of the Π matrix. The rank of the Π matrix is equal to the number of non-zero characteristic roots or eigenvalues. We use Trace and Max-Eigen test statistics to test for the presence of cointegration under the Johansen approach. The test statistics are formulated as:

$$\lambda_{trace}\,(r) = -T \sum_{i=r+1}^{g} \ln(1 - \widehat{\lambda_i}), \text{ and}$$
$$\lambda_{max}\,(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$$

where r is the number of cointegrating vectors under the null hypothesis, and $\widehat{\lambda_i}$ is the estimated value for the ith ordered eigenvalue from the matrix. λ_{trace} is a joint test where the null is that the number of cointegrating vectors is less than or equal to r against an unspecified or general alternative that there are more than r. While λ_{max} conducts separate tests on each eigenvalue, and tests the null hypothesis of r number of cointegrating vectors against an alternative of $r + 1$ (Brooks, 2008). Johansen and Juselius (1990) provided the critical values. If the test statistic is greater than the critical value obtained from the Johansen table, reject the null of r cointegrating vectors in favour of the alternative $r + 1$ (λ_{max}) or more than r for (λ_{trace}). The testing is conducted sequentially under the null, $r = 0, 1, \ldots, g - 1$.

In general, if rank (Π) $= 0$, then there is no cointegration between domestic and international commodity prices. In this case, the appropriate model would be a VAR in first difference. If rank (Π) $= n$, then the prices are stationary and we can estimate a VAR in level form; if a rank (Π) $= 1$, the prices are cointegrated, and we can examine the extent and degree of price transmission between the domestic and international maize and wheat prices. This can be done by decomposing the Π as $\Pi = \alpha\beta'$.

The matrix β gives the cointegrating vectors, which indicate how much of a given change in the world price is transmitted to the domestic price in the current period. This term is referred to as short-run adjustment or contemporaneous response. Since the prices are transformed into logarithms, β would be interpreted as the long-run price transmission elasticity between world to domestic commodity prices. The closer β is to one indicates that the world market price changes are transmitted fully to the domestic market. While, α is known as the adjustment parameter, the error correction term or feedback effect, which measures how much of the past price differences between the domestic and world prices are corrected in each period. A value closer to unity is a sign of a faster speed of price adjustment by domestic prices for deviations from long-run disequilibrium.

Following Yang *et al*. (2015), the Error Correction Model (ECM) can be specified as follows:

$$\Delta P_t^D = \sum_{j=1}^{k} \varphi_{ij}\, \Delta P_{t-j}^D + \alpha\mu_{t-1} + \sum_{j=0}^{k} \xi_{ij}\, \Delta P_{t-j}^W + \varepsilon_i \quad (5.3)$$

Here the ECM equation indicates that the domestic price is not only adjusting to world price changes, but also adjusts to the previous year's disequilibrium position. μ_{t-1} measures the extent of disequilibrium between domestic and world prices. A positive value of α indicates that domestic prices are higher than the long-run equilibrium position. Therefore, a negative value of α will bring the domestic price back to the equilibrium position. ξ is the short-run elasticity of price transmission from world to domestic prices. φ is the autoregressive term for the lagged domestic prices. We also calculated half-life, which measures how many months are required for domestic price to correct half of the price shocks stemming from world market. Half-life is computed as $h = [\ln(0.5)/(\ln(1+\alpha)]$.

5.5.1 Description of policy regimes and data

As discussed in the parity price analysis, the regime switches in the Ethiopian commodity price formation are not caused by supply and demand dynamics such as shift in production or consumption. Rather, they are caused by the government policy intervention. Therefore, the trigger for regime switches is introduced exogenously, based on the government trade policy reform period on the grain market.[28] The degree of government intervention is different for different crops. As a result, we estimate different policy regimes for maize and wheat crops. Table 5.5 below illustrates the policy interventions examined on world-to-domestic spatial maize and wheat market integration.

Table 5.5: Policy regimes for wheat and maize crops

Commodities	Policy regimes		Duration	Monthly observations
Wheat	Regime 1	Market liberalisation	Jan 2000 – Feb 2008	98
	Regime 2	Government wheat imports and distribution at subsidised prices	Mar 2008 – Jan 2017	107
Maize	Regime 1	Period of market liberalisation	Jan 2000 – Nov 2006	83
	Regime 2	Lift and re-imposition of an export ban	Dec 2006 – Jan 2017	122

One potential caveat of this study is the overlapping period of policy interventions. Since we are evaluating each of the trade policy reforms, other similar policy interventions implemented over the same period might be overlooked. Furthermore, the appropriate choice of the dating period for the policy reform is not straightforward. Many policy reforms have been partially introduced in stages over several years, and are subject to delays and temporary reversals (Baffes and Gardner, 2003). Therefore, the results of policy reforms may take time to reflect in a commodity's price behaviour. To circumvent these issues, we used the Food and Agriculture Policy Decision Analysis (FAPDA) data. The FAPDA's database categorises policy interventions as consumer support, producer oriented, and trade-related interventions, with their implementation date and year. We chose policy interventions targeting food security, trade, and market on cereals and cereal products. The dating of major trade policy reforms was

[28] Regime switches can also be imposed endogenously by examining whether the distance between domestic and international prices exceeds a certain threshold. In these cases, the appropriate methodologies are regime-dependent price transmission models such as Threshold VECM, regime switching, or Parity Bounds Models, and so on (for details, see Greb *et al*., 2012).

further complemented and validated with data obtained from Key Informant Interviews (KIIs). KIIs were conducted with experts from relevant government organisations such as the EGTE and the NBE. The EGTE has been involved in wheat importation and distribution, while NBE has implemented policies related to foreign exchange allocation.

International and domestic wheat and maize price series were obtained from the FAO Global Information and Early Warning Systems (GIEWS) food price data. GIEWS food price data was established in 2009 as part of the FAO initiatives on Soaring Food Prices (ISFP) (Greb *et al*., 2012). Descriptions of international and domestic maize and wheat prices used in this study are presented in Table 5.6 below. All the price series are converted into logarithms. Similarly, the commodity prices are reported with the same currency and quantity units (USD/metric ton).

Table 5.6: International and domestic wheat and maize prices

International prices	**Description**	**Sample period**
Wheat	US (Gulf) (US No 2, Hard Red Winter)	Jan 2000-Jan 2017
	Black Sea (milling)	Jul 2004-Jan 2017
	Canada (St Lawrence)	Jan 2000-Jan 2017
	Russian, (milling, f.o.b., deep-sea ports)	Oct 2006-Jan 2017
	Ukraine (milling, f.o.b.)	Jan 2000-Jan 2017
Maize	US (Gulf) (US No 2, yellow maize)	Jan 2000-Jan 2017
	Argentina (Argentina, Up River, f.o.b.)	Jan 2000-Jan 2017
	South Africa (SA), Randfontein (white maize), wholesale	Jan 2000-Jan 2017
Domestic prices	Addis Ababa (white wheat), wholesale	Jan 2000-Jan 2017
	Addis Ababa (white maize), wholesale	Jan 2000-Jan 2017

Source: FAO-GIEWS

5.6 RESULTS AND DISCUSSIONS

5.6.1 Unit root testing

The first step in examining the impact of government policy responses on the extent of spatial food market integration is testing for the presence of unit root. Unit root testing is essential in time series analysis to avoid deriving erroneous conclusions from spurious regression analysis. We used the ADF (1979) test to detect the presence of unit root in all the price series. The test was carried out separately for maize and wheat commodities, according to the regimes specified above.

The descriptive results for the domestic and international maize prices, including mean, maximum, and standard deviations for the full sample and sub-samples, are presented in Tables 5.7, 5.8 and 5.9 below. As can be seen from Table 5.7 below, Ethiopia's white maize prices registered the highest maize prices during full sample period. Compared with other regimes, Ethiopia's maize prices were the highest in regime 2. This is because the regime 2 sample included the periods of soaring maize prices of 2008 and 2011.

Table 5.7: Descriptive results of maize prices for full sample, (2000M01 – 2017M01)

	Argentina	Ethiopia	SA	US
Mean	162.858	211.849	194.866	165.993
Maximum	314.000	599.200	342.050	330.120
Minimum	78.500	57.500	72.870	75.440
Std. Dev.	66.140	94.660	65.884	69.921
Skewness	0.529	1.238	0.129	0.777
Kurtosis	2.218	5.942	2.127	2.557
Observations	205	205	205	205

Table 5.8: Descriptive results of maize prices for regime 1

	Argentina	Ethiopia	SA	US
Mean	97.567	134.285	136.277	101.525
Maximum	171.500	194.800	197.380	166.360
Minimum	78.500	57.500	72.870	75.440
Std. Dev.	14.179	40.102	36.856	14.466
Skewness	1.977	-0.614	0.029	1.478
Kurtosis	10.659	2.188	1.648	7.207
Observations	81	81	81	81

Table 5.9: Descriptive results of maize prices for regime 2

	Argentina	Ethiopia	SA	US
Mean	207.373	264.345	234.847	209.975
Maximum	314.000	599.200	342.050	330.120
Minimum	141.200	143.300	137.880	146.000
Std. Dev.	48.033	84.714	49.381	57.322
Skewness	0.681	1.784	0.011	0.730
Kurtosis	2.108	7.296	2.135	2.019
Observations	122	122	122	122

The descriptive results for wheat prices during full sample and sub-sample are illustrated in Tables 5.10, 5.11 and 5.12 below. With the exception of regime 1, Ethiopia's wheat prices (represented by the Addis Ababa wholesale wheat prices) experienced the highest wheat prices. The price divergence was more evident in regime 2, where Ethiopia's wheat prices reached the highest mean price of 442 USD/ton. In this regime, Ethiopia's wheat price skyrocketed and reached as high as 709 USD/ton. The average wheat price in Ethiopia was higher than most international wheat prices were. For instance, the wheat price in Ethiopia was 59 per cent, 83 per cent, and 84 per cent higher than the mean prices in the USA, Ukraine, and the Black Sea region, respectively. We believe that this widening price gap may trigger profitable arbitrage opportunities. However, because of foreign exchange restrictions and subsidised wheat prices, the private sector's involvement in international grain trade is expected to be constrained during this regime.

Table 5.10: Descriptive results of wheat prices for full sample

	Ukraine	Canada	Black Sea	Russia	USA	Ethiopia
Mean	184.424	269.621	221.737	242.919	227.331	340.186
Maximum	359.800	743.620	435.000	365.000	481.500	708.700
Minimum	89.000	136.080	110.000	167.000	110.750	117.400
Std. Dev.	78.004	103.017	69.991	58.203	80.912	129.442
Skewness	0.504	1.041	0.461	0.479	0.500	0.239
Kurtosis	2.007	4.503	2.771	2.134	2.327	2.414
Observations	205	205	151	124	205	205

Table 5.11: Descriptive results of wheat prices for regime 1

	Black Sea	Canada	Ethiopia	Russia	Ukraine	USA
Mean	178.945	205.197	229.946	259.635	122.473	173.215
Maximum	380.000	743.620	376.300	361.000	270.000	449.250
Minimum	110.000	136.080	117.400	185.400	89.000	112.000
Std. Dev.	77.207	84.471	66.455	74.230	39.532	61.949
Skewness	1.262	3.760	0.288	0.314	2.244	2.326
Kurtosis	3.326	21.032	2.239	1.291	7.314	8.909
Observations	44	96	96	17	96	96

Table 5.12: Descriptive results of wheat prices for regime 2

	Black Sea	Canada	Ethiopia	Russia	Ukraine	USA
Mean	239.333	329.624	441.523	240.264	241.623	278.048
Maximum	435.000	615.240	708.700	365.000	359.800	481.500
Minimum	155.000	202.750	287.600	167.000	162.800	181.400
Std. Dev.	58.664	79.839	81.216	55.202	58.222	60.480
Skewness	0.724	0.607	0.803	0.431	0.268	0.267
Kurtosis	3.564	3.459	4.136	2.238	1.846	2.621
Observations	107	107	107	107	107	107

Table 5.13 below reflects the unit root tests in levels and first difference for the wheat and maize commodities. All the maize price series for the full sample showed random walk processes, with values reverting to the mean on rare occasions. Hence, we model the ADF test for the full sample without the intercept and deterministic trend components. In regime 1, the

unit root tests for Ethiopian and South African maize prices were carried out without a constant and trend component, while the Argentinian and US maize prices were tested with a random walk process with drift. On the other hand, in regime 2, unit root tests for all maize price series were conducted with a random walk process. Similar to maize prices, all the full sample wheat series have shown a random walk process. Consequently, ADF tests for the full sample were executed without constant and deterministic trend elements. While in regime 1, unit root tests for Canadian and US wheat price series were conducted using a random walk process. The remainder of the price series were tested with equations using a random walk with drift. In regime 1, Russia's wheat prices are I(2), which is unlikely in most economic variables. This could be attributable to the small sample size, which comprised only 17 samples. As a result, Russia's wheat price was discarded from the analysis in regime 1. Finally, unit root tests for all wheat prices series in regime 2 were carried out using a random walk process.

One of the prerequisites for a unit root test is the absence of autocorrelation in error terms. In other words, the error term should be a white noise for the unit root test to be valid. To this end, the optimum lag length for the dependent variable was selected the AIC. From the unit root tests, it can be seen that all maize price series have a single unit root, implying that the price series are non-stationary in level, but become stationary in first difference. With the exception of Russia's wheat prices in regime 1, the same results were confirmed for wheat price series. This means that all the wheat and maize price series are integrated of order one I(1); hence, examining the effect of the policy intervention on the extent and degree of food grain market integration can be investigated using a cointegration approach.

Table 5.13: Unit root tests for maize and wheat prices

Commodity prices	Full sample		Regime 1		Regime 2	
	Level	First difference	Level	First difference	Level	First difference
Maize prices						
Ethiopia	-0.031(1)	-10.659(0)***	-0.049(1)	-6.717(0)***	-0.005(1)	-8.245(0)***
Argentina	0.520(1)	-12.014(0)***	-0.311(1)	-5.425(0)***	0.021(0)	-10.472(0)***
South Africa	0.204(1)	-10.501(0)***	0.231(1)	-5.712(0)***	0.104(1)	-9.152(0)***
USA	0.316(1)	-10.922(0)***	-0.955(1)	-5.602(0)***	-0.165(1)	-9.112(0)***
Wheat prices						
Ethiopia	0.246(1)	-10.422(0)***	-0.686(1)	-6.453(0)***	-0.216(1)	-8.003(0)***
Black sea	0.270(2)	-8.106(1)***	2.792(5)	-4.223(0)***	-0.941(2)	-7.634(1)***
Canada	0.211(1)	-11.735(0)***	1.789(1)	-2.839(2)***	-3.43(1)**	NA
Russia	-0.132(1)	-7.593(0)***	-3.13(3)	-1.53(0)	-0.764(1)	-7.599(0)***
Ukraine	0.378(4)	-6.191(3)***	1.172(1)	-4.103(0)***	-0.479(1)	-7.212(0)***
USA	0.378(1)	-11.109(0)***	2.068(1)	-7.092(0)***	-1.205(2)	-7.944(1)***

Notes: *** denotes significance level at 1 per cent; the value in parentheses are the optimum number of lags chosen, using AIC; the Canadian wheat price is stationary in the second regime.

Table 5.14: Johansen cointegration tests between domestic and world maize and wheat market price pairs

Crops	Market pairs	Full sample			Regime 1			Regime 2		
		Null	λ	λ	**Null**	λ	λ	**Null**	λ	λ
Maize	**ETH-ARG**	$r = 0$	18.68 (20.26)	15.61 (15.89)	$r = 0$	4.56 (12.32)	2.98 (11.22)	$r = 0$	23.14** (20.26)	16.84** (15.89)
		$r \leq 1$	3.07 (9.16)	3.07 (9.16)	$r \leq 1$	1.57 (4.13)	1.57 (4.13)	$r \leq 1$	6.29 (9.16)	6.29 (9.16)
	ETH-USA	$r = 0$	19.62*** (12.32)	19.53*** (11.22)	$r = 0$	4.83 (12.32)	3.39 (11.22)	$r = 0$	26.69* (20.26)	20.85* (15.89)
		$r \leq$	0.09 (4.13)	0.09 (4.13)	$r \leq$	1.44 (4.13)	1.44 (4.13)	$r \leq$	5.85 (9.16)	5.85 (9.16)
	ETH-SA	$r = 0$	17.25* (12.32)	17.15** (11.22)	$r = 0$	7.38 (12.32)	7.25 (11.22)	$r = 0$	11.16 (12.32)	11.14 (11.22)
		$r \leq 1$	0.09 (4.13)	0.09 (4.13)	$r \leq$	0.133 (4.13)	0.133 (4.13)	$r \leq 1$	0.018 (4.13)	0.018 (4.13)
Wheat	**ETH- Black Sea**	$r = 0$	23.33** (20.26)	17.38** (15.89)	$r = 0$	6.27 (12.32)	6.26 (11.22)	$r = 0$	14.03** (12.32)	13.11** (11.22)
		$r \leq$	5.95 (9.16)	5.95 (9.16)	$r \leq$	0.01 (4.13)	0.01 (4.13)	$r \leq$	0.92 (4.13)	0.92 (4.13)
	ETH- Canada	$r = 0$	15.10*** (12.32)	15.03** (11.22)	$r = 0$	16.65 (20.26)	11.94 (15.89)			
		$r \leq$	0.077 (4.13)	0.077 (4.13)	$r \leq$	4.71 (9.16)	4.71 (9.16)			
	ETH- Russia	$r = 0$	14.40** (12.32)	14.39** (11.22)				$r = 0$	13.55** (12.32)	12.97** (11.22)
		$r \leq$	0.008 (4.13)	0.008 (4.13)				$r \leq$	0.58 (4.13)	0.58 (4.13)
	ETH- Ukraine	$r = 0$	13.83** (12.32)	13.60** (11.22)	$r = 0$	8.05 (12.32)	5.03 (11.22)	$r = 0$	11.80* (12.32)	11.59** (11.22)
		$r \leq$	0.22 (4.13)	0.22 (4.13)	$r \leq$	3.02 (4.13)	3.02 (4.13	$r \leq$	0.21 (4.13)	0.21 (4.13)
	ETH-USA	$r = 0$	20.56*** (12.32)	20.42*** (11.22)	$r = 0$	9.66 (12.32)	7.60 (11.22)	$r = 0$	18.07*** (12.32)	16.63*** (11.22)
		$r \leq$	0.15 (4.13)	0.15 (4.13)	$r \leq$	2.06 (4.13)	2.06 (4.13)	$r \leq$	1.44 (4.13)	1.44 (4.13)

Notes: ***, ** significance level at 1 % and 5 %; r is the number of cointegrating vectors; critical values in parentheses

Table 5.14 above reports the results of the Johansen cointegration tests between Ethiopian and world maize and wheat market prices for different regimes. Our results indicated that during the full sample period, the Ethiopian white maize market appears to have a long-run relationship with the USA and SA maize prices. However, in contrast to our expectations, Ethiopia's maize market is not cointegrated with any world maize markets during regime 1. In regime 1, trace and maximum eigenvalue test statistics failed to reject the null hypothesis of no-cointegration ($r = 0$) between the Ethiopian maize market pairs with the Argentina, USA, and SA maize prices. This was not expected, given the fact that regime 1 is mainly characterised as an open economy period with modest government intervention in the grain market. Surprisingly, of the three market pairs in regime 2, the Ethiopian maize market has a long-run relationship with the Argentina and USA maize markets. This result may be attributed to the drought period maize imports during regime 2. Owing to its self-sufficiency in maize production, Ethiopia imports maize in times of drought periods. As described earlier, Ethiopia imported maize mainly during regime 2. For instance, since 2000, of the 25 000 tons of maize imported into the country, 60 per cent of the maize imports were made during the regime 2 periods of 2013, 2014, and 2015 (USDA, 2015).

Regarding wheat market integration, during the full sample period, the Ethiopian wheat market has a long-run relationship with all the world wheat markets considered in this study. Both test statics confirmed the presence of one cointegrating vector ($r = 1$) between the Ethiopian wheat market and wheat prices in the Black Sea region, Canada, Russia, Ukraine, and USA. In contrast to our expectations, Ethiopia's wheat market is more cointegrated with the world wheat markets during regime 2 than regime 1. The absence of cointegration between Ethiopia's wheat market and the Black Sea region during regime 1 was not expected owing to the wheat import dependency of Ethiopia on the Black Sea region. No cointegration was found between Canada's and Ethiopia's wheat prices during regime 1. This is expected, as there has not been any significant trade flows between the two countries. In this instance, price transmission is expected to be based on price signal movements between the two countries.

In general, the results for the wheat market cointegration analysis demonstrated that Ethiopia's wheat market is more cointegrated with the world wheat markets during the era of government intervention than no long-run relationships during the low-government intervention period. We thus conclude that the Ethiopian government's policy responses to soaring food prices have not blocked price signal transmissions from the international markets to the domestic wheat and maize markets. These findings are in contrast with price transmission theory and available empirical evidence. Theory suggests that government intervention in the grain market in the form of quantitative trade flow restrictions through foreign exchange rationing to private traders could block and diminish price signal transmissions. Several empirical studies have supported this argument. In his study of world-to-domestic grain price transmission analysis, Kelbore (2013) concludes that the Ethiopian government price stabilisation interventions have effectively insulated the domestic grain market from international price fluctuations. The difference between the results of our study and Kelbore's (2013) results could be in the approach employed. Kelbore (2013) used a full sample cointegration analysis for the period from July 2001 to December 2011, while we account for the effects of policy interventions by subdividing the analysis into different policy regimes. We argue that three possible reasons could justify the contrary findings. Firstly, the short time span used in regime 1 may contribute to the absence of cointegration. Our first choice was to estimate the market liberalisation period since 1990. However, owing to data limitations, the market liberalisation period was limited to a short sample period ranging only from January 2000 to March 2008 (99 monthly observations). This short sample period may have influenced the cointegration analysis outcomes.

The second possible explanation for the presence of market integration during the heavy government intervention period could be through information flows. In recent years, there are a large body of literature on spatial market integration that suggest the importance of information flows as one means of mechanisms that brings markets into equilibrium state. Information flows, which is one of the overlooked and underappreciated element of market equilibrium, may contribute to spatial market integration in the absence of physical trade flows between markets (Stephens *et al*., 2008). Following the soaring domestic prices of 2008, both the private sector and the government state trading enterprise, the EGTE, have been operating in the wheat market in Ethiopia. However, most of the wheat imports and distribution at subsidised wheat prices to poor urban consumers and flour mills have been carried out by the EGTE. While traders have been largely restricted from wheat imports because of the foreign exchange restriction and fear of the subsidised wheat distribution by the EGTE. After the introduction of the EGTE into wheat imports and distribution, there has been an increasing trend in commercial wheat imports and a sharp decline in wheat food aid. For instance, commercial wheat imports increased, on average, by more than two-fold from 0.49 million MT during 2001–2007 to 1.12 million MT during 2008–2015. The wheat aid subsided by 20 per cent from an average of 0.63 million MT during 2001–2007 to 0.50 million MT during 2008–2015. This development might worry private traders who compete with the subsidised wheat price in the domestic grain market. As a result, traders may pay close attention to the actions of the EGTE and international price signal movements in order to adjust their selling prices and target the remaining demand in the domestic wheat market. This uncertainty in the grain market environment could indirectly lead to the presence of a long-run relationship between the domestic and international wheat prices since 2008.

Table 5.15: Commercial wheat imports since 2008

Years	Commercial imports (mill MT)	EGTE imports (mill MT)	Unreported imports
2008	1.28	0.31	0.97
2009	0.99	0.23	0.76
2010	1.15	0.30	0.85
2011	1.09	0.26	0.83
2012	0.88	0.32	0.56
2013	1.72	0.30	1.42
2014	0.71	0.42	0.29
2015	1.19	0.39	0.80

Notes: mill MT stands for million metric tons;
Source: UN Comtrade (2016)

The third possible justification for the integration of the domestic and international wheat markets during regime 2 could be through private sector trade flows. Owing to the foreign exchange restriction on private traders, it is believed that the EGTE, which is the only government parastatal involved in wheat imports and distribution, has imported the entire wheat demand since 2008. However, there has been a significant difference between the wheat imports reported by the EGTE and Ethiopia's total commercial wheat imports reported by the UN Comtrade database. For instance, the EGTE imported a reported 0.3 million MT in 2013, whereas in the same year the UN Comtrade reported imports of 1.72 million MT of wheat. About 1.42 million MT of commercial wheat imports were not reported by the EGTE in 2013. Overall, between 2008 and 2015, about 6.5 million MT of commercial wheat imported into Ethiopia were not reported by the EGTE (see Table 5.15 above). Aside from the foreign exchange restriction, there has not been any trade policy implemented to prevent private traders from importing wheat. Trade policy related to foreign exchange rationing may reduce the volume of the private sector's trade, but this intervention does not fully impede the private sector's participation in international trade. Despite the problem of foreign exchange restrictions, it is reasonable to believe that private traders may also participate in wheat imports in regime 2. A key question that comes to one's mind to justify wheat imports by the private sector would be the profitability of wheat imports during regime 2. For the private sector to participate in international markets, wheat imports should be profitable. As illustrated earlier, it was profitable for traders to import wheat in 2009 and after 2013. Based on this argument, it is difficult to dismiss the possibility of market integration in regime 2 between world and the domestic wheat markets through information flows and private sector trade flows.

In the following section, we will look in detail at the estimates of the error correction model for the cointegrated market pairs for the full sample and regime 2 periods. We are particularly interested in examining the speed of adjustment of the Ethiopian wheat and maize markets for price deviations from the long-run equilibrium position. The full VECM results are presented in Tables 5.16 and 5.17 below.

Table 5.16: Error correction model results for cointegrated market pairs, (full sample)

Coefficients	Maize		Wheat				
	ETH-USA	ETH-SA	ETH- Black Sea	ETH- Canada	ETH- Russia	ETH- Ukraine	ETH-USA
Cointegrating vector & adjustment coefficient							
Constant			3.07				
P^{W}_{t-1}	1.05**	1.01**	0.54	1.04**	1.105**	1.124**	1.076**
ECT$_{t-1}$	**-0.092****	**-0.07****	**-0.081****	**-0.063****	**-0.072****	**-0.049****	**-0.073****
Half-life	**7.18**	**9.55**	**8.20**	**10.65**	**9.28**	**13.80**	**9.14**
Short-run parameters							
ΔP^{ETH}_{t-1}	**0.281***	0.275*	0.219*	0.282*	0.211*	0.294*	0.279*
ΔP^{ETH}_{t-2}			0.025*	0.031*	-0.018*		
ΔP^{ETH}_{t-3}				0.029*			
ΔP^{W}_{t-1}	-0.037	-0.049*	-0.016*	-0.003*	-0.118*	-0.063*	-0.072*
ΔP^{W}_{t-2}			0.038*	-0.158*	-0.08*		
ΔP^{W}_{t-3}				0.181*			
Model specification tests							
LM test	0.43	0.55	0.85	0.77	0.65	0.19	0.64
Adj. portmanteau test	0.69	0.79	0.98	0.91	0.83	0.43	0.87
Normality test	207***	194***	223***	573***	210***	1027.2***	177***
MARCH- LM test	19.05	21.69	40.37	100.48***	45.46**	33.29**	66.70***
ARCH- LM	-	-	-	0.804	0.72	0.71	0.52
CUSUM test	Stable	Stable	Stable	Stable	Stable	Stable	Stable

Notes: Half-life is computed as $h = [\ln(0.5)/(\ln(1+\alpha)]$, where α is the error correction term and interpreted in months; P^{W}_{t-k} represents lags of world prices; lag length is selected based on AIC; Adj. portmanteau test denotes an adjusted portmanteau test which has more powerful small sample properties than the standard portmanteau test (see Lütkepohl & Krätzig, 2004, p 127); MARCH test denotes a multivariate ARCH test; the reported values in MARCH tests are the Chi-square test statistics, while the probability value of rejecting the null hypothesis of no heteroskedasticity is reported in ARCH test; ***, ** denote rejection of the null hypothesis at 1 and 5 per cent significance levels.

Table 5.17: Error correction model results for cointegrated market pairs, (regime 2)

Coefficients	Maize		Wheat			
	ETH-ARG	ETH-USA	ETH- Black sea	ETH- Russia	ETH- Ukraine	ETH-USA
Cointegrating vector & adjustment coefficient						
Constant	3.92	2.90				
P^{W}_{t-1}	0.30	0.496	1.108**	1.108**	1.109**	1.076**
ECT$_{t-1}$	**-0.114****	**-0.135****	**-0.075****	**-0.0723****	**-0.067**	**-0.1****
Half-life	**5.72**	**4.78**	**8.89**	**9.24**	**9.99**	**6.58**
Short-run parameters						
$\boldsymbol{\Delta P^{ETH}_{t-1}}$	0.325*	0.308*	0.185*	0.212*	0.209*	0.19*
$\boldsymbol{\Delta P^{ETH}_{t-2}}$			-0.0044*			-0.03*
$\boldsymbol{\Delta P^{W}_{t-1}}$	-0.114	-0.119	-0.046*	-0.171*	-0.073*	-0.15*
$\boldsymbol{\Delta P^{W}_{t-2}}$			0.041			-0.02*
Model specification tests						
LM test	0.376	0.377	0.872	0.87	0.29	0.67
Adj. portmanteau test	0.713	0.731	0.968	0.68	0.54	0.67
Normality test	126.81***	119.32***	86.75***	199.6***	319.5***	71.84***
***MARCH-LM* test**	36.52**	33.82**	43.67	31.2**	19.14	67.13***
ARCH LM test	0.62	0.64	-	0.75	-	0.85
CUSUM test	Stable	Stable	Stable	Stable	Stable	Stable

Notes: Half-life is computed as $h = [\ln(0.5)/(\ln(1+\alpha)]$, where α is the error correction term and interpreted in months; P^{W}_{t-k} represents lags of world prices; lag length is selected based on AIC; Adj. portmanteau test denotes an adjusted portmanteau test which has more powerful small sample properties than the standard portmanteau test (see Lütkepohl & Krätzig, 2004, p 127); MARCH test denotes a multivariate ARCH test; the reported values in MARCH tests are the Chi-square test statistics, while the probability value of rejecting the null hypothesis of no heteroskedasticity is reported in ARCH test; ***, ** denote rejection of the null hypothesis at 1 and 5 per cent significance levels.

Tables 5.16 and 5.17 above illustrate the short-run and long-run price transmission elasticity results from VECM. The VECM model was estimated for cointegrated market pairs for the full sample and regime 2 periods. Our findings indicate that price shocks stemming from the international grain market were eliminated moderately slowly in the domestic market, that is, increases and decreases from world grain market prices were transmitted very slowly to the domestic market. The range of speed of adjustment is 5 to 14 months. This means that it takes about 5 to 14 months for the domestic market to eliminate half of a shock stemming from the international wheat and maize markets. Relatively, the speed of price adjustment has improved during regime 2 than full sample period. As argued by Haile *et al*. (2016), the speed at which domestic grain markets restore price shocks stemming from world commodity markets depends on the actions of market intermediaries. Adjustment costs resulting from high transaction costs could also be responsible for the sluggish speed of price transmission from the world to domestic wheat and maize markets. Another possible explanation is the presence of government intervention. It has been well documented that government intervention may block or diminish price signal transmissions from world to domestic markets. This conclusion is reinforced by our results, where maize commodities correct price deviations from international markets more quickly than wheat commodities do. This can be attributed to low government intervention in the maize market. The Ethiopian government's intervention has been heavily slanted towards wheat commodity, rather than the maize crop. The only distortion in the maize market is the export ban. The faster speed of the price adjustment in the maize market than for the wheat crop supports the view that further market liberalisation in grain market could enable traders to quickly adjust price deviations from world markets.

Model diagnostics tests for residuals autocorrelation, normality, and constant variance were examined. The presence of autocorrelation was tested using the Breusch-Godfrey (1978) LM test and the adjusted portmanteau test. Both tests failed to reject the null hypothesis of no-serial autocorrelation for the full sample and regime 2 periods. Hence, the model is free from serial autocorrelation.

The normality of the residual is checked using the Lomnicki–Jarque Bera statistic. In all cases, normality of residuals is rejected at the 1 per cent significance level. The multivariate Autoregressive Conditional Heteroskedasticity (MARCH) tests indicated a presence of heteroskedasticity in some equations. We further investigated the source of the problem by estimating a univariate ARCH test. The univariate ARCH test failed to reject the null hypothesis of no ARCH in the residuals for all equations, which modelled Ethiopia's maize and wheat prices as a dependent variable. This is the model of interest because Ethiopia's maize and wheat prices do not influence world market prices. As a result, the remaining ARCH in the residual series may not be a point of concern. CUSUM tests were also carried out to test parameter constancy assumption. This test is normally conducted on a single equation model. However, it can also be conducted in the VECM individual equations, especially when cointegration relations are known (Lütkepohl and Krätzig, 2004). Although the results for the CUSUM plots are not reported, all the estimated equations are inside the critical bound region, which is an indication of the stability of the model.

Of course, this analysis was undertaken by making some assumptions. The first assumption is that the Ethiopian wheat and maize markets do not influence world commodity prices. In other words, Ethiopia is considered as a small country in the world grain markets. Based on this assumption, Ethiopia's commodity market is influenced by world market developments. However, the converse does not hold. The second assumption is homogeneity of commodities. This assumption enables us to ignore price difference caused by variety and other attributes in market integration analysis. We are aware of the price differences between white and yellow maize varieties, but because of data unavailability, we relied on yellow maize prices in the US maize market. Finally, the national maize and wheat prices for Ethiopia are represented by the Addis Ababa wholesale market prices. Since the Addis Ababa market is regarded as a central market, the use of it as a representative national market is realistic.

5.6.2 Asymmetric response of domestic wholesale grain market to changes in world prices

Despite the presence of a long-run relationship between the Ethiopian and world maize and wheat markets in regime 2, the domestic prices have remained higher than the international maize and wheat prices. As outlined earlier in the parity price analysis, domestic maize and wheat prices were above the IPP in 2008. Once again, the domestic wheat prices have surpassed the ceiling price since 2015. What explains the price gap between the world and domestic wholesale wheat and maize markets since 2008? The answer might lie in the asymmetric response of domestic wholesale prices to changes in world prices. If increases in the world prices are well transmitted to the domestic prices, while decreases are not, the gap between the domestic and world prices will rise, over time (Morisset, 1998). Of course, the asymmetry in price transmission may also be reflected in commodity value chain stages in the domestic market. In other words, the nature of price adjustment from world to domestic markets could also be evidenced in domestic consumer markets such as the retail market and at different processing stages, such as in flour and bread prices. This issue has not been explored in detail in the price transmission literature in Ethiopia.

We have argued for the possible presence of APT on two grounds. Firstly, although regime 2 is considered as an era of heavy government intervention, substantial amounts of commercial wheat, other than the EGTE imports, have been imported into the country. Our view is, in spite of the trade restrictions caused by foreign exchange rationing, that some traders may be able to import wheat. This might have happened if a handful of government-affiliated traders enjoyed preferential treatment for accessing the limited foreign exchange available and so import wheat. This might lead to the presence of APT because of the market power arising from the domination of the import market by a few private-sector participants. In fact, the Ethiopian government was concerned about this issue and implemented a reform in foreign exchange applications. In February 2016, the NBE introduced a new transparency directive to eliminate preferential treatment in the allocation of foreign exchange. Subsequently, applications for foreign exchange by private traders have been evaluated based on a first-come, first-served principle.

A second reason for the possible presence of APT would be trade restrictions. Trade restrictions have been the commonly cited reason for explaining the causes of APT from world to domestic markets (see Knetter, 1993; Morisset, 1998). One can argue that the recent high commercial wheat imports by the Ethiopian government could alert traders to closely follow the developments in international grain prices. However, because of the foreign exchange restrictions, the participation of private traders in international trade would be limited. This would impede arbitrage activities and possibly reduce the speed of price transmission between world to the domestic grain markets. Under these conditions, traders may tend to respond more quickly to upward price changes than to downward price movements from the world market, leading to increasing price spreads over time. In a similar vein, Knetter (1993) argues that the presence of trade constraints may create import barriers in consumer markets. As a result, decreases in world commodity prices may not be transmitted fully to domestic prices because there are no incentives for the few importers to stimulate the final demand by reducing their selling prices. These two possibilities of APT motivated us to further scrutinise the price adjustment process of domestic markets to decreases and increases in world market prices. Thus, in this section, we examined whether price transmission from the world to domestic wholesale grain markets is asymmetric. This can be done using the APT approach discussed in Chapter 4. The analysis of asymmetry in this chapter is slightly different from the one discussed in Chapter 4. In this section, apart from the short-run asymmetry, we also introduced long-run asymmetric price transmission by segmenting the contemporaneous adjustment parameter into positive and negative values. This approach allows us to observe asymmetric adjustment, both its speed as well as its magnitude, and is applied to the cointegrated wheat and maize market pairs of regime 2. According to von Cramon-Taubadel (1998), the former type of asymmetry arises if the short-run elasticities of spatial price transmission differ depending on the sign of price changes, while the latter type of asymmetry occurs if the long-run transmission elasticity differs.

Table 5.18: Estimates of AECM for wheat, Mar 2008 to Jan 2017

	Ethiopian wheat price (dependent variable)			
Coefficients	**Black Sea**	**Russia**	**Ukraine**	**USA**
Constant	0.0053	0.004	0.0049	-0.0016
$\boldsymbol{\beta_1^+}$	-0.332*	0.052	0.033	-0.013
$\boldsymbol{\beta_1^-}$	-0.348**	-0.008	0.036	-0.22
ECT_{t-1}^{+}	-0.232**	-0.166**	-0.136*	-0.18**
ECT_{t-1}^{-}	-0.081	-0.044	-0.036	-0.076
$\boldsymbol{\Delta P_{t-1}^{w}}$	0.051	-0.184*	-0.079	-0.14
$\boldsymbol{\Delta P_{t-2}^{w}}$	0.049			
$\boldsymbol{\Delta P_{t-3}^{w}}$	-0.111			
$\boldsymbol{\Delta P_{t-1}^{Eth}}$	0.256**	0.312***	0.312***	0.286***
$\boldsymbol{\Delta P_{t-2}^{Eth}}$	0.06			
$\boldsymbol{\Delta P_{t-3}^{Eth}}$	0.184*			
	Model diagnostics			
LM test	0.13	0.698	0.57	0.65
ARCH	0.50	0.96	0.88	0.95
JB	40.29***	192***	201***	75.33***
Wald test H_O: $\boldsymbol{\beta_1^+ = \beta_1^-}$	0.004	0.047	0.0001	0.546
Wald test H_O: **$ECT_{t-1}^{+} = ECT_{t-1}^{-}$**	1.44	1.03	0.68	0.713

Notes: ΔP_{t-1}^{w} represents lag length of exogenous wheat markets. Initially, the AIC was used to select the optimum lag length, and subsequently reduced to the more parsimonious models.
JB is the Jarque-Bera test for the normality of residual; the Breusch-Godfrey (1978) and ARCH tests denote tests for higher-order serial correlation and homoskedasticity of the residual. The tests rejected the presence of autocorrelation and heteroskedasticity in all equations.
***, **, * denote rejection of the null hypothesis at 1 %, 5 %, and 10 % significance levels, respectively.

Findings from the Asymmetric Error Correction Model (AECM) between the domestic and world wheat markets during regime 2 are presented in Table 5.18 above. In all market pairs, we are unable to find any statistical evidence of asymmetry, in both contemporaneous adjustment and short-run deviations from the cointegration relations. Although the short-run asymmetry is statistically insignificant, there is considerable difference in the magnitude of domestic wheat market adjustment to positive and negative price deviations from long-run equilibrium relationships. Interestingly, the domestic wheat market only corrects to decreases, rather than to increases, in the world wheat markets considered in this study. In all equations, increases in world prices were not corrected by the domestic wheat markets. However, this does not allow us to draw a conclusion that the domestic wheat market price adjustment to world price changes is characterised by negative price transmission. Despite the magnitude difference, the Wald test fails to reject the null hypothesis of no asymmetry in the short-run elasticity between domestic and world wheat markets. This type of price adjustment is also expected to pass-through to the domestic wheat value chain, i.e. from wholesale to consumer markets**,** such as in retail, flour, and bread market prices.

Although the policy intervention period is characterised by the absence of wheat price asymmetry, the speed of price adjustment is still very slow. For instance, only 14 per cent and 17 per cent of the decreases in Ukraine and Russia's wheat market prices, respectively, were corrected within a month during this period. This means that the domestic wheat market takes a long time to fully correct price decreases in the international wheat market. This sluggish price adjustment could lead to the persistence of high price differences between the domestic and international wheat market prices.

Table 5.19: Estimates of AECM for maize, Mar 2008 to Jan 2017

Ethiopian maize prices (dependent variable)		
Coefficients	**Argentina**	**USA**
Constant	0.0044	0.005
$\boldsymbol{\beta_1^+}$	0.140	0.072
$\boldsymbol{\beta_1^-}$	0.126	0.045
ECT_{t-1}^+	-0.124**	-0.132**
ECT_{t-1}^-	-0.081	-0.080
$\boldsymbol{\Delta P_{t-1}^{w}}$	-0.131	-0.116
$\boldsymbol{\Delta P_{t-2}^{w}}$	0.105	0.205
$\boldsymbol{\Delta P_{t-1}^{Eth}}$	0.292***	0.282***
$\boldsymbol{\Delta P_{t-2}^{Eth}}$	0.092	0.076
Model diagnostics		
LM test	0.91	0.59
ARCH	0.93	0.90
JB	138.26***	121.34***
Wald test H_O: $\beta_1^+ = \beta_1^-$	0.001	0.0045
Wald test H_O: $ECT_{t-1}^+ = ECT_{t-1}^-$	0.213	0.291

Notes: ΔP_{t-1}^{w} represents lag length of exogenous wheat markets. Initially, the AIC was used to select the optimum lag length, and subsequently reduced to the more parsimonious models.
JB is the Jarque-Bera test for the normality of residual.
The Breusch-Godfrey (1978) and ARCH tests denote tests for higher-order serial correlation and homoskedasticity of the residuals. The tests rejected the presence of autocorrelation and heteroskedasticity in all equations.
***, **, * denote rejection of the null hypothesis at 1 %, 5 %, and 10 % significance levels, respectively.

Table 5.19 above illustrates the AECM results for maize commodities during regime 2. The same conclusion is reached for the price transmission analysis between the domestic and world maize prices. We found no evidence of APT between the Ethiopian white maize and Argentinian and US maize prices. Although there is no statistical difference, the domestic maize market price adjustment is faster to decrease in accordance with the world maize price than to increase. As is the case for wheat, the speed of price adjustment from the world to the domestic maize market is not rapid.

Model diagnostics results demonstrated that the presence of serial correlation and heteroskedasticity are rejected in all maize and wheat AECM equations. However, we fail to reject non-normality of residuals. The non-normality of residuals is caused by kurtosis. Skewness results in all equations are close to zero. Hence, we should not worry about the non-normality distribution of the residual.

5.6.3 Threshold cointegration and asymmetry

So far, we have argued for the presence of cointegration and asymmetry in world to domestic wheat and maize markets without taking into account the effect of transaction costs. The above cointegration approaches, including the Johansen and Juselius maximum likelihood procedure (Johansen and Juselius, 1990) and the extended Engle–Granger AECM, do not account for the effect of transaction costs in market integration analysis.

Using the Enders and Siklos (2001) threshold cointegration approach, this study takes into account the possible effect of transaction costs on a long-run equilibrium relationship and asymmetric adjustment. This is very important because Ethiopia is a landlocked country. Therefore, transaction costs would play a crucial role in influencing cointegration and the speed of adjustment of the domestic grain market to world market price changes. For instance, transaction costs[29] constitute about 39 per cent of the Addis Ababa wholesale wheat price. Hence, ignoring the influence of transaction costs from a cointegration analysis might produce biased results. Since Ethiopia is a net importer of wheat, transaction costs are more important in wheat market integration than those for maize are. For this reason, this section only examines the extent and speed of spatial price transmission between the world and domestic wheat markets, using a threshold autoregressive (TAR) model proposed by Enders and Siklos (2001).

TAR models are praised for capturing the dynamics of market linkage without requiring actual transaction costs. However, these approaches are not devoid of criticisms. One limitation is the assumption of constant transaction costs over time, while the other shortcoming rests on Chan's (1993) grid search estimation technique of the threshold parameter. Van Campenhout (2007) argues that the simulation-based estimation of standard errors is not feasible because the approach takes a long time. To overcome these limitations, Van Campenhout (2007) includes a time trend in both the threshold and the adjustment parameters. In spite of these limitations and the recent development on the TAR models, this study used a threshold autoregressive econometric (TAR) model for analysing world-to-domestic wheat market integration. More specifically, we apply two alternative non-linear models proposed by Enders and Siklos (2001), namely the consistent Threshold Autoregressive (TAR) and the Momentum Consistent TAR

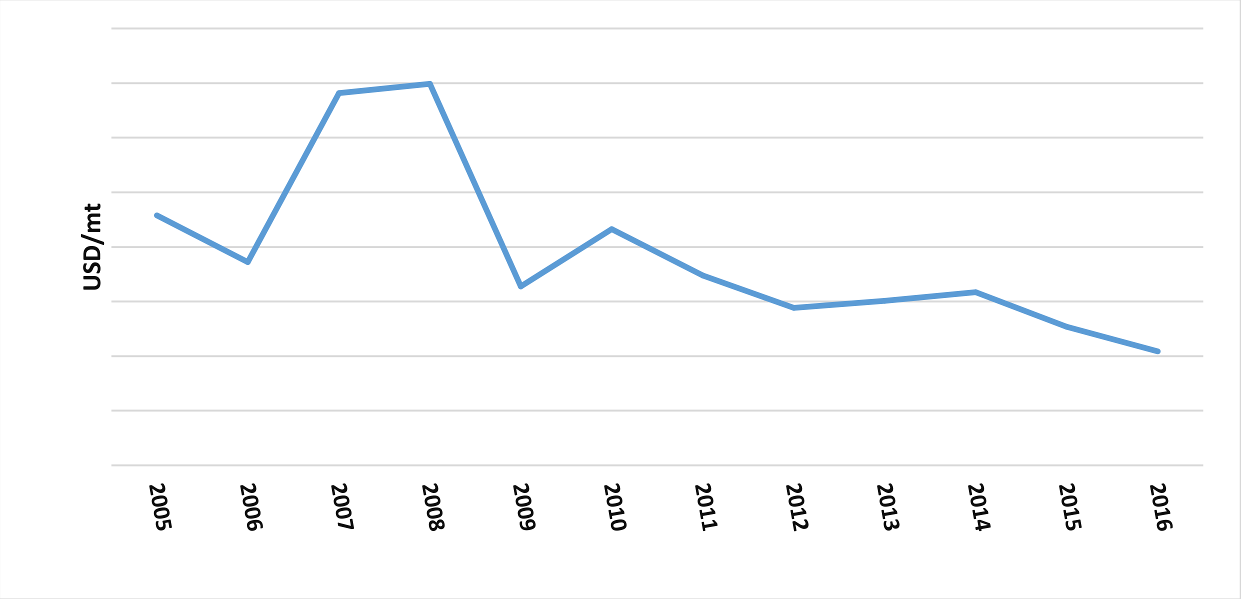
[29] The reported transaction costs constitute the average value from 2005 to 2016. In this context, transaction costs include freight costs from the Pacific North West (PNW) port to Djibouti port, insurance costs, the import tariff, port handling, inland transport, and loading and unloading costs.

(MC-TAR) models. The model specifications and findings of the consistent TAR and MC-TAR models for domestic wheat market integration with world wheat markets are presented in Appendix B (1).

The findings indicate that the inclusion of threshold effects into the cointegration analysis does not seem to change the results. We fail to reject the null hypothesis of symmetric price transmission in all wheat market pairs. It is thus possible to conclude that threshold cointegration and adjustment is not evident in the market integration analysis between the domestic and international wheat markets. In general, the absence of threshold adjustment in our study indicates that even if the price difference between the domestic and world wheat market exceeds a certain threshold value, i.e. transfer costs, this does not necessarily trigger price adjustment. In a competitive market environment, whenever a price differential exceeds a critical threshold value and exceeds the costs of adjustment, arbitrage activities restore prices back to an equilibrium position. However, in the Ethiopian context, because of heavy government intervention in the domestic market and trade restrictions, grain traders have been restricted to do the necessary price adjustment. Thus, even though there is a profitable price difference that exceeds transfer costs, traders are incapable of implementing the necessary price adjustment because of foreign exchange rationing and subsidised wheat distribution. We believe that this is the mean reason that has contributed to increasing price spreads between the domestic and international wheat market prices.

Broadly speaking, the effect of transaction costs on spatial market integration has recently been reduced in Ethiopia. One plausible explanation is the recent reduction in the shipping cost component in the total wheat price. As can be seen from Figure 5.3 below, the trends in wheat shipping costs have declined after the oil price spikes of 2007 and 2008. Furthermore, the domestic transport sector has been subsidised by the government. Even when oil prices skyrocketed in 2008 and reached USD147 a barrel, the gasoline price in Ethiopia remained unaffected because of a government subsidy. This subsidy bills reached close to USD700 million (Rashid and Minot, 2010). This huge subsidy may have insulated Ethiopia's grain market from oil price shocks and subsequently reduced transaction costs on imported wheat grain from Djibouti port to the domestic Addis Ababa grain market.

Figure 5.3: Wheat shipping costs, 2005 to 2016



Note: The shipping costs are calculated for the route from the Pacific North West (PNW) port to Djibouti/Mombasa ports. The freight cost is obtained from the US wheat associates weekly data. Simple averages were used to convert to monthly and yearly prices.

According to Balke and Fomby (1997) and Enders and Siklos (2001), if adjustment is nearly symmetric, then the power of the Engle–Granger (EG) test exceeds that of non-linear threshold models. Under such situations, the assumption of asymmetric adjustment in threshold models entails the needless estimation of an additional coefficient with a consequent loss of power. We therefore base our conclusions for cointegration and asymmetric adjustment on the results generated from the Johansen cointegration and AECM.

5.7 CHAPTER SUMMARY

In this chapter, we examined the impact of the policy intervention of the Ethiopian government on spatial wheat and maize market integration with the world market. The findings from the cointegration analysis indicate that the Ethiopian government's interventions in the grain market have not blocked price transmission from the world to the domestic grain markets. The surprising finding is that the domestic wheat and maize markets are more strongly integrated with world markets during a period of government intervention than they are during low periods of intervention. This is not expected in a heavily regulated market. The implicit motives of the Ethiopian government intervention in grain market are twofold: (1) to reduce prices by insulating the domestic market from international price shocks; and (2) to mitigate the soaring food price risks for the vulnerable urban poor consumers. Despite the presence of a long-run relationship, high commercial wheat imports, and absence of APT, the domestic wheat prices have been higher than the upper bound IPP since 2008. We attribute the increasing price gap to trade flow restrictions caused by foreign exchange rationing and subsidised wheat distribution below market prices. Traders are constrained to import the necessary wheat to stabilise the domestic market because of the foreign exchange restriction. Furthermore, the discretionary government imports are crowding private sectors out and producing uncertainty in the grain market. These interventions seem to have limited the traders' ability to respond quickly to price decreases in international grain markets. This is what Byerlee *et al*. (2006) referred to as the danger of adopting 'a half-way market liberalisation' by allowing private sectors to compete with state trading enterprises:

> *"Many countries seem stuck in a vicious cycle in which chronic under-provision of public goods hinders market development which, in turn, is used to justify continued government intervention. As a result, countries get mired half-way in the reform process, hovering between old parastatal models and market-led approaches. Such 'half-way' reforms may create the worst of all possible worlds in which the private sector is encouraged to operate in an environment where government continues to intervene in discretionary and unpredictable ways that make prices even less stable and predictable".*

CHAPTER 6:
MODELLING PRICE FORMATION IN THE ETHIOPIAN WHITE MAIZE MARKET

6.1 INTRODUCTION

In this chapter, we shall discuss the factors that drive price formation of white maize market in Ethiopia. As outlined in the previous chapter, in the majority of cases, previous studies on spatial and vertical grain price transmission analysis have depended solely on the price of a commodity to draw conclusions about the performance of grain markets. While understanding whether inter-regional maize market prices are integrated or not does provide valuable information about market integration and efficiency of a maize market, this does not tell us much about price formation, and supply and demand induced maize price instability, which is more useful to policy makers. Therefore, augmenting maize price transmission analysis with a better understanding of the factors that govern price formation is essential to provide a more complete picture of the dynamics of the maize market in Ethiopia.

The main objective of this chapter is to develop a framework for the maize sub-sector in Ethiopia that could be used to examine the impacts of various supply and demand induced shocks, agricultural and macroeconomic policies on the Ethiopian maize sub-sector. This chapter also provides a baseline outlook for the maize industry in Ethiopia over the medium term (2016–2025). In order to improve the reliability of findings for forecasting and policy analysis, the results generated from the partial equilibrium model are validated using graphical and statistical model adequacy tests.

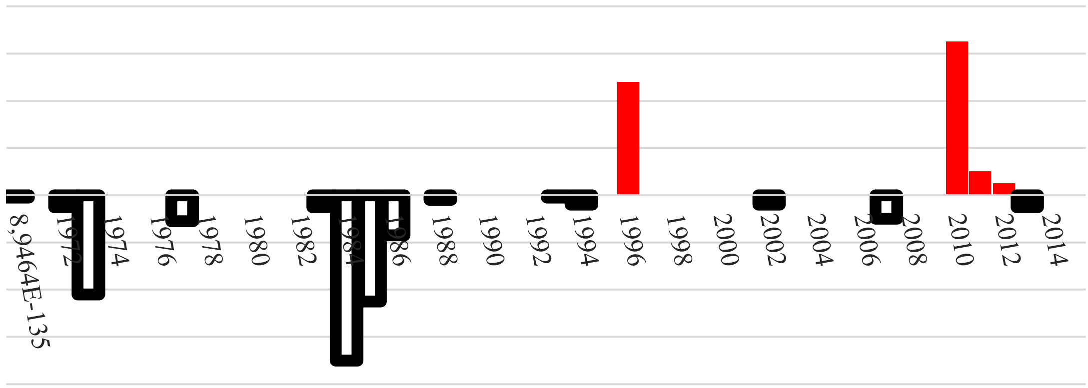
The chapter is organised into six sections. Section one discusses the maize price discovery in Ethiopia, with special emphasis on the import and export trends of maize commodities in Ethiopia. Section two describes the concepts and assumptions of the partial equilibrium model. Section three describes the data sources of the study. Section four illustrates the econometric specifications for the different components of a partial equilibrium model. Section five presents and explains the findings from the econometric analysis of the factors influencing maize price formation. Section six presents model adequacy tests, using graphical and statistical techniques. Once the results generated from the single equations are adequate for forecasting, we proceed further to baseline projections for the maize industry for the period from 2016 to 2025. These results, in turn, are used to assess the impacts of a bumper harvest and weather-induced shocks on the maize market in Ethiopia.

6.2 PRICE DISCOVERY IN THE ETHIOPIAN MAIZE MARKET

In order to understand price formation and the likely sources of price instability in the Ethiopian maize market, it is essential to first identify the trade regime under which the Ethiopian maize market operates. As outlined in Chapter 1, Ethiopia is trading in an autarky trade regime. In an autarky trade regime, the domestic maize price is expected to be unrelated to international market price shocks. Rather, the dynamics of domestic supply and demand factors, apart from government policies, are responsible for maize price formation and instability.

Figure 6.1 below presents the export and import trends of maize in Ethiopia. As can be seen from Figure 6.1, there is evidence of small quantities of maize exports in the 2010, 2011 and 2012 production seasons. Maize exports reached the highest of 65 000 tons in 2010. Similarly, negligible quantities of maize production, close to 10 000 and 5 000 tons, were exported in 2011 and 2012, respectively. The 2010 and 2011 exports coincided with the two-year period when the export ban on maize commodity had been lifted. The Ethiopian government lifted the export ban in July 2010. However, the lifting of the export ban did not last long, as the government re-imposed the ban in March 2011. Given the presence of the export ban on maize, the 2012 maize export would have been less likely to contribute to commercial exports. Perhaps the exports that were noted were accounted for by the domestic procurements by the World Food Programme (WFP) for providing humanitarian assistance to other countries. With the understanding that domestic maize consumption relies heavily on domestic production and that the maize market is insulated from international shocks as a result of the Ethiopian government intervention, the present study adopts a model closure technique on price (more details on this are discussed in the methodology section).

Figure 6.1: Net maize trend (‘000 mt), (1970–2015)



Source: Author’s calculation using USDA data (2015)

6.3 DISTINCTION BETWEEN PRICE FORMATION AND MARKET INTEGRATION

Market integration analysis is designed to provide an understanding of the functioning of markets by providing valuable information on price transmission and speed of price adjustment among vertical and spatial markets. Since this analysis most often relies on price analysis, it ignores the demand and supply dynamics, and the policy effects on domestic price formation. This is because, apart from price shock transmission among markets, there are dynamics such as policies, local demand and supply, and climatic conditions that could play a major role in commodity price formation.

Both price transmission and price formation include arbitrage processes, which is an equilibrium concept that drives LOP. The premise of LOP reveals that the gap between two spatially integrated market prices should never be greater than the transaction costs. The strong assumption of LOP indicates that arbitrage opportunities prevent spatial market prices from drifting too far apart. Arbitrage conditions in two markets are dependent on the demand and supply in different markets. That is, according to Meyer *et al*. (2006), when arbitrage between two markets does not exist, the local supply and demand forms the domestic price, known as the equilibrium-pricing condition. The authors further iterated that when arbitrage connects regions, the equilibrium price in one region may define the equilibrium price in another region. This can also be explained using the Ravallion (1986) dominant–satellite market price relationship. According to Ravallion (1986), if a central market exists, then price formations in the regional markets are influenced by a central market. However, the dominant market price is not affected by the price shocks coming from satellite markets. Instead, the supply and demand dynamics in the dominant market determine commodity price formation. However, supply and demand shocks in the dominant market diffuse to other regional or dependent markets because of market linkage. Therefore, to appreciate spatial market integration, it is vital to understand the price formation of local prices.

Examining the impact of exogenous and endogenous variables that affect the equilibrium market price aids in understanding how domestic prices form. These variables include exchange rates, interest rates, population, per capita GDP, transaction costs, rainfall, and policies. Analysing price formation, which is also known as the equilibrium price condition, provides a detailed explanation on how a change in policy or a shock in an exogenous variable affects the pricing systems and the market structure of a specific industry.

The relevant trade and policy regime also alters the equilibrium price, which leads to possible market changes. Depending on a country's production potential and consumption pattern, commodity price formation depends on which of three trade regimes is prevalent: autarky, IPP, or EPP. If a country is a net importer of a commodity, then the price formation depends on the IPP. The domestic price should then be a function of world price, exchange rates, transportation costs, and possible import tax (Meyer *et al*., 2006). In this trade regime, one would expect a high degree of price transmission from world to domestic markets. On the other hand, if a country is a net exporter of a commodity, then the trade regime switches to EPP. Under such conditions, the extent of price shock transmission from world to domestic markets become high. When a country reaches a self-sufficient position, domestic price formation lies within the price band of IPP and EPP. In the autarky trade regime, the domestic price is determined by the interaction of domestic supply and demand conditions and is unrelated to international price shocks (Meyer *et al*., 2006). As outlined above, the maize sub-sector in Ethiopia is trading in an autarky trade regime. Hence, domestic demand and supply dynamics are expected to determine maize price formation in Ethiopia.

6.4 CONCEPT OF PARTIAL EQUILIBRIUM MODELLING

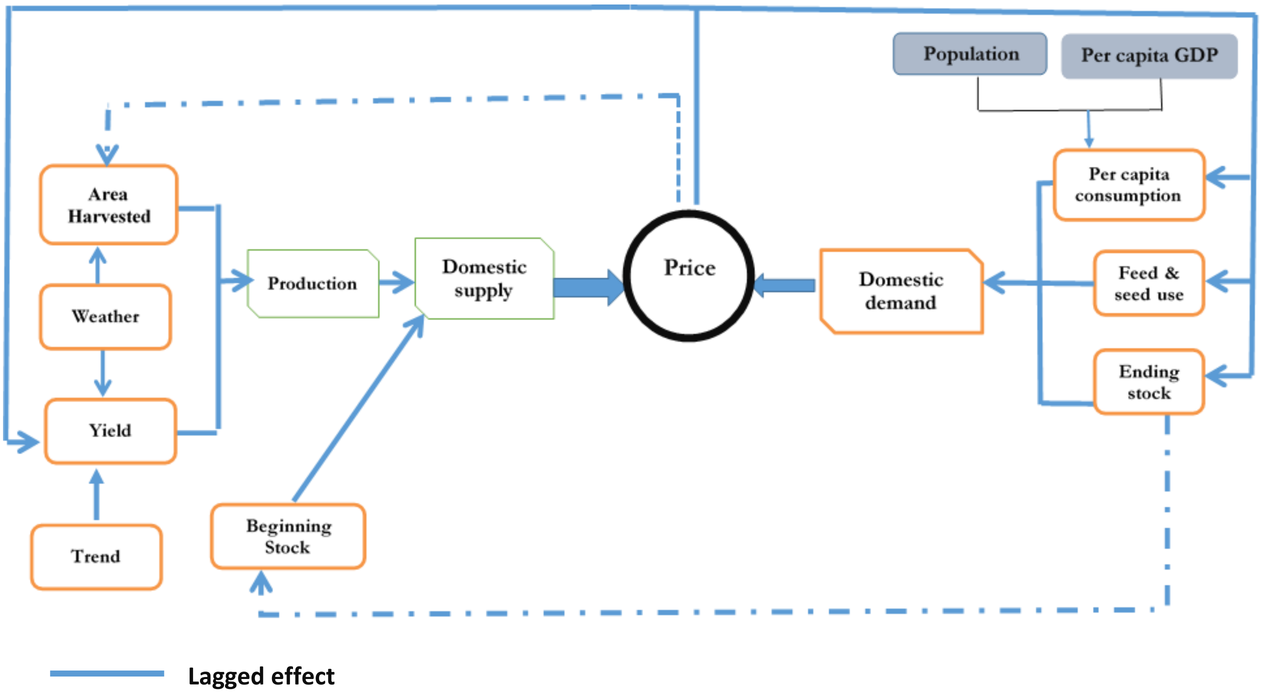
This section provides theoretical explanation on the concepts and assumptions of the partial equilibrium model and model closure techniques under different trade regimes. A flow diagram is also presented in Figure 6.2 below to conceptually explain the model structure and closure technique under an autarky trade regime. The diagram depicts the different demand and supply components of the white maize market in Ethiopia. Since Ethiopia is operating in an autarky trade regime, the flow diagram does not incorporate an explanation of trade and price linkage equations. Estimation procedures and model validation steps to ensure a true reflection of reality of behavioural equations are also discussed. Modelling procedures are discussed in the model specification section.

Due to their coverage of the whole economy, general equilibrium models are preferred for analysing the factor flows across sectors. Partial equilibrium models are, however, applied in sectorial analysis where the sector is too small to have a wider impact on other sectors of the economy, or when an in-depth treatment is required to assess the effects of various policies on the sector. However, the effect of the economy on the agricultural sector is captured through exogenous variables. Unlike the general equilibrium model which requires a rich dataset, a partial equilibrium model has the ability to examine the impact of policies using a limited dataset. Another advantage of a partial equilibrium model is that it offers results in disaggregated level. With regard to analysis, partial equilibrium models tend to be more transparent and simple. Modelling is straightforward and results can be easily explained.

The fundamental assumption of the partial equilibrium model is the neo-classical approach, which assumes that the balance between consumption and production in the economy is maintained by producers' and consumers'profit maximising and utility motives (Garforth and Rehman, 2006; Kotevska *et al*., 2013). Thus, the key behavioural assumptions of economic agents in partial equilibrium models are utility and profit maximisation.

Typically, partial equilibrium models include supply, demand, trade, and price linkage blocks. The supply block consists of area harvested, yield, production, and beginning stocks. The demand block consists of human consumption, feed utilisation and amount retained for seed, and ending stocks. Figure 6.2 below displays the price formation for a commodity when a country is in an autarky trade regime. Since the maize industry in Ethiopia is trading in an autarky trade regime, this graphical explanation of the behavioural relationships can capture the features of white maize market price formation in Ethiopia. The broken lines indicate lagged relationships between variables. Farmers make their decisions to plant a crop based on lagged own price and prices of substitutes. Beginning stocks equals lagged ending stocks or inventory.

Figure 6.2: White maize price formation in Ethiopia under an autarky trade regime



Source: Adapted from Meyer *et al*. (2006).

Farmers' decisions to grow maize start from land allocation decisions. Maize farmers have to make an initial decision on the size of maize area to be planted. Farmers' decisions on maize area allocation depend on own price, prices of substitutes, weather conditions, and prices of inputs. Measuring the effects of the above-mentioned price and non-price related factors on farmers' land allocation decisions is called supply response analysis. One of the most important issues in agricultural development economics is supply response, since the responsiveness of farmers to economic incentives largely determines agriculture's dynamics and contribution to the economy. Furthermore, the response elasticity is also important for policy decision-making as it gives an indication of the factors that constrain farmers' responsiveness to output price changes. According to Tripathi (2008), the agricultural supply response represents change in agricultural output due to a change in agricultural output price.

Maize is a stable food crop in Ethiopia. As a result, the Ethiopian government's main target is to maintain food self-sufficiency and improve the marketability of the commodity. Therefore, policies that encourage greater production of maize and the transition from a subsistence to a market-oriented farming system necessitate the carrying out of supply response studies. In annual agricultural crop production, farmers observe the output price after production has been obtained. As a result, farmers' planting decisions are made based on price expectations at harvesting time. Hence, producers' price expectations play a pivotal role in acreage allotment for annual crops. In general, two models are widely used to analyse the elasticities of supply response in annual agricultural crops. These approaches are the Nerlovian expectations and partial adjustment models. In the Nerlovian expectations model, farmers make their production decisions based on expectations of future prices. The assumption is that a rational farmer is more likely to respond to the price he or she expects, rather than to the price in the previous period, and the expected price will depend only to a limited extent on the actual price in the previous period.

On the other hand, the Nerlovian adjustment model assumes that farmers form their expectations about what will happen in the future based on what has happened in the past. Farmers, especially in developing countries, are facing problems in obtaining relevant market price information. Therefore, rational expectation behaviour is not relevant in the absence of future market information. Although the Ethiopian government has recently opened an exchange market, the trading of cereals including maize and wheat is relatively negligible, as compared with high-value exportable crops. Hence, this study has assumed that the Nerlovian adjustment model would be adequate for the Ethiopian maize market context.

With the advancement of time series analysis, serious methodological issues have been raised on the Nerlovian agricultural supply response model and its estimation techniques. For instance, the Nerlovian model has failed to capture the full dynamics of agricultural supply response (Thiele, 2000). The model is also incapable of providing an adequate distinction between short- and long-run elasticities (McKay *et al*., 1998). Furthermore, the analysis may use non-stationary series, which is a source of spurious regression (Granger and Newbold, 1974). To account for these shortcomings of the Nerlovian model, recent studies on supply response have proposed cointegration models. This study also applied a cointegration approach of the Error Correction Model (ECM) to estimate maize supply response. To the best of author's knowledge, only Alemu *et al*. (2003) have applied this approach in grain supply response estimation in Ethiopia.

After a producer decides on how many hectares of land to allocate for maize production, the maize yield, which is influenced by weather conditions, determines the total maize production. Total maize production or domestic production is obtained by multiplying the maize area harvested by the yield level. In the demand block, human consumption, feed and seed consumption, and ending stocks determine the total demand for Ethiopian white maize. Following the law of demand, human and feed consumption are expected to have a downward slope or negative relationship with price. A positive relationship between income, population and human consumption is expected. Ending stocks comprise the demand for storage and speculation, which indicates a negative relationship between ending stocks and prices.

The above supply and demand block behavioural equations can be estimated using different econometric techniques to drive the equilibrium maize market price. There are two methods to estimate parameter values for single behavioural equations. They are the econometric and calibration methods. In the econometric approach, coefficients for single behavioural equations can be estimated using various econometric techniques (single equation, simultaneous equation, and Instrumental Variable (IV) estimation techniques like the two-stage least square and Generalised Method of Moments (GMM)). A commonly used approach to estimate single equations is OLS. This method takes the dependent and independent variables in level form, including own prices, complementary product prices, and shift variables. The robustness of this approach is largely evaluated by the signs of coefficients and goodness of fit. However, this approach is exposed to the problem of spurious regression in the case of non-stationary variables. Since the estimated parameter values from single equations are used for baseline projections, any misspecifications in the initial stage can contaminate the next stage estimations of baseline projections and model simulation outcomes. In an attempt to overcome this misspecification, the present study estimated the behavioural equations using a combination of OLS (for stationary equations) and an Error Correction Model (ECM) (for non-stationary and cointegrated series).

In the calibration approach, which is also called a synthetic estimation approach, coefficients are obtained based on economic theory and previous empirical evidence. This estimation approach is preferred when a researcher is faced with data limitations on certain explanatory variables. It can also be used when the estimation approach generates undesirable coefficient signs beyond economic theory. In this approach, the estimated elasticity values from previous similar empirical studies are calibrated and used in the estimation of initial equilibrium coefficients. Later, the results from the calibration estimation approach could be refined, depending on data availability. In this study, we used a combination of econometric and calibration estimation approaches. As we discussed above, OLS and ECM were used to estimate the single behavioural equations. Additionally, a calibration approach was employed in ending stock and maize yield equations. This is because of undesirable coefficient signs of real wholesale maize prices in the ending stock equation, and rainfall amount for production in the maize yield equation. The synthetic coefficient estimation techniques are illustrated as follows:

$$Elasticity = \frac{\partial y}{\partial x}\ x\ \frac{\mathrm{E(x)}}{E(y)} \tag{6.1}$$

$$= \text{(Coefficient value) x } \frac{\mathrm{E(x)}}{E(y)}$$

$$\text{Coefficient} = Elasticity\ x\ \frac{\mathrm{E(y)}}{E(x)}$$

where E(y) and E(x) denote mean of dependent and independent variables

After estimating the single behavioural equations using the relevant approaches discussed above, the next step is model closure. Different closure techniques can be used, depending on the trade regimes. As illustrated in Figure 6.2 above, model closure under an autarky trade regime is determined by equating total supply and total demand. Price is thus solved not as an endogenous variable in behavioural equations. Under an autarky trade regime, no profitable international trade opportunity exists to trigger arbitrage activities, as the domestic price fluctuates between the two border prices (IPP and EPP). As a result, net trade does not have an impact on domestic equilibrium prices. Model closure techniques are different for import parity and export parity regimes. In the case of an import parity regime, the model is closed on net imports, while net exports are used to close the model in the export parity regime (Meyer *et al*., 2006).

Once the behavioural equations are estimated, it is important to make sure that the results are capturing a true reflection of the maize market decision-making behaviour in Ethiopia. One way of checking robustness of model estimation is through model validation techniques. Graphical and statistical methods are used to evaluate the adequacy of the model. The commonly utilised techniques for model validation is to plot the actual and simulated values on a graph and to conduct a visual inspection of how well the model fits the turning points in the data. The ability of a model to track the turning points or rapid changes in the actual data is an important criterion for model evaluation (Meyer *et al*., 2006; Gebrehiwet *et al*., 2010).

6.5 DATA SOURCES

The study used various sources, including the Food and Agricultural Organization of the United Nations (FAO), the International Monetary Fund (IMF), the United States Department of Agriculture (USDA), the Central Statistical Agency of Ethiopia (CSA), EGTE, and the National Meteorological Agency of Ethiopia (NMA). Time series data on producer and wholesale prices of white maize and sorghum commodities were obtained from the FAO. The price series are from 2001 to 2015. Real prices were used by deflating the nominal prices by the Consumer Price Index (CPI).

Monthly rainfall data was obtained from the NMA. Rainfall data from eleven of the surplus maize producing districts from Amhara and Oromia regions were used. From the Amhara region, rainfall data from Bahir Dar, Gondar, Dembecha, and Debre-Markos districts were used, while rainfall data from seven of the maize surplus producing towns of Oromia region, comprising Arsi-Negele, Bure (Illubabore zone), Bako, Jimma, Nekemete, Meki, and Ziway, were included in model estimation. Time series data on maize areas harvested, stocks, production, yield, net trade, and trends of maize crop utilisation (feed, seed, and human consumption) were extracted from the USDA database. The historical data for the supply and demand components of maize commodity balance sheet range from 2001 to 2015.

Table 6.1 below illustrates the mean, maximum, and minimum values of the major exogenous and endogenous variables that comprise the Ethiopian white maize balance sheet. These included maize area harvested, maize yield, maize production, per capita consumption, real producer and wholesale maize and sorghum prices, and population growth. The whole white maize balance sheet is displayed in Appendix Table C.1. It incorporates total supply (production, import, and beginning stocks) and total demand (consumption, export, and ending stocks) components for the period from 2001 to 2015.

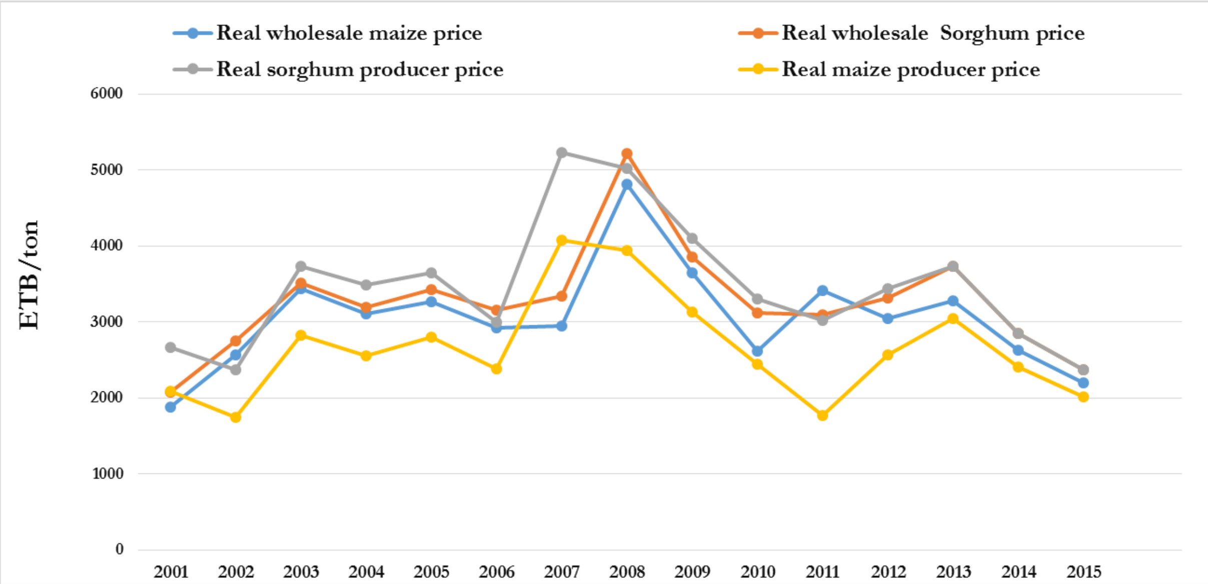
Table 6.1: Description of endogenous and exogenous variables of maize balance sheet, 2001-2015

Variables	Units	2001-2006			2007-2011			2012-2015		
		Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
Population	million	73.51	78.7	68.4	85.34	89.7	80.9	95.77	99.4	92.2
Real maize producer price	ETB/tone	2399	2830	1746	3074	4082	1771	2510	3047	2012
Real wholesale maize price	ETB/tone	2862	3434	1882	3487	4818	2613	2786	3274	2204
Real sorghum producer price	ETB/tone	3149	3727	2374	4136	5233	3017	3097	3734	2366
Real sorghum wholesale price	ETB/tone	4701	5306	3990	5884	7178	4257	4934	5488	4229
Area harvested	1000 ha	1524	1975	1191	1907	2055	1767	2097	2230	1995
Yield	mt/ha	1.86	2.23	1.50	2.40	2.95	2.12	2.90	3.25	2.35
Production	1000 mt	2848	3776	1788	4602	6069	3750	6070	6580	5050
Human consumption	1000 mt	2477	3085	1626	3838	4899	3175	5103	5443	4536
Per capita maize consumption	kg per capita	33.65	43.11	23.10	44.81	54.52	39.25	53.36	57.57	45.64

From Table 6.1, it can be seen that the maize crop has shown tremendous growth, in both area harvested and productivity per hectare. On average, the maize area harvested expanded from 1.5 million ha to more than 2 million ha between 2001–2006 and 2012–2015. For the same period, the maize yield also increased substantially, from 1.86 to 2.9 tons/ha. Because of this growth, maize production has been boosted recently, surpassing 6 million MT. During 2001–2006 and 2012–2015, maize production registered a 113 per cent growth rate, on average, from 2.8 million MT to 6.1 million MT. It is evident that the growth rate in maize production offset the rapid population growth and increased maize consumption. Despite a 30 per cent population growth, per capita maize consumption rose by 59 per cent, from 33.65 kg per person in 2001–2006 to 53.36 kg per person in 2012–2015.

The developments in wholesale maize price trends were covered in detail in Chapter 4. The general trend in real price levels for maize and its close substitute, sorghum, indicates that both producer price levels experienced upward swings in 2007 and 2008. Recently, both producer and wholesale sorghum and maize prices have shown a declining trend (Figure 6.3 below). This may be attributed to the Ethiopian government policy responses to soaring food prices.

Figure 6.3: Trends of real producer and wholesale sorghum and maize prices, 2001–2015



Source: Author's computation from FAO data (2015)

6.5.1 Model estimation and validation

To understand maize price formation and the effects of government policy interventions on maize prices, a partial equilibrium model was developed for the white maize market in Ethiopia. The maize market price formation comprises three blocks: supply and demand blocks, and model closure. Including the identity and model closure, the partial equilibrium model for the Ethiopian white maize commodity incorporates eight individual equations.

Several approaches have been employed to estimate behavioural single equations in commodity modelling. The most common approach is OLS. However, as outlined above, this approach is exposed to a spurious regression problem in the case of non-stationary variables. In an attempt to overcome this misspecification, the study detects the presence of non-stationarity on endogenous and exogenous variables using the ADF unit root test (Dickey and

Fuller, 1979). Based on the results of the unit root tests, maize area harvested and ending stock equations were estimated using ECM, while maize yield and per capita maize consumption equations were estimated using OLS. Furthermore, structural break tests were conducted to incorporate breaks in the data series. The existence of breakpoints was tested using the Chow breakpoint test. Shift variables are also used for policy changes, such as the export ban on maize.

After estimating the single behavioural equations, we validated the robustness of results obtained from the above estimated individual equations. Model accuracy is critical since market outlook and a '*what if*' analysis depend on the results generated from the behavioural equations. This would also improve the accuracy of our model that will be used for forecasting purpose or policy analysis. Model adequacy tests were carried out using graphical and statistical methods.

Concisely, the graphical method provides comparison of the actual and fitted values of the dependent variable. If the estimated value tracks the actual value, it is a sign of good predication. The actual values are the original values of the dependent variable, whereas the fitted values are the predicted values from a regression estimation. The difference between the two values represents the error or unexplained factors in forecasting, which is incurred by either overestimating or underestimating the predicated values.

6.6 MODEL SPECIFICATIONS AND RESULTS

The following section describes the model specifications and results of the partial equilibrium model for the Ethiopian white maize commodity. As stated earlier, the model incorporates eight individual equations. The model is developed based on neo-classical economic theory and knowledge of the maize industry. Modelling of partial equilibrium is classified into three blocks: demand and supply blocks, and model closure. Each block has its own exogenous and endogenous single behavioural equations.

This section begins with description of the specification and estimation of each individual equation. After describing the model components of each single equation, the section follows by presenting findings of the estimated single behavioural equations. The final section provides a model adequacy test for the estimated models.

6.6.1 Domestic supply block

The total domestic maize supply is the sum of domestic production, imports, and lagged ending stocks (beginning stocks). Domestic maize production was estimated as an identity by multiplying the total maize area planted by the maize yield. Domestic maize production is represented as follows:

$$MPROD_t = AREA_t * YIELD_t \quad (6.2)$$

where MPROD	Domestic maize production (1000 tons)
AREA	Area of maize planted (1000 ha)
Yield	Yield of maize (tons/ha)

6.6.1.1 Maize acreage response to prices

This section examines the role of maize producer price expectation in shaping maize-planting decisions. The underlying purpose of the maize supply response equation is to find out how a maize farmer intends to react to movements in own and competing crop prices. In the endeavour to quantify maize supply responsiveness to prices, the acreage planted is proxied by maize area harvested. Furthermore, actual output is not used as a dependent variable because in most agricultural activities, actual output is not a good proxy for intended output. This is because farmers have better control over area harvested than over output. Output can be influenced by other climatic-related factors, such as weather anomalies and outbreaks of diseases, which are beyond the control of farmers.

Previous studies on grain supply responses in Ethiopia used time series data. Most of these studies applied the Nerlovian adjustment model (see the World Bank (1987); Fernando (1992); Zerihun (1995); and Abebe (1998)). However, as illustrated above, the Nerlovian adjustment models are susceptible to spurious regression problems. Most economic time series data are trended over time, and regression among trended series may violate the classical regression assumption of mean reverting and constant variance, which may produce nonsense regression results, such as significant and high R^2s (Granger and Newbold, 1974). Spurious regression and inconsistent and indistinct short-run and long-run elasticity estimates are major problems exhibited by traditional adaptive expectation and partial adjustment models (Hallam and Zanoli, 1993; McKay *et al*, 1998). It is common practice to use cointegration analysis, such as Error Correction Model (ECM), to overcome the problem of spurious regression (Hallam and Zanoli, 1993; Townsend and Thirtle, 1994; Schimmelpfennig *et al*., 1996; Townsend, 1997; Alemu *et al*., 2003; McKay *et al*., 1998; and Thiele, 2000).

Agricultural production is affected by several factors. Tripathi (2008) summarised these factors into four categories: rural infrastructure, human capital, technology, and agro-climatic conditions. Rural infrastructure services, such as irrigation facilities, rural roads development, access to market facilities, farmers' access to credit, extension services, availability of improved farm technologies (fertiliser, improved seeds and pesticides), and communication facilities, are expected to positively affect agricultural output. Among the agro-climatic factors, rainfall fluctuation is the most decisive factor for supply response, especially in a rainfed farming system. With these factors in mind, the maize area harvested is assumed to be impacted on by supply shifters, including own prices, prices of substitutable crops, climatic conditions, and technological progress. The long-run maize supply response equation is specified as follows:

$$AREA_t = \delta_0 + \delta_1 PRMAZPROD_t + \delta_2 REPSORG_t + \delta_3 RAINL_t + \delta_4 TREND_t + \varepsilon_t \quad (6.3)$$

$AREA_t$ is the dependent variable capturing the planned maize acreage, proxied by area harvested, in thousand hectares. It has been common practice to proxy an acreage decision by area harvested because of the lack of data on area planted (Meyer and Kirsten, 2010). Area harvested is preferred to output because farmers have more control on the former than on the latter.

$PRMAZPROD_t$ indicates the deflated maize producer price. It is obtained by dividing the nominal maize producer price by CPI, indexed at the 2010 price. Area harvested and own price is expected to have a positive relationship and the value is interpreted as the long-run elasticity of supply response.

$REPSORG_t$ represents the real producer prices for a competing crop. In lowland and mid-altitude crop growing areas, maize competes for factors of production with sorghum. In some highland wheat belt areas of the country, highland maize also competes for land with bread wheat production. Since maize is grown mainly in lowland and mid-altitude areas, it has the same planting pattern as sorghum has. Hence, the sorghum crop price is considered as being a substitute crop that influences the acreage decisions of maize farmers. The effect of changes in own prices on quantity supplied are represented by movements along the same supply curve, while changes in the producer prices of competing crops are expected to cause shifts in supply curve, depending on the direction of influence of the competing crop prices.

$RAINL_t$ is rainfall. Rainfall conditions prior to a sowing period influence farmers' decisions to allocate land for maize production. We filtered out rainfall months that do not influence maize land allocation decisions. This is because rainfall months that affect crop planting and production decisions are quite different. Following the maize crop production calendar in Ethiopia, the rainfall patterns for the months of March, April, May, and June are expected to affect the maize-planting decisions of farm households (RATES, 2003). The average precipitations of these four months from the major maize-producing districts were incorporated into the equation, rather than annual cumulative rainfall. About 82 per cent of maize production is produced in Amhara and Oromia regions in Ethiopia (Rashid and Minot, 2010). To this end, the rainfall patterns in these two regions would greatly affect the intensity of land allocation for maize production in Ethiopia. For this reason, the average rainfall data from eleven surplus maize producing districts in the two regions were used. From the Amhara region, rainfall data from the four major maize-producing districts of Bahir Dar, Gondar, Dembecha, and Debre-Markos were used to examine the effects of production shocks on maize land allocation decisions. Rainfall data from seven of the maize surplus producing districts of Oromia region, Arsi-Negele, Bure (Illubabore zone), Bako, Jimma, Nekemete, Meki, and Ziway, were included in maize acreage model.

$TREND_t$ is a time trend variable used to capture technological progress in maize farming. Full historical data on public support service provision to maize farmers, including infrastructural service, research and extension service provision, accessibility to credit, irrigation infrastructural facilities, and improved seed distribution and agro-chemical fertiliser provision, are hardly available in Ethiopia. To account for these factors in the maize supply response equation, a time trend variable is introduced in the long-run equation.

Since the supply response equation uses time series data, we begin the analysis by testing the order of integration of the series. The order of integration of a series is determined by the number of times a variable is differenced before it is actually become stationary. The order of integration is tested using the ADF unit root test, and the results are reported in Table 6.2 below. The test for unit root is estimated with an intercept and random walk process. With the exception of area harvested, the rest of the acreage variables are estimated with no intercept and no trend specification. The results from the unit root tests indicate that all maize supply response variables are non-stationary in levels, but become stationary after first difference. Therefore, all variables are integrated of order one, I(1).

Table 6.2: Unit root test results using ADF test

Variables	ADF tests with intercept	ADF test with no intercept & no trend
Log maize area harvested	-1.954	
Δ Log maize area harvested	-10.877***	
Log real maize producer price		-0.095
Δ Log real maize producer price		-4.084***
Log real sorghum producer price		-0.175
Δ Log real sorghum producer price		-4.024***
Rainfall for maize area		-1.182
Δ Rainfall for maize area		-5.766***

Note: Δ stands for first difference

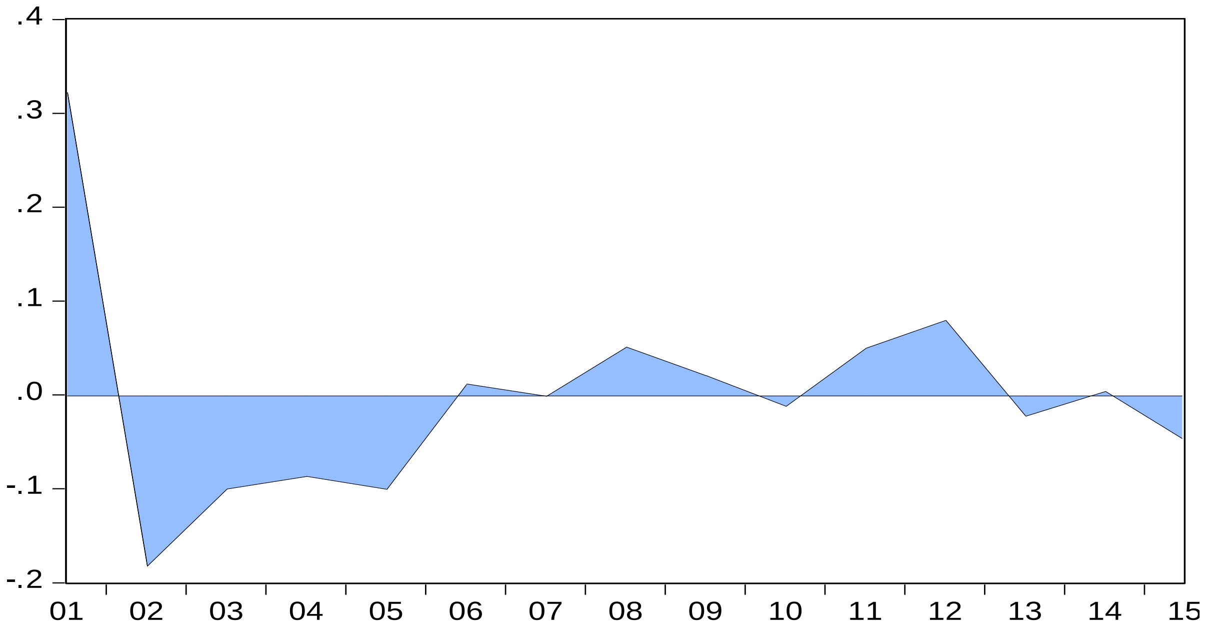
As illustrated in the order of integration results in Table 6.2 above, all variables are non-stationary and integrated of order one, I(1). In this case, estimating the maize supply response using adaptive expectation and partial adjustment models would lead to spurious regression. Alemu *et al*. (2003) have pointed out that spurious regression and inconsistent and indistinct short-run and long-run elasticity estimates are the major pitfalls of the traditional Nerlovian supply response models. We have made an attempt to estimate a maize acreage model using an ECM. ECM overcomes spurious regression problem and gives robust estimates of short-run and long-run elasticities.

According to Engle and Granger (1987), if cointegration among variables is confirmed, then the variables can be represented in a dynamic error correction framework. We modelled the maize supply response equation using the two-stage approaches proposed by Alemu *et al*. (2003). First, a static long-run equilibrium regression, given by Equation (6.3) above, is estimated. Second, a dynamic error correction model as specified in Equation (6.4) below is conducted by including the lagged residual from Equation (6.3) (of course, the residual from Equation (6.3) should be stationary). The second stage ECM model is specified as follows:

$$\Delta AREA_t = \theta_0 + \theta_1 \Delta RMAZPROD_t + \theta_2 \Delta\, REPSORG_t + \theta_3 \Delta\, RAINL_t - \lambda\,(Y_t - \alpha_0 - \alpha_1 RMAZPROD_t - \alpha_2 REPSORG_t - \alpha_3\, RAINL_t - \alpha_4\, TREND_t) + \nu_t \quad (6.1)$$

We start modelling the maize supply response by testing for the presence of long-run equilibrium relationships. To put it in other words, we determine whether the variables in the static equation (6.3) are cointegrated. Cointegration is tested based on the residual-based approach proposed by Engle and Granger (1987). The residual-based approach is based on the assumption that all variables are integrated of order one, I(1). The test uses the residual generated from the long-run equation (6.3) and tests whether the residual is non-stationary against the alternative of stationary process or I(0). The graphical result is presented in Figure 6.4 below, and indicates that the residual is stationary. Therefore, the results confirmed the presence of long-run equilibrium relationships or cointegration between the maize area harvested and the independent variables in the supply response model.

Figure 6.4: A residual plot for stationarity test



After we confirm the presence of cointegration, we proceed further to the second stage of maize supply response modelling by estimating ECM. Table 6.3 below summarises the results obtained from the dynamic error correction model by regressing maize acreage on deflated own and substitute crop prices, time trend, and rainfall for maize area for the period 2001–2015. The area harvested and sorghum and maize real producer prices were converted to logarithmic values in order to easily interpret values as elasticities. The results reveal that all the coefficients in both the static and ECM equations appeared with the expected signs. The short-run own price elasticity value is inelastic and insignificant. In the short run, a 10 per cent increase in own maize price would increase the maize area harvested by 0.6 per cent. Similarly, the short-run cross-price elasticity coefficient is also insignificant and inelastic, where a 10 per cent change in the sorghum producer price would decrease the maize area harvested by 0.57 per cent. When we look closely at the results of short-run and long-run supply elasticity, we can infer that the long-run elasticity values are relatively higher than those for short-run elasticity are. This is in line with our expectations. Why is the supply response lower in the short run than in the long run? Owing to the biological nature of agriculture, it is hard for farmers to shift factors of production in the short run, since most of the variables are considered as fixed costs. So, most of the short-run costs in farming are viewed as sunk costs. For instance, once farmers have planted the crop, it is hard to change the planting decision in response to market incentives. However, in the long run, farmers have options to make necessary adjustments, depending on price expectations.

Rainfall amount, prior to sowing period, impacted on the maize planting decision positively and significantly, at 5 per cent significance level. This is not surprising, given the fact that maize farming in Ethiopia is mainly produced in rainfed farming systems. The trend variable which is used as a proxy for technological progress is also significant, at 5 per cent significance level, and positively influences the acreage decision. The selected variables in the long-run equation together explained about 52 per cent of the variation in maize acreage. Likewise, about 59 per cent of the variations in the maize acreage decision are explained by the variables included in the ECM equation. The error correction term in this equation also appeared with the required sign, but is not significant. This suggests that there is no error correction mechanism for deviations of the maize acreage from its long-run equilibrium level in a year. We leave the explanation for this to other studies, as it is beyond the scope of this study.

Attempts were made to account for the sudden change in the maize market price situation after 2007. Maize crops have experienced soaring market prices in Ethiopia since late 2005. As depicted in Figure 6.3 above, maize prices rose sharply in 2007 and 2008. Break variables were introduced for the 2007 and 2008 maize producer prices. However, the results from the Chow breakpoint test rejected the presence of breaks in 2007 and 2008.

In general, our findings suggest that farmers respond very little to price in planning their maize acreage. The estimates of inelastic and insignificant short-run and long-run price elasticities of supply are comparable with the results that have been obtained by other studies in the field of supply response in Ethiopia and elsewhere in smallholder farmers' responsiveness to market incentives (Alemu *et al*. 2003; Tripathi, 2008). The low price elasticities of supply can be attributed to structural constraints that have limited farmers in making informed adjustments to market incentives. Some of the structural constraints that contributed to low and insignificant own and cross-price elasticities include credit access problems and poor marketing facilities. The land tenure system also contributes to the low magnitude of the agricultural supply response in Ethiopia. In Ethiopia, land belongs to the state and farmers cannot lease it or get it from other farmers. As a result, farmers continue to practice farming within their small landholding sizes, with little or no prospects for acquiring additional land or for expanding their cultivation.

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The other reason for the low supply response is the subsistence nature of maize farming practices in Ethiopia. Farmers are more concerned for household consumption than market incentives. Because of the practice of subsistence farming, production and consumption decisions are non-separable in Ethiopia. As discussed above, maize is mainly produced for household consumption (> 75 per cent). This is evidenced by the low marketability of the commodity; only 13 per cent of maize production is marketed (CSA, 2015).

Furthermore, we also noticed that non-price factors are more important determinants in the maize supply response than price-related factors are. Hence, from this analysis, it can be inferred that price is not a significant factor in influencing the maize acreage decision. Rather, the analysis confirms that rainfall and technological progress are relatively more important for higher maize acreage growth.

Table 6.3: Error correction model results for maize supply response

Variables	Coefficient	Std. Error
Short-run elasticities		
Constant	0.043**	0.016
D(RMAZPROD)	0.062	0.174
D(REPSORG)	-0.057	0.199
D(RAINL)	0.0004**	0.0002
Error (-1)	-0.205	0.115
Adjusted R^2	0.59	
F-statistics	2.87*	
Long-run supply response		
Constant	897.74	521.87
RMAZPROD	0.167	0.329
REPSORG	-0.139	0.268
Trend	65.061**	16.662
RAINL	1.128	1.006
Adjusted R^2	0.52	
F-statistics	4.750**	

Note: ***,** stand for significance at 10 % and 5 % levels, respectively

6.6.1.2 Maize yield

The maize yield equation was estimated as a function of rainfall, maize area under irrigation, improved seed utilisation, and technological improvement over time. The rainfall pattern during land preparation, planting, and maturity stages influences the maize yield. In Ethiopia, maize grows from moisture stressed areas to high rainfall areas, and from lowlands to highlands (Kebede *et al*., 1993). Given this agrological diversity, it is very hard to come up with uniform maize production months in Ethiopia. Broadly speaking, three production patterns are being followed by farmers for maize production. Most farmers produce maize during the main long rainy seasons from June to September. In some areas, a small amount is also produced in the short rainy period from February to May. Farmers in the western region also plant maize using the residual moisture in January and then harvest in June/July (Worku *et al.*, 2001). This study, therefore, used the long rainy months as the main maize production rainfall months in Ethiopia. The maize yield equation is specified as:

The maize yield equation is specified as:

$$YIELD_t = f\,(RAINP_t,\ IRRIG_t,\ SEED_t,\ LNTREND_t) \qquad (6.5)$$

where, $YIELD_t$	Maize yield (tons/ha)
$RAINP_t$	Average rainfall (mm) for the months of June, July, August and September
$IRRIG_t$	Irrigated maize area (ratio)
$SEED_t$	Maize planted with improved seed (ratio)
$LNTREND_t$	Log linear trend to capture the effects of maize technological improvement on yield over time

Table 6.4: Results for maize yield equation

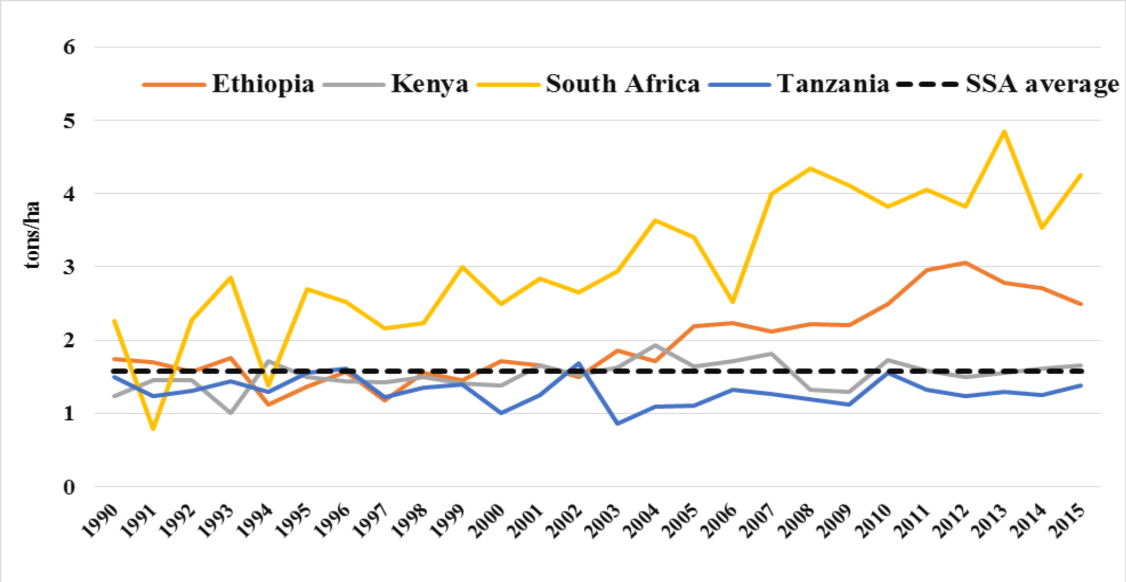
Variables	(1) Robust OLS	**(2) Elasticity**
IRRIG	0.308	0.003
	(28.14)	
SEED	0.381	0.038
	(1.059)	
LNTREND	0.460**	0.369
	(0.191)	
RAINP	0.005	1.65
	(NA)	
Constant	-2.4	
	(1.110)	
Observations	15	
Adjusted R^2	0.61	
F-statistics	6.49**	

Notes: robust standard errors in parentheses; ** p<0.05, * p<0.1; no standard errors are reported for the rainfall variable. Because of undesirable coefficient signs, we modified the value of the rainfall variable using a synthetic estimation technique. A synthetic elasticity coefficient value of 1.65 was used to obtain the rainfall coefficient. Given the high dependency of maize production on rainfall, the use of a 1.65 elasticity value is reasonable.

In the estimated yield equation, the result for the adjusted R-squared was 0.61 (Table 6.4 above). This suggests that 61 per cent of the variations in the maize yield in Ethiopia have been explained by the incorporated exogenous variables. The overall significance of the incorporated variables in explaining the yield equation was given by the F-statistics. The result indicated that the F-statistics value of 6.49 is significant at 5 per cent significance level. This implies that the model, as a whole, significantly explains the maize yield variation in Ethiopia.

In the yield equation, the trend variable appeared with the expected positive sign, and it is statistically significant at 5 per cent significance level. Technological introduction and progress in the maize commodity over the years has, thus, positively contributed to maize yield improvement in Ethiopia. As mentioned earlier, maize is grown in almost all agrological conditions in Ethiopia, from rainfed highland areas to moisture-stressed lowland areas. Given this wide adaptability, large numbers of households are growing the crop; close to nine million smallholder farmers are growing maize in Ethiopia, more than any other crop being grown in the country. With regard to maize productivity, Ethiopia has registered tremendous growth in boosting maize yields. The five-year average maize yield between 2011 and 2015 was estimated at 2.94 tons/ha (USDA, 2015). Maize yields reached a historic high level of 3.25 tons/ha in 2013. As demonstrated in Figure 6.5 below, it is only South Africa and Ethiopia that have managed to exceed 3 tons/ha in maize yields in Sub-Saharan Africa (SSA). With the exception of Zambia and Uganda, the remaining SSA countries are below 2.5 tons/ha (Abate *et al.*, 2015).

Figure 6.5: Maize yield in major SSA maize producing countries, (1990–2015)



Source: Author's calculation using USDA data (2015)

It is important to highlight the main drivers that have contributed to the dramatic change in maize yield and production in Ethiopia. Here, we list three success factors of the maize green revolution in Ethiopia. Firstly, there is relatively good coordination among the various actors involved in maize technology promotion and popularisation. The success of maize technology promotion and adoption, including the introduction of hybrid, stress-tolerant and Quality Protein Maize varieties (QPM) in Ethiopia is the result of strong collaborative work by private and public seed enterprises, NGOs (Sasakawa Global 2000), and the national and international research institutes. The introduction of high-yielding and stress-tolerant improved maize varieties has played a key part by replacing the traditional low-yielding maize varieties in Ethiopia. Since 1973, the National Agricultural Research System (NARS) has released a total of 61 maize varieties (Abate *et al.*, 2015). Currently, various institutions are working together to improve maize production and its contribution to food security in Ethiopia. The International Maize and Wheat Improvement Centre (CIMMYT) is the main source of maize germplasm. The Bako Agricultural Research Institute, under the Ethiopian Institute of Agricultural Research (EIAR), has the mandate to coordinate maize research and technology adaptation and generation in Ethiopia. Regional and federal seed enterprises multiply basic and certified maize seed for wider dissemination. Moreover, private sector participants, such as Pioneer Hybrid, are also involved in hybrid maize seed production and marketing to farmers. The Ministry of Agriculture (MoA) and EIAR have the mandate to popularise and demonstrate newly released maize varieties and empower farmers through subsequent training sessions. The recently established Agricultural Transformation Agency (ATA) is also working on maize value chain development in Ethiopia.

Secondly, the focus given by the Ethiopian government to modernising the agricultural extension system and improving its accessibility to farmers needs great appreciation. The introduction of new technologies alone does not guarantee yield improvement, unless accompanied by a modern extension system. The agricultural extension approach of Ethiopia could serve as a role model for Africa. In every district, the government has assigned three professional agricultural extension workers to help farmers with crop technology, livestock husbandry, and sustainable land management practices. Since 2000, Ethiopia has trained 63 000 extension agents. This has improved the extension agent-to-farmer ratio. Ethiopia's extension agent-to-farmer ratio is estimated at 1:476, compared to 1:1000 for Kenya, 1:1603 for Malawi, and 1:2500 for Tanzania (Kassie *et al*., 2015). This achievement is believed to improve the uptake of modern farm-enhancing technologies.

Thirdly, the even distribution of rainfall over the last two decades has played a favourable role in increasing maize productivity in Ethiopia. The mean annual rainfall in the major maize producing districts is displayed in Table 6.5 below. The mean annual rainfall has fluctuated between 2096 mm in Nekemete to 692 mm in the Rift Valley moisture-stressed maize-growing districts of Meki and Ziway. These rainfall amounts are favourable for maize production, as maize requires 450 to 600 mm of precipitation per season. Therefore, the adequate rainfall has helped the normal growth of maize production and productivity. However, there were also drought years in Debre-Markos and Bako.

Table 6.5: Annual rainfall (mm) for major maize producing districts, (1995–2014)

Regions	**Districts**	**Elevations (masl)**	**Mean**	**Std. Dev.**	**Min**	**Max**
Amhara	Bahir Dar	1827	1364.85	304.07	635	1957
	Gondar	1973	1161.82	223.92	653	1761
	Debre-Markos	2446	1253.46	297.57	164	1590
Oromia	Bako	1650	1081.58	530.45	148	2381
	Jimma	1718	1465.79	282.02	831	1967
	Nekemete	2080	2095.82	232.41	1706	2551
	Meki & Ziway	1640	691.68	185.45	346	1042

Source: Author's calculation using NMA data (2015)

With the exception of the calibrated rainfall elasticity value, the maize yield in general is inelastic to changes in the rest of the independent variables. The elasticity coefficient for the irrigated maize area is 0.003, implying that a 10 percentage change in the proportion of irrigated land would increase the maize yield by 0.03 per cent. Typically, irrigation access and maize yield are expected to have a positive correlation. This is because supplemental irrigation minimises complete crop failure during dry seasons (Kahinda *et al*., 2007). Although the positive relationship is maintained, the magnitude of the elasticity value between irrigation access and maize yield is low in Ethiopia. Two factors could be mentioned for the low responsiveness of maize yield to the proportion of maize planted with irrigation. Firstly, in most cases, common crops such as maize are grown in the rainfed farming system in Ethiopia. Cash crop production using irrigation is practised in the lowland areas of the country such as the Afar region. However, unlike rainfed farming, irrigated farming requires better understanding of soil composition and the use of relatively more improved farm techniques. To better harness the advantage of irrigation access, it is crucial to complement irrigation with recommended use of improved farm technologies such as chemical fertiliser. A study in Zimbabwe (Maisiri *et al*., 2005) found that fertiliser use, not irrigation, was determining of the final yield. Limited capital for purchasing the necessary irrigation equipment and the inadequate credit system influence the performance of irrigation farming. Without having such things in place, it would not be logical to expect high maize yields under irrigation farming.

Secondly, maize planting using supplemental irrigation methods such as Rainwater Harvesting (RWH) is a new experience for Ethiopian farmers. RWH at the household level has been promoted in Ethiopia, but both the adoption and the performance of the system are very low. As noted by Moges *et al*. (2011), who studied three RWH systems in Oromia region, found that the water availability was low in relation to crop water needs, particularly for maize. Because of the recent introduction of such technologies, it will take time for farmers to understand the techniques for growing maize under supplemental irrigation farming, which is a completely new experience compared with rainfed maize farming.

The elasticity value for the use of improved maize seed is 0.038, which indicates that a 10 per cent increase in the proportion of area planted with improved maize seed would improve the maize yield by 0.38 per cent. The inelastic response of the maize yield to improved seed utilisation might have been associated with the use of recycled seed as improved seed. Maize is one of the Open Pollinated Varieties (OPVs) where farmers can use recycled seeds for planting, although its effect on yield decreases over time. The trend variable elasticity value was higher, as compared with the elasticity values for the proportion of maize planted with improved seed and the irrigated area. The elasticity value for the trend variable, which is used as a proxy for technological progress such as improvement in extension service advice, is 0.369. This implies that a 10 per cent increase in such improved infrastructural and advisory services would boost maize yield by about 3.7 per cent.

Beginning stock is modelled as an identity equation and equal to lagged ending stock:

$$BEGSTOCK_t = ENDSTOCK_{t-1} \quad (6.6)$$

where, $BEGSTOCK_t$ Beginning stock (1000 tons)
$ENDSTOCK_{t-1}$ Lagged ending stock (1000 tons)

6.6.2 Domestic demand block

Total domestic maize use (human consumption, seed, and feed use) and ending stock constitute the total demand for maize in Ethiopia. The data reported by USDA on seed and feed use are unreliable. As a result, these two maize uses are not estimated in individual demand equations, but are included as exogenous variables in the calculation of total domestic maize use in Ethiopia. Domestic maize consumption was estimated as an identity by multiplying the per capita white maize consumption by the total population of Ethiopia, and is specified as below:

$$DMCON_t = PCONS_t * POP_t \quad (6.7)$$

where, DMCON Domestic maize consumption (1000 tons)
PCONS Per capita maize consumption (kg/person)
POP Ethiopian population (million)

The Food, Seed, and Industrial consumption (FSI) recorded in the USDA data were subdivided into human consumption and seed. To do this, we relied on the CSA crop utilisation survey results. In 2001 and 2009, the crop utilisation report of CSA revealed that 76 per cent of maize production was consumed at home, while 9 per cent was used for seed. Similar results were obtained in 2008, 2010, and 2011, where 75 per cent of maize production was retained for household consumption and 10 per cent for seed use. The industrial utilisation of maize is not developed in Ethiopia. According to CSA (2015), the remaining maize utilisations are for 'in kind' wage payments (1 per cent) and marketing (12 per cent).

Maize production is mostly consumed at household level, both as green and dry grain. The popularity of maize in Ethiopia is partly due to its wider adaptability and its high value as a food crop, as well as the growing demand for stover as animal fodder and a source of fuel for rural families. As stated in the previous chapter, maize is the most important staple crop in terms of calorie intake in rural Ethiopia.

The findings for the drivers of per capita white maize consumption in Ethiopia are illustrated in Table 6.6 below. Per capita maize consumption is modelled in Equation (6.8) below as a function of own price, price of substitutable crop (i.e. sorghum), real per capita GDP, and two shift variables capturing the soaring food price phenomena and changes in the policy environment from free trade to export ban. A trend variable is also incorporated to examine the changing trend in the consumption habits of maize consumers over time.

The per capita maize consumption is modelled as:

$PCONS_t = f\,(RMPRICE_t\ RSORGPRICE_t, RPCGDP_t, SHIFT05, SHIFT2011, TREND_t)$ (6.8)

where, RMPRICE	Real wholesale maize price (ETB/ton)
RSORGPRICE	Real wholesale sorghum price (ETB/ton)
RPCGDP	Real per capita GDP (USD/person)
SHIFT05	Shift variable for the period of soaring food prices in domestic grain market. It takes 1 for period since 2005 and 0 otherwise
SHIFT2011	Shift variable for the export ban; 1 for period since 2011 and 0 otherwise
TREND	Trend variable for change in maize consumption habit

Table 6.6: Results for per capita maize consumption

Variables	(1) Robust OLS	(2) Elasticity
RMPRICE	-0.0045	-0.322
	(0.008)	
RPCGDP	0.117	0.012
	(0.167)	
RSORGPRICE	0.007	0.074
	(0.008)	
SHIFT05	11.12*	
	(5.592)	
SHIFT2011	14.65*	
TREND	-2.894	-0.0071
	(3.867)	
Constant	12.72	
	(22.567)	
Observations	15	
Adjusted R^2	0.64	
F-statistics	5.086**	

Note: robust standard errors in parentheses; ** p<0.05, * p<0.1

The estimated per capita maize consumption has a corrected R-squared value of 0.64, implying that 64 per cent of the variations in white maize consumption are captured by the included explanatory variables. Furthermore, the F-statistics also confirm that the incorporated variables used to explain the maize consumption equation perform pretty well. The F-statistics for the overall model is 5.086 and significant at 5 per cent significance level. This suggests that the overall model is able to significantly explain the variation in the per capita white maize consumption in Ethiopia.

All the estimated variables in the per capita white maize consumption have the expected signs. Economic theory has taught us that basic goods tend to have an inelastic demand. Maize is a basic commodity in Ethiopia and, therefore, as the maize price increases, consumers do not immediately alter their usual consumption of maize. Instead, they decrease their maize consumption moderately. This is evidenced by the negative elasticity coefficient of the real wholesale maize price, which is 0.322, implying that a 10 per cent increase in real wholesale maize price would lead to a decrease in per capita maize consumption by 3.22 per cent. The estimated income elasticity is 0.012, suggesting that a 10 per cent increase in real per capita GDP would increase maize per capita consumption by 0.12 per cent.

The trend variable appeared with a negative sign, indicating the decline in the share of maize in the consumption basket of consumers, over time. This could be attributed to the increase in urbanisation. It has been well documented that owing to urbanisation, people tend to move away from the consumption of root crops and coarse grains to wheat and rice. However, the effect of the trend variable is small, which is an indication that the composition of food baskets in Ethiopia is fairly constant. The elasticity for the trend variable was -0.0071, which implies that in each year, per capita maize consumption decreases by 0.071 per cent. The elasticity is small because the majority (85 per cent) of the Ethiopian population reside in rural areas. In the rural areas of Ethiopia, maize is the main staple food crop. Hence, the decreasing trend being captured at the national level is because of changes in the diets of urban consumers. In urban areas, wheat and teff crops are the most preferred crop for consumption. This is because the maize processing industry has not shown any significant improvement in line with the expansion of urbanisation in Ethiopia. As a result, wheat and teff crops continue to serve as the main preferred dishes for urban consumers.

The real wholesale sorghum price incorporates the effect of substitutes in maize consumption in Ethiopia. The sorghum price has a positive effect on maize consumption: if the price of a substitute crop increases, maize consumption will increase. However, maize consumption is inelastic to the sorghum price. A 10 per cent increase in the sorghum price would lead to an increase in per capita maize consumption by 0.74 per cent. Both shift variables that take into account the effect of soaring food price phenomena and the export ban on maize consumption were positive and significant at 10 per cent significance level. Maize is one of the food crops that have experienced soaring food prices in the domestic grain market. The positive and significant relationship of maize per capita consumption to high market price environment is not a surprise. As stated earlier, maize is mainly produced for home consumption. Therefore, the decision to produce maize is mainly influenced by subsistence requirements, rather than by market price dynamics. One possible reason for the positive relationship between maize consumption and price hikes could be that farmers may increase the marketing of high price commodities such as wheat. An increase in the marketability of other cereals could increase the use of maize for household consumption. Maize consumption has shown an upward trend since 2005. On average, maize per capita consumption increased by 46 per cent from 31.8 kg per person during 2001–2004 to 46.57 kg per person during 2005–2015.

The shift variable (SHIFT2011), capturing the effect of an export ban on maize consumption, is also significant and positive. This result is consistent with a prior expectation and economic theory that an export ban in the face of high domestic maize production would lower maize price in the domestic market. As a result, consumers would enjoy low prices through increasing their maize consumption. However, this assertion would work only if the export of maize became profitable. Removing an export ban has no effect if exports are not profitable. The experiences of other countries on the effects of export bans on domestic prices are mixed. Diao *et al*. (2013) found that the maize export ban in Tanzania reduced maize producer prices by 9 to 19 per cent. In contrast, Porteous (2012) and Chapoto and Jayne (2009) found no significant relationship between an export ban and domestic prices. The authors argue that in most countries, export bans are implemented in response to soaring domestic grain prices. Unless the prices in other trading partner countries rise much faster, the higher domestic prices are likely to make exports unprofitable and the ban unnecessary.

Ending stock is modelled as a function of beginning stock, maize production, real wholesale maize price, and wheat food aid.

$$ESTOCK_t = f\,(BSTOCK_t, MPROD_t, RMPRICE_t, AID_t) \tag{6.9}$$

where, ESTOCK	Ending maize stock (1000 tons)
BSTOCK	Beginning maize stock (1000 tons)
MPROD	Domestic maize production (1000 tons)
RMPRICE	Real wholesale maize price (ETB/tons)
AID	Wheat food aid quantity (1000 tons)

Since all the variables are non-stationary, running OLS on the ending stocks equation would lead to spurious regression results. However, the variables become stationary after first difference. Hence, ECM is suitable for analysing the equation and producing valid and consistent results. The results for ECM are presented in Table 6.7 below. From the ECM results, we can see that the error correction term appeared with the right negative sign and is significant at 5 per cent significance level.

Table 6.7: Estimated results for ending stock

Variables	(1) ECM	(2) Elasticity
D(MPROD)	0.0952	1.04
	(1.624)	
D(RMPRICE)	-0.1192	
	(NA)	-1.2
D(BSTOCK)	0.310	
	(1.083)	0.319
D(AID)	-0.096	
	(-0.954)	-0.139
ECT(-1)	-1.345**	
Constant	20.672	
	(0.059)	
Observations	14	
Adjusted R^2	0.45	
F-statistics	3.095*	

Notes: No standard errors are reported for the real wholesale maize price. The reported value is a calibrated coefficient value using a hypothetical elasticity value of -1.2; robust standard errors in parentheses; ** p<0.05, * p<0.1

With the exception of the real wholesale maize price, the estimated variables in the ending stock equation are consistent with our expectations. As opposed to our expectation and economic theory, the real wholesale maize price was positive in the original ECM model. This means that as the wholesale price increases, traders would sell maize production to the EGTE. This is not realistic because when the wholesale price increases, traders become reluctant to sell to the EGTE. Instead, they tend to sell to the open market at higher prices. To overcome this difficulty, a calibration technique was employed to arrive at the expected negative sign. The rest of the variables appeared with the expected signs. As expected, the wheat food aid quantity impacted on ending stocks negatively. This means that as the food aid quantity becomes high, the government through its parastatal organisation, the EGTE, would only get involved in the grain market for price stabilisation purposes. The EGTE is the only parastatal organisation involved in the procurement of maize from farmers, and is so for four purposes: a price stabilisation role through procuring buffer stocks, national food reserve, school feeding, and the Productive Safety Net Programme (PSNP). Hence, in a high food aid expectation year, the government can cover the PSNP through releasing stocks, which otherwise would be met through local purchases. A 10 per cent increase in food aid would decrease the ending stocks by about 1.4 per cent. The ending stock parameter is elastic for maize production. A 10 per cent increase in maize production raises maize ending stocks by 10.4 per cent.

6.6.3 Model closure

The techniques used to close systems of equations depend on the prevailing market regimes (Meyer *et al*., 2006). As illustrated in the price discovery section, Ethiopia is a self-sufficient maize producer. The country imports maize in times of periods of drought. The volume of imports is, however, negligible and is thus assumed to have no great impact on the domestic maize market prices. Furthermore, the price transmission process is expected to be affected by the presence of high government intervention in the domestic grain market. Price linkage and trade equations are therefore not relevant in such cases. However, to gain a complete picture of the impact of maize imports during drought seasons, the domestic maize price linkage with the world market was examined in Chapter 5.

Since Ethiopia is largely self-sufficient in maize production and hence consumption, it is trading in an autarky trade regime. In an autarky trade regime, price is used as a closing identity for the model. The maize price is, therefore, not estimated by an equation, but rather it is an identity determined by the interaction of domestic supply and demand forces.

$$\text{Maize price} = \text{Total Domestic use} - \text{Production} - \text{Beginning stock} + \text{Ending stock} \qquad (6.10)$$

The model would solve the market clearing identity using a Gauss-Seidel iterative algorithm which involves a step-wise iterative process to estimate a solution (Meyer *et al*., 2006).

6.6.4 Model performance

As stated in the method section, the model performances of individual behavioural equations are tested using both graphical and statistical techniques. The ability of a simulation model to correctly predict the key turning points in the actual data is an important criterion for model assessment (Pindyck and Rubinfeld, 1991, quoted by Mapila *et al*., 2011). The graphical results for the model adequacy test are illustrated in Figure 6.6 below. The visual inspection of the estimated single equations has demonstrated that, with the exception of ending stocks, the equations for all the remaining estimated models perform well in capturing the turning points in the actual values.

Figure 6.6: Actual versus predicted values of the behavioural equations, 2001-2005

Statistical methods were also used to evaluate the robustness of our estimated models. Statistical approaches that examine the forecasting ability of models largely assess a forecast error value, which is obtained as the deviation of the forecast value from the actual value. A model that produces a low error value is considered to have good forecasting ability, and the results are qualified for using in forecasting and policy purposes (Gebrehiwet *et al*., 2010). The forecast evaluation was carried out using in-sample periods by using the historical periods from 2001 to 2015. We employed different forecast statistics to evaluate how well our model captures the real actual values. Following Pindyck and Rubinfeld (1991, quoted by Mapila *et al*., 2011), the following seven statistical techniques, namely Mean Average Error (MAE), Mean Average Percentage Error (MAPE), Root Mean Squared Error (RMSE), Theil Inequality Coefficient (U), Bias, Variance and Covariance proportions were employed to evaluate the forecasting ability of the individual equations. The specifications for the first four methods are described below.

The Mean Average Error is computed as the average value of the absolute value of the error terms occurring in each period, and is given in Equation (6.11) below:

$$MAE = \frac{1}{T}\sum_{t=1}^{T}|\hat{y}_t - y_t| \tag{6.11}$$

On the other hand, the Mean Average Percentage Error (MAPE) captures the error in terms of a percentage of the actual value. MAPE is calculated using Equation (6.12):

$$MAPE = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{\hat{y}_t - y_t}{y_t}\right| \tag{6.12}$$

The Root Mean Squared Error (RMSE) represents the standard deviations of the forecast errors. RMSE is computed using Equation (6.13), as follows:

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{y}_t - y_t)^2} \tag{6.13}$$

The other statistical method for evaluating the forecasting ability is the Theil Inequality Coefficient (U) (Theil, 1967). The formula used to compute U is specified in Equation (6.14) below. The numerator of the formula is the root mean squared errors. The Theil Inequality Coefficient lies between 0 and 1, with 0 indicating a perfect fit. It is important to note that RMSE and MAE depend on the scale of a dependent variable, while the next two statistics (MAPE and Theil Inequality Coefficient) are scale invariant.

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{y}_t - y_t)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{y}_t)^2}\ \sqrt{\frac{1}{T}\sum_{t=1}^{T}(y_t)^2}} \tag{6.14}$$

Bias proportion indicates how far the mean of the forecast is from the mean of the actual series. Likewise, the variance proportion indicates how far the variance of the forecast is from the variance of the actual series. The covariance proportion measures the remaining unsystematic forecasting errors. It is important to note that the bias, variance and covariance proportions add up to one and are given as proportions out of 1. If the forecasts are said to be good, the bias and variance proportions should be small, which is the case in all the estimated behavioural equations. The results for the forecast evaluation are given in Table 6.8 below.

Table 6.8: Forecast evaluation for the estimated single equation models

Forecast statistics	Behavioural equations			
	Area harvested	Per capita consumption	Yield	Ending stocks
Theil Inequality Coefficient (U)	0.0484	0.0513	0.058	0.1524
Bias Proportion	0.000	0.000	0.00	0.0027
Variance Proportion	0.105	0.0581	0.081	0.248
Covariance Proportion	0.895	0.9419	0.919	0.749
Mean Absolute Percentage Error (MAPE)	7.288	8.6465	10.326	32.297
Mean Absolute Error (MAE)	121.11	3.1784	0.2307	124.087
Root Mean Squared Error(RMSE)	176.64	4.4799	0.273	145.05

Source: Model output

The reported forecast statistics value indicates that most of the forecast accuracy statistics using Theil's Inequality Coefficient (U) produced results closer to zero, which is an indication for good model forecast. In addition, except the ending stocks equation, the mean absolute percentage error is around or below ten per cent for the remaining models. Hence, we can conclude that the single behavioural models perform reasonably well in tracking the actual values, and therefore can be used for forecasting and policy analysis. Once we make sure that the model is adequate in approximating the real maize market phenomena, it is possible to proceed to analyse maize market outlooks and simulation analysis in the maize industry.

6.7 MAIZE MARKET OUTLOOKS AND SIMULATION RESULTS

This section illustrates the findings from maize market outlooks and simulation analysis on maize yield and rainfall. Understanding the effects of government policy, productivity, and weather-related shocks on the maize industry will support evidence-based policy interventions in the maize sub-sector. Moreover, the simulation analysis provides disaggregated impacts of yield and drought shocks on the different components of the maize industry in Ethiopia. This further simplifies policy decision-making and interventions in the maize sub-sector by providing policy options as to whether to target maize yield improvement or investment in agricultural output and support service institutions.

The simulation period is from 2017 to 2025. In order to examine the maize industry outlooks from 2016 to 2025, the exogenous variables were forecasted. The forecasted values for CPI and population growth rate are obtained from the projections made by the International Monetary Fund (IMF) and the World Bank. The section begins by briefly discussing the assumptions of the maize market outlook analysis. This is followed by discussion of the overall maize market outlooks for Ethiopia during the projection period from 2016 to 2025. The final section further utilises the projections for the maize sub-sector to provide evidence on the effects of yield and weather-induced shocks on the maize market prices. The shocks are introduced into the model in the 2017 outlook period.

6.7.1 Assumptions for maize market outlooks

Macroeconomic variables

- The projected values for the main macroeconomic and exogenous variables for the outlook periods are presented in Table 6.9 below. On average, the CPI is expected to increase at a 2 per cent growth rate from 2016 to 2025. The real *per capita* GDP is projected to decrease by 1.3 per cent in 2016, from 486 USD in 2015 to 480 USD in 2016. However, the per capita GDP has shown a steady increase for the remaining forecasted periods and will reach 708 USD/person in 2025. The World Bank forecast for the population growth rate has indicated that the Ethiopian population is expected to grow annually by a constant 2 per cent from 2016 to 2025, and will reach 125 million by 2025. The population growth rate will reach a peak level of 2.48 per cent in 2016.

Policy, price, and weather variables

- The maize export ban has been assumed to remain in effect for the outlook period. As a result, the net trade is zero for the periods from 2016 to 2025.

- The rainfall patterns for both area and main season maize production months are assumed to be at the average rainfall of 2001 to 2015.

- The real producer price of the substitutable crop (sorghum) is projected to show a decreasing trend and will reach 2312 ETB/ton in 2016. With the exception of 2017 where the sorghum producer price is projected to grow by 26 per cent, the real producer price is expected to decrease annually by 2 per cent from 2018 to 2025. The same trend is also projected for the real wholesale sorghum price. The projected real wholesale sorghum price is expected to show a declining trend from 2018 to 2025. The wholesale sorghum price is projected to decrease by 2 per cent during these periods. However, it is projected to increase by 25 per cent from 2312 ETB/ton in 2016 to 2901 ETB/ton in 2017.

- The food aid amount for the outlook period is assumed to be the average amount of wheat aid from 2001 to 2015. The average wheat aid between 2016 and 2025 is 530 000 tons. This represents a declining trend by 7 per cent from the average wheat aid of 567 000 tons during 2001 and 2015. Wheat aid reached an all-time peak level of 973 000 tons in 2009. This could be due to the increase in international aid to counteract the threat posed by soaring and volatile food prices in the domestic grain market. Likewise, the trend in per capita wheat aid subsided during the outlook period. On average, per capita wheat aid has decreased from 7.1 kg/person from 2001 to 2015 to 4.7 kg/person over the projected periods from 2016 to 2025. This figure represents a decrease by 34 per cent in per capita wheat aid between these two periods.

Table 6.9: Summary of macroeconomic and exogenous variables for the outlook periods

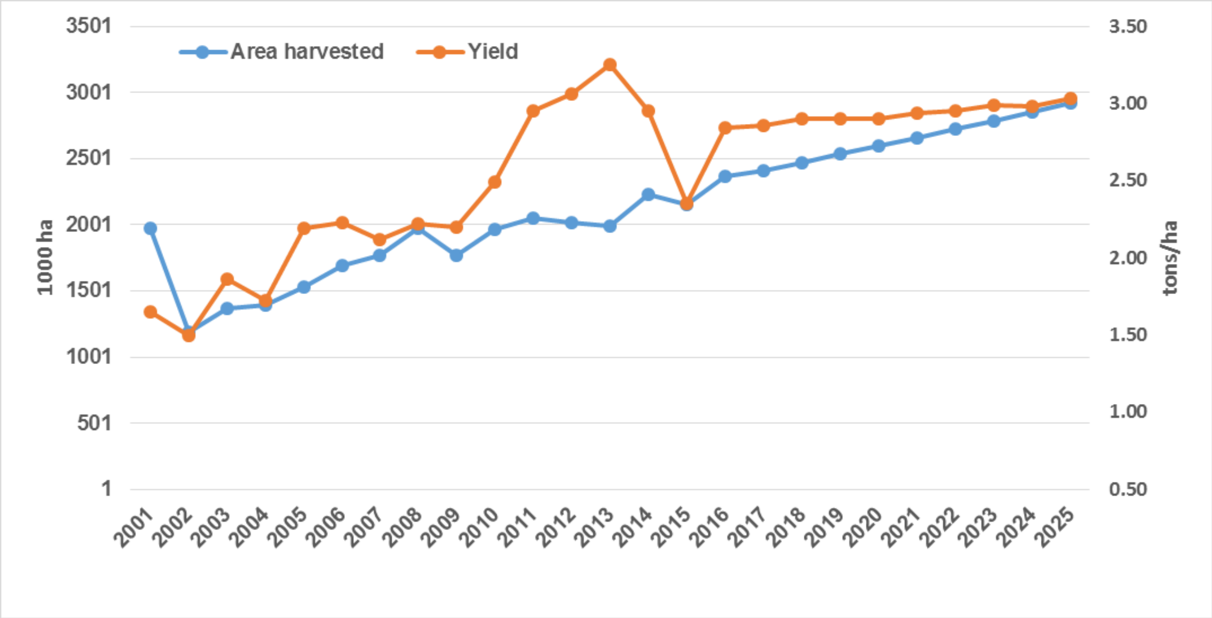
Variables	Units	2016	2017	2018	2019	2020	2021	2022	2023	2024	2015
CPI	Index	220	221	240	258	277	295	313	329	345	361
Per capita GDP	USD/person	480	508	536	562	587	612	637	661	685	708
Population	Million	102	104	107	109	112	115	117	120	122	125
Rainfall for area	mm	377	372	369	365	364	358	355	352	346	351
Rainfall for production	mm	788	783	785	773	764	764	759	758	748	755
Wheat aid	1000 tons	567	561	575	521	527	504	516	524	516	486
Per capita wheat aid	kg/person	5.57	5.38	5.38	4.76	4.71	4.40	4.40	4.38	4.22	3.89

Source: Model output

6.7.2 Maize market outlooks

Maize production is expected to grow during the forecasted period from 2016 to 2025. Production is expected to reach 8.7 million tons by 2025. The average maize production during the forecasted period is 7.7 million tons. This represents an increase of 81 per cent over the fifteen-year period average of 4.29 million tons during 2001–2015. As shown in Figure 6.7 below, the increase in maize production during the forecasted period is mainly driven by the expansion in the maize area harvested than the yield improvement. The maize area harvested is projected to increase by 46 per cent from 1.8 million ha from 2001–2015 to 2.6 million ha for the period 2016–2025. On the other hand, the maize yield is expected to rise by 26 per cent from the fifteen-year average of 2.3 tons/ha to 2.9 tons/ha for the forecasted period.

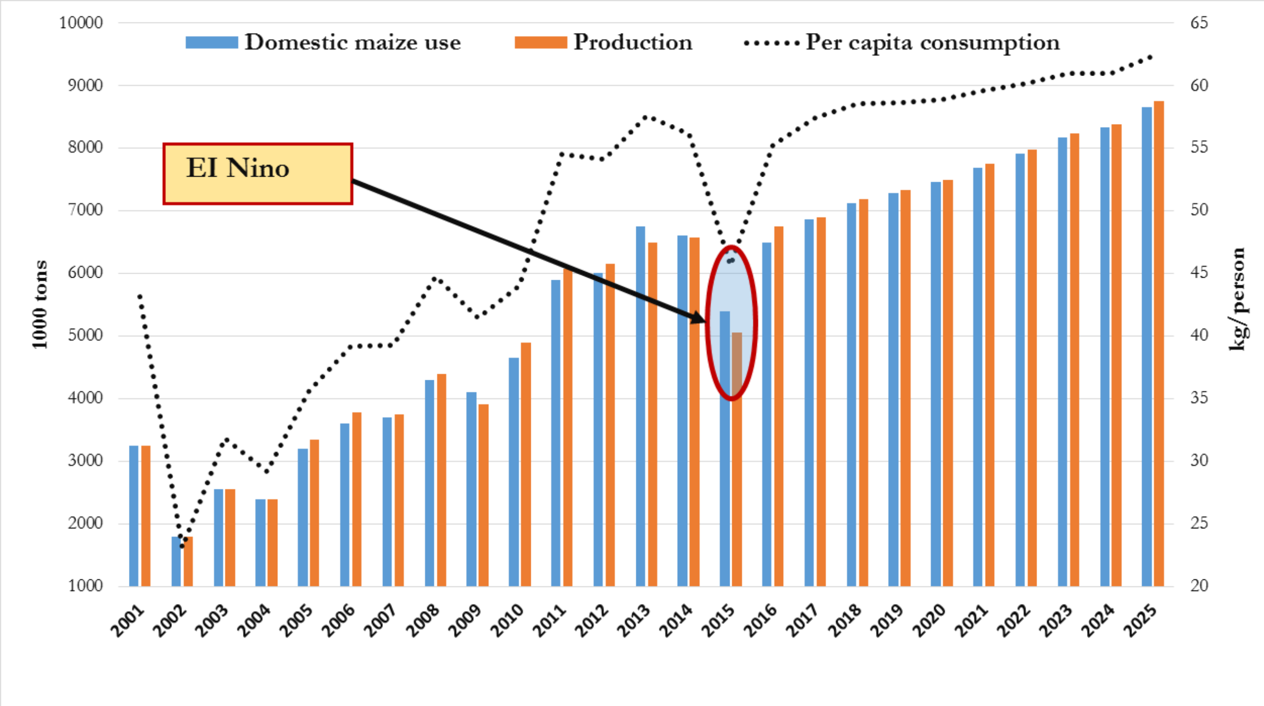
Figure 6.7: Projected maize area harvested and yield trends, 2001–2025



Source: Model outcome

The increase in maize production during the baseline period is, however, not enough to offset the growth on the demand side. On average, human consumption is expected to reach 6.7 million tons during the forecasted period. This shows an increase by 85 per cent over the fifteen-year period of 3.6 million tons from 2001 to 2015. The per capita maize consumption is expected to reach 62.3 kg per person in 2025. The average projected per capita consumption from 2016 to 2025 is 59.3 kg/person, which is 39 per cent higher than the average per capita maize consumption of 42.63 kg/person during 2001–2015.

Figure 6.8: Maize production and domestic maize use outlook, (2001–2025)

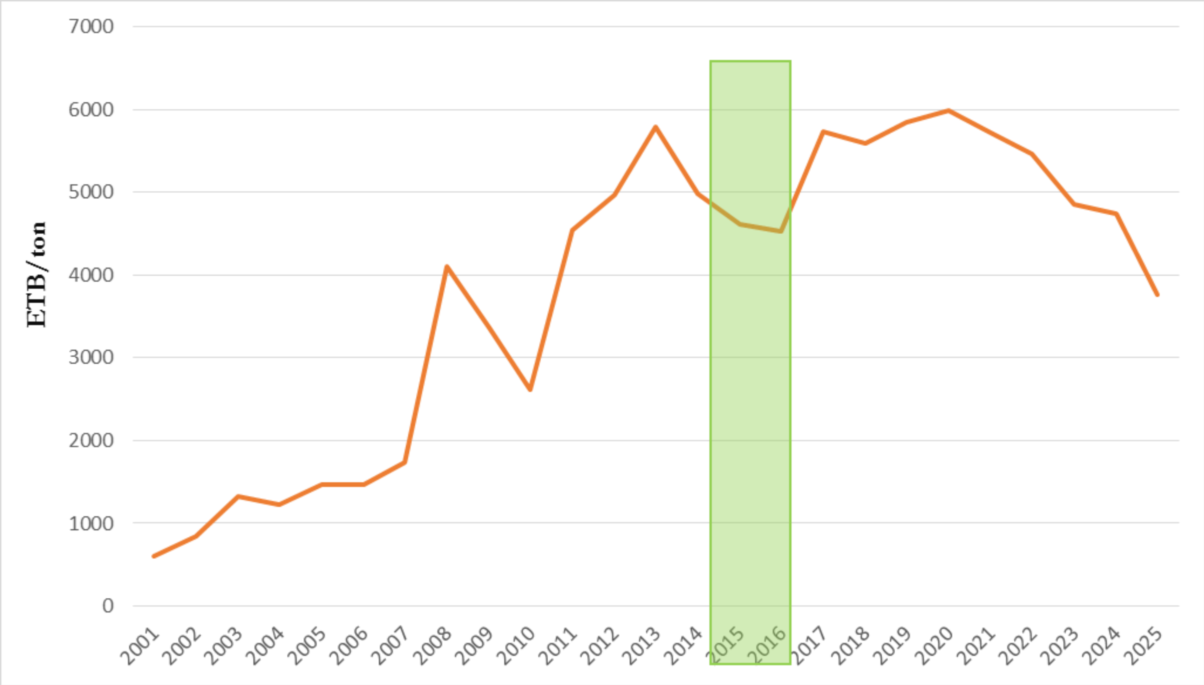


Source: Model output

As demonstrated in Figure 6.8 above, the country had been hit by El Nino in 2015, which significantly affected crop production. The drought caused a decline in maize production and consumption in 2015. As compared with 2014, maize production reduced by 23 per cent in 2015. Consequently, maize consumption also dwindled by 17 per cent, from 5.4 mil tons in 2014 to 4.5 mil tons in 2015. This is not surprising, given the fact that the majority of maize production in Ethiopia is produced in rainfed farming. As shown in Figure 6.9 below, maize prices remained steady during this period, but had started to rise afterwards. This may have been associated with the Ethiopian government's proactive responses through imports and distribution. According to USDA (2016), Ethiopia imported 5 thousand tons of maize in 2015. In addition, the government imported about 2 million tons of wheat to mitigate the humanitarian crisis posed by El Nino in 2016.

The mismatch between the high growth rates in human consumption over maize production is expected to increase the nominal wholesale maize price. On average, the nominal wholesale maize price is expected to increase from 2910 ETB/ton during 2001–2015 to 5223 ETB/ton during the projected period 2016–2025. This represents an increase of 79 per cent during the outlook period.

Figure 6.9: Nominal wholesale maize price outlook, (2001–2025)



Source: Model output

6.7.3 Model simulation results

In this section, we illustrate the dynamic effects of invoking different shocks in the developed partial equilibrium model for the Ethiopian white maize market. We are particularly interested in examining the impact of a bumper harvest and weather-induced shocks on the maize market outlook period from 2017 to 2025. It is safe to say that these shocks have commonly occurred in the maize market in Ethiopia. Therefore, the introduction of these shocks into the system takes into account the current trends in the maize market in Ethiopia.

An illustration of the simulation results are presented in Tables 6.10 to 6.13 below. The simulation analysis is presented by comparing the baseline period with the simulation values after the introduction of shocks in 2017. In this context, the baseline period refers to the above-mentioned developed maize outlook period from 2001 to 2025, while the scenario period refers to the period after invoking disturbances into the maize partial equilibrium model.

6.7.3.1 Impact of maize yield shocks

Ethiopia is one of the two countries in Africa (the other is South Africa) that has attained > 3 tons per hectare in maize yields. This is regarded as a big achievement for a smallholder-dominated maize producer country such as Ethiopia. Ethiopia exceeded 3 tons per hectare in the 2012 and 2013 production seasons (USDA, 2016). The average maize yield during these two periods was 3.16 tons/ha. This figure represents a 50 per cent increase, compared with the preceding eleven years (2001–2011) which had a maize yield average of 2.10 tons/ha. The success in maize yield improvement emanates from a better breeding strategy that considers the heterogeneous typology of maize production in Ethiopia. However, there is still much scope for improving the current maize yield through the intensification of chemical fertiliser utilisation, conservation farming, mechanisation, and investment in irrigation infrastructure. Therefore, it is reasonable to believe that the country can replicate the success in maize productivity with the expected improvement in government investment in infrastructural facilities. To this end, we introduced a shock in maize yield into the partial equilibrium maize model for Ethiopia. The shock was introduced in the 2017 baseline period.

Suppose that the introduction of a technological innovation (a new maize variety or conservation farming) raises maize farmers' yields by 20 per cent. How does this increase in yield change the maize price? Does yield improvement render maize consumption better or worse than it was before? In this section, we shall address these questions by comparing the simulation results with the baseline values. We answer the question about the impact of maize yield simulation in three steps. Firstly, we examine the short-run and long-run responses of the different components of the maize market model. Then, we consider the direction and proportion of the shift. Finally, we quantify how these dynamic changes in the supply and demand components translate into the maize market equilibrium price.

The dynamic responses of the maize sub-sector to a bumper harvest are summarised in Table 6.10 below. From the yield simulation analysis, it is clear that a 20 per cent increase in maize yield would result in an increase in maize production by 20 per cent. The impact of the yield simulation is more pronounced and persistent for maize ending stocks and the nominal maize price. As compared with the baseline, a 20 per cent increase in the maize yield could reduce the nominal maize price substantially, by 81 per cent. In the short run (within the year), a positive change in yield would increase maize ending stocks by 87 per cent, and the effect will continue in the long run. A 20 per cent positive change in maize yield would lead to an increase in ending stocks by 34 per cent, 14 per cent, 6 per cent, and 2 per cent in 2018, 2019, 2020, and 2021, respectively. A moderate impact is noticed on domestic maize use; a 20 per cent change in maize yield could increase domestic maize use by 14 per cent. Maize area harvested has remained unaffected by a 20 per cent positive change in maize yield.

Table 6.10: Yield simulation and percentage increase compared with the baseline

Affected components	2017	2018	2019	2020	2021	2022	2023	2024	2025
Maize yield	**Tons/ha**								
Baseline	2.86	2.91	2.89	2.88	2.92	2.93	2.96	2.94	3.00
Scenario	3.43	2.91	2.89	2.88	2.92	2.93	2.96	2.94	3.00
Absolute change	0.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**20 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Maize production	**Thousand tons**								
Baseline	6890	7193	7324	7498	7759	7972	8242	8374	8755
Scenario	8262	7193	7324	7498	7759	7972	8242	8374	8755
Absolute change	1373	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**20 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Domestic maize use	**Thousand tons**								
Baseline	6858	7126	7277	7455	7692	7909	8165	8325	8661
Scenario	7849	7337	7372	7498	7711	7918	8169	8326	8662
Absolute change	991	211	95	43	19	9	4	1	0
% Change	**14 %**	**3 %**	**1 %**	**1 %**	0 %	0 %	0 %	0 %	0 %
Ending stocks	**Thousand tons**								
Baseline	441	509	556	599	666	728	805	854	948
Scenario	823	680	632	632	681	734	808	855	949
Absolute change	382	171	76	34	15	6	3	1	1
% Change	**87 %**	**34 %**	**14 %**	**6 %**	**2 %**	**1 %**	0 %	0 %	0 %
Nominal wholesale maize price	**ETB/ton**								
Baseline	5733	5599	5845	5989	5717	5465	4855	4742	3759
Scenario	1061	4545	5347	5756	5609	5416	4833	4732	3755
Absolute change	-4672	-1054	-498	-233	-108	-49	-22	-10	-4
% Change	**- 81 %**	**-19 %**	**-9 %**	**-4 %**	**-2 %**	**-1 %**	0 %	0 %	0 %

Source: Model outcome

6.7.3.2 Impact of a 10 per cent decrease in rainfall during planting period

Crop production in Ethiopia is predominantly dependent on a rainfed farming system. As a result, it is becoming a common event to see a humanitarian crisis develop whenever the rainfall amount fluctuates below the average level. Staple food crops, such as maize, are prone to weather-related shocks in Ethiopia. In 2015, maize production and consumption subsided owing to the effect of drought (El Nino). Drought reduced maize production by 23 per cent in 2015. This is not surprising because the majority of maize is produced in rainfed farming. Only 2 per cent of maize production is grown under irrigation (CSA, 2015). Therefore, understanding the possible impact of rainfall shocks on the maize market is crucial for designing an early warning system and a price stabilisation policy. Moreover, since Ethiopia has been a major recipient of food aid, the food aid agencies would also benefit from knowing about the likely impacts of weather-induced shocks on maize production, market price, consumption, and government food stocks.

In this section, we introduced a 10 per cent decrease in rainfall as a shock during the planting and main season production periods. The shocks are introduced into the model in 2017. The results for the simulation models are presented in Tables 6.11, 6.12, and 6.13 below. The effects of a 10 per cent decrease in the rainfall amount during a planting period in the major maize producing areas will be linked to the model by influencing maize producer land allocation decisions. This change will also reduce maize production and consumption at the national level. Subsequently, the decrease in rainfall during planting times will increase the maize market price, thus prompting farmers and traders to target the open market instead of selling to the EGTE for stocks. As a result, maize ending stocks will decrease.

From an analysis of the simulation results, it can be shown that a 10 per cent decrease in rainfall during a planting period has impacts on maize area harvested, production, consumption, ending stocks, and the nominal wholesale maize price. However, maize yield is not affected by the disturbance invoked into the system of equations. The magnitude of influence is relatively higher for ending stocks and wholesale maize price. In the short run, a 10 per cent decrease in rainfall during a planting period in the major maize producing regions would decrease maize ending stocks by 8 per cent. The combined effect of decreases in area harvested and in maize production would increase the nominal maize prices by 7 per cent. From a food security perspective, maize consumption is reduced modestly by the introduction of rainfall shocks into the system. A 10 per cent decrease in rainfall during a planting period could reduce maize consumption by 1 per cent.

Table 6.11: Impact of a 10 per cent decrease in rainfall during a planting period

Affected components	2017	2018	2019	2020	2021	2022	2023	2024	2025
Area harvested	**Thousand Hectare**								
Baseline	2408	2472	2536	2602	2661	2725	2789	2850	2922
Scenario	2366	2472	2536	2602	2661	2725	2789	2850	2922
Absolute change	-42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**-2 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Maize production	**Thousand tons**								
Baseline	6890	7193	7324	7498	7759	7972	8242	8374	8755
Scenario	6770	7193	7324	7498	7759	7972	8242	8374	8755
Absolute change	-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**-2 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Domestic maize use	**Thousand tons**								
Baseline	6858	7126	7277	7455	7692	7909	8165	8325	8661
Scenario	6772	7107	7268	7452	7690	7909	8165	8325	8661
Absolute change	-86	-18	-8	-4	-2	0	0	0	0
% Change	**-1 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Ending stocks	**Thousand tons**								
Baseline	441	509	556	599	666	728	805	854	948
Scenario	408	494	549	596	665	728	805	854	948
Absolute change	-33	-15	-7	-3	1	0	0	0	0
% Change	**-8 %**	**-3 %**	**-1 %**	0 %	0 %	0 %	0 %	0 %	0 %
Nominal wholesale maize price	**ETB/ton**								
Baseline	5733	5599	5845	5989	5717	5465	4855	4742	3759
Scenario	6141	5692	5889	6010	5726	5469	4857	4743	3759
Absolute change	408	92	43	20	9	4	2	1	0
% Change	**+7 %**	**+2 %**	**+1 %**	0 %	0 %	0 %	0 %	0 %	0 %

Source: Model outcome

6.7.3.3 Impact of a 10 per cent decrease in rainfall during a production period

This shock is introduced into the model in 2017. The impact of a decrease in rainfall during a production period is expected to influence the system of equations by reducing maize yield and production. This effect will lead to a decrease in ending stock. This change ultimately reduces maize consumption. Because of the combined effects of a decrease in maize yield and production, the maize price is expected to rise.

The simulation analysis results are illustrated in Table 6.12 below. In the short run, a 10 per cent decrease in the rainfall amount during production seasons would decrease maize yield, production and consumption by 13 per cent, 13 per cent, and 10 per cent, respectively. The effect is much more pronounced and persistent on the wholesale maize price and ending stocks.

This means that it will take a longer time for the disturbance to bring the wholesale maize price and maize ending stocks to equilibrium level. In the short run, a 10 per cent decrease in the rainfall amount during the main season maize production months would decrease maize ending stocks by 58 per cent. In the long run, a 10 per cent decrease in rainfall for production months would decrease maize ending stocks by 22 per cent, 9 per cent, 4 per cent, and 1 per cent in 2018, 2019, 2020, and 2021, respectively. Moreover, a 10 per cent decrease in rainfall during main season production months would increase the maize price by 54 per cent. The maize area is not affected by the shock.

Table 6.12: Impact of a 10 per cent decrease in rainfall during a production period

Affected components	2017	2018	2019	2020	2021	2022	2023	2024	2025
Maize yield	**Tons/Ha**								
Baseline	2.86	2.91	2.89	2.88	2.92	2.93	2.96	2.94	3.00
Scenario	2.48	2.91	2.89	2.88	2.92	2.93	2.96	2.94	3.00
Absolute change	-0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**-13 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Maize production	**Thousand tons**								
Baseline	6890	7193	7324	7498	7759	7972	8242	8374	8755
Scenario	5975	7193	7324	7498	7759	7972	8242	8374	8755
Absolute change	-915	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**-13 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Domestic maize use	**Thousand tons**								
Baseline	6858	7126	7277	7455	7692	7909	8165	8325	8661
Scenario	6198	6985	7214	7427	7679	7904	8163	8324	8660
Absolute change	-660	-141	-63	-28	-13	-5	-2	-1	-1
% Change	**-10 %**	**-2 %**	**-1 %**	0 %	0 %	0 %	0 %	0 %	0 %
Ending stocks	**Thousand tons**								
Baseline	441	509	556	599	666	728	805	854	948
Scenario	186	395	505	576	656	724	803	853	948
Absolute change	-255	-114	-51	-22	-10	-4	-2	-1	0
% Change	**-58 %**	**-22 %**	**-9 %**	**-4 %**	**-1 %**	**-1 %**	0 %	0 %	0 %
Nominal wholesale maize price	**ETB/ton**								
Baseline	5733	5599	5845	5989	5717	5465	4855	4742	3759
Scenario	8847	6302	6177	6145	5789	5498	4870	4749	3762
Absolute change	3115	703	332	155	72	33	15	7	3
% Change	**+54 %**	**+13 %**	**+6 %**	**+3 %**	**+1 %**	**+1 %**	0 %	0 %	0 %

Source: Model outcome

6.7.3.4 Impact of a drought

In this simulation analysis, we combined the effect of a 10 per cent decrease in rainfall for the planting and the production periods. In doing so, we simulated the possible impact of a drought occurrence on the maize market in Ethiopia. The shocks were invoked into the system in 2017. Table 6.13 below presents the findings from the simulation analysis. From the analysis, it can be seen that the components most affected by drought are ending stocks and maize price. The effects are also more persistent in these two components. A 10 per cent combined decrease in rainfall amount during the planting and the main season maize production months in the major maize-producing areas would decrease maize ending stocks by 64 per cent in the short run. The effect also continues in the long run, where ending stocks would decrease by 25 per cent, 10 per cent, and 4 per cent during 2018, 2019, and 2020, respectively. Moreover, in the short run, the effect of a drought would increase maize prices by 61 per cent. In the long run, a 10 per cent combined decrease in rainfall amount during the planting and the main season maize production months would lead to an increase in maize prices by 14 per cent, 6 per cent, and 3 per cent during 2018, 2019, and 2020, respectively.

Table 6.13: Impact of a drought (combined effect of a 10 per cent decrease in rainfall during planting and production periods)

Affected components	2017	2018	2019	2020	2021	2022	2023	2024	2025
Area harvested	**Thousand Hectare**								
Baseline	2408	2472	2536	2602	2661	2725	2789	2850	2922
Scenario	2366	2472	2536	2602	2661	2725	2789	2850	2922
Absolute change	-42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**-2 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Maize yield	**Tons/Ha**								
Baseline	2.86	2.91	2.89	2.88	2.92	2.93	2.96	2.94	3.00
Scenario	2.48	2.91	2.89	2.88	2.92	2.93	2.96	2.94	3.00
Absolute change	-0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**-13 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Maize production	**Thousand tons**								
Baseline	6890	7193	7324	7498	7759	7972	8242	8374	8755
Scenario	5871	7193	7324	7498	7759	7972	8242	8374	8755
Absolute change	-1019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Change	**-15 %**	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Domestic maize use	**Thousand tons**								
Baseline	6858	7126	7277	7455	7692	7909	8165	8325	8661
Scenario	6123	6969	7206	7424	7678	7903	8162	8324	8660
Absolute change	-735	-157	-70	-31	-14	-6	-3	-1	-1
% Change	**-11 %**	**-2 %**	**-1 %**	0 %	0 %	0 %	0 %	0 %	0 %
Ending stocks	**Thousand tons**								
Baseline	441	509	556	599	666	728	805	854	948
Scenario	157	382	500	574	655	723	803	853	948
Absolute change	-284	-127	-56	-25	-11	-5	-2	-1	0
% Change	**-64 %**	**-25 %**	**-10 %**	**-4 %**	**-2 %**	**-1 %**	0 %	0 %	0 %
Nominal wholesale maize price	**ETB/ton**								
Baseline	5733	5599	5845	5989	5717	5465	4855	4742	3759
Scenario	9201	6382	6215	6162	5797	5502	4872	4750	3762
Absolute change	3469	783	370	173	80	37	17	8	3
% Change	**+61 %**	**+14 %**	**+6 %**	**+3 %**	**+1 %**	**+1 %**	0 %	0 %	0 %

Source: Model outcome

6.7.4 Should maize be exported?

An interesting question to ask is whether shocks (a bumper harvest) in the maize industry would necessitate a temporary lift of the export ban on maize. Addressing this question is essential for answering the most contentious policy issue of whether to lift the export ban temporarily in case of a bumper harvest. This can be done by comparing the domestic maize prices with the Import Parity Price (IPP) and Export Parity Prices (EPP) under different domestic maize harvest scenarios.

There are two simple rules to be followed in order to make profitable import and export decisions. Border prices (IPP and EPP) would give us an indication of whether it would be profitable to import or export a commodity by comparing the international and domestic market prices. An importer could make profitable import decisions where the IPP is lower than the domestic price, after adjusting for shipping and distribution costs. In this case, an importer could profitably resell the commodity by shipping it in from a potential trade-partner country, while in the case of exports, an exporter could make profitable exports if the domestic price is below the lower threshold export parity price.

From the perspectives of producers and export firms, they want to know the competitiveness of maize production in Ethiopia, compared with that in other neighbouring countries. This computation is useful for exporters in comparing the maize price in the domestic market in relation to the international market, which improves their understanding of whether it is profitable to sell maize in the domestic market or to other countries.

Government intervention in grain markets has been prevalent in developing countries to tame soaring food prices. One major form of government intervention comprises export bans. The Ethiopian government has imposed an export ban on maize commodities since 2008. The ban was temporarily lifted on two occasions, following the bumper harvests of 2010 and 2014. From a food security perspective, the ban is expected to improve domestic maize consumption. Indeed, as we demonstrated in the partial equilibrium results, it is clear that the dummy variable indicating an export ban has become positive in the maize consumption equation. This implies that maize consumption has improved following the export ban. However, the export ban may also create a disincentive for production if the domestic maize price were to decline below the export parity price. Since maize is a major food crop in Ethiopia, any price instability in the domestic maize market is expected to have an adverse effect on other tradable and non-tradable goods. In order to solve this pressing issue, the Ethiopian government has requested the agricultural advising agency, Agricultural Transformation Agency (ATA), to provide research evidence as to whether to temporarily lift the export ban in case of good harvest and drought seasons. This section has attempted to support the on-going policy discussions by providing evidence on the likely impact of production shocks in the Ethiopian white maize trade regime. We compared the outlook period maize parity price analysis during a normal harvest season with a hypothetical parity price analysis for a bumper harvest and a drought season. These production shocks were introduced into the model in the 2017 outlook period. Several assumptions were made to conduct the maize parity price analysis under different domestic maize harvest scenarios. The assumptions are listed below:[30]

- The 2017 wholesale maize price for Ethiopia was obtained from the developed maize market outlook analysis (2017–2025), while the international US yellow maize free on board (FOB) price was obtained from the International Monetary Fund (IMF) commodity price projection.

- The US No 2, yellow maize price is used as the international maize market price. Our first choice was to compare border price trends between the South Africa Futures Exchange (SAFEX) and the Ethiopian white maize market price. The use of the SAFEX maize price would be appealing since most African countries consume and import white maize. Nevertheless, South Africa (SA) is the major white maize import source for most African countries, including Kenya and members of the Southern African Development Community (SADC). However, the major caveat to using the SAFEX price as the international maize price is data scarcity, especially direct freight costs from Durban port to Djibouti port. The only available shipping costs data is from the port of Durban to Mombasa port, Kenya. Moreover, such freight cost data is available only from 2005 to 2010.

- Port handling, loading/unloading, and inland transport costs from Djibouti port to the central Addis Ababa wholesale maize market were assumed to remain constant during the simulation period of 2017.

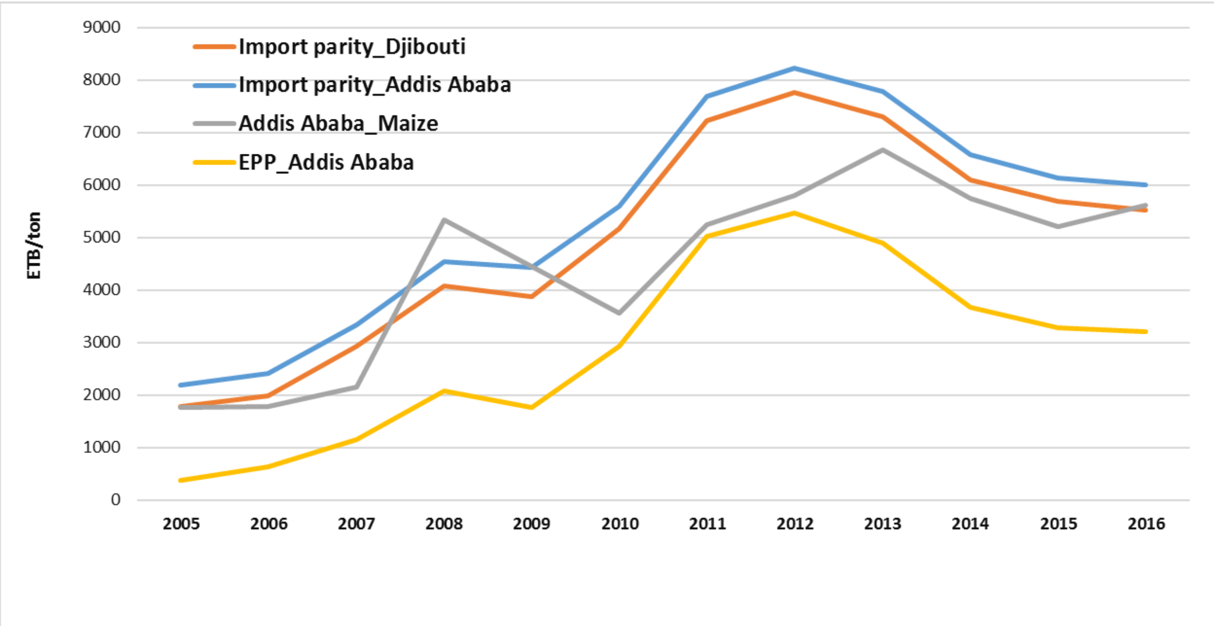
- The exchange rate forecast for Ethiopia was obtained from the Focus Economics report. In the IPP and EPP analysis, the official exchange rate was not used to convert USD to local currency. Rather, the Effective Exchange Rate (EER) was employed. Owing to the limited foreign exchange availability, investors have been assumed to exchange foreign currency for their day-to-day business using the EER.

[30] Parity price analysis for wheat commodity has been discussed in Chapter 5. Here, we focus only on the simulation analysis of the maize crop.

- Apart from the 5 per cent import tariff rate, other policy effects such as surtax, excise duty and withholding taxes were not incorporated into the calculations of the EPP and IPP analysis.

The complete cost breakdown for the maize IPP calculations is presented in Appendix Table C.2. From the parity price analysis in Figure 6.10 below, it can be seen that it was profitable to import maize during 2008. However, for the remaining years, the maize price wanders between the two border prices, suggesting that domestic maize price movement is not directly influenced by the world price. Instead, domestic maize price formation is mainly determined by domestic supply and demand dynamics. In 2012, the domestic wholesale maize price moved closer to the lower threshold EPP. This coincided with the maize bumper harvest of 2012. Ethiopia exceeded 3 tons per hectare in maize yield in the 2012 and 2013 production periods. These were also the periods when the Ethiopian government temporarily lifted the export ban on maize.

Figure 6.10: Parity price analysis for white maize, 2005–2016

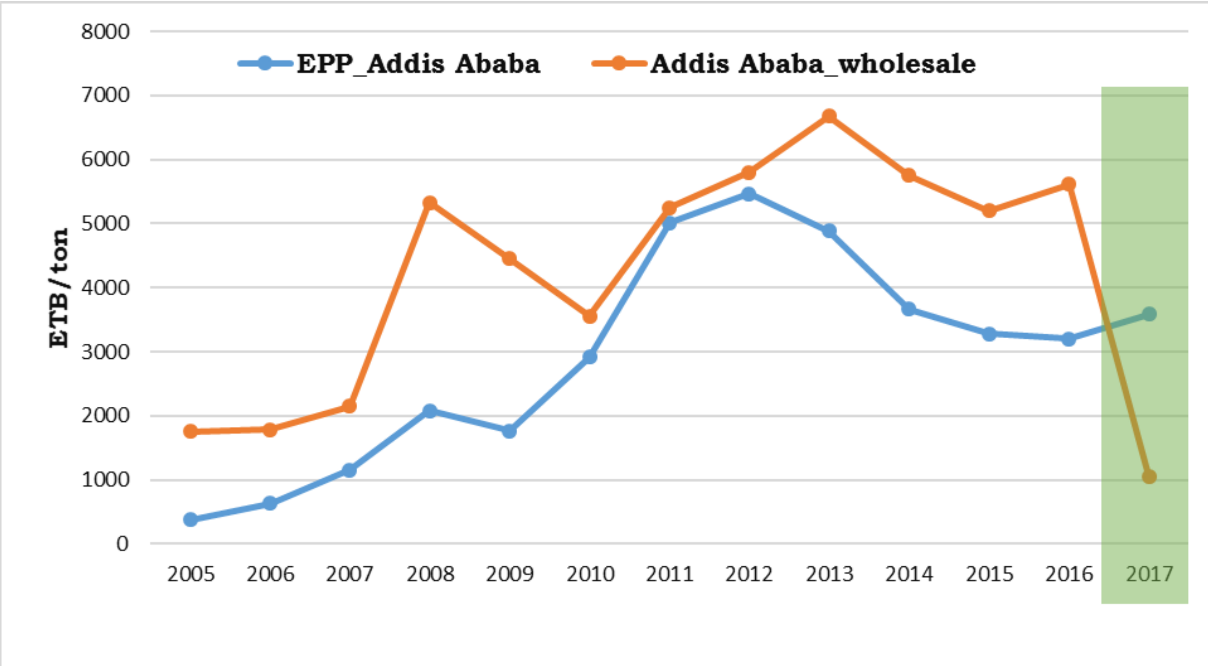


Note: Import and export parity analyses are calculated using the US No 2, yellow maize, Gulf of Mexico
Source: Author's calculation

6.7.4.1 Simulation 1: A bumper harvest (20 per cent yield increase)

As we noted in the yield simulation analysis, a 20 per cent increase in the maize yield would decrease the nominal maize price by 81 per cent. Because of an increase in the maize yield, the domestic maize price would become lower than the EPP for the shock period. In the short run (within the year), the domestic maize price declines 238 per cent (110 USD/t) below the lower threshold EPP. This makes maize exports profitable and has resulted in a trade regime shift from autarky to export parity trade regime for the Ethiopian white maize market (Figure 6.11 below). In this scenario, therefore, lifting the export ban on maize would be an advisable policy option for curbing further reductions in the maize price. Removal of the export ban would increase the domestic maize prices above what the prices would be under the ban. This would, in turn, encourage domestic maize producers and private traders who operate in the maize market.

Figure 6.11: White maize export parity price analysis with scenario 1, 2005–2017

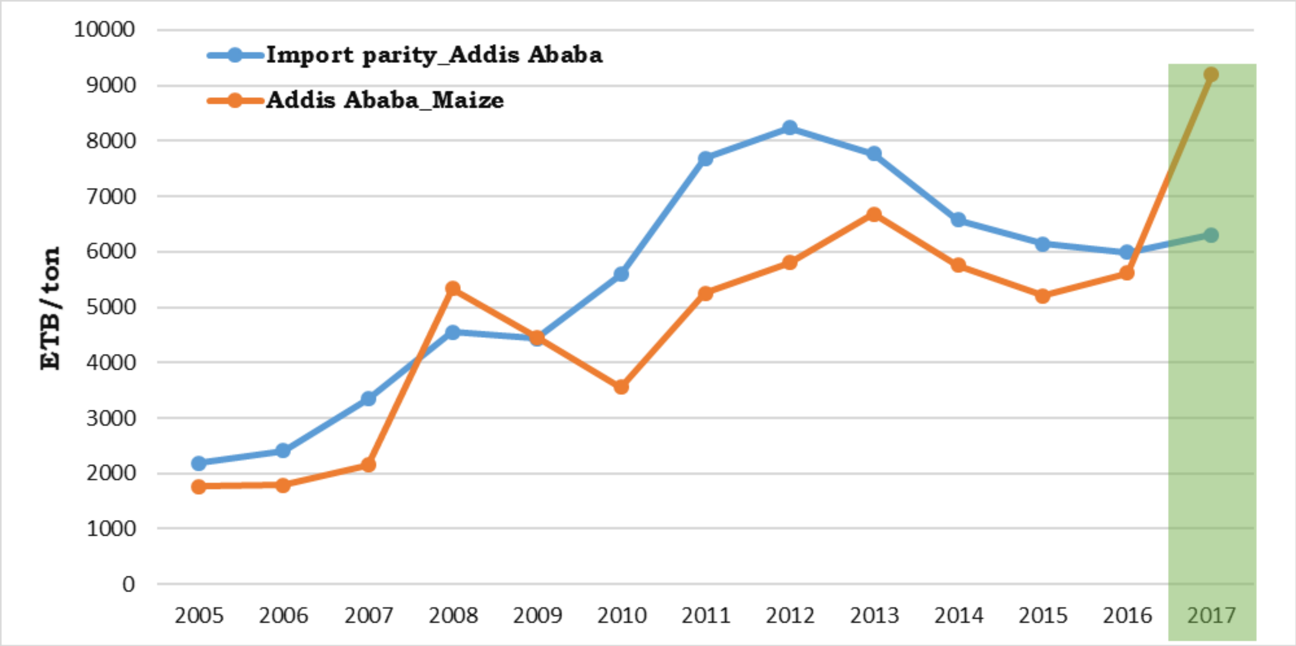


Note: Export parity analysis is calculated using the US No 2, yellow maize, Gulf of Mexico
Source: Author's calculation

6.7.4.2 Simulation 2: Drought season

Drought is used in this context as representing the combined effect of a 10 per cent rainfall reduction during the planting and production months in the major maize-producing areas. As stated above, the effect of drought would increase the nominal maize price by 61 per cent in the short run. This has resulted in the domestic wholesale maize price moving over the upper threshold IPP by 46 per cent (126 USD/t). As a result, maize imports would become profitable (Figure 6.12 below).

Figure 6.12: Import parity price analysis for white maize with scenario 2, 2005–2017



Note: Import parity analysis is calculated using the US No 2, yellow maize, Gulf of Mexico
Source: Author's calculation

6.7.5 Potential exportable markets

Ethiopia could possibly export maize to the deficit South Sudan and Kenyan maize markets. South Sudan has increased maize import because of a decrease in sorghum imports from North Sudan. Maize imports increased from 176 thousand tons in 2009 to 583 thousand tons in 2013. Moreover, the domestic demand for maize has increased; and per capita maize consumption is higher than per capita sorghum consumption in Juba (Dorosh, e*t al.*, 2016). The other export destination market could be the Kenyan maize market, through the Moyale border. In this section, we tested long-run relationships between Addis Ababa maize market prices with South Sudan and Kenya regional maize markets using the Johansen and Juselius (1990) cointegration approach.[31] The results are given in Table 6.16 below.

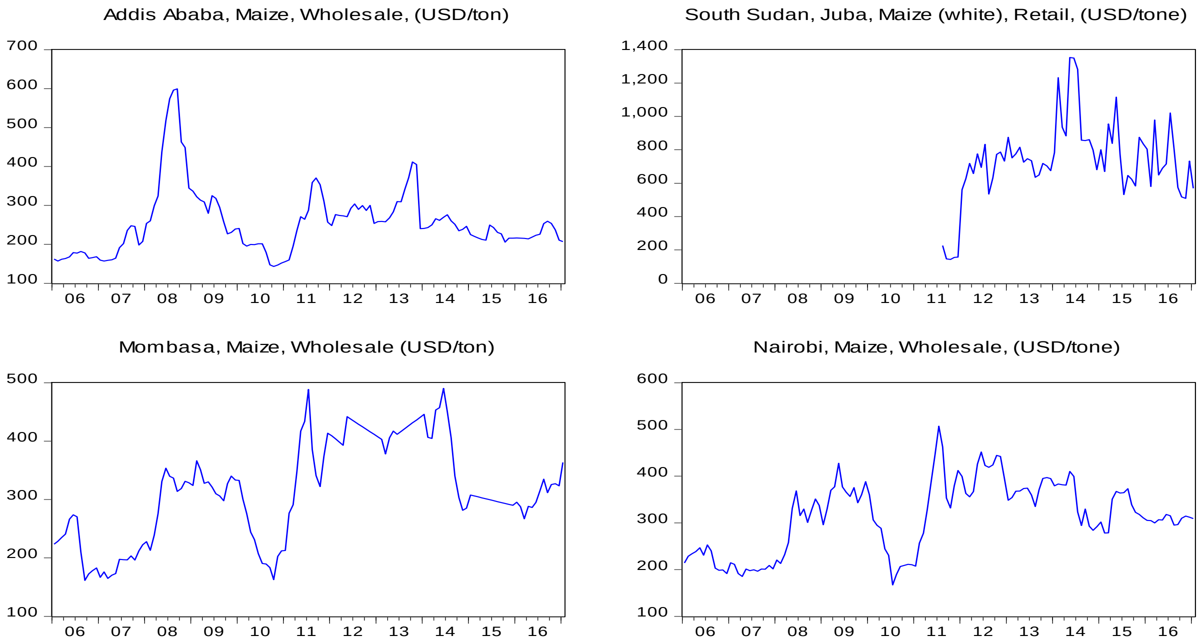
[31] The model specification for the Johansen and Juselius (1990) cointegration approach is presented in Chapter 5.

Table 6.14: Descriptive results for regional maize market prices, (USD/ton)

	ETH	Juba	Mombasa	Nairobi
Mean	256.457	730.557	314.647	314.064
Maximum	599.200	1352.780	490.200	507.030
Minimum	143.300	143.000	161.540	167.170
Std. Dev.	85.317	244.279	85.311	75.898
Skewness	1.760	-0.066	-0.025	-0.089
Kurtosis	7.235	4.487	2.059	2.158
Observations	133	66	133	133

Table 6.14 above reports the descriptive results for regional maize market prices of Ethiopia, Juba, Mombasa, and Nairobi. The highest price is observed in the Juba maize market. Two reasons could be mentioned for this. First, the renewed political instability in the country could increase the risks of trade and thus increase maize prices. Second, the use of retail prices might also increase prices through value addition such as transportation. Owing to the unavailability of wholesale price data, retail maize prices were used for the Juba maize market.

Figure 6.13: Trends of regional maize prices



Plots of regional maize prices are given in Figure 6.13 above. As can be seen from the trends of the price series, all regional maize prices appear to follow a random walk process, with values reverting to mean on rare occasions. Hence, we modelled the ADF (1979) unit root tests without intercept and deterministic trend components. Table 6.15 below reports the unit root tests in levels and first difference for regional maize prices. All maize prices series are converted to logarithms. From the unit root tests analysis, it can be seen that all regional maize price series have a single unit root, implying that the price series are non-stationary in level, but become stationary in first difference. This means that all maize price series are integrated of order one I(1). It is thus valid to proceed to examine the degree and extent of regional maize market integration using a cointegration approach.

Table 6.15: Unit root tests for regional maize prices

Maize market	Level	First difference
Addis Ababa	0.036(1)	-8.570(0)***
Mombasa	0.212(4)	-6.031(3)***
Nairobi	0.167(2)	-8.323(1)***
Juba	0.582(3)	-5.272(2)***

Notes: *** denotes significance at 1 per cent significance level; the values in parentheses are the optimum number of lags chosen, using AIC.

Having found that all maize price series are integrated of order one I(1), we proceed by estimating the presence of a long-run relationship using Trace and Maximum-eigenvalue test statistics (Table 6.16 below). Based on the trace test statistics, we found no cointegration between Addis Ababa and Kenya's maize markets at Nairobi and Mombasa. The absence of a long-run relationship could be attributed to high transport costs linking Ethiopia with Kenya. The average wholesale monthly white maize price from January 2006 to January 2017 in Addis Ababa was 256 USD/ton, while it was 314 USD/ton in the Nairobi and 315 USD/ton in the Mombasa maize markets. According to Rashid *et al*. (2010), even a price difference of 100 USD/ton would not trigger profitable maize exports because of the high transport costs on the routes from Addis Ababa to Nairobi. The section between Awassa and Moyale in Ethiopia, and the section between Moyale and Marsabit, are in particularly bad condition. In addition, there are occasional security problems between Moyale and Marsabit. The poor road infrastructure and security risks may raise transportation costs, which reduce the EPP in Ethiopia (Minot, 2013). However, in the simulation analysis, because of a 20 per cent positive yield shock, the Addis Ababa wholesale maize price could decrease by 110 USD/ton below the EPP. This may be enough to stimulate profitable maize exports to Kenya.

Table 6.16: Johansen cointegration tests between regional maize markets

Market pairs	Sample period	Lag length	Hypothesis	λ_{trace}	λ_{max}
Nairobi-Addis Ababa	2006 M01- 2017 M01	1	r = 0	12.26 (12.32)	12.25** (11.22)
			$r \leq 1$	0.01 (4.13)	0.01 (4.13)
Mombasa -Addis Ababa	2006 M01- 2017 M01	1	r = 0	10.37 (12.32)	10.31 (11.22)
			$r \leq 1$	0.065 (4.13)	0.065 (4.13)
Juba-Addis Ababa	2011M08-2017M01	1	r = 0	15.71** (12.32)	15.66*** (11.22)
			$r \leq 1$	0.052 (4.13)	0.052 (4.129)
Juba-Addis Ababa with shift dummy	2011M08- 2017M01	2	r = 0	22.15*** (12.32)	22.03*** (11.22)
			$r \leq 1$	1.53 (4.13)	1.53 (4.13)

Notes: ***, ** significance levels at 1 % and 5 %; r is the number of cointegrating vectors; Lag length is selected using Akaike Information Criterion (AIC); Critical values in parenthesis; All maize prices series are converted to logarithms; South Sudan received independency in July 2011. Therefore, Juba's maize price is from August 2011 onward.

South Sudan has experienced a renewed civil war since December 2013. Although a peace agreement was signed in 2015, the war continues. To account for the impact of the renewed civil war in the cointegration rank, a shift dummy variable was incorporated. We used a shift variable of December 2013 to account for the effect of the conflict. The shift variable takes the value of 1 from 2013M12 onward and 0 otherwise. According to Lütkepohl and Krätzig (2004), the inclusion of a shift variable may affect the asymptotic distribution and could alter the results of the cointegration test. The results for the cointegration rank test, with and without a structural shift variable, are reported in Table 6.16 above. In both cases, the trace and Maximum-eigenvalue test statistics rejected the null of zero cointegrating vector ($r = 0$) in favour of one cointegrating vector. Thus, cointegration between the Juba and Addis Ababa maize markets presents in both cases. The only difference is that the value of the test statics increase when we take into account a structural break for the renewed conflict. This makes perfect sense because, in the presence of war, transaction costs are likely to increase and thus reduce the possibility of cointegration.

Table 6.17: VECM results for Juba and Addis Ababa market pairs

Coefficients	Co-integrating vector and adjustment coefficient
P_{t-1}^{ETH}	**1.139****
ECT_{t-1}	**-0.236***
Half-life	**2.57**
Short-run parameters	
ΔP_{t-1}^{JUBA}	-0.209
ΔP_{t-2}^{JUBA}	0.073
ΔP_{t-1}^{ETH}	-0.618
ΔP_{t-2}^{ETH}	-1.007
Shift13	**0.076***
Model specification tests	
LM (3) test	0.71
Adj. portmanteau test	0.39
Normality test	438***
MARCH-LM test	54.77**
ARCH LM test	0.36
CUSUM test	Stable

Notes: Half-life is computed as $h = [\ln(0.5)/(\ln(1+\alpha)]$, where α is the error correction term (ECT_{t-1}) and interpreted in months; Adj. portmanteau test denotes adjusted portmanteau test which has more powerful small sample properties than the standard portmanteau test (see Lütkepohl and Krätzig, 2004, 127); MARCH-LM test denotes multivariate ARCH test; the reported value in ARCH tests are the Chi-square test statistics; ***, ** reject the null hypothesis at 1 and 5 % significance levels, respectively.

Evidence of cointegration between the Addis Ababa and Juba maize markets was not expected because of two reasons. Firstly, the cross-border trade between Ethiopia with South Sudan faces high risks and transportation costs, making maize export less profitable for traders. However, our results indicated that the occurrence of war does not fully impede trade and price signal flows across spatial maize markets. These results are in line with the findings of Dorosh *et al*. (2016). Secondly, the maize export ban is expected to impede trade between regional maize markets. One possible explanation for the presence of cointegration could be that, because of the proximity of South Sudan to Ethiopia, trade flows might not be the only price signal transmission mechanism. Instead, these two regional maize market prices may follow each other through information flows via informal cross-border trade, which might bring prices back to the equilibrium position in the long run. However, the speed of price adjustment to the previous year disequilibrium is low. As reported in Table 6.17 above, it takes more than 2 months for the Juba maize market to correct 50 per cent of Addis Ababa maize price shocks.

Model diagnostics tests for residuals autocorrelation, normality, and constant variance were examined. The presence of autocorrelation was tested using the Breusch-Godfrey (1978) LM test and the adjusted portmanteau test. Both tests failed to reject the null hypothesis of no serial autocorrelation. The normality of residual is checked using the Lomnicki–Jarque Bera statistic. In all cases, normality of residuals is rejected at 1 per cent significance level. The multivariate Autoregressive Conditional Heteroskedasticity (MARCH) tests indicated the presence of heteroskedasticity in the VECM equation. We further investigated the sources of the problem by estimating a univariate ARCH test. The univariate ARCH test failed to reject the null hypothesis of no ARCH in the residual for the equation, which modelled Juba maize prices as a dependent variable. This is the equation of interest because Juba's maize prices do not influence Ethiopia's maize market prices. Therefore, the remaining ARCH in the residual series may not be a point of concern. CUSUM tests for individual VECM equations indicated that the estimated equations are inside the critical bound region, which is an indication of model stability.

6.8 CHAPTER SUMMARY

The aim of this chapter was to develop a framework for the maize sub-sector in Ethiopia that could be used to examine the impacts of various supply and demand induced shocks, and agricultural and macroeconomic policies on the maize sub-sector in Ethiopia. The modelling of the partial equilibrium is classified into three blocks: demand and supply blocks, and model closure. The results generated from the partial equilibrium model were validated using graphical and statistical model adequacy tests. The model adequacy tests indicated that the single behavioural models perform reasonably well in tracking the actual values, and therefore can be used for forecasting and simulation analysis.

In this chapter, we discussed the dynamic effects of weather-induced and bumper harvest shocks on the developed partial equilibrium model for the Ethiopian white maize market. From the yield simulation analysis, we found that a 20 per cent increase in maize yield would result in an increase in maize production by 20 per cent. The impact of the yield simulation was more pronounced and persistent on maize ending stocks and the nominal maize price. As compared with the baseline, a 20 per cent increase in the maize yield would reduce the nominal maize price by 81 per cent. On the other hand, the occurrence of a drought would increase the maize price by 61 per cent in the short run.

We have also looked at the possible impact of such shocks on the profitability of maize import and export decisions. We demonstrated that, owing to a 20 per cent increase in the maize yield, the domestic maize price would become lower than the export parity price for the shock period. In the short run (within the year), the domestic maize price would fall 238 per cent below the lower threshold EPP. This makes maize exports profitable and shifts the trade regime from autarky to an export parity regime. In this scenario, therefore, the lifting of the export ban on maize would be an advisable policy option for cushioning further reductions in the maize price. Therefore, if a maize harvest is expected to be above average, it is advisable for the government to lift the export ban on maize. Of course, the yield assessment needs to be estimated meticulously so as not to repeat the mistakes made by Malawi. Removing the export ban on maize would set a limit on the domestic price of maize equal to the EPP. This would keep farmers from being discouraged by low maize prices during good harvest seasons. On the other hand, the effect of drought would result in the domestic wholesale maize price moving over the upper threshold IPP by 46 per cent (126 USD/t).

The regional market integration of Ethiopia's white maize market with the South Sudan and Kenyan maize markets was also examined using cointegration analysis. Despite the renewed conflict in South Sudan, the Addis Ababa maize market is cointegrated with Juba's maize market. Therefore, it is recommended that, in order to complement the Ethiopian government's price stabilisation efforts, it is essential to allow private sector involvement in cross-border trade to avoid maize market price distortion, and thus improve food availability for the poor. The involvement of the private sector in cross-border trade could stabilise the domestic price during low maize price seasons. At the current market price, the domestic maize price is wandering between the border prices and it is unprofitable to export maize. Therefore, lifting the export ban, even during normal harvest seasons, would not do any harm to the domestic maize price.

CHAPTER 7:
SUMMARY, CONCLUSIONS, AND POLICY IMPLICATIONS

7.1 SUMMARY AND CONCLUSIONS

Since 2003, the domestic food prices in Ethiopia have been rising at a higher rate than international prices have. In response, the Ethiopian government pursued a wide range of policy interventions after 2008 to stabilise domestic grain markets. The purpose of this study was to address two key questions related to the above situation. The first was to understand and explain why the inflation in food prices has persisted in Ethiopia, in spite of the observed growth in food production, and the second was to investigate how government policy interventions have influenced price stability in domestic food markets. To answer these questions, one needs to isolate the possible market-related causes of soaring food prices. There are two potential candidates for this: (1) the manner in which international price shocks are transmitted to local markets, and (2) domestic supply and demand dynamics. It is therefore important to understand the structure and functioning of domestic food markets and how they are spatially interlinked, locally and with international food markets. Understanding the market-related causes of high grain prices requires a holistic approach to modelling grain price formation, market structure, international price shock transmissions, and trade policy shifts. Such an in-depth analysis has not been carried out in Ethiopia and hence that is the intended contribution of this study. Knowledge of the causes of high grain prices in domestic commodity markets is critical for designing sound policy responses to manage price volatility risks, with important implications for the welfare of grain producers and consumers alike.

Relevant literature attributes the persistence of price inflation trends in the presence of food crop production growth to imperfect price transmission, where traders are reluctant to fully respond to market price movements, and the speed of transmission depends on the direction of the price change. This represents a structural market phenomenon known as Asymmetric Price Transmission (APT). Accordingly, this study pursued the following three objectives: (1) to test for the presence of APT among integrated wholesale maize markets during the post-agricultural market liberalisation period from July 2004 to March 2016; (2) to gain an understanding of the influence of government interventions on the performance of maize and wheat grain markets;

and (3) to examine the effect of domestic supply and demand dynamics in the maize market with a partial equilibrium modelling framework. Maize and wheat have been chosen as they are the two main food staples in Ethiopia that are globally traded, rather than teff, which is the major food staple which is primarily produced and consumed locally.

In pursuit of the first objective, this study estimated an Asymmetric Vector Error Correction Model (AVECM) to analyse market integration and the price adjustment responses of regionally differentiated Ethiopian wholesale maize markets to positive and negative price deviations from previous year disequilibria (i.e. test for presence of APT). Findings from the inter-regional maize market integration indicate that 10 out of 14 maize market pairs confirm a long-run relationship. Nevertheless, the conclusion of the cointegration tests altered with the consideration of the breakpoints in the analysis. When structural breaks are considered in the price series, all regional maize market pairs became cointegrated with the central Addis Ababa wholesale maize market. Cointegration of all the maize market pairs considered in this study is a reflection of strong spatial maize market linkages in Ethiopia after the introduction of a Structural Adjustment Program (SAP). Not only has spatial maize market integration improved, but the complete pass-through of price signals has also improved substantially, with no evidence of positive APT in the regional wholesale maize markets in Ethiopia.

Notwithstanding the widely held belief by consumers and government that the inappropriate price adjustments of traders contribute to the persistence of soaring food prices in Ethiopia, we found no evidence to support this argument. Instead, wholesale maize traders tend to adjust homogenously to increases and decreases in maize price deviations from the central Addis Ababa maize market. Hence, the widely held perception that considers traders as constituting the main contributor to the recent soaring food price situation in Ethiopia is simply a misconception. In this study, it is argued that the recent surge in grain price in Ethiopia has little to do with APT in maize markets.

The second objective examined the extent of the integration of the Ethiopian wheat and maize markets with the world markets. This study employed a regime-dependent Vector Error Correction (VECM) model to examine the extent of the integration of the Ethiopian wheat and maize markets with the world markets and the effect of policy interventions on the spatial integration of food markets. The findings of the cointegration analysis indicate that domestic wheat and maize markets are more strongly integrated with the world markets during periods in which the government intervened than during periods of low intervention. In other words, the involvement of the Ethiopian government in commercial wheat imports and distribution at subsidised prices has not insulated the domestic grain market from international price risks. This is not expected in a heavily regulated market because the government imports considerable amounts of wheat for distribution at subsidised prices, which private sectors cannot compete with. Despite the presence of a long-run relationship and absence of APT, the domestic wheat prices are distorted by the government's secretive and unplanned interventions. Domestic wheat prices have surpassed the ceiling price during heavy government intervention periods (i.e. since 2008). This suggests that the Ethiopian government's food price stabilisation efforts through the state trading enterprise have not only failed to stabilise prices, but have even exacerbated the price spreads between the domestic and world wheat prices. We argue that the increasing price gap between the domestic and world wheat markets since 2008 is attributable to trade flow restrictions caused by foreign exchange rationing and subsidised wheat distribution. This is because traders are constrained to import the necessary wheat to stabilise the domestic market because of foreign exchange restriction. Furthermore, the discretionary government imports are crowding private sectors out and introducing uncertainty into the grain markets.

A single commodity partial equilibrium approach was used to investigate the maize price formation and a likely impact of a bumper harvest and drought shocks on the maize market and on the trade regime in Ethiopia. Including the identity and model closure equations, the partial equilibrium model for the Ethiopian white maize commodity incorporates eight individual equations. The study estimated the behavioural equations using a combination of an Error Correction Model (ECM) (for non-stationary and cointegrated series) and OLS (for stationary equations). Based on the results of the unit root tests, the maize area harvested and ending stocks equations were estimated using the ECM, whereas the maize yield and per capita maize consumption equations were estimated using OLS. The findings from the behavioural equations reveal that farmers respond very little to price in planning their maize acreage. Rather, the analysis demonstrated that rainfall and technological progress were relatively more important for higher maize acreage growth. Regarding the supply-side shocks (a bumper harvest and drought) on maize prices, we found that a 20 per cent increase in maize yield could reduce the nominal maize price by 81 per cent. This implies a decrease in the maize price level of 238 per cent (110 USD/t) below the export parity price. This makes maize exports profitable, and shifts the trade regime from autarky to an export parity regime. On the other hand, the effect of drought could increase maize prices by 61 per cent in the short run (within the year). The effect could result in the domestic wholesale maize price moving over the upper threshold import parity price by 46 per cent (126 USD/t). As a result, maize imports would become profitable. The regional market integration of Ethiopia's white maize market with the South Sudan and Kenyan maize markets was also examined using cointegration analysis. Despite the renewed conflict in South Sudan, the Addis Ababa maize market is cointegrated with Juba's maize market.

Based on the trend of the domestic maize price in relation to parity prices, it is recommended that private traders should become involved in maize trade. Previous studies (Dorosh *et al*., 2009 and 2016) conducted in African countries that faced soaring food prices have proved that allowing the private sectors to import or export can increase food security. In order to complement the Ethiopian government's price stabilisation efforts, it is essential, therefore, to allow the private sector to get involved in cross-border trade. The involvement of the private sector in cross-border trade can stabilise domestic prices during low maize price seasons. At the current market price, the domestic maize price is wandering between the border prices and it is unprofitable to export maize. Therefore, lifting the export ban, even during normal harvest seasons, would not do any harm to the domestic maize price.

7.2 POLICY IMPLICATIONS

The policy implications drawn from this study are as follows:

Create a conducive environment for traders: The presence of strong inter-regional spatial maize market integration and the absence of APT, in both the inter-regional and domestic-to-the world grain market integrations, is an indication that private traders are more efficient in responding homogeneously to upward and downward price signals. Under such circumstances, government interventions should be reduced, and thus interventions should only be considered in times of drought and bumper harvests. The results from the cointegration analysis support the view that the Ethiopian government could allow the private sector to continue its operations by limiting the government's direct interventions in the grain market without harming poor consumers and market performance.

The government should continue to create a conducive market environment by playing a regulatory and facilitating role in the grain market. This should be accompanied by minimising the state trading enterprise's direct involvement in the grain market. In order to improve access to affordable food by lowering food prices, greater attention should therefore be given to creating space for the private sector to effectively carry out spatial and inter-temporal arbitrage operations.

Strengthening public-private sector interaction**:** Since food price stabilisation involves different actors, it is always essential for governments to reach consensus with different role players. The Ethiopian government could restore stability and trust in the grain market environment by developing positive interaction with private traders. This can be done by following rules-based state interventions in the domestic market and by allowing tolerable price fluctuations, and following price bands to gauge intervention. The basic idea of this form of intervention is that private traders would continue to carry out the normal marketing activities, while the role of the state in direct interventions would only arise when markets fail to stabilise prices beyond a certain threshold value. In this case, the Ethiopian government could intervene in the import markets to stabilise the domestic prices. The government could also release stocks during anticipated periods of shock such as a drought occurrence. However, the design of state intervention should involve the input of every stakeholder in the grain market. In this type of intervention, the timing of government intervention, and the amount and purpose of imports and stock releases should be communicated well in advance to every stakeholder to avoid any uncertainty arising in the domestic grain market. Such coordination and positive interaction would reduce the fiscal costs of food price stabilisation by allowing the private sector to do the necessary price stabilisation. Consequently, this would support the government in focusing on long-term market development by freeing scarce resources for investment in roads and agricultural research and extension. As argued by Cummings *et al*. (2006), government investment in agricultural research, extension services, road infrastructure, and communication facilities are considered to be more productive public investments from the point of view of poverty reduction, than direct price stabilisation interventions are.

Transparent trade policy: The frequent and unpredictable lifting and re-imposition of export bans and discretionary government commercial wheat imports have created uncertainty in the grain market in Ethiopia. Coupled with foreign exchange rationing, the unpredictable trade policy environment has discouraged the spatial arbitrage operation. Thus, intensive dialogue between the government and the private sector about trade policy decision-making would restore trust in the grain market environment. Furthermore, the introduction and re-introduction of export restrictions should be made predictable and transparent. Such a move from discretionary to predictable state interventions would boost the confidence of the private sector in grain marketing.

While we encourage private-sector participation in grain trade, we are not advocating the full withdrawal of government support to poor people. Given the current situation of high commodity price risks, the Ethiopian government is compelled to intervene in the domestic market through subsidised wheat distributions to vulnerable people. Hence, in the transition process from state-led to private-sector marketing, supporting the poor consumers against any food price risks should continue. However, this intervention should be designed and executed in a predictable and transparent manner so as not to distort the grain market environment.

***Revisit the export ban policy*:** The Ethiopian government should revisit some of the policy interventions such as export bans on maize commodities. In our study, we have shown that, given the current maize price trends, it is not relevant to impose the ban since maize exports are unprofitable. As a policy alternative, we recommend that the government should lift the maize export ban, depending on the magnitude of any production shocks such as drought and a bumper harvest.

Promote regional trade: The findings from the regional maize market integration analysis have shown that, despite the renewed conflict in South Sudan, the Addis Ababa maize market is cointegrated with Juba's maize market. Better market integration with regional maize deficit markets would reduce maize price instability in times of bumper harvests in Ethiopia. However, the cross-border trade between Ethiopia with regional deficit markets, such as those in South Sudan and Kenya, faces high risks and transportation costs, making maize exports less profitable for traders. Therefore, there is a need to invest in the road transportation infrastructure that links Ethiopia with potential maize export destinations such as markets in

Kenya and South Sudan. Since maize is traded mainly through cross-border trade, better infrastructural development would enable Ethiopia to become a consistent maize exporter to neighbouring eastern African countries. This would improve the competitiveness of maize exports. Public investment in roads can reduce transportation costs and increase maize export parity prices, making maize exports more profitable to private traders.

7.3 IMPLICATIONS FOR OTHER AFRICAN COUNTRIES

In many African countries, the majority of consumers are poor individuals. As a result, high food prices present huge risks to the food security status of the region. In this instance, the question should not be whether African governments ought to intervene, but instead, how African governments could provide stability to grain prices without disrupting the domestic grain market environment. This is the challenge for many African countries that are responding with short-term stabilisation interventions by allowing state marketing parastatals to undertake the price stabilisation job. This traditional method of price stabilisation is counterintuitive by impeding private traders, and could make prices even more unstable and unpredictable. This was the case for Sub-Saharan African countries such as Zambia, Malawi, and Kenya. These countries allowed grain-marketing boards to stabilise domestic maize prices through maintaining strategic reserves, importing, and distribution at subsidised prices. Such interventions, however, have exacerbated grain price increases in these countries (Minot, 2014). Hence, African governments need to find effective means of managing food price risks.

According to Jayne (2012), most countries in eastern and southern Africa follow the same discretionary state-led interventions in stabilising grain markets. This form of intervention is characterised by unplanned and sudden export bans, and the issuing of government tenders for imports, which will be sold at subsidised prices in domestic markets without being well publicised to other stakeholders. Therefore, our results can be generalised to other African countries that follow the same form of state-led interventions in managing food price risks. However, the implementation of each policy alternative depends on country context. In the following discussions, we provide some policy alternatives for African governments to consider for mitigating food price risks:

***Long-term market development*:** African governments should focus more on long-term market price stabilisation interventions rather than on short-term fire-fighting policy responses to price instability (Byerlee *et al*., 2006). In this respect, public investment in major market fundamentals, such as information communication, marketing institutions, and infrastructural development, would facilitate sustainable long-term market development in the region. Furthermore, public investment priority should be given to investment in agricultural research and extension, and developing the capacity of private traders so as to enable them to conduct inter-temporal arbitrage operations through grain storage.

Encouraging developments have been seen in Ghana and Ethiopia in introducing market-based risk-smoothing institutions to counteract price risks. In an effort to improve coordination among stakeholders and improve the efficiency of grain marketing, the Ethiopian government introduced the Ethiopian Commodity Exchange (ECX) in April 2008. Many experts and international institutions have welcomed this move. However, the role of ECX with regard to cereal price stability has been severely limited by discretionary government intervention in commodity markets, which goes against the basic fundamental objective of the establishment of this institution. As a result, the trading activity of ECX has been restricted to high value and exportable commodities such as coffee and oil crops. In an environment where a state trading enterprise dominates grain-marketing, the role of market-based instruments and institutions in counteracting the causes of price risks would be minimal. In order to fully benefit from market-based instruments, governments need to create space for these institutions to bring about the necessary market stability.

Rule-based government intervention: Although we advocate the transition from old parastatal to market-led interventions as the best option to manage food price risks, there are several compelling reasons to justify government interventions in African food markets. However, government interventions in food markets should be designed and implemented in a predictable and transparent manner. One option to bring stability to food markets in the presence of state intervention is rule-based intervention (Byerlee *et al*., 2006; Jayne, 2012).

***Promote diversification of crop production*:** In some African countries, food consumption mainly depends on non-tradable commodities, for instance example the teff crop in Ethiopia, and cassava and potatoes in western and eastern Africa. However, these crops are not receiving much recognition in the national research agenda for mitigating soaring food prices. The productivity of the teff crop has been the major bottleneck in Ethiopia. Therefore, African governments need to improve the production and marketing of non-tradable or traditional commodities, through strengthening research and extension, that can serve as a substitute crop in times of drought and soaring food prices for tradable commodities. According to Jayne (2012), the production of perennial crops such as cassava and banana can safeguard farmers from drought conditions and soaring food prices. Since these crops are harvested at all times of the year, they can serve as good substitutes in times of high commodity prices for tradable commodities.

7.4 IMPLICATIONS FOR FUTURE RESEARCH

Of course, there is much room for improvement. First, the spatial market integration and asymmetry analysis could be extended to asymmetric vertical price transmission by incorporating other market intermediaries along the maize commodity value chain, such as retail and producer prices. Second, further analysis is required using higher frequency data, such as weekly price data, to validate the robustness of the results obtained. The frequency of the data may influence the contemporaneous adjustment coefficient and test for asymmetry. As suggested by von Cramon-Taubadel (1998), failure to reject the null hypothesis of symmetry may reflect insufficient data frequency, rather than an absence of asymmetry. Third, further research is also required to understand the effect of oil price shocks and exchange rate fluctuations on grain market prices. Investigating the effects of these two shocks on food price instability will contribute in gaining a better understanding of the causes of recent grain price surges in Ethiopia. Further research could investigate the dynamic effects of these two shocks on the domestic commodity prices through a variety of cointegration approaches, such as the Error Correction models, Toda and Yamamoto's (1995) Granger Causality approach, generalised Impulse response function, and Computable General Equilibrium (CGE) models.

REFERENCES

Abate, T., Bekele S., Abebe M., Dagne, W., Yilma, K., Kindie, T., Menale, K., Gezahegn, B., Berhanu, T., & Tolera, K. 2015. Factors that transformed maize productivity in Ethiopia. *Food Security*, 7:965–981.

Abebe, H. 1998. The supply responsiveness of peasant agriculture in Ethiopia: Some macro econometric results from cereal production. *Ethiopian Journal of Economics,* 7(2):1-23.

Abdulai, A. 2000. Spatial price transmission and asymmetry in the Ghanaian maize market. *Journal of Development Economics*, 63:327-349.

Acosta, A. 2012. Measuring spatial transmission of white maize prices between South Africa and Mozambique: An asymmetric error correction model approach. *African Journal of Agricultural and Resource Economics*, 7(1):1-13.

Acosta, A., Ihle, R. & Robles, M. 2014. Spatial Price Transmission of Soaring Milk Prices from Global to Domestic Markets. *Agribusiness*, 30(1):64-73.

Acquah, H.D. & Dadzi, S.K.N. 2010. An application of the von Cramon-Taubadel and Loy error correction models in analysing asymmetric adjustment between retail and wholesale maize prices in Ghana. *Journal of Development and Agricultural Economics*, 2(4):100-106.

Admassie, A. 2004. A Review of the performance of agricultural finance in Ethiopia: pre- and-post reform periods. Paper presented at the International Conference on Agrarian Constraints and Poverty Reduction on 17-18 December 2004 in Addis Ababa, Ethiopia. 14p.

Admassie, A. 2013. The political economy of food price: The case of Ethiopia. World Institute for Development Economic Research (WIDER), Working Paper No. 2013/001.

Alemu, Z.G., K. Oosthuizen & H.D. van Schalkwyk. 2003. Grain-supply response in Ethiopia: An error-correction approach. *Agrekon,* 42:389-404.

Alemu, Z. G. 2005. Causes of instability in cereal production in Ethiopia. Department of Agricultural Economics, Faculty of Natural and Agricultural Sciences at the University of the Free State.

Alemu, Z. G., & Ogundeji, A. 2010. Price transmission in the South African food market. *Agrekon*, *49*(4): 433-445.

Anderson, J.R. 2001. Risk Management in Rural Development: A Review, Rural Development Strategy Background Paper 7. The World Bank, Washington DC.

Ariga, J., T.S., J. & J., N. 2006. Factors driving the growth in fertiliser consumption in Kenya, 1990-2005: Sustaining the momentum in Kenya and lessons for broader replicability in

Sub-Saharan Africa. Tegemeo Institute of Agricultural Policy and Development, Egerton University, Kenya.

Asche, F., Gjølberg, O. & Guttormsen, A.G. 2012. Testing the central market hypothesis: a multivariate analysis of Tanzania sorghum markets. *Agricultural Economics*, 43:115-123.

Assefa, T., Kuiper, T. W., & Meuwissen, P. 2014. The effect of farmer market power on the degree of farm retail price transmission: A simulation model with an application to the Dutch ware potato supply chain. *Agribusiness, 30*(4):424-437.

Azzam, A.A. & Hawdon, D. 1999. Estimating the demand for energy in Jordan: A Stock-Watson Dynamic OLS (DOLS) approach. University of Surrey, Surrey Energy Economics Discussion Paper, UK.

Bacon, R. W. 1991. Rockets and feathers: The asymmetric speed of adjustment of UK retail gasoline prices to cost changes. *Energy Economics, 13*:211-218.

Baffes, J. & Gardner, B. 2003. The Transmission of world commodity prices to domestic markets under policy reforms in developing countries. *Policy Reform*, 6:159-180.

Bai, J. & Perron, P. 1998. Estimating and Testing Linear Models with Multiple Structural Changes. *Econometrica*, 66(1):47-78.

Balcombe, K. & Morrison, J. 2002. Commodity price transmission: A critical review of techniques and an application to selected tropical export commodities. Report prepared for FAO ESCR. FAO Economic and Social Development Department, Rome, Italy.

Balke, N.S. & Fomby, T.B. 1997. Threshold cointegration. *International Economic Review*, 38(3):627-645.

Barassi, M.R. & Ghoshray, A. 2007. Structural change and long-run relationship between US and EU wheat export prices. *Journal of Agricultural Economics*, 58(1):76-90.

Barrett, C.B. 1996. Market analysis methods: are our enriched toolkits well suited to enlivened markets? *American Journal of Agricultural Economics*, 78(3): 825–829.

Barrett, C.B. & Li, J.R. 2002. Distinguishing between Equilibrium and Integration in Spatial Price Analysis. *American Journal of Agricultural Economics*, 84(2):292-307.

Baulch, B. 1997. Transfer costs, spatial arbitrage, and testing for food market integration. *American Journal of Agricultural Economics*, 79:477-487.

Benson, T., Minot, N., Pender, J., Robles, M. & Braun, J. 2008. Global Food Crisis: Monitoring and Assessing Impact to Inform Policy Responses. International Food Policy Research Institute (IFPRI), Washington, D.C.

Berhane, G., Paulos, Z., Tafere, K., & Tamru, S. 2011. Food grain consumption and calorie intake patterns in Ethiopia. IFPRI, Addis Ababa.]

Bonger, T., G., Ayele. & T., Kumsa. 2004. Agricultural extension, adoption and diffusion in Ethiopia. Ethiopian Development Research Institute, Addis Ababa.

Borenstein, S., Cameron, C.A. & Gilbert, R. 1997. Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes? *The Quarterly Journal of Economics*, 112(1):305-339.

Bourdon, H. M. 2011. Agricultural commodity price volatility: An overview. OECD Food, Agriculture and Fisheries.

Breusch, T.S. 1978. Testing for autocorrelation in dynamic linear models. *Australian Economic Papers*, 17(31):334-55.

Brooks, C. 2008. Introductory Econometrics for finance, Second edition, Cambridge University press, UK.

Byerlee, D., Jayne, T.S. & Myers, J.R. 2006. Managing food price risks and instability in a liberalising market environment: Overview and policy options. *Food Policy*, 31:275-287.

Byerlee, D.R., Spielman, D.J., Alemu, D. & Gautam, M. 2007. Policies to promote cereal intensification in Ethiopia: A review of evidence and experience. IFPRI Discussion Paper 0070.

Central Statistical Agency (CSA). 2015. Country and regional level consumer price indices. Addis Ababa, Ethiopia.

Chan, K.S. 1993. Consistency and limiting distribution of the least squares estimation of a threshold autoregressive model. *The annals of Statistics*, 21:520-533.

Chapoto, A. & Jayne, T. 2009. The Impacts of Trade Barriers and Market Interventions on Maize Price Predictability: Evidence from Eastern and Southern Africa. Michigan State University International Development Draft Working Paper 102.

Clarke, J.A. & Mirza, S. 2006. A Comparison of some common methods for detecting Granger non-causality. *Journal of Statistical Computation and Simulation*, 76(3):207-31.

Conforti, P. 2004. Price transmission in selected agricultural markets. FAO, Rome, Italy.

Cummings, J.R., Rashid, S. & Gulati, A. 2006. Grain price stabilisation experiences in Asia: What have we learned? *Food Policy*, 31:301-12.

Cutts, M., & Kirsten, J. 2006. Asymmetric price transmission and market concentration: An investigation into four South African agro-food industries. *South African Journal of Economics*, 74(2): 323-333.

Davis, K., B. Swanson, & D., Amudavi. 2009. Review and Recommendations for Strengthening the Agricultural Extension System in Ethiopia. International Food Policy Research Institute (IFPRI).

Dawe, D. 2008. Have Recent Increases in International Cereal Prices Been Transmitted to Domestic Economies? The experience in seven large Asian countries. The Food and Agriculture Organisation of the United Nations (FAO), Italy.

Degife, B. & Nega, B. 2000. Annual Report of the Ethiopian Economy. Ethiopian Economic Association. Addis Ababa.

Demeke M. 2012. Analysis of incentives and disincentives for maize in Ethiopia. Food and Agriculture Organisation of the United Nations (FAO). Rome, Italy.

Demeke, M., Opazo, C.M. & Doroudian, A. 2014. Staple Food Prices in sub-Saharan Africa in the Context of a Crisis: Challenges and Policy Options.

Dercon, S., & B. Van Campenhout. 1999. Dynamic price adjustment in spatially separated food market with transaction costs: community targeting for poverty reduction in Burkina Faso. Centre for Economic Studies. Leuven, Belgium.

Diao, X., Kennedy, A., Mabiso, A. & Pradesha, A. 2013. Economy wide impact of maize export bans on agricultural growth and household welfare in Tanzania: A Dynamic Computable General Equilibrium Model Analysis. International Food Policy Research Institute (IFPRI).

Dickey, D.A.; & Fuller, W.A. 1979. Distribution of the estimator for autoregressive time series with a unit root. *Journal of American Statistics Association, 74* (366):427-431.

Doldado, J.; Jenkinson, T. & Sosvilla-Rivero, S. 1990. Cointegration and unit roots. *Journal of Economic Surveys*, 4(3):249–73.

Dorosh, P. & Ahmed, H. 2009. Foreign Exchange Rationing, Wheat Markets and Food Security in Ethiopia. IFPRI and EDRI, Addis Ababa, Ethiopia.

Dorosh, P.A., Dradri, S. & Haggblade, S. 2009. Regional trade, government policy and food security: Recent evidence from Zambia. *Food Policy,* 34:350-66.

Dorosh, P.A., Rashid, S. & van Asselt, J. 2016. Enhancing food security in South Sudan: the role of markets and regional trade. *Agricultural Economics,* 47:697-707.

Enders, W. 1995. *Applied Econometric Time-Series.* 1st edn, John Wiley and Sons, New York.

Enders, W., & Dibooglu, S. 2001. Long-run purchasing power parity with asymmetric adjustment. *Southern Economic Journal*, 68(2):433-445.

Enders, W. & Granger, C.W.J. 1998. Unit root tests and asymmetric adjustment with an example using the term structure of interest rates. *Journal of business and economic statistics*, 16:304-311.

Enders, W., & Siklos, P. 2001. Cointegartion and asymmetry in Price Adjustment. *Journal of Business and Economics Statistics,* 19(2):166-176.

Engle, R.F. & Granger, C.W.J.1. 1987. Cointegration and error correction representation, estimation and testing. *Econometrica*, 55(2): 251-276.

Ethiopian Roads Authority (ERA). 2015. Assessment of 17 Years Performance of the Road Sector Development Program, Addis Ababa.

Fackler, P.L., & Goodwin, B.K. 2001. Spatial price analysis. In: Handbooks of Agricultural Economics, Vol. 1, Gardner BL, Rausser GC (eds). Elsevier Science B.V.: Amsterdam, the Netherlands.

FAO (Food and Agriculture Organisation of the United Nations). 2015. Commodity Balance Sheet. Available: http://www.fao.org/faostat/en/#data [2015, 11/27].

Famine Early Warning Systems Network (FEWS NET). 2016. East Africa Cross Border Trade Bulletin. March *2016, Vol, 13.*

Fernando, B. 1992. Agricultural supply response, how to pass from war to a peace economy: The Ethiopian case. Research Program contracted by the EC to DIAL, Nber R/821.

Fiamohe, R., Seck, P.A., & Alia, D.Y. 2013. Price transmission analysis using threshold models: an application to local rice markets in Benin and Mali. *Food Security*, 5(3):427-438.

Food and Agriculture Policy Decision Analysis Tool (FAPDA). 2017. [Homepage of FAO], [Online]. Available: http://www.fao.org/in-action/fapda/tool/index.html#main.html [2017, 01/18].

Franzel, S., Colburn, F. & Degu, G. 1989. Grain marketing regulations: Impact on peasant production in Ethiopia. *Food Policy*: 4:347-58.

Gabre-Madhin E.Z. 2001. Of markets and middlemen: brokers in the Ethiopian grain market. International Food Policy Research (IFPRI).

Garforth, C. & Rehman, T. 2006. Research to understand and model the behaviour and motivations of farmers in responding to policy changes. Department for Environment, Food and Rural Affairs Research Project EPES 0405/17. University of Reading, England.

Gebrehiwet, Y.F., J.F. Kirsten & F. Meyer. 2010. Modelling agricultural input expenditure in a multi-market modelling framework. PhD thesis edn, Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, South Africa.

Getnet, K., Verbeke, W. & Viaene, J. 2005. Modelling spatial price transmission in the grain markets of Ethiopia with an application of ARDL approach to white teff. *Agricultural Economics*, 33(1):491-502.

Getnet, K. 2009. Optimising the policy cost of market stabilization: Which commodity matters most in Ethiopia? *Journal of International Development*, *21*(3):362-378.

Global Agricultural Information Network (GAIN). 2012. Ethiopia grain and feed annual report. United States Department of Agriculture (USDA), Addis Ababa, Ethiopia.

GOOGLE MAPS. 2017. Map from Djibouti port to Addis Ababa, Ethopia. Availabile from https://www.google.co.uk/maps/dir/Port+De+Djibouti,+Avenue+General+Galleni,+Djibouti/Addis+Ababa,+Ethiopia/@10.2265278,38.7051418,7z/data [Accessed 27 January, 2017].

Granger, C.W.J. & Newbold, P. 1974. Spurious regressions in econometrics. *Journal of Econometrics*, 2:111-120.

Greb, F., Jamora, N., Mengel, C., Cramon-Taubadel, S. & Würriehausen, N. 2012. Price transmission from international to domestic markets. University of Gottingen, Germany.

Godfrey, L.G. 1978. Testing for higher order serial correlation in regression equations when the regressors include lagged dependent variables. *Econometrica*, 46(6):1303-1310.

Gosh, M. 2011. Agricultural policy reforms and spatial integration of food grain markets in India. *Journal of Economic Development*, 36(2):15-37.

Gujarati, D.N. 2003. *Basic econometrics*, McGraw Hill, 2003.

Haile, M.G., Kalkuhl, M., Algieri, B. & Gebreselassie, S. 2016. Analysis of Price Shock Transmission: Case of the Wheat-Bread Market Value Chain in Ethiopia. FOODSECURE Working paper no. 50.

Hallam, D. & Zanoli, R. 1993. Error correction models and agricultural supply response. *European Review of Agricultural Economics*, 2:151-166.

Hayakawa, K. & Kurozumi, E. 2006. The Role of "Leads" in the Dynamic OLS Estimation of Cointegrating Regression Models. Department of Economics, Hitotsubashi University, Japan.

Houck, P.J. 1977. An approach to specifying and estimating non-reversible functions. *American Journal of Agricultural Economics*, 59(3):570-72.

Ihle, R., von Cramon-Taubadel, S. & Zorya, S. 2009. Markov-switching estimation of spatial maize price transmission processes between Tanzania and Kenya. *American Journal of Agricultural Economics*, 91(5):1432-1439.

International Fertiliser Development Center (IFDC). 2012. Ethiopia Fertiliser Assessment. Alabama 35662, USA.

International Trade Center (ITC). 2016. Online. Available: http://www.trademap.org/Country [2016, 08 February].

Ismet, M., Barkley, A.P. & Llewelyn, R.V. 1998. Government intervention and market integration in Indonesian rice markets. *Agricultural Economics*, 19:283-295.

Jaleta, M. & Gebremedhin, B. 2009. Price Cointegration Analyses of Food Crop Markets: The case of Wheat and Teff Commodities in Northern Ethiopia. *The International Association of Agricultural Economists Conference*, Beijing, China; August 16-22, 2009.

Jayne, T.S. 2012. Managing food price instability in East and Southern Africa. *Global Food Security*, 1:143-149.

Johansen, S. 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12(3): 231–254.

Johansen, S., & Juselius, K. 1990. Maximum likelihood estimation and inference on cointegration with application to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52(2): 169–210.

Johansen, S. 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*, 59(6):1551-1580.

Kahinda, J.M., Taigbenu, A.E. & Boroto, J.R. 2007. Domestic rainwater harvesting to improve water supply in rural South Africa. *Physics and Chemistry of the Earth*, 32:1050-1057.

Kassa, B. 2003. Agricultural. Extension in Ethiopia: the case of participatory demonstration and training extension system. *Journal of Social Development in Africa*, 18(1):49-84.

Kassie, M., Teklewolde, H., Jaleta, M., Marenya, P. & Erenstein, O. 2015. Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy*, 42:400-411.

Kebede, M., Gezahegne, B, Benti, T., Mosisa, W., Yigzaw D, & Assefa A.1993. Maize production trends and research in Ethiopia. pp 4-12. In Benti Tolessa and J.K. Ransom (eds). Proceedings of the First National Maize Workshop of Ethiopia. IAR/CIMMYT, Addis Ababa, Ethiopia.

Kelbore, Z.G. 2013. Transmission of World Food Prices to Domestic Market: The Ethiopian Case. University of Trento.

Kelbore, G.Z. 2014. Essays on the Ethiopian Agriculture. Ph.D. Dissertation. University of Trento, Italy.

Knetter, M.M. 1993. International Comparisons of Pricing-to-Market Behavior. *American Economic Review,* 83(3):473-86.

Kotevska, A., Dimitrievski, D. & Erjavec, E. 2013. Partial equilibrium model as a tool for policy analysis in agriculture: an empirical evidence of Macedonia. *Agriculture and Rural development - Challenges of Transition and Integration Processes*, pp. 52.

Larson, D.F., Anderson, J.R. & Varangis, P. 2004. Policies on managing risk in agricultural markets. *The World Bank Research Observer,* 19(2):199-230.

Lipper, L., Cavatassi, R. & Winters, P.C. 2005. Seed system, households' welfare, and an economic methodology applied in Ethiopia. Agricultural and Development Economics Division, the Food and Agricultural Organisation of United Nation.

Loening, J.L., Durevall, D. & Birru, Y.A. 2009. Inflation Dynamics and Food Prices in an Agricultural Economy: The Case of Ethiopia, University of Gothenburg.

Lumsdaine, R.L. & Papell, D.H. 1997. Multiple trend breaks and the unit root hypothesis, *Review of Economics and Statistics,* 79(2):212-18.

Lütkepohl, H. & Krätzig, M. (eds).2004. *Applied time series econometrics.* Cambridge University Press.

MacKinnon, J.G. 1991. Critical values for cointegration tests in Long-run Economic Relationships: eds. R. F. Engle and C. W. J. Granger, in Oxford: Oxford University Press, pp. 267-276.

Maisiri, N., A. Senzanje., J. Rockstrom & S.J. Twomlow. 2005. On farm evaluation of the effect of low cost drip irrigation on water and crop productivity compared to conventional surface irrigation system. *Physics and Chemistry of the Earth,* 30:783-791.

Mapila, M., Kirsten, J.F. & Meyer, F.H. 2011. Assessment of the macro-micro linkages between rural livelihoods, agricultural research innovation systems and agricultural policy changes in Malawi. PhD thesis edn, Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, South Africa.

McKay, A., Morissey, O. & Vaillant, C. 1998. Aggregate Supply Response in Tanzanian Agriculture. *The Journal of International Trade and Economic Development*, 8(1):107-123.

Meyer, F. & J., Kirsten K. 2010. Modelling the wheat sector in South Africa. *Agrekon,* 44:225-37.

Meyer F, Westhoff P, Binfield J & Kirsten JF. 2006. Model closure and price formation under switching grain market regimes in South Africa. *Agrekon,* 45(4): 369-380.

Meyer, J. & von Cramon-Taubadel, S. 2004. Asymmetric price transmission: A survey. *Journal of Agricultural Economics,* 55(3):581-611.

Ministry of Economic Development and Cooperation (MEDAC). 1999. Survey of the Ethiopian economy*:* review of post-reform developments (1992/93-1997/98), Addis Ababa.

Minot, N. 2011. Transmission of World Food Price Changes to Markets in Sub-Saharan Africa. International Food Policy Research Institute (IFPRI).

Minot, N. 2013. Grain Export Bans in Theory and in Practice Draft Policy Note. International Food Policy Research Institute (IFPRI), Washington, DC.

Minot, N. 2014. Food price volatility in sub-Saharan Africa: Has it really increased? *Food Policy,* 45:45-56.

Minten, B., Stifel, D. & Tamiru, S. 2012. Structural Transformation in Ethiopia: Evidence from cereal markets. Ethiopia Strategy Support Program II. Addis Ababa.

Moges, G., H. Hengsdijk. & H.C. Jansen. 2011. Review and quantitative assessment of ex situ household rainwater harvesting systems in Ethiopia. *Agricultural Water Management,* 98:1215-1227.

Morisset, J. 1998. Unfair Trade? The Increasing Gap between World and Domestic Prices in Commodity Markets during the Past 25 Years. *The World Bank Economic Review,* 12(3):503-26.

Myers, R.J. & Jayne, T.S. 2011. Multiple-regime spatial price transmission with an application to maize markets in Southern Africa. *American Journal of Agricultural Economics,* 94(1):174-188.

National Bank of Ethiopia (NBE). 1992. Interest rates Directives NBE/INT 1/92, October 1, 1992, Addis Ababa.

________________________. 2014. Annual report for 2014/15. Addis Ababa, Ethiopia.

Ndibongo, T.L., Myers, J.R., Jayne, T.S. & Meyer, F.H. 2010. Measuring Integration and Efficiency in Maize Grain Markets: The Case of South Africa and Mozambique. *Contributed Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA)*, Cape Town, South Africa, September 19-23, 2010.

Negassa, A. & Jayne, T.S. 1997. The Response of Ethiopian Grain Markets to Liberalisation. Ministry of Economic Development and Cooperation, Addis Ababa.

Negassa, A., Myers, J.R & E. Gabre-Madhin. 2004. Grain Marketing Policy Changes and Spatial Efficiency of Maize and Wheat Markets in Ethiopia. International Food Policy Research Institute, MTDI Discussion Paper 66.

Negassa, A. & Myers, J.R. 2007. Estimating Policy Effects on Spatial Market Efficiency: An Extension to the Parity Bound Model. *American Journal of Agricultural Economics,* 2(89): 338-352.

Nelsson, C.R. & Plosser, C.I. 1982. Trends and random walks in macroeconomic time series: some evidence and implications. *Journal of monetary economics*, 10(2):139-162.

Ngare, L. S., Wambugu, J. N., & Shisanya, C. 2013. Asymmetric price transmission in food markets in the highlands of central Kenya. *Paper Presented at the 4th International Conference of the African Association of Agricultural Economists, 22–25 September, Hammamet, Tunisia.*

Nogales, E.G, & Fonseca, J. 2014. Institutional procurement of staples from smallholders: The case of purchase for progress in Ethiopia. FAO.

Organization for Economic Co-operation and Development (OECD). 2006. Documentation of the AGLINK Model. Working Party on Agricultural Policies and Markets, *AGR-CA-APM(2006)16/Final. Directorate for Food, Agriculture and Fisheries, Committee for Agriculture, Organization for Economic Co-operation and Development, Paris*.

Perron, P. 1989. The great crash, the oil price shock, and the unit root hypothesis. *Econometrica*, 57(6):1361-1401.

Perron, P. & Vogelsang, T.J. 1992. Testing for a Unit Root in a Time Series with a Changing Mean: Corrections and Extensions. *Journal of Business and Economic Statistics*, 10(4):467-70.

Perron, P. 1997. Further Evidence on Breaking Trend Functions in Macroeconomic Variables. *Journal of Economics*, 80(2):355-385.

Petrucelli, J.D. & Woolford, S.W. 1984. A threshold AR (1) model. *Journal of Applied Probability*, 21:207-286.

Phillips, P.C.B.1986. Understanding spurious regression in econometrics. *Journal of Econometrics*, 33(1):311-40.

Pokhrel, D.M., & Thapa, G.B. 2007. Are marketing intermediaries exploiting mountain farmers in Nepal? A study based on market price, marketing margin and income distribution analyses. *Agricultural Systems*, 94, 151-164.

Porteous, O.C. 2012. Empirical Effects of Short-Term Export Bans: The Case of African Maize. Working Paper, Dept of Agricultural Economics, University of California, Berkeley.

Prakash, A. 1999. The transmission of signals in a decentralised commodity marketing system. The case of the UK pork market. PhD Dissertation, Wye College, University of London.

Quinones, M. & Takele, G. (eds). 1996. *An overview of the Sasakawa-Global 2000 project in Ethiopia*, In: Breth, SA (OO.), Achieving Greater impact from Research Investment in Africa, Mexico City, Sasakawa Africa Association; 16-27, edn, Mexico City, Sasakawa Africa Association; 16-27.

Rafailidis, P. & Katrakilidis, C. 2014. The relationship between oil prices and stock prices: a non-linear asymmetric cointegration approach. *Applied Financial Economics*, 24(12):793-800.

Rapsomanikis, G., Hallam, D. & Conforti, P. 2003. Market integration and price transmission in selected food and cash crop markets of developing countries: review and applications in Commodity Market Review, 2003–2004. FAO, Rome.

Rashid, S., Kindie, G. & Solomon, L. 2010. Maize Value Chain in Ethiopia, Constraints and Opportunities for enhancing the system. IFPRI Project paper, International Food Policy Research Institute.

Rashid, S., & Lemma, S. 2014. Public wheat imports into Ethiopia since 2008: The rationales and cost-effectiveness. IFPRI.

Rashid, S. & Negassa, A. 2011. Policies and Performance of Ethiopian Cereal Markets. Ethiopia Strategy Support Program II, Ethiopia.

Rashid, S., & Minot, N. 2010. Are staple food markets in Africa efficient? Spatial price analysis and beyond. Food Security Collaborative Working Papers 58562, Michigan State University, Department of Agricultural, Food, and Resource Economics.

Rashid, S. 2011. Inter-commodity price transmission and food price policies: An analysis of Ethiopian cereal markets. IFPRI.

Rashid, S., Tefera, N., Minot, N. & Ayele, G. 2013. Fertiliser in Ethiopia: An Assessment of Policies, Value Chain, and Profitability, IFPRI Discussion Paper 01304.

Ravallion, M. 1986. Testing market integration. *American Journal of Agricultural Economics*, 68(1):102-09.

Regional Agricultural Trade Expansion Support Program (RATES). 2003. Maize Market Assessment and Baseline Study for Ethiopia, Nairobi, Kenya.

Sadoulet, E. & v de Janvry, A. 1995. Quantitative Development Policy analysis, Johns Hopkins University Press.

Sanogo, I. & Amadou, M.M. 2010. Rice market integration and food security in Nepal: The role of cross-border trade with India. *Food Policy*, 35:312-322.

Schimmelpfennig, D., Thirtle, C. & Van Zyl, I. 1996. Crop level supply response in South African Agriculture: An error-correction. *Agrekon*, 35(3):111-122.

Smith, L.D. 1997. Price stabilisation, liberalisation and food security: conflicts and resolutions? *Food policy*, 22(5):379-92.

Spielman, D.J., Dawit, K. & Dawit A. 2011. Seed, Fertiliser, and Agricultural Extension in Ethiopia. Development and Governance Division, IFPRI, Addis Ababa, Ethiopia.

Stephens, C.E., Mabaya, E., von Cramon-Taubadel, S. & Barrett, C.B. 2008. Spatial price adjustment with and without trade. Selected paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, FL, July 27-29, 2008.

Stock, J.H. & Watson, M.W. 1993. A simple estimate of cointegrating vector in higher ordered integrated systems, *Econometrica*, 61(4):783-820.

Stommes, E. & Sisaye, S. 1979. The administration of agricultural development programmes: a look at the Ethiopian approach. *Agricultural Administration*, 6(3):221-239.

Taffesse, A. S., Dorosh, P., & Asrat, S. 2011. Crop production in Ethiopia: Regional patterns and trends: Ethiopia Strategy Support Program II (ESSP II).

Takele, G. 1997. Sasakawa Global 2000 in the Intensification of Agriculture in Ethiopia. Paper presented in the 13th International Conference of Ethiopian Studies, Koyoto, 12-17 December.

Tamru, S. 2013. Spatial integration of cereal markets in Ethiopia. Ethiopia Strategy Support Program II. ESSP working paper 56.

Tappata, M. 2009. Rockets and feathers: Understanding asymmetric pricing. *RAND Journal of Economics*, *40*(4):673-687.

The Ethiopian Grain Trade Enterprise (EGTE). 2016. Wheat import trends and subsidized wheat distribution, Addis Ababa.

The Food and Agriculture Organisation (FAO). 2015. FAOSTAT production database. Retrieved 05/20/2015, from http:/faostat3.fao.org.

The United States Agency for International Development (USAID). 2010. USAID Office of Food for Peace Ethiopia Bellmon Estimation. September, 2010.

Theil, H. 1967. *Economics and Information Theory, Amsterdam, North Holland.*

Thiele, R. 2000. Estimating the Aggregate Agricultural Supply Response: A Survey of Techniques and Results for Developing Countries, Kiel Institute for World Economics, Kiel, Germany.

Toda, H.Y. & Yamamoto, T. 1995. Statistical inference in vector auto-regressions with partially integrated processes. *Journal of Econometrics*, 66(2):225-50.

Tong, H. 1990. *Non-linear time series: a dynamical system approach.* Oxford University Press, Oxford.

Townsend, R. & Thirtle, C. 1994. Dynamic acreage response: An error correction model for maize and tobacco in Zimbabwe. *Occasional Paper No. 7, International Association of Agricultural Economics.*

Townsend, R. 1997. Policy distortions and agricultural performance in the South African economy. Development Bank of Southern Africa Development Information Business Unit.

Tripathi, A. 2008. Estimation of Agricultural Supply Response Using Cointegration Approach. Indira Gandhi Institute of Development Research, Mumbai.

Ulimwengu, J. M., Workneh, S., & Paulos, Z. 2009. Impact of soaring food price in Ethiopia: does location matter? IFPRI.

UN Comtrade. 2016. United Nations Commodity Trade Statistics database. Available: http://comtrade.un.org/db/.

United States Department of Agriculture (USDA). 2015. Commodity database. Available: http://apps.fas.usda.gov/psdonline/psdquery.aspx [2015, 24 March].

__________.2016. Commodity database. Available: http://apps.fas.usda.gov/psdonline/psdquery.aspx [2016, 8 June].

_________. 2017 Commodity database. Available: http://apps.fas.usda.gov/psdonline/psdquery.aspx [2017, 13 February].

Van Campenhout, B. 2007. Modelling trends in food market integration: Method and an application to Tanzanian maize markets, *Food Policy*, 32:112-127.

Von. Cramon-Taubadel, S. & Loy, J.P. 1996. Price Asymmetry in the international Wheat Market: Comment, *Canadian Journal of Agricultural Economics*, 44(3):311-17.

Von Cramon-Taubadel, S. & S. Fahlbusch. 1997. Estimating asymmetric price transmission with the error correction representation: An application to the German pork market. University of Kiel, Department of Agricultural Economics, Kiel, Germany.

Von Cramon-Taubadel, S. 1998. Estimating Asymmetric Price Transmission with the Error Correction Representation: An Application to the German Pork Market. *European Review of Agricultural Economics*, 25(1): 1-18.

Ward, R.W. 1982. Asymmetry in Retail, Wholesale, and Shipping Point Pricing for Fresh Vegetables. *American Journal of Agricultural Economics*, 64(2):205-212.

Woldegiorgis, L.N. 2011. Maize Value Chain Analysis in Ethiopia: Implication of challenges and opportunities on Food security. International Institute of Social Studies (ISS), the Hague, the Netherlands.

Wolffram, R. 1971. Positivistic Measures of Aggregate Supply Elasticities: Some New Approaches: Some Critical Notes. *American Journal of Agricultural Economics,* 53(2):356-59.

Wondemu, K. 2015. Price transmission Asymmetry in Spatial Grain markets in Ethiopia. *African Development Review*, 27(2):106–116.

Worako, T.K., van Schalkwyk, H.D., Alemu, Z.G. & Ayele, G. 2008. Producer price and price transmission in a deregulated Ethiopian coffee market. *Agrekon*, 47(4): 492-508.

Worako, T. 2012. Dynamics of food price trends and policy options in Ethiopia. Preliminary draft report for ASARECA's Project on Food Price Trend Analysis and Policy Options.

Worku, M., Jemal, A., Leta, T., Haji, T., Legesse, W., Kassa, Y., Wonde, A., Aschalew, G., Sewagegne, T., Teshale, A., Tamirat, B., Yoseph, B. & Habtamu Z. 2001. Second National Maize Workshop of Ethiopia. 12-16 November 2001.

World Bank. 1987. An export action programme. Division. The World Bank, Ethiopia.

The World Bank. 2016. World Development Indicators, the World Bank. Available: http://data.worldbank.org/data-catalog/world-development-indicators. [2015, 05/27].

World Food Programme (WFP). 1989. Rehabilitation of Forest, Grazing, and Agricultural Lands, Vol. 1. World Food Programme, Addis Ababa.

Yami, M., Begna, B., Girma, B., Fita, T., Solomon, T., Tilahun, W., Eticha, F., Badebo, A., Assefa, A., Habte, D., Dembel, W., Tadesse, Z., Gelelcha, S., Kelemu, F. & Gebre, D. 2013. Enhancing the adoption of rust tolerant wheat varieties: experience of EAAPP in Ethiopia. Eastern Africa Wheat Regional Centre of Excellence. Ethiopian Institute of Agricultural Research (EIAR). Addis Ababa, Ethiopia.

Yami, M., Meyer, F. & Hassan, R. 2017. Testing price leadership in major regional maize markets in Ethiopia: implications for targeted market intervention. *Agrekon*, 56(2):97-109.

Yang, G., Huang, J., Kalkuhl, M., Braun, J.V. & Hu., J. 2015. Spatial price transmission under different policy regimes: the case of Chinese soy and maize market. Selected Paper prepared for presentation for the 2015 Agricultural and Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco, CA, July 26-28.

Yeboah, I.A. 2012. Spatial Price Transmission in the Regional Maize Markets in Ghana , University of Bonn, Food and Resource Economics, Swedish University of Agricultural Science and Institute of Economics.

Zapata, H.O. & Rambaldi, A.N.1997. Monte Carlo evidence on cointegration and causation. *Oxford Bulletin of Economics and statistics*, 59(2):285-98.

Zerihun, G.A. 1995. The supply response of agriculture and individual crops in Ethiopia. MSc Thesis edn, Addis Ababa University, Addis Ababa.

Zewdie, B., Yonas, S. & Belay, S. 2008. The status of the Ethiopian seed industry. In Thijssen, M.H., Z. Bishaw, A. Beshir and W.S. de Boef, 2008 (Eds.). Farmers, seeds and varieties: supporting informal seed supply in Ethiopia. Wageningen International.

Zivot, E. & & Andrews, D. 1992. Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. *Journal of Business and Economic statistics*, 10(3):251-70.

APPENDICES

Appendix A. DOLS cointegration results

Table A.1: DOLS estimation for Gondar and Bahir-Dar maize markets

Gondar & Addis Ababa market pairs		
Variables	**Coefficients**	**t-Statistic**
ADDIS_ABABA	1.103150***	22.70508
Constant	-9.281382	-0.503707
GONDAR14	29.50859	0.359313
GONDAR12	-67.77707	-0.795885
GONDAR08	-37.60981	-0.423458
GONDAR07	-2.531691	-0.030894
Adj. R^2	0.933685	
Panel B: Cointegration test for the market pairs		
U_t = -2.88***		
Bahir-Dar & Addis Ababa market pairs		
ADDIS_ABABA	1.071257***	20.31933
Constant	-25.06004	-1.258135
BHR14	7.648379	0.082763
BHR11	-25.44759	-0.259723
BHR08	-83.63719	-0.840354
Adj. R^2	0.9133	
Panel B: Cointegration test for the market pairs		
U_t = -3.15***		

Notes: Leads and lags specifications are based on AIC criterion
U_t is the innovation series obtained by dynamic ordinary least squares cointegration equation.
***, **, * denote rejection of the null hypothesis at 1 %, 5 %, and 10 % significance level

Table A.2: DOLS estimation for Mek'ele and Dese maize markets

Mek'ele & Addis Ababa market pairs		
Variables	**Coefficients**	**t-Statistic**
ADDIS_ABABA	1.147482***	23.40933
Constant	-12.04595	-0.650447
MEK14	-10.06959	-0.121052
MEK12	-28.36490	-0.327944
MEK08	-4.748222	-0.052642
Adj. R^2	0.915206	23.40933
Panel B: Cointegration test for the market pairs		
U_t = -3.59***		
Dese & Addis Ababa market pairs		
ADDIS_ABABA	1.018479***	32.38286
Constant	4.708561	0.393120
DES08	41.39164	0.748466
Adj. R^2	0.956383	
Panel B: Cointegration test for the market pairs		
U_t = -2.97***		

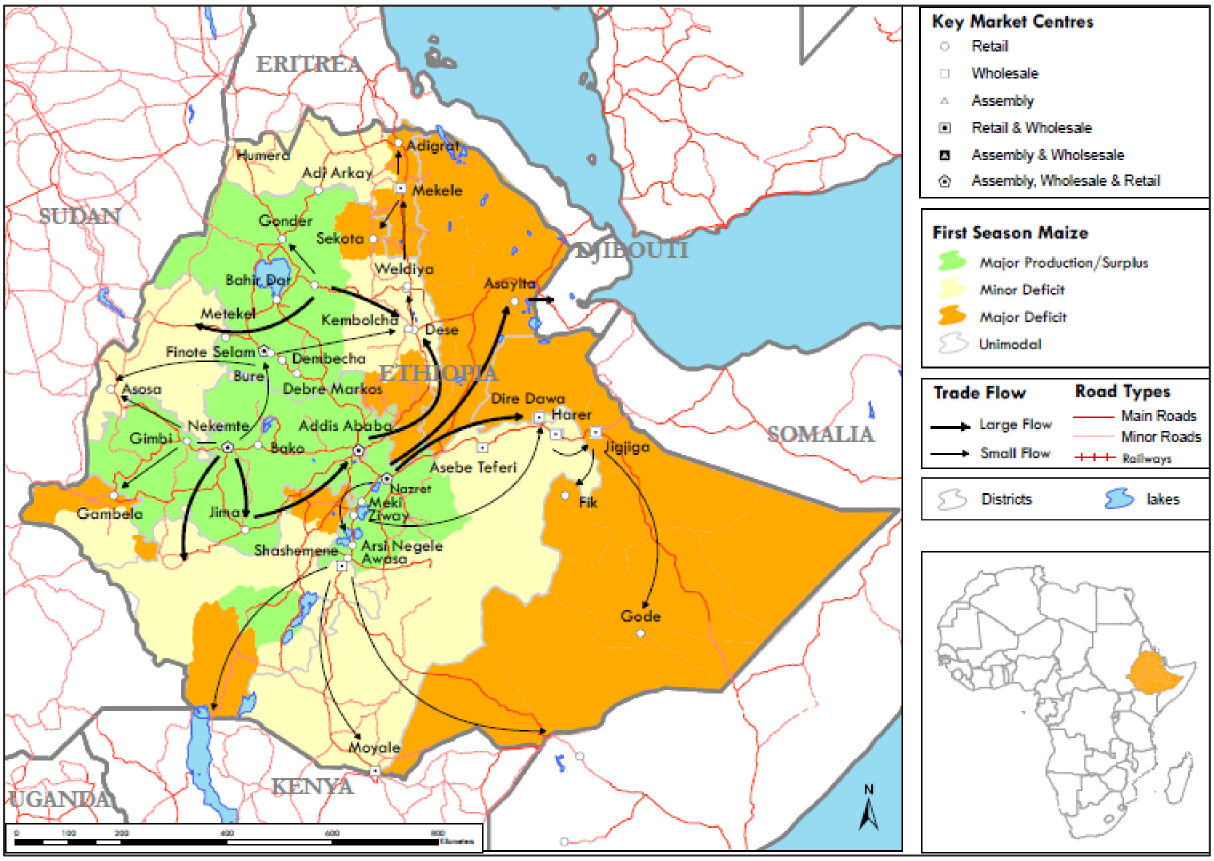
Notes: Leads and lags specifications are based on AIC criterion
U_t is the innovation series obtained by dynamic ordinary least squares cointegration equation.
***, **, * denote rejection of the null hypothesis at 1 %, 5 %, and 10 % significance level

Table A.3: DOLS estimation for Nekemete and Ziway maize markets

Nekemete & Addis Ababa market pairs		
Variables	**Coefficients**	**t-Statistic**
ADDIS_ABABA	0.949913***	46.85332
Constant	-18.65277**	-2.396138
NEK09	-11.10391	-0.307655
Adj. R^2	0.965883	
Panel B: Cointegration test for the market pairs		
U_t = -3.02***		
Ziway & Addis Ababa market pairs		
ADDIS_ABABA	1.083121***	35.08491
Constant	-29.63028**	-2.512397
ZWA12	-2.921515	-0.056234
Adj. R^2	0.954341	
Panel B: Cointegration test for the market pairs		
U_t = -2.46**		

Notes: Leads and lags specifications are based on AIC criterion
U_t is the innovation series obtained by dynamic ordinary least squares cointegration equation.
***, **, * denote rejection of the null hypothesis at 1 %, 5 %, and 10 % significance level

Appendix Figure 1(a): Map of maize producing regions and market flow in Ethiopia



Source: FEWS NET (2016)

Appendix B (1). Enders and Siklos threshold cointegration tests

Following the studies of Enders and Granger (1998) and Enders and Siklos (2001), we estimate a threshold autoregressive econometric (TAR) model to test for a long-run relationship and presence or absence of APT from the world-to-domestic grain markets. The method uses a modified asymmetric version of Dickey Fuller test. Instead of a constant adjustment coefficient throughout the entire period, Enders and Siklos (2001) proposed estimating cointegration by decomposing the adjustment coefficient as positive and negative departures from the long-run equilibrium, as indicated in the TAR model below:

$$\Delta\mu_t = \rho_1 I_t \mu_{t-1} + \rho_2 (1 - I_t)\mu_{t-1} + \sum_{i=1}^{k} \lambda_i \, \Delta\mu_{t-1} + \nu_t \qquad (7.1)$$

where ρ_1 and ρ_2 are the speed of adjustment coefficients to positive and negative discrepancy from the equilibrium, and K is the lag length to approximate a white noise process. The necessary and sufficient conditions for the stationarity of μ_t requires ρ_1 and ρ_2 be less than zero and $(1 + P_1) + (1 + P_2) < 1$ for any value of τ (Petrucelli and Woolford, 1984). I_t is the Heaviside indicator to include asymmetric adjustment in cointegration analysis, and is given as follows:

$$I_t = \begin{Bmatrix} 1 \; if \; \mu_{t-1} \geq \tau \\ 0 \; if \; \mu_{t-1} < \tau \end{Bmatrix} \tag{7.2}$$

where τ is the threshold value.

From Equation (7.1), the presence of a long-run relationship is checked by testing the null hypothesis of $\rho_1 = \rho_2 = 0$. Failure of the rejection of the null hypothesis led to the conclusion of no cointegration between price series. Since the test follows a non-standard distribution, we use the critical values simulated by Enders and Granger (1998) and Enders and Siklos (2001). Once cointegration is confirmed, the next step is testing asymmetric price adjustment. This entails testing for symmetric null hypothesis ($\rho_1 = \rho_2$) against its alternative of asymmetric adjustment ($\rho_1 \neq \rho_2$). It follows a standard F statistic because the estimates for ρ_1 and ρ_2 have an asymptotic multivariate normal distribution (Tong, 1990). If asymmetry is accepted, then the restricted constant adjustment parameter assumption of the Engle and Granger test and Johansen cointegration models is not appropriate to our data. In other words, traders do not react homogenously to price decreases and increases from world grain markets.

Another alternative approach to examine threshold cointegration is the Momentum Threshold Model (M-TAR). The above TAR model in Equation (7.1) differs from the M-TAR model in how it establishes the Heaviside indicator. In the TAR model, it is created using μ_{t-1} as in Equation (7.2), whereas in M-TAR model, as shown in Equation (7.3), the first difference of μ_{t-1}that is $\Delta\mu_{t-1}$is used for setting the Heaviside indicator.

$$M_t = \begin{Bmatrix} 1 \; if \; \Delta\mu_{t-1} \geq \tau \\ 0 \; if \Delta\mu_{t-1} < \tau \end{Bmatrix} \tag{7.3}$$

The M-TAR model is preferred to the TAR model when deviations from the equilibrium are believed to exhibit more momentum in one direction (Enders and Siklos, 2001). Specifically, this study uses two alternative non-linear models, namely consistent Threshold Autoregressive

(TAR) and Momentum Consistent TAR (MC-TAR) models. One major advantage of these approaches is that they allow transaction costs (τ) to be different from zero, which is not the case in TAR and M-TAR models. The threshold value takes zero in the case of TAR and M-TAR models, while it is unknown for the consistent TAR and MC-TAR models. We estimate the threshold value using Chan's (1993) grid search procedure. This approach is summarised as follows: firstly, estimate the long-run equilibrium relationships and sort the estimated residuals in ascending order; secondly, discard the 15 per cent maximum and minimum values and use the remaining 70 per cent as potential thresholds, and finally, choose the residual for threshold that yields the lowest residual sum of squares from long-run equilibrium regression.

Conditional on the acceptance of cointegration and asymmetric adjustment, further model selection criteria using AIC is carried out to choose between the two alternative non-linear models. The model with the lower AIC better fits to the empirical data. Because of the small country assumption of the Ethiopian wheat market, the subsequent dynamic error correction model is not relevant to our case.

Table B1.1: Consistent TAR model results for domestic-to-world wheat markets, full sample

Parameters	**ETH- Black Sea**	**ETH-Canada@**	**ETH-Russia@**	**ETH-Ukraine@**	**ETH-USA**
τ	0.172	-0.310	0.187	0.25	-0.152
ρ_1	-0.051**	-0.0385**	-0.129**	-0.038**	-0.058**
ρ_2	-0.085**	-0.135**	-0.059**	-0.075**	-0.102**
$\rho_1 = \rho_2 = 0$	3.952	6.70	4.31	5.57	**-2.052****
$\rho_1 = \rho_2$	0.500	4.356	1.174	1.00	0.956
Diagnostic					
Q(6)	0.94	0.99	0.79	0.58	0.70
AIC	-2.411	-2.011	-2.597	-2.483	-2.136
Lags	2	4	2	2	2

Notes: Q(6) is the Ljung-Box test for the presence of autocorrelation up to six lags order; Lag length is selected using AIC; * ** *** rejection of the null at 1 %, 5 % and 10 %, respectively.

Table B1.2: Consistent M-TAR model results for domestic-to-world wheat markets, full sample

Parameters	ETH- Black Sea	ETH- Canada	ETH- Russia	ETH- Ukraine	ETH-USA@
τ	0.036	-0.052	-0.009	-0.057	-0.036
ρ_1	-0.014**	-0.067**	-0.062**	-0.067**	-0.043**
ρ_2	-0.09**	-0.220*	-0.119**	-0.018*	-0.165**
$\rho_1 = \rho_2 = 0$	4.25	**10.34****	3.828	0.804	**8.581****
Φ (t-max)	-0.28	**-2.34****	-1.421	-0.348	-1.675
$\rho_1 = \rho_2$	1.71	6.52	0.775	5.174	6.05
Diagnostic					
Q(6)	0.92	0.99	0.66	0.58	0.67
AIC	-2.414	-1.98	-2.592	-2.481	-2.128
Lags	2	4	2	2	2

Notes: Q(6) is the Ljung-Box test for the presence of autocorrelation up to six lags order; Lag length is selected using AIC; * ** *** rejection of the null at 1 %, 5 % and 10 %, respectively.

Table B1.3: Consistent TAR model results for domestic-to-world wheat markets, regime 1

Parameters	ETH- Black Sea	ETH- Canada	ETH- Ukraine	ETH-USA
τ	-0.168	-0.127	0.178	-0.186
ρ_1	-0.059**	-0.112**	-0.057**	-0.091**
ρ_2	-0.101*	-0.067**	-0.086**	-0.061**
$\rho_1 = \rho_2 = 0$	3.62	4.32	3.84	0.239
Φ (t-max)	**-1.90****	-1.44	-1.27	-1.309
$\rho_1 = \rho_2$	0.52	0.493	0.261	3.387
Diagnostic				
Q(6)	-2.41	0.88	0.66	0.94
AIC	0.94	-2.206	-2.851	-2.503
Lags	2	3	2	2

Notes: Q(6) is the Ljung-Box test for the presence of autocorrelation up to six lags order; Lag length is selected using AIC; * ** *** rejection of the null at 1 %, 5 % and 10 %, respectively.

Table B1.4: Consistent M-TAR model results for domestic-to-world wheat markets, regime 1

Parameters	**ETH- Black Sea**	**ETH- Canada**	**ETH- Ukraine**	**ETH-USA**
τ	0.027	0.058	0.047	0.055
ρ_1	-0.006	-0.23*	-0.210*	-0.167*
ρ_2	-0.446	-0.07**	-0.052**	-0.063**
$\rho_1 = \rho_2 = 0$	3.077	5.94	4.328	4.03
Φ (t-max)	-0.018	**-2.02****	-1.767	**-1.89****
$\rho_1 = \rho_2$	2.01	3.47	6.045	1.4332
Diagnostic				
Q(6)	0.97	0.88	0.65	0.94
AIC	-3.35	-2.202	-2.850	-2.502
Lags	6	3	2	2

Notes: Q(6) is the Ljung-Box test for the presence of autocorrelation up to six lags order; Lag length is selected using AIC; * ** *** rejection of the null at 1 %, 5 % and 10 %, respectively.

Table B1.5: Consistent TAR model results for domestic-to-world wheat markets, regime 2

Parameters	**ETH- Black Sea**	**ETH- Ukraine**	**ETH-USA**
τ	0.102	-0.101	0.172
ρ_1	-0.14**	-0.136**	-0.204*
ρ_2	-0.06**	-0.06**	-0.074**
$\rho_1 = \rho_2 = 0$	4.52	4.34	5.65
Φ (t-max)	-1.34	-1.12	-1.71
$\rho_1 = \rho_2$	1.30	1.45	3.01
Diagnostic			
Q(6)	0.66	0.84	0.98
AIC	-2.79	-2.75	-2.755
Lags	3	2	5

Notes: Q(6) is the Ljung-Box test for the presence of autocorrelation up to six lags order; Lag length is selected using AIC; * ** *** rejection of the null at 1 %, 5 % and 10 %, respectively.

Table B1.6: Consistent M-TAR model results for domestic-to-world wheat markets, regime 2

Parameters	ETH- Black Sea	ETH- Ukraine	ETH-USA
τ	-0.067	-0.059	-0.015
ρ_1	-0.066**	-0.061**	-0.048**
ρ_2	-0.231*	-0.233*	-0.22*
$\rho_1 = \rho_2 = 0$	6.02	5.856	7.15
Φ (t-max)	-1.073	-1.572	-1.065
$\rho_1 = \rho_2$	4.07	4.28	5.78
Diagnostic			
Q(6)	0.64	0.58	0.98
AIC	-2.78	-2.48	-2.76
Lags	3	2	5

Notes: Q(6) is the Ljung-Box test for the presence of autocorrelation up to six lags order; Lag length is selected using AIC; * ** *** rejection of the null at 1 %, 5 % and 10 %, respectively.

Appendix B (2): Wheat parity analysis

The calculation for wheat import parity consists of the FOB (Free on Board) wheat price at the port of North West Pacific (NWP) region, plus transportation costs for shipping wheat to Djibouti/Mombasa port, added to insurance costs, port handling, import tariffs, and distribution costs from the port to Addis Ababa. In 2005, we used the weekly freight costs from NWP to port of East Africa/Middle East (Egypt/Israel). For the remaining years, we used freight costs coming from NWP, USA, to Djibouti/Mombasa port. Wheat costs coming from NWP include higher freight costs than from the US Gulf. The route from NWP, USA, to Djibouti/Mombasa port is the most common trade route that has been used by Ethiopia. Since Ethiopia relies on Djibouti port, it makes sense to use this port for wheat parity price analysis. However, IPP would have been lower if we had used the US Gulf to East Africa/Mid-East (Egypt/Israel) trade route.

The port of Djibouti is the main entry port for both commercial and food aid grains imported into Ethiopia. The port is about 864 km from Addis Ababa, and imports take about two days to reach Addis Ababa by truck (see Appendix Figure 2(b) below). Distribution costs from the port of Djibouti to Addis Ababa are obtained from the USAID Bellmon study (USAID, 2010). These costs include port handling, inland transport, and loading/unloading costs.

Appendix Figure 2(b): Trade routes from Djibouti to Addis Ababa, Ethiopia

Source: Google Maps (2017)

Table B2.1: Wheat import parity price calculation, 2005-2016

Cost components	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
F.O.B price HRW (Pacific North West (PNW) region, U.S. $/t)	158	194	273	355	217	241	319	318	326	298	234	202
Ocean freight ($/t)	46	45	94	96	58	57	48	48	51	53	51	45
Insurance (1 %)	2	2	3	4	2	2	3	3	3	3	2	2
CIF at Djibouti ($/t)	205	240	369	455	278	300	370	369	381	354	288	249
Official Exchange Rate (OER)	9	9	9	10	13	16	17	18	19	20	21	22
CIF in ETB/t	1781	2113	3414	4737	3579	4833	6403	6743	7261	7113	5944	5413
Import tariff (5 %)	89	106	171	237	179	242	320	337	363	356	297	271
Distribution costs from port to Addis wholesale mkt												
Port handling (ETB/t)	233	233	233	233	233	233	233	233	233	233	233	233
Inland Transport (ETB/t)	380	380	380	438	528	394	431	435	448	447	427	440
Unloading (ETB/t)	320	320	320	320	320	320	320	320	320	320	320	320
Wheat IPP (ETB/t)	2803	3151	4517	5964	4839	6022	7707	8067	8625	8468	7221	6677
Addis Ababa_ wholesale wheat (white) ($/t)	230	300	332	555	485	336	426	396	406	471	486	415
Addis Ababa_ wholesale wheat (white) (ETB/t)	1992	2641	3072	5786	6247	5402	7365	7240	7751	9460	10036	9025

Notes: HRW: Hard Red Winter wheat; The cost estimates for port handling, inland transport costs, and unloading are based on USAID Bellmon study (USAID, 2010); freight costs are collected from US wheat associates (www.uswheat.org)

Appendix C

Table C.1: Balance sheet for Ethiopian white maize sub-sector, 2001–2015

Attributes	Units	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Area Harvested	1000 ha	1975	1191	1367	1392	1526	1694	1767	1978	1772	1963	2055	2013	1995	2230	2150
Yield	mt/ha	1.65	1.5	1.86	1.72	2.19	2.23	2.12	2.22	2.2	2.49	2.95	3.06	3.25	2.95	2.35
Production	1000 mt	3250	1788	2543	2394	3337	3776	3750	4398	3900	4895	6069	6158	6492	6580	5050
Beginning Stocks	1000 mt	0	0	0	0	0	137	313	373	471	271	451	610	763	510	495
Imports	1000 mt	0	0	0	0	0	0	10	0	0	0	0	0	5	5	5
Total Supply	**1000 mt**	**3250**	**1792**	**2543**	**2394**	**3337**	**3913**	**4073**	**4771**	**4371**	**5166**	**6520**	**6768**	**7260**	**7095**	**5550**
Exports	1000 mt	0	0	0	0	0	0	0	0	0	65	10	5	0	0	0
Feed and Residual	1000 mt	0	0	0	0	200	200	200	200	200	400	500	500	750	600	400
Human consumption	1000 mt	2948	1626	2307	2172	2722	3085	3175	3720	3538	3856	4899	4990	5443	5443	4536
Seed	1000 mt	302	166	236	222	278	315	325	380	362	394	501	510	557	557	464
Total domestic use	1000 mt	3250	1792	2543	2394	3200	3600	3700	4300	4100	4650	5900	6000	6750	6600	5400
Ending Stocks	1000 mt	0	0	0	0	137	313	373	471	271	451	610	763	510	495	150
Total Demand	**1000 mt**	**3250**	**1792**	**2543**	**2394**	**3337**	**3913**	**4073**	**4771**	**4371**	**5166**	**6520**	**6768**	**7260**	**7095**	**5550**

Table C.2: Maize import parity price calculation, 2005–2017

Description	Maize Import Parity (2005–2016)													Outlook period	Scenario 2 (a drought)
	Currency	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2017
US (Gulf)_FOB, Maize (US No 2, Yellow)	**$/ton**	98,45	121,4	162,7	222,2	165,5	185,3	292	298,3	259,8	192,9	170,1	159,32	187,38	187,38
Ocean freight (US-Djibouti)	**$/ton**	42,47	37,08	68,20	69,76	58,02	57,22	47,67	48,08	51,48	52,54	51,52	45,29	45	45
Insurance – 0.3 % of FOB	**$/ton**	0,30	0,36	0,49	0,67	0,50	0,56	0,88	0,89	0,78	0,58	0,51	0,48	0,56	0,56
CIF at Djibouti port	**$/ton**	141,2	158,8	231,4	292,6	223,9	243,0	340,5	347,2	312,0	246,0	222,1	205,09	232,94	232,94
Effective Exchange rate (EER)	**ETB/$**	10,42	10,55	11,09	12,50	15,47	19,32	19,55	20,66	21,55	22,71	23,36	24,55	22,90	22,90
CIF at Djibouti port in ETB	**ETB/t**	1470	1675	2566	3659	3465	4695	6657	7173	6725	5588	5188	5036	5334	5334
Import tariff (5 %)	**ETB/t**	73,55	83,77	128,3	182,9	173,2	234,8	332,8	358,7	336,2	279,4	259,4	251,8	266,7	266,7
Port handling	**ETB/t**	233	233	233	233	233	233	233	233	233	233	233	233	233	233
Import parity_Djibouti	**ETB/t**	1777	1992	2928	4075	3871	5163	7222	7765	7294	6100	5681	5521	5834	5834
Distribution costs															
Transport costs from Djibouti port to Addis Ababa (864 km)	**ETB/t**	380	380	380	437	527	394	431	435	448	447	427	440	440	440
Unloading	**ETB/t**	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Import parity_Addis Ababa	**ETB/t**	2189	2404	3340	4544	4430	5589	7685	8232	7774	6579	6140	5993	**6306**	6306
Addis Ababa_Maize (white)	$/ton	169	169	194	426	288	184	268	281	310	253	223	229	250	250
Addis Ababa_Maize	**ETB/t**	1760	1782	2152	5333	4452	3557	5247	5802	6674	5751	5203	5616	**5733**	**9201**

Notes: The cost estimates for port handling, inland transport costs, and unloading are based on USAID Bellmon study (USAID, 2010); freight costs are collected from US wheat associates (www.uswheat.org)